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AN OVERVIEW OF SITRA'S R&D WORK AND SERVICES - 2019-20

It is heartening to note that 4 mills, comprising of 2 full members and 2 associate members enrolled newly as members, despite the not-so-favourable trading conditions that prevailed during the year, especially the later part of the 4th quarter due to the onset of COVID-19 pandemic. While 8 mills opted to resign from the membership mainly because of poor operating profits and 5 mills forfeited their membership for defaulting payment of overdue subscriptions. The total membership of SITRA during the year was 145, comprising of 201 units. SITRA's services were also utilised by 37 small mills under the Technical Support Scheme. In all, 237 units have access to SITRA's services, apart from many units in the decentralised sector which utilised the services offered by 7 Powerloom Service Centres, one Textile Service Centre and 4 CAD Centres.

The overall financial position of SITRA during the year has been satisfactory, resulting in a surplus income over the expenditure.

While SITRA continued to focus its attention to address the problems of mills with significant amount of staff time on these activities, nevertheless it has been possible to continue its good work in the R &D sphere with progress recorded on most projects during the year. SITRA concentrated on many in-house projects, with such projects outnumbering Ministry sponsored projects. The year witnessed SITRA working on as many as 24 projects, of which 13 were completed.

An overview of the work done during the year in different areas are given below.

FIBRE TO YARN CONVERSION

The project on effect of apron surface modification on yarn quality in ring frame has attempted to study the effect of surface modified bottom aprons of two different types (SM1 & SM2) and compare the same with existing regular aprons on yarn properties such as imperfections, hairiness, tenacity, elongation and infrequent yarn faults. Yarn samples from three different apron combinations were produced from 100% combed cotton material in a ring frame. Results revealed that in all the three yarn counts, no significant difference was observed in yarn unevenness and imperfections between the yarns spun out of surface modified and regular aprons. No variations were observed in both hairiness index (H) and S3 values within the three yarn counts between the three different apron combinations. Similarly, no variations were observed in the yarn tenacity in the three yarn counts produced using the two surface modified aprons and regular aprons. A noticeable reduction in total classimat faults was observed in all the three yarn counts produced using surface modified aprons. In short thick objectionable faults (10 classes), SM-1 showed lower yarn faults by about 18%, 16% & 9.7% than that of the regular aprons. SM-2 have shown lower short-thick objectionable yarn faults by about 16%, 39% & 25.6 % than that of the regular aprons. In Long thick faults, SM-1 have shown lower yarn faults by about 73%, 44% and 18% and SM-2 apron have shown 50%, 76% & 25% lower yarn faults than that of the regular aprons. In Long thin faults, both SM-1 & SM-2 aprons have shown lower yarn faults than that of the regular aprons.

The study on yarn contraction in 100% modal spun yarns aimed to investigate the behavior of contraction in conventional yarn vis-à-vis compact yarns and estimate the yarn contraction based on spindle speed, twist multiplier, yarn count and roving hank. Based on the findings, it has been planned to derive an empirical formula to calculate yarn contraction for 100% modal yarns based on the process parameters, twist multiplier, spindle speed, yarn count and roving hank. Four counts Ne 20, Ne 40, Ne 60 and Ne 80 were spun from 100 % modal fibres. The yarn samples were from both compact and conventional ring spinning systems using 6 different twist multipliers under identical machine conditions. The studies were conducted on LMW LR6/S model pilot ring frame having P 3-1 drafting with Suessen compact system.

Results showed the yarn contraction is directly proportional to twist multiplier. An increase in twist multiplier leads to increase in the yarn contraction and vice versa in the conventional yarn. When spinning conventional yarns from 2.5 TM to 3.2 TM, the yarn contraction showed an anamolous behaviour and was found to be negative (i.e. elongation) because of uncontrolled stretch between the front roller and the package. Increases in % contractions were observed when spinning with twist multipliers 3.6 and above. When spinning with a TM of 3.2, increase in spindle speed from 12000 rpm to 22000 rpm resulted in the absolute yarn contraction getting reduced by 1.4% in conventional yarns. In 12000 rpm, the yarn contraction was observed to be 0.550%. When the speed was increased to 22000 rpm, the yarn had elongated (yarn elongation is 0.90%).

While spinning modal compact yarns, the yarn contraction levels were found to vary when the tension draft of the compact roller was altered. When the tension draft was 1.065, at 2.5 TM, the yarn contraction was found to be negative and the yarn got extended by 3.115% and the same trend followed upto the TM level of 4.0. At the TM level of 4.5, a yarn contraction of 0.806% was observed. At 1.026 tension draft of the compact roller, the yarn contraction was found to be higher compared to the levels at 1.065 tension draft. The same trend was confirmed with 1.005 tension draft at 2.5 TM and 3.2 TM. The results establish the fact that tension draft is also an important influencing factor in 100% modal fibre processing. This phenomenon is an eye opener to mills. If the compact tension draft varies between spindles/machines, then the yarn contraction also will vary, thereby influencing the yarn count deviation and leading to increase in count CV% also. Similar trials are being carried out for other counts also.

The study on combing efficiency in modern combers has attempted to revisit the existing formula, provided by SITRA way back in 1975 and later on revised in 2010 in line with the changes in comber technology, to judge the combing performance and take necessary process control measures. The earlier method of assessment using digital fibro-graph, which measures fiber length based on span length concept has almost become obsolete in the industry. Even though the HVI instrument measures the fibre length in the similar span length concept of Digital fibrograph, many times when the combing efficiency is calculated based on the HVI measured 50% span length for the modern combers the efficiency values are very low and hence the comber performance cannot be decided based on these values. Samples were collected from various mills and tested at SITRA and using the available AFIS data, a formula was derived to calculate the **Combing index** which is given as

$$\frac{[\text{Noil Extracted \%} - (\text{SFC(W) in lap} - \text{SFC(W) in sliver})]}{\text{Noil extracted \%}}$$

Using the available AFIS data, another formula is derived to calculate the **Length Improvement Index** which is given by the formula,

$$\frac{(\text{L(n) of comber sliver} - \text{L(n) of comber lap}) \quad \text{X} \quad 100}{\text{L(n) of comber lap \% of noil extracted}}$$

In both the formulae, higher the value, better the length improvement.

The formulae is under validation with further data for different nipping rates and waste index. Similarly, the chances of improvement in fibre length L(n) due to parallelization as well as the changes in SFC(w) by drafting in lap and combed sliver for high speed combing will also be investigated.

The study on effect of modified cots and top roller load on yarn quality in ring frame has made an attempt to reduce the rubber cots' width and maintain same load per unit area in front, middle and back top roller in ring frame drafting which can result in savings on raw material of rubber and bare shell roller and could also result in energy savings with lower consumption of air. 15 mm rubber cots width in ring frame drafting rollers were used in the study as against the standard practices followed generally in mills. The total pressure on the top rollers was changed by adjusting the pressure in the compressed air hose via a reducing valve at the end of the machine, and distributed to the individual rollers through a system of levers. The trials were conducted using 40 Ne combed conventional process on LMW LR6/S model pilot ring frame having P 3-1 pneumatic drafting system with Suessen compact system.

The results showed that there was no difference in yarn unevenness (U%) and imperfections, between the two pressure levels both in normal and extra-sensitive levels. The Deviation Rate (DR) % decreased by 16% in the pressure level of 1.5 kgs/cm^2. Also, no significant differences were observed in hairiness between the two levels. Zweigle hairiness (S3) value decreased by 30% in the pressure level of 1.5 kgs/cm^2. Improvement in yarn tenacity by 5.6% was observed between the trials, while no differences were observed in the elongation %. Even by reducing the total applied load from 2.5 kgs/cm^2 to 1.5 kgs/cm^2 and maintaining the same load per unit area in the drafting system (around 0.750 kg/mm for front, back rollers and 0.5 kg/mm for middle roller) no marked difference was observed in the yarn quality. Similar trials for other counts are under planning towards understanding yarn quality changes thereof.

In another study on product development using hemp /cotton blended yarns spun in cotton spinning system, an attempt was made to blend hemp fibres and cotton fibres towards developing hemp /cotton blended yarns in ring and rotor spinning systems. Three blends of 30/70, 40/60, and 50/50 (hemp/cotton) proportions in two yarn counts namely Ne 16 (36.90 Tex), Ne 30 (19.68 Tex) as well as 100% cotton yarns of same count in short staple ring spinning & only Ne 16 (36.90 Tex) in the rotor spinning system were attempted. Since hemp fibre is around 16 times coarser than cotton fibre, the interaction of hemp with cotton was not homogeneous, resulting in greater migration of hemp fibres to yarn sheath. With increase in the percentage of hemp fibre, the quality decreased. Among the three blended yarns, the 30:70 blend showed lower imperfections, higher CSP, single yarn strength and elongation than that of their two other blend counterparts in both Ne 16 and Ne 30.

During the uniaxial extension of a solid fabric material, besides the deformation in the direction of the applied force, a certain amount of lateral contraction, perpendicular to the direction of the applied stress occurs. This observable fact is called the Poisson's effect. SITRA took up a project to study the relevance of Poisson's ratio for made-up garment characteristics towards utilizing the same for their design/fabrication. Twelve samples were tested for Poisson's ratio by subjecting the material to uniaxial stress using Zwick-Roell UTM. Spun bonded fabric was subjected to a uniaxial strain and Poisson's ratio was calculated for both the machine and cross direction. The uniaxial strain was applied in 10 steps (viz. 2.5%,5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20%, 22.5% & 25%) and the fabric contraction was measured to evaluate the Poisson's ratio at all extension levels.

The results showed that the tensile strength of the fabric in machine direction was almost double to that in the cross direction. The flexural rigidity and elongation value in cross direction were higher than machine direction for all the spun bonded fabric samples. With multiple layers, the flexural rigidity increases for the same GSM. The Poisson's ratio was noticed to change in the process of the extension of the fabric sample. The Poisson's ratio increases initially and then decreases slightly as the extension is increased in the machine direction. The graph flattens for cross direction after 15% extension for all the fabrics. The results lend credence to the fact that as the number of layers increase for spun bonded fabric, the value of Poisson's ratio also increases when compared with fabrics of same GSM. The contraction level in machine direction was higher than the cross direction. In the machine direction, the extension contributed much less and there may be other factors like binder film, melt structure, degree of orientation of fibrils, etc., influencing the Poisson's ratio. In SMS fabrics, the Poisson's ratio increased as the gauge length increased at both the directions irrespective of GSM. Contraction % was more pronounced in the case of shorter widths & the Poisson's ratio increased as the width decreased.

Non-woven anisotropy and variation in tensile properties with the direction of extension was an important aspect observed in spun bonded non-woven studied. By analyzing the tensile, elongation, fabric bending and Poisson's ratio characteristics at two orientations (machine wise & crosswise) of the fabric, one could design the layout for medical products (surgical gowns) manufacture. As the elongation values are higher and lower contraction (lower Poisson's ratio) is found in cross direction, the manufacture of surgical gown may be patterned accordingly to provide more comfort and stability during use for the surgeons.

Tea bags are becoming popular for brewing tea across the globe due to its simplicity and convenience. Although most of the teas across the world are brewed using tea bags, information regarding the impact of tea bag material parameters on tea bag infusion and brewed tea is slender. Hence, SITRA took up a study to characterize tea bags for their thickness, wettability, surface topography, pore size, porosity, and permeance towards understanding their influence on infusion kinetics.

Major tea brands available in sachets in the Indian market were identified & their products collected. Investigation involved physical characterisation of the string & sachet used while chemical analysis involved study of pesticide residues, insecticides (chlorophenols), pH, formaldehyde, Alleyl Phenol Ethoxylates, lubricants, etc. Initial studies do not reveal any striking deficiencies on these aspects. Further studies are under way to study the toxicity of the extract of the teabag sachets. Three varieties of tea bags sachets made from different materials viz., Nylon, Poly Lactea Acid and nonwoven (spun bonded) will be analysed for various parameters and will be characterized physically and chemically.

OPERATIONAL STUDIES

Since 1997, SITRA has been regularly conducting a unique inter-mill study on “Costs, operational performance and yarn quality” covering various key parameters affecting cost of production, productivity and profit of spinning mills. Analysis of data collected for the 35th study covering the period October-December 2019 showed that in the 4th quarter of 2019, mills on the whole had registered about 20% reduction in the contribution when compared to the 4th quarter of 2018. During the 4th quarter of 2019, the yarn sale value had registered a decrease of 12% when compared to the same quarter of 2018. The raw material cost (RMC) had also witnessed a reduction of 14% in terms of Rs per spindle per year and 11% reduction with respect to Rs per kg of yarn. When compared to the 4th quarter of 2018, salaries and wages cost had increased by 3% in the 4th quarter of 2019. However, the power cost had remained the same among the common mills. Further analysis showed that out of the 76 common mills, only close to 30% of the mills (22 mills) registered an increase in the contribution (by Rs 1080 per spindle per year) with the increase ranging from Rs 60 to Rs 3210 between mills. The increase in the contribution in the 22 mills was mainly due to reduction in input costs viz. RMC, salaries & wages cost and power cost which offsets the decrease in sales turnover (by Rs 246 per spindle per year). The remaining mills recorded a reduction of Rs 1550 per spindle per year in the contribution ranging from Rs 70 to Rs 6490 between mills. In these mills, the decrease in the RMC value by Rs 2080 per spindle per year is not enough to offset the reduction in sale value (by Rs 3420 per spindle per year) and increase in other input costs (by Rs 210 per spindle per year).

The 8th study on inter-mill comparison of fibre to yarn conversion cost was based on the data collected from mills in the 35th CPQ study, covering the data for the fourth quarter of 2019 comparing those mills that had furnished the count-wise conversion particulars covering all the elements of cost. The study covered the conversion cost particulars of as many as 154 different counts and varieties of yarns. A detailed analysis was made for 12 different counts for which 4 and above mills (in each count) had furnished the relevant data. In addition, the trend in the movement of conversion cost between 2010 and 2019 was also covered. Data revealed that the average conversion cost, in terms of per kilogram of yarn was found to increase as the count becomes finer, i.e. as low as Rs 53.7 in 24s CH to a high of about Rs 165.8 in 80s C-Comp. Counts. Between mills, the conversion cost varied considerably in all the counts, i.e standard deviation ranging from as low as 4 to more than 31 with the overall difference being high at 13. Such a huge variation in the conversion cost between mills was largely due to the differences in the operational parameters like production rate, labour productivity, capacity utilisation, energy consumption, etc. and cost parameters such as wage rate, staff salary, power cost per unit, stores and packing materials cost, interest commitment and investment on plant and machinery and partly because of the in-correct method of estimation of yarn cost.

In terms of per kilogram per count, the conversion cost did not show any clear trend between counts. The conversion cost averaged at Rs 1.96 per kg per count with the cost ranging from Rs 1.56 to Rs 2.59 between counts, i.e. average ±0.52 paise. However, in terms of per spindle per shift, it showed a declining trend as the count became finer i.e. in 24s CH, it was around Rs 13 whereas in 80s, it was only about Rs 8.

During the period October to December 2019, only 7 counts managed to earn profit whereas the rest of the counts registered a net loss. Compact and compact hosiery counts (both domestic and export) were found to be more beneficial. Since, the external factors that tend to affect the commercial parameters viz., YSP and RMC, on most occasions, are not under control of the managements, the mills must give top priority to optimise the conversion cost on a regular basis towards earning a reasonable profit margin.

Component-wise conversion cost also showed an increasing trend as the count become finer. For example, the salaries and wages cost in 24s CH averaged about Rs 15.6 per kg of yarn where as in the fine counts (80s), it was almost 3 times higher at about Rs 45 per kg of yarn. The power cost which was around Rs 18 per kg of yarn in 24s count was more than 4 times higher at about Rs 61 per kg of yarn.

Another interesting finding was that amongst the 6 cost components, power cost was found to be the largest component with a share of 34% followed by salaries and wages cost (25%). The interest cost stood at 3rd place (15%) followed by stores and packing materials cost (10%), depreciation cost (10%) and administrative overheads (6%).

With an aim to keep mills informed about the trend in the movement of count-wise yarn selling price (YSP) and raw material cost (RMC) between months, SITRA has been conducting a monthly online survey on RMC and YSP since April 2013. The findings of this survey report helps the mills to compare their RMC, YSP, net out-put value (NOV) as well as their yarn quality and productivity level with other mills every month. This unique survey covers almost 250 different counts and varieties of yarn. As on March 2020, SITRA has successfully completed 84 studies with the overwhelming participation of as many as 80 mills from different parts of the country. Participant mills submit their data on count-wise average RMC, YSP, yarn realisation and production per spindle pertaining to nearly 10 major counts on SITRA's portal www.rmcysp.sitraonline.org, between 1st and 7th of every month. Between 8th and 20th of every month, the submitted data is critically scrutinized and analyzed at SITRA's end. On 21st of every month, a survey report covering the data of all the participating mills is uploaded on the above web portal along with database supported queries. Apart from the above, a follow up report on the trend in the movement of average YSP, RMC and NOV of popular counts is also uploaded every month.

A case study on cost reduction in spinning mills showed that there is a good scope to reduce the input costs without major investments and by exercising good control over Incidence of wastes, particularly hard waste, sweep waste and invisible loss; ring frame machine efficiency; employment of operatives strictly as per SITRA suggestion; maintenance of machinery and following energy conservation measures.

CHEMICAL PROCESSING

Under a project sponsored by the Ministry of Textiles, Govt. of India, an attempt was made to develop an eco-friendly reduction process of natural indigo dyes using greener reducing agents and also greener alkali sources to replace the conventional chemicals i.e., sodium dithionite or hydrose and caustic process which generates non-regenerable oxidation products and causes various problems in the disposal of the dye bath and the washing water. After successful lab scale trials, the SITRA developed natural indigo technology was applied on Slasher dyeing machine in the dye house of the industrial partner using 2500 meters of yarn which included Ne 10 K, Ne 16 RSSL and Ne 30 C. Natural indigo process being applied in Slasher dyeing machine is the first of its kind in the world. Commercially developed natural indigo dyed samples produced thus, based on the above process were tested for colour fastness properties. Results of the commercial trials revealed that the fastness of the fabrics was excellent after washing and no staining took place on the adjacent fabrics. Further, the yellowing nature of indigo was arrested due to the after treatment process (mainly washing process). The light fastness was in the range of 4, which is acceptable. Further, the whole process resulted in good wet rubbing fastness property which was in the range of 3-4. The best results were obtained using the optimized recipe combination of natural indigo dye, RA3 reducing agent and AK2 green alkali. This technology named Green Reduction of Indigo Dyeing **(GRIN)** was launched in the Textile fair “WEAVES” at Texvalley, Erode.

Under a project sponsored by Science & Engineering Research Board (DST-SERB), a study was taken up for identification of nano- sized fumed silica particles and low cost cross linking agents to replace the high cost silane cross linkers and their formulation and application on the fabric surface by pad-dry-cure process in order to change the surface tension of the textile materials. The water repellency (hydrophobic nature) of woven fabrics coated with fumed silica particle based formulation developed under the project, was at par with the results of fabric treated with commercial formulation chemicals. Commercial TEOS (Tetraethyl Orthosilicate) cross linker was successfully replaced with low cost carboxylic acids. The highest water contact angle was obtained when salicylic acid was used as the cross linker during the silica sol preparation for the hydrophobic coating on the cotton fabric. One more formulation also made using natural thickener (TKP- Tamarind Karasl Powder), which was very efficient and the coating was even, also resulted in good water repellency and good durability upto 10 laundry washes.

The study demonstrated that using the surface treatment with fumed silica nano particle, a low cost cross- linker and silane additive, is a promising alternative to perfluorochemicals for achieving hydrophobic surface.

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There is great demand for natural dyes in the present times due to resurgence of natural dyes (ND) in the dyeing industry. Identification and standardization of natural dye are two major issues. The determination of purity, method of extraction and different sources of the dyes are the important factors of the dyes. There are no testing protocols available for natural dyes in the literature among ISO, DIN, ASTM, BIS or others. Understanding the need for developing easy methods for identification of natural dyes based on simple chemical test and chromatographic methods which would also reveal the purity content and provide chemical information having good repeatability and reliability, SITRA took up the work to use the methods available namely Kit method (Preliminary test); Chromatographic tests which include Thin Layer Chromatography (TLC) (Mandatory test); High Performance Thin Layer Chromatography (optional test) and High Performance Liquid Chromatography (optional test) and Spectroscopy tests which include UV-Visible Spectroscopy (optional test), FT-IR Spectroscopy (optional test) and NMR Spectroscopy (optional test) to characterize indigo dye, fruit extract of terminalia arjuna and thespesia populnea. The extracted dyes were analyzed for phytochemical composition, such as total phenol, tannin and flavonoids. It was observed that the phenolic compounds present in plants are good sources of natural dye. The phytochemical analysis of dye extract was carried out using FT-IR and GC-MS. The colour components in the plant extract of Terminalia arjuna and Thespesia populnea were identified by GC-MS analysis. The interaction between the colour component, mordant and fabric was studied. The tests carried out under the study will pave a way to select the appropriate natural mordant for the dyeing of textile materials using natural dyes.

Disposal of mixed salt is an environmentally sensitive problem and recycling and use of wastes are considered as the preferred options for sustainable development, rather than incineration or land filling. But sometimes it is not straight forward because of sensitivities and contaminants like heavy metals, etc. Considering this, SITRA took up a study to identify usage of mixed salt for dyeing applications which explored the possibilities of usage of contaminated salt for dyeing as an exhaustion agent. The quality parameters of mixed salt and commercial salt and the possibility to dye fabrics using the mixed salt were studied. Dyed samples were subjected to computer colour analysis for evaluation. Results showed that hardness of the water was detrimental on dyeing of textiles. Usage of mixed salt for dark and medium shades based on industrial bulk trials was standardized and found successful. Mixed salt can be used and utilized for dyeing as an exhaustion agent for medium and dark shades with an additional of 20 % quantity and also by adding suitable sequestering and oxidizing agent.

The textile wet processing industry today, is interested in newer technologies which can address both effluents as well as lead to an eco friendly process. Hence, the elimination of water and chemicals would be a real breakthrough for the textile dyeing industry. Water free dyeing technology using supercritical carbon dioxide (SC-CO_2) can be a solution to the problem. SITRA has recently setup a pilot supercritical CO_2 dyeing machine. Multiple trials were carried out to develop a water free dyeing technique by using the machine. The feasibility of dyeing of synthetic and cotton materials without water and to get uniform, reproducible interaction between dye molecules and whole surface of textile material were explored. Initially, 100 % polyester woven fabric (GSM – 70 and filament yarn) was used for the study. Dyed fabrics were tested for color fastness to rubbing (dry and wet rub) according to the ISO 105 X12-2016. It was observed that fastness properties improved with an increase in temperature, pressure and time. Higher evenness and shade reproducibility was also achieved at higher temperatures (120^{0}C) and higher pressure (250 bar). The K/s values showed that the colour shade in polyester fabric changed with an increase in dyeing temperature, time and pressure. It is also proposed to develop a method of natural dye extraction by using $SCCO_2$ and also explore the means of using the technology for dyeing of cotton fabrics with continuous trials.

Under a study sponsored by DST Women Scientist Scheme- A, Govt. of India, which has been just initiated, an attempt is being made to replace the non-biodegradable polymer and costly carrier molecules in textile materials (used as encapsulating agents) by eco-friendly and readily available raw materials, thus ensuring customer wellness through eco-friendly means. The work plan is carrying out nano-encapsulation of Vitamin E from natural and commercial sources, the application of nano-formulation on the textile fabric by Pad-Cure method, evaluation of anti-oxidant property of finished fabric and also a Vitamin E release study through readily available natural sources.

Kovai Kora cotton sarees, which have acquired Geographical Indicator (GI) tag recently, have lost their market share in recent times due to the infusion of synthetic sarees and also due to their poor fastness properties. Under a project sponsored by the Department of Handloom & Textiles, SITRA took up a study to identify and suggest a dyeing method that can improve the fastness properties of these sarees. After extensive trials at the laboratory level and bulk dyeing trials at a few units in and around Sirumugai, SITRA has developed a suitable method - Single bath partial degumming and dyeing with Sodium bicarbonate – which has yielded good strength of dyed yarn when compared to grey silk yarn and in addition also giving an improved fastness.

MEDICAL TEXTILES

With increasing requirements for garment comfort, more and more studies have started focusing on comfort properties of fabrics. Scientific design and development of surgical gown, sportswear with wearing and functional comfort and bed linens with skin sensory comfort enhance not only the well-being and health of the real user, but also in human performance. With no comprehensive comfort index available for surgical gowns that can help users to understand the comfort properties of fabrics, SITRA took up a research work to develop a comfort index for commercially available products such as surgical gowns, sportswear, bed linens, etc., by combining the test results from sophisticated instruments available at SITRA for the measurement of comfort properties. Total Hand/Touch value was derived based on the Primary Sensory Indices (PSI) namely smoothness, softness and warmness provided by the Fabric Touch Tester (FTT) on 13 physical indices. Further analysis carried during the year revealed that an increase in knitted fabric GSM, thickness and stitch density results in decreased moisture vapour transmission property of the fabric. With the increase of fibre shape (non roundness) factor, the overall moisture management property of the fabric gets better, while air permeability as well as water vapour transmission reduces to a certain extent. As the pore size of the fabric increases, there is an increase in moisture vapour transmission (r= 0.63) and air permeability (r=0.54). Also the increased shape factor (non –roundness) of the fibre results in an increase the Overall Moisture Management Capacity (OMMC) of the fabric due to an increase in fibre specific surface area and also increase in the wicking rate through the fabric.

The study revealed that the Qmax value, which indicates the pace of movement of heat from the body to the fabric surface resulting in a cooler feeling fabric, was better when the thickness, GSM and stitch density of the fabric was lower.. Further, Qmax increased with increase in water vapour transmission rate.

Antimicrobial coated fabrics are increasingly being used in recent times to develop curtains, wound dressings, surgical gowns, drapes, sutures, hernia mesh etc., in the health care sectors. Though these materials have good market potential as they combat against microbial infection and assist save the patients from pathogens, its usage in feminine hygiene products such as sanitary napkin, tampons, wipes, diaper etc., needs to be studied carefully. Hence, an attempt was made to study the effect of antimicrobial coated hygiene products such as sanitary napkins and wet wipes on the normal flora of vagina and skin cells. The study results revealed that sanitary napkins and wet wipes when impregnated with antimicrobial compound, not only kill microorganisms but also damage the skin cells.

Under a project sponsored by DRDO, SITRA developed medical textile products such as blood absorptive gauze, blood absorptive packing gauze, natural polymer based wound dressings and multi layer wound care products for further evaluation at DRDO.

The role of hydrogels for wound dressings meant for treatment of chronic wounds like venous ulcer, diabetic and pressure ulcer have been extensively investigated in recent times. Gelatin based hydrogel are found to be biocompatible, biodegradable and possess multiple functions. Gelatin's property to assist in the controlled delivery and release of bioactive agents and being able to protect biomolecules from degradation and release them over extended time periods make them ideal to be used for wound dressings. SITRA took up a study wherein a combination of hydrogel and metals was studied for their ability to treat infection and improve the healing with copper oxide nanoparticles acting as an antimicrobial agent and gelatin as a carrier. Results indicate that the hydrogel developed in the study can be used for treating moderately exudating infected wounds after further confirmation through appropriate in vivo models and clinical trials.

An in-house project was initiated during the year with aim to study and fabricate multifunctional, biodegradable, eco and skin friendly, nonwoven tissues using electrospinning of polymers for the production of facial beauty masks and advanced skin medications. Polysaccharides (cellulose, starch, chitin and chitosan) which are biodegradable, skin-friendly and obtained from renewable resources were used for the study. Herbs were encapsulated in these polymers and electrospun for the production of Peel off mask and hydrogel sheet mask. The antioxidant activity of the selected extracts were assessed using FRAP (Feric Reducing Antioxidant Powder) assay and it was revealed that the extracts showed excellent antioxidant activity. The phytochemical analysis showed the presence of alkaloids, flavonoids, saponins, phenol and tannin in the plant extracts. The hydrogel mask and the peel off mask showed 99.99% antibacterial activity against *Escherichia coli* and *Staphylococcus aureus*

CONSULTANCY SERVICES

Under specific requests from mills, SITRA took up consultancy assignments on wide areas of specialisation. It is gratifying to note that the requests for consultancy services have been consistent from the mills in recent years. During the year, more than 150 consultanciy assignments were attended to which was utilised by as many of 33 member mills and 117 non-member units .

TESTING AND CALIBRATION SERVICES

The physical and chemical laboratories have been accredited by NABL for ISO/IEC-17025 for the various fibre, yarn and fabric samples tested for their physical and chemical properties. Several mills are seeking SITRA test reports with NABL logo for export purposes. The year witnessed 2,03,839 tests of fibre, yarn, fabric and PPEs being carried out for their physical, chemical or biological properties.

Since 2016, SITRA's physical and chemical testing laboratories have started functioning in two shifts with an aim to provide test results to the mills on a fast track. The introduction of the dual shift system has helped in hastening the testing process by reducing the turnaround time to process a request. Last year, SITRA introduced the "Rapid testing facility" to mills for speedy testing of samples. This has been made possible by subjecting the samples to the rapid conditioning system and preparing the pre-opened cotton fibres quickly for High Volume cotton testing.

A total of 4069 calibration certificates, for testing of quality control instruments were issued during the year, for the 170 mills that utilised these services. Testing the quality of spinning and weaving accessories/ spares in order to select the right quality is another service being offered by SITRA and 2,582 samples covering various accessories like paper cones, worm & worm gear wheel, cots, partition pad, spinning rings, spindles, ring travellers and carton boxes received from 373 units were tested.

TRAINING

Sixteen different training programmes were offered by SITRA during the year. This included 7 functional programmes, 8 in-house programmes, 1 international training and 16 multi-specialisation programmes in medical textiles, wherein a total of 466 persons were trained. Under operatives training, 156 operatives were trained during the year on right methods of working in textile mills for effective performance.

SERVICES TO DECENTRALISED SECTOR

The services of the 7 Powerloom Service Centres (PSC) in Tamil Nadu, managed by SITRA, have been extensively used by the powerloom sector. A total of 31224 samples comprising of yarn and fabrics have been tested and 509 persons were trained in the area of loom maintenance, operation of shuttleless looms, calculation of fabric production, etc. The PSCs have attended to 2,928 liaison visits and also inspected 21,810 looms during the year. A total of 90 consultancy assignments were carried out and 198 designs were created during the year.

MOUs/MoAs SIGNED

During the year, Memorandums of Understanding / Agreement were signed with the following organisations/ Institutions/agencies:

a) **M/s. MAK India Ltd., Coimbatore**, an established business house with commitments for bringing about environment friendly solutions to the industry through partnership with SITRA for study, analysis, conducting trials and work out possible industrial adaptation and commercial viability in the application of various technologies, inventions, solutions derived from research works of SITRA.

b) **M/s. WWF India, New Delhi**, a NGO with a mission to ensure use of sustainable renewable natural resources, to utilise SITRA's services for conducting quality testing of water samples taken from river basins.

c) **Nehru Arts and Science College, Coimbatore**, an educational institution for conducting Training programmes and workshops regularly for their students.

d) **M/s Shiva Texyarn Limited, Tirupur,** for utilizing the services of SITRA's NABL accredited laboratories for testing of their materials covering fibres to finished materials.

PATENTS FILED

1) Process of manufacturing breathable viral resistant film and laminates, Patent application no: 201941033758 Dt. 22.8.2019

2) Development of transdermal patch for selected cardiovascular drugs, Patent application no: 201941034173. Dt. 24.8.2019

PUBLICATIONS

During the year, SITRA brought out 23 publications which included 1 monograph, 4 research / inter-mill study reports, 12 online reports, 4 focus, 2 Etech letters (SITRA news publication).

SITRA scientists published 3 research papers in technical journals and presented 12 papers in conferences and seminars.

New Chairman and Vice-Chairman of SITRA's Council of Administration

The 67th AGM of SITRA which was held at SITRA on 19th September, 2019 elected the new Chairman and Vice Chairman of SITRA.

Shri Sanjay Jayavarthanavelu, who has been a member of the CoA since 2001 and the Vice-Chairman since 2016, and **Shri E.Sathyanarayana**, Managing Director, Sree Sathyanarayana Spinning Mills, Tanuku, who has been a member of the CoA since 2012, took over as Chairman and Vice Chairman respectively for the period 2019-22.

MEMBERSHIP

In spite of the general economic slackness in the textile industry, 4 mills, comprising of 2 full members and 2 associate members enrolled newly as members during the year. While 8 mills opted to resign from the membership mainly because of poor operating profits, SITRA had to take the painful decision of terminating the membership of 5 mills due to non-payment of arrears. The total membership of SITRA during the year was 145, comprising of 201 units (Table 1).

SITRA is pleased to extend a warm welcome to the following mills which enrolled as a full members during the year:

1. Sri Sivajothi Spg Mills P Ltd., Erode.
2. Saurer Textiles Solution, Coimbatore.

SITRA also extends its welcome to the following mills which are enrolled as an Associate member:

1. Sudiva Spinners Private Limited, Bilwara
2. Sumicot Limited, Bharuch.

SITRA's services are also utilised by 37 small mills under the Technical Support Scheme. In all, 238 units have access to SITRA's services, apart from many units in the decentralised sector which utilised the services offered by 7 Powerloom Service Centres, one Textile Service Centre and 4 CAD Centres.

FINANCE

The financial position of SITRA continued to be satisfactory during the year that ended with a surplus of income. The total recurring expenditure of SITRA during the year after depreciation and appropriation from reserves was Rs 11.70 crores. The total income, including the grants from the Ministry of Textiles, Govt. of India was Rs 12.43 crores.

SPONSORED PROJECTS

During the year under review, SITRA was involved in 11 sponsored research projects, 2 of which were sponsored by the Ministry of Textiles (MoT), Government of India and rest of the projects by agencies such DST, DRDO, DST-SERB, BIRAC, SCTIMST, and KVIC.

Table 1 Region-wise membership

Region	Spinning mills	Composite mills	Fibre manufacturers, Machinery manufacturers and others	Total
SITRA zone	105	19	4	128
Other States	6	7	2	15
Overseas	1	1	-	2
Total members	112	27	6	145
Total units	148	47	6	201

Work relating to the following projects, sponsored by different agencies, was completed during the year

1. Durable non-fluorinated functional textiles using fumes silica sols (DST/SERB)

2. Design and fabrication of an instrument to assess the puncture resistance of surgical material by using sharp edge puncture probe/syringe needles (DST)

3. Development of Novel, Biodegradable Adult Incontinence Device, sponsored by the Biotechnology Industry Research Assistance Council (BIRAC).

4. Identify the potability of drinking water from poor sanitation- Foldscope (Biotech Consortium of India)

Apart from the above, work was also completed for the following project in which SITRA worked in close association with the sponsoring industry and initiated the project based on their request :

1. Leukodepletion filter, (Sree Chitra Thirunal Institute of Medical Sciences and Technology, Tiruvananthapuram).

The following 2 projects, sponsored by MoT which were sanctioned last year are progressing well.

1. Development of total comfort index paradigm for textile structures

2. Development of Eco - Clothing by Greener Reduction Process of Natural Indigo Dye

Work relating to the following projects, sponsored by other sponsoring agencies, is progressing well

1. Kovai kora cotton sarees, sponsored by Department of Handlooms and Textiles, Govt of Tamil Nadu

2. Medical Textile Products identified by INMAS for wound healing and radio protective equipment based on textiles, sponsored by the Defence Research and Development Organisation (DRDO)

During the year, SITRA also received funding for the following projects and work on them has been initiated

1. Antioxidant cosmetotextiles : Durable nano encapsulate vitamin E finishes on textile fabrics and its controlled release study (sponsored by DST).

2. Field dissemination of technology of high productivity hand operated charka (KVIC)

MACHINERY AND EQUIPMENT

Equipping its laboratories /pilot mills with state-of-the-art machinery/instruments is a continuous activity to ensure that the institution has the latest generation machinery that can offer the best of the services to the industry. During the year under review, SITRA made a fairly large investment of Rs. 2.7 crores on state of art machinery and equipment, apart from other infrastructural requirements. Some of the important machinery and equipment installed during the year include Supercritical fluid dyeing machine, Micro dust trash analyser, GCMS system with accessories, HPLC system with accessories, High temperature infra red black body calibrator, Liquid bath calsys, Pyrometer, Portable temperature & humidity calibrator, Deep freezer and N^2 generator.

STAFF

There was a marginal reduction in the staff strength of SITRA following the resignation/reirement of some of the staff during the year, even as new recruitments were made to fill in the vacant positions. The number of staff during the year stood at 92 as against 99 last year. The number at the PSCs was down to 29 during the year, as against 30 last year.

OVERSEAS VISIT

SITRA deputed the following staff to visit the ITMA 2019 fair themed 'Innovating the World of Textiles', which was held at Fira de Barcelona, Gran Via venue, Barcelona, Spain during 20 to 26 June, 2019. The exhibition, showcased the latest technologies and sustainable solutions for the entire textile and garment manufacturing value chain, as well as fibres, yarns and fabrics.

1. Mr.D.Jayaraman, Asst. Director & Head, Spinning division
2. Mr.M.Muthukumaran, Principal Scientific Officer & Head, Engineering & Instrumentation division
3. Mr.S.Sivakumar, Principal Scientific Officer & Head, Chemistry division.

CONVERSION OF FIBRE TO YARN

YARN CONTRACTION IN 100% MODAL SPUN YARNS

In the manufacturing of staple yarns, twist is inserted into the fine strand of fibres to hold the fibres together and impart the desirable properties to the spun yarns. Twist may be defined as the spiral disposition of the components of a thread, which is usually the result of relative rotation of the two ends. Twist is generally expressed as the number of turns per unit length of yarn, e.g. turns per inch (tpi), turns per metre (tpm), etc.

In mills, 100 percentage yarn production is calculated by converting the length of material delivered by the front rollers into weight by using the average wrapping count, since the wrapping count refers to the 'twisted' yarn and the 'length delivered' is that untwisted strand, an apparent 'loss' in production takes place due to twist contraction. The present study aims to investigate the behavior of contraction in conventional yarn vis-à-vis compact yarns and to estimate the yarn contraction based on spindle speed, twist multiplier, yarn count and roving hank.

Objective of the study

1. To derive an empirical formula to calculate yarn contraction for 100% modal yarns based on the process parameters
2. The process parameters are twist multiplier, spindle speed, yarn count and roving hank
3. Individual and interactive effect of process parameters are taken in to account while deriving the formula

Proposed experimental plan

In this study, four counts Ne 20, Ne 40, Ne 60 and Ne 80 are to be spun from 100 % modal fibres. The yarn samples were from both compact and conventional ring spinning systems using 6 different twist multipliers under identical machine conditions. The studies were conducted on LMW LR6/S model pilot ring frame having P 3-1 drafting with Suessen compact system. The trials were carried out as per the experimental plan given in Table 2.

The proposed process parameters are given in Table 3.

Table 2 Proposed experimental plan

Particulars	No.of counts	Compact system	Conventional system	No.of Twist multiplier	No.of spindle speeds	No. of trials
Twist multiplier based trials						
20 Ne	1	1	1	6	1	12
40 Ne, 60 Ne and 80 Ne	3	1	1	6	1	36
Spindle speed based trials						
20 Ne	1	1	1	1	2	4
40 Ne, 60 Ne and 80 Ne	3	1	1	1	2	12
					Total number of trials	64

Table 3 Process parameters in ring frame

Parameters	(Compact/Conventional)			
	20 Ne	40 Ne	60 Ne	80 Ne
Twist multiplier (TM)	2.5,2.8,3.2,3.6,4.0 and 5.5	2.5,2.8,3.2,3.6,4.0 and 5.5		
Average spindle speed(rpm)	16500	18000		
Maximum spindle speed(rpm)	20000 @3.2 TM	22000 @3.2 TM		
Minmum spindle speed (rpm)	12000 @3.2 TM	12000 @3.2 TM		

Materials and methods

The study was started with spinning of Ne 80 from 100% modal fibres. The raw material quality attributes are given in Table 4.

Table 4 Quality attributes of raw material

Fibre fineness	0.9 denier
Cut length	34 mm
Roving hank	1.70 Ne

Preliminary results and discussion

Conventional yarn

Yarn contraction is directly proportional to twist multiplier. An increase in twist multiplier leads to an increase in the yarn contraction and vice versa in the conventional yarn. The yarn contraction% for 80 Ne conventional modal yarn is given in Table 5.

Table 5 80 Ne conventional yarn contraction%

Twist multiplier (TM)	Spindle speed (rpm)	Yarn contraction %
2.5	18000	(-)1.030
2.8	18000	(-)0.590
3.2	12000	0.550
3.2	18000	(-)0.108
3.2	22000	(-)0.904
3.6	18000	0.961
4.0	18000	1.492
5.5	18000	3.814

'(-)' sign indicates yarn elongation

When spinning conventional yarns from 2.5 TM to 3.2 TM, the yarn contraction shows an anamolous behaviour and was found to be negative (i.e. elongation) because of uncontrolled stretch between the front roller and the package. Contraction % increases were observed when spinning with twist multipliers 3.6 and above.

When Spinning with a TM of 3.2, increase in spindle speed from 12000 rpm to 22000 rpm resulted in absolute yarn contraction getting reduced by 1.4% in conventional yarns. In 12000 rpm, the yarn contraction is observed to be 0.550%. When the speed was increased to 22000 rpm, the yarn gets elongated (yarn elongation is 0.90%).

Compact yarn

While spinning the modal compact yarns, an interesting behaviour was observed. The yarn contraction levels were varying when the tension draft of the compact roller was altered. When the tension draft was 1.065, at 2.5 TM, the yarn contraction was found to be negative and the yarn got extended by 3.115% and the same trend followed upto the TM level of 4.0. At the TM level of 4.5, a yarn contraction of 0.806% was observed. The preliminary results of yarn contraction% for 80 Ne compact yarn is given in Table 6.

Table 6 80 Ne compact yarn contraction %

Twist multiplier (TM)	Spindle speed (rpm)	Yarn contraction %		
		Compact zone tension draft		
		1.065	1.026	1.005
2.5	18000	(-)3.115	(-)0.300	0.785
2.8	18000	(-)2.214	(-)0.802	#
3.2	18000	(-)1.074	1.156	1.554
3.6	18000	(-)0.669	1.786	#
4.0	18000	(-)0.253	2.214	#
4.5	18000	0.806	#	#

Where'(-)' sign indicates yarn elongation; # - Trials are in progress

At 1.026 tension draft of the compact roller the yarn contraction was found to be higher compared to the levels at 1.065 tension draft. The same trend was confirmed with 1.005 tension draft at 2.5 TM and 3.2 TM. This establishes the fact that the tension draft is also an important influencing factor in 100% modal fibre processing.

This phenomenon is an eye opener to mills. If the compact tension draft varies between spindles /machines then the yarn contraction also will vary, there by influencing the yarn count deviation. This can lead to increase in count CV% also.

Similar trials are to be conducted and the yarn quality have to be studied for other counts also.

PRODUCT DEVELOPMENT USING HEMP /COTTON BLENDED YARNS SPUN IN COTTON SPINNING SYSTEM

Hemp is one of the earliest textile fibre materials used by human beings of early first century BC known as Cannabis sativa species. It is also one of the bast fibres known to ancient Asians before the birth of Christ. It is grown chiefly in the Philippines, China, Mexico, Russia, West Indies and India. In India, Deccan hemp is grown both as a crop and hedge plant cultivated largely in Maharashtra, Tamil Nadu and north Gujarat. Hemp belongs to the Mulberry family (Morracea) and cultivated hemp varieties belong to the Cannabis sativa species. Hemp fibres are relatively coarse and hence only coarser counts can be produced. Hemp yarns are mainly used for the production of twine, rope and cord.

The length of the hemp fibre bundle is about 1500 - 2500 mm and its breaking strength is a little higher than that of flax fibre, but its elongation is low (2-3%). Blending flax with hemp improves both the elongation and the flexibility of the yarns, which is low in 100% hemp yarns. However, these blends also decrease the strength of the yarns. Due to the hygroscopic nature of the hemp, its moisture regain is 12% and this has a favourable effect on all fibre processing. In its chemical composition, cellulose constitutes 75%, pectin/lignin 9.5%, water soluble substances 21%, mineral matter, vegetable wax and fat in traces (0.6-0.8%).

SITRA took up the task of blending hemp fibres and cotton fibres and developing hemp /cotton blended yarns in ring and rotor spinning systems. Three blends of 30/70, 40/60, and 50/50 (hemp/cotton) proportions in two yarn counts namely Ne 16 (36.90 Tex), Ne 30 (19.68 Tex) as well as 100% cotton yarns of same count in short staple ring spinning & only Ne 16 (36.90 Tex) in the rotor spinning system were attempted.

Cotton fibres were tested in High Volume Instruments (HVI) and Hemp fibres were tested for their fibre fineness & single fibre strength in Lenzing Vibroskop and ZwickRoell instruments respectively. The test results are given in Table 7

Table 7 Quality attributes of cotton and hemp fibres

Fibre properties	Cotton*	Hemp fibre
2.5% span length (mm)	29.0	--
Uniformity ratio (%)	46.5	--
Cut length (mm)	---	40
Fibre fineness (dtex)	1.45 (3.7 µg/inch)	23.40 (59.43 µg/inch)
Bundle fibre strength (g/tex)	22.8	--
Single fibre strength (g/den)/mPa	-	8.61/ 653.75
Fibre elongation (%)	5.1	4.10

**As the compatible cotton variety to match hemp fibre parameter is not available, a slightly superior variety cotton used for that count range is selected.*

Spinning of 100% hemp yarns is not possible due to the stiff nature of hemp and hence they need to be softened before being blended with other fibres. The hemp fibres were initially softened by using softening oil mixed with water in appropriate proportion and sprayed on the hemp fibres. The mixture of softening oil and water used for spraying on 30/70, and 40/60 hemp/cotton blends are 300 ml in 1 litre of water and 600ml in 1 litre of water for 50: 50 blends respectively. Softened hemp fibres were conditioned for 24 h to 36 h separately and blended with pre-opened cotton fibres which were also conditioned for 24 h in room temperature and three blend ratios of 30:70, 40:60 & 50:50 (Hemp/cotton) were prepared. The blended hemp/cotton fibres were then opened again and cleaned in blow room line and laps were prepared with a linear density of 350 GSM. The blow room laps were processed through preparatory machineries of carding (C1/3), draw frame (LR DO/2S), speed frame (LF1660) and (LR G5/1) compact ring spinning with a suction pressure of 33mbar. Hemp/cotton blended yarns were produced in two yarn counts of Ne 16 (36.90 tex) & Ne 30 (19.68 tex) respectively. Similarly, 100% cotton yarns were also produced in both the yarn counts using the same processing machineries for comparing the yarn properties of hemp/cotton blended yarns to that of 100% cotton yarns. In the same manner, Ne 16 (36.90 tex) rotor yarns was also produced with draw frame sliver materials in three blend ratios and 100% cotton yarns as well.

The yarn samples were tested for their quality attributes like unevenness, imperfections and hairiness in Uster Tester 4 by standard testing procedure. The tensile properties such as single yarn tenacity, elongation % and count strength product (CSP) were tested in Uster Tenso rapid 4 & Lea strength testing instruments respectively.

The yarn quality of 100% cotton & hemp/ cotton blended ring spun yarns of Ne 16 (36.90 tex) & Ne 30 (19.68 tex) are given in Table 8.

It can be seen that

- In both the yarn counts spun using ring spinning (Ne 16 & Ne 30), all the three hemp/cotton blended yarns have shown inferior yarn quality in terms of unevenness (U %), normal, extra-sensitive imperfections and hairiness when compared to that of 100% cotton yarns. The yarn qualities of the hemp/cotton blended yarns deteriorate with an increase in hemp proportion in the blend.

Table 8 Yarn irregularity and tensile properties of 100% cotton & Hemp blended cotton ring spun yarns

S. No.	Properties	Ne16 (36.90 tex)	Ne 16 (36.90 tex) Hemp/cotton			Ne 30 (19.68 tex)	Ne 30 (19.68 tex) Hemp/cotton		
		100% cotton	30:70	40:60	50:50	100% cotton	30:70	40:60	50:50
1	Unevenness U%	10.33	29.88	33.46	34.68	14.1	32.18	33.47	34.48
2	Thin (-50%)	0	5613	7973	9994	39	7353	8880	9968
3	Thick (+ 50%)	100	4684	5500	6100	823	5672	6320	6571
4	Neps (+200%)	272	7636	9283	11770	1216	11190	12640	13650
5	**Total Normal Imp/km**	**372**	**17933**	**22756**	**27864**	**2078**	**24215**	**27840**	**30099**
6	Thin (- 40%)	37	9184	11050	13680	792	10970	13640	12950
7	Thick (+ 35%)	651	6824	7609	8424	2436	7718	8440	8584
8	Neps (+ 140%)	814	13150	15220	18470	3710	16860	19640	21060
9	**Total Ex. Sens. Imp/km**	**1502**	**29158**	**33875**	**40574**	**6878**	**35548**	**41720**	**42594**
10	Hairiness index (H)	5.50	5.75	6.29	6.43	4.26	4.5	4.55	4.60
11	**Single yarn tenacity (g/tex)**	**20.80**	**11.3**	**9.18**	**9.12**	**19.0**	**12.50**	**10.70**	**8.59**
12	Elongation (%)	8.86	6.21	5.01	4.4	6.16	6.0	5.33	4.51
13	CSP	3027	1731	1650	1525	2937	1472	1342	1037
14	CV% of CSP	4.44	6.14	10.05	10.18	4.97	7.69	8.94	14.50

- Among the three hemp/cotton blended yarns, in Ne 16 count, 30:70 hemp/cotton blended yarns have shown lower normal imperfections by about 26% & 55%, and 16% & 39 % in extra-sensitive imperfections than that of 40:60 and 50:50 blended yarns.

- In Ne 30 count also, 30:70 hemp/cotton blended yarns have demonstrated lower normal imperfections by about 15% & 24% and 17% & 19% in extra-sensitive imperfections respectively. The reason for the higher imperfection levels in hemp/cotton blended yarns mght be due to the coarser nature of the hemp fibres which would have caused more difficulties in drafting and hence the yarn quality is inferior as compared to 100% cotton yarns.

- The hairiness values of the three hemp/cotton blended yarns have shown higher hairiness than that of the 100% cotton yarns. Higher hairiness of the hemp/cotton blended yarns might be due to the coarser nature of hemp fibres which would have migrated to the sheath of the yarn structure.

- Among the three hemp/cotton blended yarns, in Ne 16 count, 30:70 blended yarns have shown a lower hairiness index than that of the other two blended yarns which is statistically significant. No significant difference was observed in Ne 30 count between the tree hemp/cotton blended yarns.

- In both the yarn counts, the CSP, single yarn strength & elongation of the three hemp/cotton blended yarns are lower than that of 100% cotton yarns. In Ne 16 yarn count, among the three hemp/cotton blended yarns, 30:70 hemp blended yarns have shown higher CSP by about 5% & 11%, single yarn strength by about 18% to 19%, elongation by 19% & 29% respectively than that of the 40:60 & 50:50 blended yarns.

- In Ne 30 yarn count, 30:70 blended yarns have shown higher CSP by about 9% & 29%, single yarn strength by about 14.1% and elongation by 11.4% respectively.

- Since hemp fibres have lower fibre elongation than that of cotton, higher proportion of hemp in the blend has reduced the single yarn strength as they

Table 9 Yarnr irregularity and tensile properties of Ne 16 100% cotton & hemp/ cotton blended rotor spun yarns

S. no.	Material	Ne16 (36.90 tex)	Ne 16 (36.90 tex) Hemp/cotton blend		
		100% cotton	30:70	40:60	50:50
1	Unevenness U%	10.09	15.05	17.33	18.76
2	Thin (-50%)	2	190	143	374
3	Thick (+ 50%)	17	2420	1910	2998
4	Neps (+200%)	85	2453	4068	5822
5	**Total Normal Imp/km**	**104**	**5003**	**6121**	**9194**
6	Thin (- 40%)	103	2023	1517	2876
7	Thick (+ 35%)	274	3473	4270	4934
8	Neps (+ 140%)	866	8183	8182	10700
9	**Total Ex. Sens. Imp/km**	**1243**	**13679**	**13969**	**18510**
10	Hairiness index (H)	3.76	3.79	3.88	4.58
11	**Single yarn tenacity (g/tex)**	**14.67**	**11.80**	**10.7**	**8.2**
12	Elongation (%)	5.6	5.2	4.85	4.63
13	CSP	2193	1708	1530	1171
14	CV% of CSP	4.88	5.79	7.10	9.09

have not enable to contribute for the tensile stress during the tensile testing.

The yarn properties of Ne 16 (36.90 tex) 100% cotton & hemp/cotton rotor spun yarns are given in Table 9.

It is observed that the three hemp/cotton blended rotor spun yarns have shown higher normal and extra sensitive imperfections than that of 100% cotton yarns. Among the three hemp/cotton blended yarns, 30:70 hemp/cotton blended yarns have shown lower normal imperfections by about 22% & 83% and extra-sensitive imperfections by 2% and 35% respectively than that of 40:60 and 50:50 blended yarns. In rotor spun yarns also, the imperfections level increase with an increase in hemp component in the blend as observed in ring spun yarn quality. In Hairiness index, a marginal increase in hairiness values is observed in the three hemp/cotton blended yarns than that of 100% cotton yarns. Among the three blended yarns, 30:70 blended yarns have shown lower hairiness index than that of the other two blended yarns.

In Ne 16 (36.90 tex) rotor spun yarns, the three hemp/cotton blended yarns have shown lower CSP, single yarn strength & elongation than that of 100% cotton yarns. Among the three blended yarns, 30:70 blended yarn has exhibited higher CSP by about 10% & 31%, single yarn strength by about 9% & 30% than that of 40:60 and 50:50 blended yarns.

Conclusions

Since hemp fibre is around 16 times coarser than cotton fibre, the interaction of hemp with cotton is not homogeneous. This also results in greater migration of hemp fibres to yarn sheath. This phenomenon is very much evident from the yarn results. Also, as the percentage of hemp fibre increases the yarn quality decreases.

The findings of the study are as follows:

- In Ne 16 & Ne 30 ring yarns, the imperfections of both normal and extra- sensitive levels of the three hemp/cotton blended yarns are considerably higher than that of 100% cotton ring yarns. Among the three blended yarns, 30:70 has shown lower imperfection than that of their blend counterparts.

- In CSP, single yarn strength & elongation%, the three hemp/cotton blended yarns have shown lower single yarn strength, CSP & elongation than that of 100% cotton yarns. Among the three blended yarns, 30:70 blended yarn has shown higher CSP, single yarn strength, and elongation when compared to that of the other two blended yarns.

- In Ne 16 rotor spun yarns, the imperfection levels of the three hemp/cotton blended yarns are higher than that of 100% cotton yarns. In blended yarns, 30:70 hemp/cotton blended yarn has shown lower level of imperfections than that of their blend counterparts.

- In the tensile properties, the three hemp/cotton blended yarns have shown lower CSP, single yarn strength & elongation than that of the 100% cotton yarns. Among the three blended yarns, 30:70 yarn has shown higher CSP, single yarn strength elongation than that of the other two blended yarns.

EFFECT OF APRON SURFACE MODIFICATION IN RING SPINNNG ON YARN QUALITY

In a double apron drafting arrangement, a set of aprons (bottom apron and top apron) are used to control the fibre movement in the main drafting zone. The top apron is driven by the bottom apron through frictional contact. To guide the fibres in the drafting zone, the top apron must be pressed against the bottom apron with a controlled force. It has been established that the slippage between bottom apron to top apron disturbs the movement of fibres in the apron zone, which results in the deterioration of yarn quality

In the main drafting zone, the primary condition of controlling the movement of fibres between the aprons is that both the aprons should move at the same speed. If this happens, the fibre strand will also have a streamlined movement between the aprons and one can expect a controlled movement of fibres in the main drafting zone. As there is no positive transmission of motion from the bottom apron to top apron, controlling the movement of the fibres between them seems to be difficult. Due to this, there is every possibility of stick-slip effect i.e. top apron moving at a slower speed than the bottom apron, resulting in an uncontrolled movement of fibres in between the aprons. Although many research papers have been published on the effect of apron slippage on various process factors such as the influence of roving hank, break draft, etc use of surface modified aprons and their effect on yarn quality in the ring frame has not been studied so far.

In ring frame drafting, majority of the fibres accelerate only near the leading edge of the apron cradle. At this point, if the friction is too high or low, then the fibre movement would not be uniform and can result in variations in yarn quality. In general, the coefficient of friction is higher with the materials having smooth surface at slow sliding speeds. This phenomenon has been explained in an earlier study which showed that high friction values are obtained on the new rubber surfaces provided the surfaces are clean, dry and free from any coating like wax. Further, the explanations reveal that the highest frictions are observed on clean, smooth surfaces where the maximum actual area of contact is possible. Another phenomenon has been studied in SITRA by using Zwick instrument on the smooth surface aprons which has shown that higher stick-slip effect was observed when compared to that of the surface modified aprons.

Considering this aspect, an attempt has been made study the effect of surface modified bottom aprons of two different types and compare the same with existing regular aprons on yarn properties such as imperfections, hairiness, tenacity, elongation and infrequent yarn faults.

Yarn samples, using three different apron combinations, were produced from 100% combed cotton material in a ring frame. The quality attributes of the cotton used in this study and the process parameters adopted in ring frame are given in Tables 10 & 11.

Table 10 Quality attributes of cotton fibres

S.No.	Fiber properties	20s	40s	80s
1	2.5% span length (mm)	28.5	30.7	32.5
2	Uniformity ratio (%)	45.4	45.6	46.2
3	Bundle fibre strength(g/tex)	21.3	23.5	24.4
4	Fibre fineness (µg/inch)	4.1	3.9	3.85

Table 11 Process parameters in Ring frame

Process parameters	20s CW	40s CW	80s CW
Rove hank (Nec)	0.8	1.0	1.82
Total draft	27.50	41.32	43.95
Break draft	1.14	1.14	1.14
Bottom Apron size(mm)	80.5*1.09	80.5*1.09	80.5*1.09
Spacer size (mm)	4.0	3.0	2.75
TPI	17.32	26.31	37.57
Spindle Speed (rpm)	16500	17500	18300

Table 12 Experimental plan of the study

Combination	Top apron	Bottom apron	Counts spun	No. of samples
Regular	Regular	Regular	Ne 20, Ne 40 & Ne 80	3
Surface modified -1 (SM 1)	Regular	Surface modified	Ne 20, Ne 40 & Ne 80	3
Surface modified – 2 (SM 2)	Regular	Surface modified	Ne 20, Ne 40 & Ne 80	3
			Total	9

Table 12 shows the experimental plan of the study.

Three combed yarn counts (Ne 20, Ne 40 & Ne 80) were produced. In total, 9 yarn samples were produced with three yarn counts from each combination.

The frictional characteristics of the surface modified aprons were measured using Zwick testing instrument. The testing was carried out according to DIN EN ISO 8295 standard test method. The testing speed and the gauge length were 50 mm/min and 200 mm respectively. The instrument measures the coefficient of static friction (µS), coefficient of dynamic friction (µD) ,static force (FS) and dynamic force (FD). The test results are given in Table 13.

From Table 13, it is observed that the surface modified aprons have shown lower coefficient of friction values than that of the regular aprons with regard to both static as well as dynamic coefficient of friction.

The yarn samples produced were tested for various yarn properties like unevenness (U %), imperfections of both normal / extra-sensitive and hairiness index (H) in Uster Evenness Tester 5. Hairiness (S3) was tested in Zweigle Hairiness tester. Yarn tenacity was measured in UTR 4 single yarn tensile testing instrument. Infrequent yarn faults were evaluated in Uster Classimat - 5 instrument.

Yarn quality results of surface modified aprons and regular aprons are given in Table 14.

Table 13 Friction test results

Type of aprons	μ_S	F_s (Newton)	μ_D	F_D (Newton)
Regular	0.35	3.07	0.35	3.08
SM 1	0.28	2.45	0.25	2.21
SM 2	0.29	2.59	0.26	2.39

Table 14 Yarn quality results of SM-1, SM-2 & regular aprons

Yarn properties	Ne 20 CW			Ne 40 CW			Ne 80 CW		
	SM-1	SM-2	REG	SM-1	SM-2	REG	SM-1	SM-2	REG
U %	8.6	8.58	8.57	10.57	10.71	10.63	13.38	13.22	13.26
CVm	10.87	10.85	10.82	13.37	13.53	13.44	16.96	16.74	16.82
Thin - 50%	0	0	0	2	3	1	111	101	113
Thick + 50%	15	18	16	59	56	57	230	217	239
Neps +200 %	35	37	37	73	70	65	309	285	344
Total normal ipi/km	50	55	53	134	129	123	650	603	696
Thin - 40%	6	4	4	90	113	98	953	933	952
Thick + 35%	156	153	139	476	499	482	1234	1178	1228
Neps +140 %	126	133	131	323	350	316	1464	1320	1574
Total extra sensitive ipi/km	288	290	274	889	962	896	3651	3431	3754

Table 14 Yarn quality results of SM-1, SM-2 & Regular aprons (Contd..)

Yarn properties	Ne 20 CW			Ne 40 CW			Ne 80 CW		
	SM-1	SM-2	REG	SM-1	SM-2	REG	SM-1	SM-2	REG
Hairiness index (H)	5.88	5.92	5.88	4.69	4.82	4.65	3.78	3.77	3.74
Zweigle S3 hairiness	1423	1342	1039	1044	1061	941	1113	1342	1039
Tenacity RKM (g/tex)	19.19	19.0	19.27	19.51	19.33	19.39	17.15	16.8	17.02
CV%	6.1	7.0	5.36	7.49	8.57	7.06	12.07	13.0	12.39
Classimat 5									
Raw material faults	410	485	533	781	666	824	5959	5817	7086
Objectionable faults 10 classes (Short thick)	111	114	136	86	58	95	207.5	170.9	229.9
Long thick faults	8	15	30	19	8	34	56	52	69
Long thin faults	5	0	10	7	2	8	543	489	555
Total classimat faults / 100 km	**530**	**610**	**697**	**883**	**728**	**945**	**6748**	**6518**	**7918**

SM-1 Surface modified apron 1; SM-2 Surface modified apron 2; REG Regular apron

Yarn unevenness and imperfections

Table 14 shows the yarn quality results obtained with the three combinations of surface modified aprons and regular aprons in three yarn counts. From the test results, it is observed that in Ne 20, Ne 40 & Ne 80 counts, no significant difference is observed in yarn unevenness (U%) and imperfections both in normal and extra-sensitive levels between the three count combinations and aprons. In Hairiness index (H) also, there is no significant difference in the three yarn counts between the three different combinations. Similarly, in Zweigle hairiness (S3) values also, no significant difference was observed.

Yarn tenacity

Single yarn tenacity of the yarn samples are given in Table 14. From the test results, it is observed that in all the three yarn counts, Ne 20, Ne 40 & Ne 80, no statistically significant difference is observed in yarn tenacity between the trials.

Classimat yarn faults

Infrequent yarn faults of the yarn samples evaluated in Classimat 5 test instrument are given in Table 14. It is observed that in Ne 20 count, the total classimat yarn faults in SM-1 apron and SM-2 apron are lower by about 26% & 13% respectively than that of the regular apron. In Ne 40 & Ne 60 counts, the total classimat yarn faults of SM-1 & SM-2 are lower by about 6.5% & 23% and 14% & 17% respectively than that of normal apron.

Under short thick objectionable faults (10 classes), yarn faults in all the three yarn counts were lower by 18%, 16% & 9.7% using surface modified apron (SM-I) than that of the yarns produced using regular aprons. Similarly, surface modified apron (SM-2) has also shown lower yarn faults in all the three yarn counts by about 16%, 39% & 25.6 % than that of the yarns produced using regular aprons.

Under long thick faults, yarn faults in all the three yarn counts were lower by 73%, 44% and 18% using surface modified apron (SM-1) than that of the yarns produced using regular aprons. Similarly, surface modified apron (SM-2) has shown lower long thick yarn faults by about 50%, 76% & 25% than that of the regular aprons. In long thin faults also, in all the three yarn counts. SM-1 & SM-2 aprons have shown lower yarn faults than that of the regular aprons.

Conclusions

- § In all the three yarn counts, no significant difference was observed in yarn unevenness and imperfections between the yarns spun out of surface modified and regular aprons.
- § No significant difference in both hairiness index (H) and S3 values were observed in the three yarn counts between the three different apron combinations.
- § No significant difference in yarn tenacity was observed in the three yarn counts produced using the two surface modified aprons and regular aprons.

- § A noticeable reduction in total classimat faults was observed in all the three yarn counts produced using surface modified aprons. In short thick objectionable faults (10 classes), SM-1 showed lower yarn faults by about 18%, 16% & 9.7% than that of the regular aprons. SM-2 have shown lower short thick objectionable yarn faults by about 16%, 39% & 25.6 % than that of the regular aprons.

- § In long thick faults, SM-1 have shown lower yarn faults by about 73%, 44% and 18% and SM-2 apron have shown 50%, 76% & 25% lower yarn faults than that of the regular aprons. In long thin faults, both SM-1 & SM-2 aprons have shown lower yarn faults than that of the regular aprons.

STUDIES ON COMBING EFFICIENCY IN MODERN COMBERS

In the process of yarn spinning, the role of comber is to improve the quality of raw material mainly by removing short fibres, with associated removal of trash particles and neps present in them. The quality of combed yarn depends on the type of raw material, amount of noil extracted and selection of process parameters at comber and comber preparatory. Generally the quantity of waste to be extracted is fixed arbitrarily by the mills. However, while fixing the noil level, the improvement in yarn quality being taken to be proportional to the quantity of waste extracted. It is not, however, uncommon to find wide variations in the quantity of waste extracted between mills and there are a number of instances where the improvement in the yarn quality is not commensurate with the level of waste extracted. Apart from the type of cottons used, poor upkeep of combers, inadequate maintenance and improper process parameters would lead to poor performance of combers and excessive waste. Considering the above practices, SITRA has provided a guideline way back in 1975 to judge the combing performance and take necessary process control measures and the same was revised in the year 2010 in line with the changes in comber technology. The method of assessment uses Digital fibro-graph, which measures fiber length based on span length concept.

$$\text{Combing efficiency (\%)}^{*} = \frac{\text{(SL of comber sliver} - \text{SL of comber lap)}}{\text{SL of comber lap \% of noil extracted}} \times 100$$

SL- 50% span length;''per 1% noil extraction*

The above formula is used for calculating the combing efficiency using the 50% span length of comber sliver and lap tested in Digital fibro-graph. But the use of this instrument is almost obsolete in the industry. Even though the HVI instrument is measuring the fibre length using the similar span length concept of Digital fibrograph, with the use of automated fibre sampler Uster is not recommending HVI for testing well paralleled fibres like comber lap, combed sliver, etc. While the well paralleled fibre is tested using HVI, the results are not accurate, reliable and repeatable due to problems in the method of sample preparation. Because of the above reasons, many times when the combing efficiency is calculated based on the HVI measured 50% span length for the modern combers, the efficiency values are very low and hence the comber performance cannot be decided based on these values.

To revisit the existing formula, an in-house project was taken up and it was planned to conduct trials at mills and collect the samples to be tested at SITRA in AFIS tester to find out the suitable test parameters to arrive at a formula that estimates a consistent and repeatable value as a measure of comber performance. Samples were collected from various mills and tested at SITRA and using the available AFIS data the following formula has been derived to calculate an index.

$$\text{Combing index} = \frac{\text{(Noil Extracted \%} - \text{(SFC(W) in lap} - \text{SFC(W) in sliver))}}{\text{Noil extracted \%}} \quad \text{— (1)}$$

Based on this, if the output is
Towards 0 – Superior towards 1 – Poor

Lower the value, better is the improvement.

The meaning is, theoretically all short fibres are to be removed in comber. But it is practically not so. Hence, the value lies between 0 and 1. Using the available AFIS data another formula has been derived to calculate the length improvement index

$$\text{Length improvement index} = \frac{\text{(L(n) of comber sliver} - \text{L(n) of comber lap)} \times 100}{\text{L(n) of comber lap \% of noil extracted}} \quad \text{--- (2)}$$

Based on this, if the output is
towards 1 – Superior towards 0 – Poor

Higher the value, better is the length improvement.

The AFIS test results of the comber lap and combed sliver are given in the Table 15. Based on AFIS fibre length results obtained from the samples collected from various mills, combing index is calculated based on the formula (1) and the results shows the combing index from 0.61(Superior) to 0.83 (Poor) between different makes and noil levels.

The mean fibre length (L(n)) improvement index is calculated with respect to percentage noil extracted and length results obtained from the testing, using formula (2) and the values are between 0.43 (Poor) to 1.33 (Superior).

The formula is to be validated with further data for different nipping rates and waste index. Similarly, the chances of improvement in fibre length L(n) due to parallelization as well as the changes in SFC(w) by drafting in lap and combed sliver for high speed combing need to be investigated.

Table 15 AFIS test results of Comber lap and combed sliver

Particulars / Mill no.	1		2		3		4		3		1		5	
Machine	LH10	LK54	LH10	LK54	LH10	LK54	LH10	LK54	LH10	LK69	SL/RL	LK250	SL/RL	LK54
Material	Lap	Sliver	Lap	Sliver	Lap	Sliver	Lap	Sliver	Lap	Sliver	Lap	Sliver	Lap	Sliver
L (W) Length in mm	26.2	27.0	24.5	25.2	24.7	25.9	25	26.5	24.7	26.4	25.4	27.1	29.6	30.6
Upper Quartile Length (w) in mm	32.0	32.3	31.5	31.4	31.3	32.0	31.5	32.0	31.3	32.2	31.2	32.2	37.1	37.6
Short fibre content % SFC (w)	7.7	4.6	12.1	7.7	11.6	5.9	10.5	4.2	11.9	4.5	8.8	4.3	6.4	2.5
L (n) Length in mm	21.7	23.4	18.5	20.7	18.5	21.7	19	22.7	18.5	22.5	20.7	23.6	23.1	26.3
Short fibre content % SFC (n)	21.5	12.0	32.4	19.5	32.4	16.1	30	11.7	32.8	12.7	24.0	11.8	22.1	8.1
5% fiber length in mm	36.9	38.0	36.1	36.9	36	37.0	36.4	37.8	36.1	37.8	36	38.0	43.3	44.5
Noil%	18		20		19		22		19		18		20	
Nep removal effi.%	62.9		64.5		77.6		85.4		82.1		71.1		84.7	
Short fibre removal effi.%	44.2		39.8		50.3		61.0		61.3		50.8		63.3	
CombingIndex	0.83		0.78		0.70		0.71		0.61		0.75		0.81	
Length improvement index (L(n))	0.43		0.59		0.91		0.88		1.13		0.77		0.69	
Particulars / Mill no.	**6**		**6**		**6**		**6**		**6**		**1**			
Machine	Unilap	E65	Unilap	E65	Unilap	E65	Unilap	E65	Unilap	E65	E32	E66		
Material	Lap	Sliver	Lap	Sliver	Lap	Sliver	Lap	Sliver	Lap	Sliver	Lap	Sliver		
L (W) Length in mm	31.7	32.1	31.4	31.5	31.5	31.8	30.7	31.2	29.9	30.8	26.1	27.6		
Upper Quartile Length (w) in mm	38.8	38.7	38.6	38.4	38.9	38.6	38.3	38.0	37.0	37.3	31.8	32.8		
Short fibre content % SFC (w)	4.1	1.3	4.8	1.8	4.5	1.6	6	1.9	5.1	1.7	7.8	3.6		
L (n) Length in mm	25.7	28.4	25.2	27.6	25.3	27.9	24	27.3	23.7	27.0	21.5	24.3		
Short fibre content % SFC (n)	17	4.8	18.5	6.2	18.4	5.6	22.1	6.4	19.7	5.9	21.9	10.2		
5% fiber length in mm	44	44.9	43.9	44.3	44	44.6	43.5	43.9	42.5	43.4	36.5	38.3		
Noil%	13		13		13		13		13		20			
Nep removal effi.%	51.9		70.5		76.9		66.7		78.9		68.0			
Short fibre removal effi.%	71.8		66.5		69.6		71.0		70.1		53.4			
CombingIndex	0.78		0.76		0.77		0.67		0.73		0.79			
Length improvement index (L(n))	0.81		0.73		0.79		1.06		1.33		0.65			

A STUDY ON EFFECT OF MODIFIED COTS AND TOP ROLLER LOAD ON YARN QUALITY IN RING FRAME

It is well known that in a spinning mill, ring frame is considered as a key machine which is responsible for the final yarn quality and the working performance of yarn in downstream processing like knitting and weaving. During the conversion of roving material to a final yarn, maximum draft is applied in the ring frame to produce yarns of the required linear density. The combination of draft and top roller loading controls the fibre movement in the drafting zone. There are two types of loading methods for the top rollers in a drafting system, namely pneumatic loading system and spring loading system.

In general, drafted fibre strand width in ring frame drafting zone varies from 9 mm (finer hank roving bobbin) to 17 mm (coarser hank roving bobbin). But, we are using 28 mm rubber cots width in ring frame drafting rollers. The preliminary trials were planned, to reduce the rubber cots width and maintain same load per unit area in front, middle and back top roller in ring frame drafting. We can save raw material of rubber and bare shell roller directly by reducing the rubber cots width. We will expect to save in the form of energy by lower consumption of air and lesser drafting load on the ring frame based on this expectation, the study was proposed.

Functioning of Pneumatic 3 over 3 drafting system FS 160 P 3-1

The loading support is stamped from the steel sheet and is mounted on a continuous hexagonal section tube

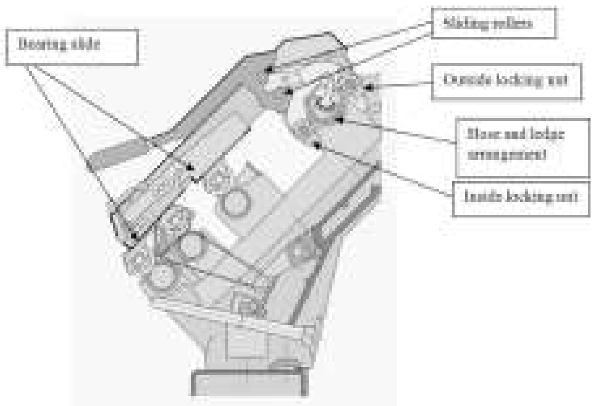


Figure 1 Parts of Pneumatic top arm P 3-1

behind the rollers (Figure1). The tube contains the rubber hose connected to a central compressor line. Three top roller holders mounted on two bearing slides are accommodated in the loading support itself. The two bearing slides form a double lever system.

Depending on where a pin is inserted in one of the three holes as the pivot at 'm' the total pressure coming from the compressed air hose and acting on the entire pressure arm via a cam is applied more strongly to the back roller or the two front rollers. Pressure can also be distributed differently between the two front rollers via a second pin/hole system in the bearing slide of these two rollers at 'n'.

The total pressure on the top rollers is changed by simply adjusting the pressure in the compressed air hose via a reducing valve at the end of the machine, and distributed to the individual rollers through a system of levers. The trials were conducted on LMW LR6/S model pilot ring frame having P 3-1 pneumatic drafting system with Suessen compact system.

Hence, a study was taken up with the following key points in mind :

- Raw material cost used for manufacturing the synthetic rubber covered rollers may get reduced, thereby direct savings in cots replacement cost.
- The overall top arm load exerted on the bottom roller will get reduced thereby the chances for the deformation of the bottom rollers will also get reduced.
- Savings in energy due to the reduced drafting load.
- There is a scope for increasing the number of spindles in the existing machine design as there is a possibility of reducing the spindle gauge from the existing 70mm to about 60 mm.The trials are to be carried out as per experimental plan given in Table 16.

This investigation proposed to reduce the top arm loading and maintain the same load per unit area by reducing the top roller rubber cots width and investigate the effect on yarn quality. The proposed modification in rubber cots are given in Figure 2.

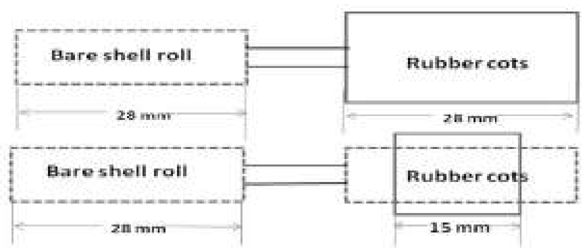


Figure 2 Proposed modification in rubber cots

The experimental plan for in top arm loading, cots width and their load per unit area is given in Table 17.

Table 16 Experimental plan

Material	Count (Ne)	Process	Conventional		Compact		No. of trials
			2.5 bar	1.5 bar	2.5 bar	1.5 bar	
Cotton	20 and 40	Carded & Combed	4	4	4	4	16
	80 and 100	Combed	2	2	2	2	8
PC blend (65/35)	20, 40, 60 and 80	Carded	4	4	4	4	16
Polyester	20, 40 and 60	Carded	3	3	-	-	6
Viscose	20, 40, 60 and 80	Carded	4	4	-	-	8
Modal	20, 40, 60 and 80	Carded	4	4	-	-	8
Total number of trials							62

Table 17 Experimental plan

Parameters	Pressure 2.5 (in kgs/cm^2)			Pressure 1.5 (in kgs/cm^2)		
	Front roller	Middle roller	Back roller	Front roller	Middle roller	Back roller
Load in Kgs.	21.0	14.0	21.8	11.3	7.4	11.6
Cots width (mm)	28 mm	28 mm	28 mm	15 mm	15 mm	15 mm
Load in (kg/mm)	0.757	0.503	0.778	0.753	0.493	0.773

The study was started with 40 Ne combed conventional process. The quality attributes of the cotton used in this study and the process parameters adopted in ring frame are given in Table 18 & 19.

Table 18 Quality attributes of raw material used

S.No	Fiber properties	40 Ne Combed
1	2.5% span length (mm)	30.7
2	Uniformity ratio (%)	45.6
3	Bundle fibre strength(g/tex)	23.5
4	Fibre fineness (µg/inch)	3.9

Table 19 Process parameters in Ring frame

Process parameters	40 Ne Combed conventional
Rove hank (Ne)	1.10
Total draft	38.52
Break draft	1.14
Bottom roller setting(mm)	42.5/60
Top roller setting (mm)	51/59
Spacer size (mm)	3.0
Twist per inch (TPI)	26.31
Average spindle Speed (rpm)	18000

It is observed from the yarn quality results given in Table 20 that in 40 Ne combed conventional yarn, there is no statistical significant difference in yarn unevenness (U%) and imperfections both in normal and extra-sensitive levels between two pressure levels. The deviation rate (DR) % decreased by 16% in the pressure level of 1.5 kgs/cm^2.

In Hairiness index (H) also, there is no significant difference between two different levels. In Zweigle hairiness (S3) value decreased by 30% in the pressure level of 1.5 kgs/cm^2 is observed. From the test results, it is observed that 5.6 % improvement is observed in yarn tenacity between the trials and the elongation % shows no statistical significant difference at 95 % confident level.

Reducing the total applied load 2.5 kgs/cm^2 to 1.5 kgs/cm^2 and maintain the same load per unit area in the drafting system (around 0.750 kg/mm for front, back rollers and 0.5 kg/mm for middle roller) has no significant different in the yarn quality.

Table 20 Yarn quality results of 40 Ne Combed conventional process

Parameters	**40s Combed conventional**	
Pressure (kg/cm^2)	**2.5**	**1.5**
U%	10.37	10.38
CVm	13.10	13.14
DR 1.5Mt. 5%	14.1	11.9
Normal imperfection		
-50%	3	3
50%	43	39
200%	73	84
Total	**119**	**126**
Extra sensitive imperfection		
-40%	104	101
35%	359	350
140%	356	390
Total	**819**	**841**
Uster tester -5 Hairiness		
H	**4.92**	**4.67**
Sh	1.13	1.06
Zweigle - Hairiness		
S 3	**584**	**406**
Index	111	66
Single yarn tenacity-UTR		
RKM	**18.04**	**19.11**
RKM Cv%	8.27	8.96
Elongation%	**4.17**	**4.20**
Elongation Cv%	7.97	8.27

Similar trials are planned to be conducted for other counts towards understanding the influence of cot width on yarn quality.

POISSON'S RATIO OF NON-WOVEN SPUN BONDED FABRIC FOR MEDICAL APPARELS

Medical apparel like surgical gown, which are used to protect the operating room personnel from transfer of micro-organisms, body fluids and particulate material are dependent on their mechanical behavior which influences the scope of end use, as they are subjected to stress and strain in real time use.

Poisson's ratio is the ratio of transverse contraction strain to longitudinal extension strain in the direction of stretching force. During the uniaxial extension of a solid fabric material, besides the deformation in the direction of the applied force, a certain amount of lateral contraction, perpendicular to the direction of the applied stress occurs. This observable fact is called the Poisson's effect. Tensile deformation is considered positive. Poisson's ratio is a unit less scalar quantity.

The relevance of Poisson's ratio for made-up garment characteristics are studied towards utilizing the same of for their effective performance. Spun bonded fabric was subjected to a uniaxial strain and Poisson's ratio is calculated for both the machine and cross direction. The uniaxial strain was applied in 10 steps (viz. 2.5%,5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20%, 22.5% & 25%)and the fabric contraction was measured to evaluate the Poisson's ratio at all extension levels given above.

- Multiple investigations have been done in this area and salient among them indicate the following
- Higher the structural firmness of the fabric, higher the Poisson's ratio and a higher linear correlation exists between crimp interchange and Poisson's ratio.
- Increase in Young's modulus ratio increases the Poisson's ratio. The increase in diameter ratio between warp and weft yarns also increased the Poisson's ratio. The effect of structural parameters is more pronounced than the yarn mechanical parameters.
- The Poisson's ratio was constant for mono-filament yarn when compared to spun and filament yarns. As the longitudinal strain was low, the Poisson's ratio for filament and spun yarns were large but as the strain increased apparent Poisson's ratio decreased.

Twelve samples were tested for Poisson's ratio by subjecting the material to uniaxial stress using Zwick-Roell UTM. The details of the study done on spun bonded fabrics are given in Table 21(a) &Table 21(b).

Table 21(a)

Variety	GSM	Sample
SMS	35 & 50	Sample no 1,2,3
Antistatic SMS	35& 50	Sample no 4,5
Alcohol Repellent and Antistatic SMS	35 & 45	Sample no 6,7
SMMS	35	Sample 8
SSMMS	35 & 43 & 50	Sample 10,11
BVB	70	Sample 12

Table 21(b)

S.no	Experimentation done	Sample
1.	Poisson's ratio	Sample 1-12
2.	Varying Width with constant Gauge length (50mm) 25mm,50mm,75mm,100mm Varying Gauge length with constant Width (50mm) 50mm,100mm,150mm,200mm	Sample 2 & 3

The fabric samples were prepared with dimensions of 200*50 mm with 5 specimens in machine direction (MD) and cross direction (CD) each. This sample size was adopted based on the research on strip quadratic method done by Tadeja Penko & Jelka Gersak [4].The speed of extension was maintained at 10mm/min.

The fabric was measured for contraction at 10 extension levels (viz, 2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20%, 22.5% & 25%). The cyclic test (Program) enables the test to be conducted at various extension levels and allows a time lag (30sec) to measure the contraction on the fabric at the desired extension. A pre-tension of 0.5N was maintained and the gauge length at 50mm. The fabric samples were marked at the centre so as to make the contraction measurement at the midline.

The fabric was marked with lines as shown in the Figure. 3. Lines A& B indicate clamping lines and line C represents the midline (Figure. 4).

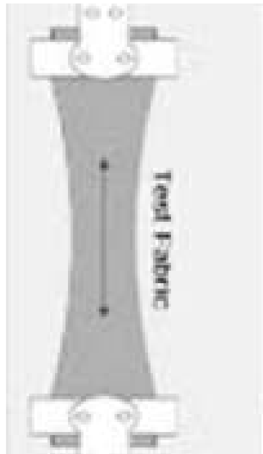


Figure 3 Experimental set-up on Zwick Roell equipment

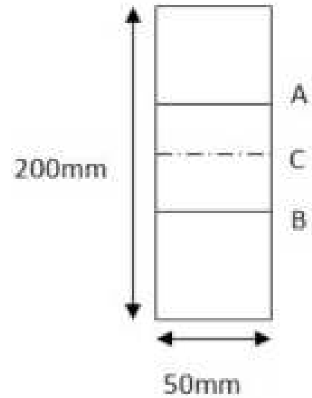


Figure 4 Diagrammatic representation

Five evaluations were done in machine direction and cross direction and averaged. The values were recorded and Poisson's ratio was calculated by the formula

$$\text{Poisson's Ratio} = \frac{\text{Lateral contraction\%}}{\text{Longitudinal extension\%}}$$

The areal density was assessed as per ASTM 9073-1; the tensile strength was evaluated as per EN ISO 9073-3 in both the machine and cross direction. The thickness of the nonwoven fabrics was measured as per ASTM 9073-2. The flexural rigidity of the nonwoven fabrics was evaluated on the FTT (Fabric Touch Tester from SDL) as per M293 manufacturer's protocol. The flexural rigidity is measured in terms of force needed to bend the fabric per radian. A higher flexural rigidity means that the fabric exhibits higher resistance to bending and flexing.

Table 22 Physical characteristics of the spun bonded fabric studied

Sample no	Thickness (mm)	GSM	Machine direction			Cross direction		
			Tensile Strength (N)	Elongation %	Flexural Rigidity gm*mm/rad	Tensile Strength (N)	Elongation %	Flexural Rigidity gm*mm/rad
1	0.25	35	90.45	52.08	104.3	40.45	56.37	36.4
2	0.30	35	107.3	53.64	196.2	51.98	56.41	69.1
3	0.31	50	95.53	54.50	62	51.19	57.32	29.8
4	0.26	35	75.65	50.32	189.4	40.75	65.42	92.1
5	0.33	50	123.56	52.41	161.9	56.57	50.56	51.1
6	0.23	35	71.7	41.55	50	32.32	51.1	38.8
7	0.28	45	100.74	35.98	54.7	42.75	48.42	20.2
8	0.23	35	76.77	38.11	50.8	36.93	42.34	12.7
9	0.26	35	89.21	56.36	180.3	41.14	63.64	112.8
10	0.31	43	110.52	51.74	183.1	52.73	59.11	62.1
11	0.35	50	112.34	52.31	318.1	52.04	59.5	111.6
12	0.34	70	113.91	39.13	125.5	57.93	55.08	47.3

Table 22 represents the thickness, tensile strength, elongation and flexural rigidity characteristics of the spun bonded nonwoven surgical gown fabric analyzed. The value of the tensile strength in machine direction is approximately double to that in the cross direction value for all samples. The elongation values for all the spun bonded materials are higher in the case of cross direction when compared to machine direction.

The value of flexural rigidity is higher for machine direction than cross direction for all the samples. The value of flexural rigidity and tensile strength is found to be less for alcohol repellent and antistatic finish when compared to ordinary SMS fabric of same GSM. As the number of layers (eg: SSMMS) increases the flexural rigidity also increases for the same GSM. In spite of higher GSM and thickness the BVB sample exhibits lower tensile strength values. Very low flexural rigidity value was observed in SMMS sample at cross direction.

Figures 5a & 5b represent the spatial deformation of the fabric sample with extension, It is evident that fabric contractions are small at the beginning of stretching. With increase in extension or fabric stretching the values of fabric contraction also increase.

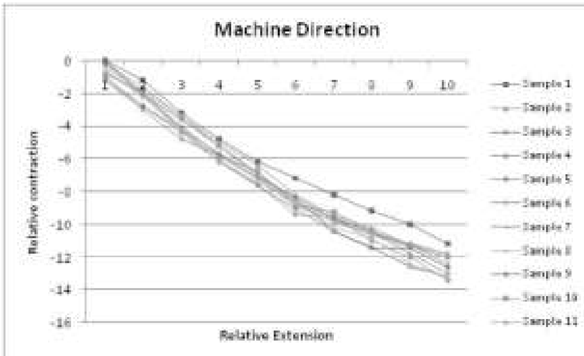


Figure 5a Spatial deformation of the fabric in the machine direction

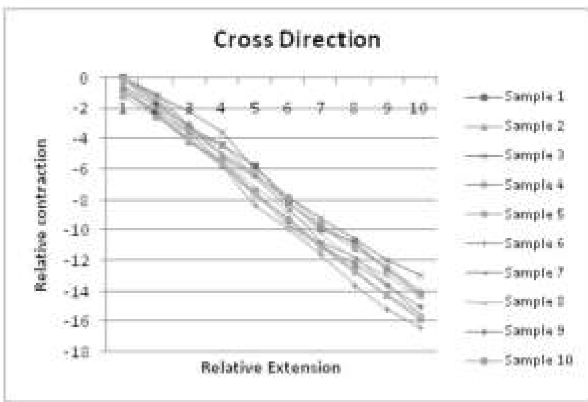


Figure 5b Spatial deformation of the fabric in the cross direction

From Figure 6, it is also observed that the Poisson's ratio is found to be almost similar for all the samples at various extension levels in machine direction. It is seen that the Poisson's ratio increases initially (till 15%) and then decreases as the extension is increased (upto 25%) in machine direction.

From Figure 7, it can be seen that in the cross direction the plot flattens above 15-20% for all the fabric varieties studied. The Poisson's ratio increases non-linearly and after having reached the peak value it decreases. These two zones represent the two different processes in the deformation of the fabric. The first zone represents the

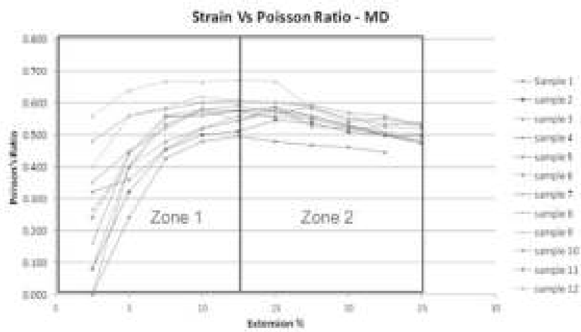


Figure 6

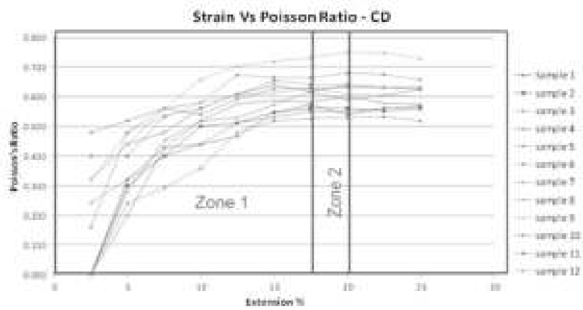


Figure 7 Strain Vs Poisson Ratio

way of the lateral contraction because of the longitudinal stretching. The second zone shows the termination of the lateral contraction of the fabric and the fabric is stretching without any further contraction. The plot flattens above 15% for all the fabric varieties studied.

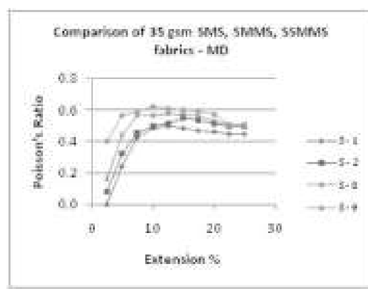


Figure 8

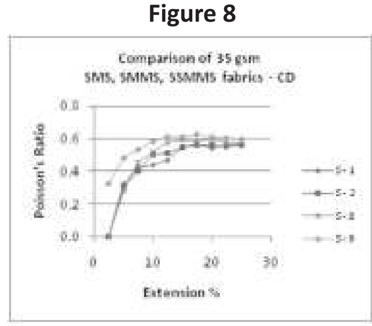


Figure 9

Figure 8 & 9 Comparison of SMS, SMMS, SSMMS fabric of 35 GSM

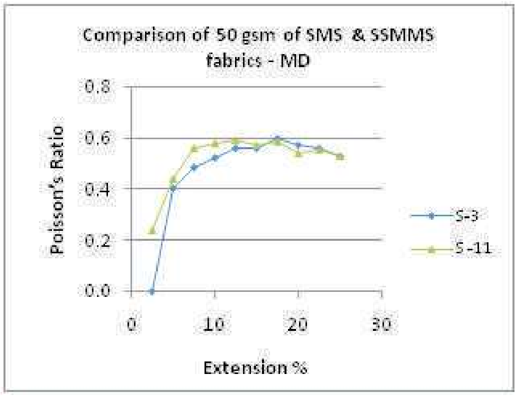


Figure 10

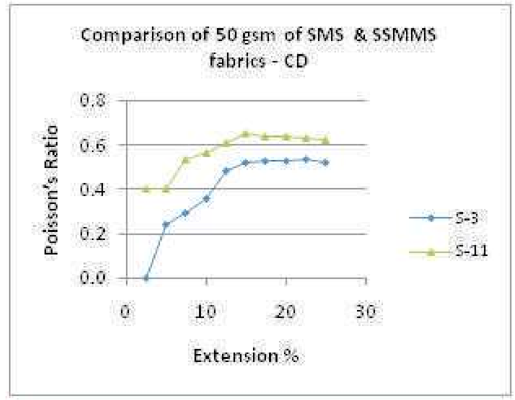


Figure 11

Figure 10 & 11 Comparison of SMS, SSMMS fabric of 50 GSM

From the plots shown in Figures 8, 9,10 & 11 it is seen that the value of Poisson's ratio is higher for the SSMMS samples and lower for SMS samples. It can be inferred that as the number of layers increases for spun bonded fabric, the value of Poisson's ratio also increases. The trend remains the same for 35 GSM as well as 50 GSM fabrics.

Table 23 Regression between Poisson's Ratio and Extension %

S. No	Sample Particulars Variety	Machine Direction Linear Equation	M	R^2	Cross Direction Linear Equation	m	R^2
1	SMS	Y= -0.0168X+0.1783	-0.017	0.4875	Y= 0.019X+0.1825	0.019	0.6691
2	SMS	Y= 0.0131X+0.2647	0.0131	0.4811	Y= 0.0189X+0.1886	0.0172	0.5701
3	SMS	Y= 0.0159X+0.2591	0.6036	0.462	Y= 0.0205X+0.1184	0.0205	0.7619
4	ANTISTATIC	Y= 0.0035X+0.4645	0.0035	0.1273	Y= 0.0125X+0.3852	0.0125	0.7515
5	ANTISTATIC	Y= 0.0003X+0.5594	0.0003	0.0035	Y= 0.0139X+0.276	0.0139	0.851
6	ALCOHOL REPELLENT & ANTISTATIC	Y= 0.0114X+0.3257	0.0114	0.3315	Y= 0.0162X+0.3568	0.0162	0.5759
7	ALCOHOL REPELLENT & ANTISTATIC	Y= 0.0059X+0.4168	0.0059	0.213	Y= 0.0233X+0.1483	0.0233	0.7161
8	SMMS	Y= 0.0083X+0.3833	0.0083	0.2481	Y= 0.0199X+0.2019	0.0199	0.6051
9	SSMMS	Y= 0.001X+0.5418	0.001	0.0115	Y= 0.0095X+0.4269	0.0095	0.5766
10	SSMMS	Y= 0.0068X+0.3875	0.0068	0.3839	Y= 0.0068X+0.4908	0.0068	0.8481
11	SSMMS	Y= 0.0079X+0.4101	0.0079	0.3114	Y= 0.0108X+0.4206	0.0108	0.7145
12	BVB	Y= -0.0041X+0.6648	-0.004	0.2832	Y= 0.017X+0.4027	0.017	0.7455

Table 23 gives the linear equation between Poisson's ratio and Extension%, the slope value and linear regression value. It may be seen from the data in Table 3 that the slope 'm' of the linear equation of the plot of Poisson's ratio and extension levels is lower when tested in the machine direction compared to values for cross direction of fabric, which means the contraction level in machine direction is higher than the cross direction. This characteristic correlates with the work done by J.W.S Hearle&V.Ozsanlav.

The R2 value is found to be higher for cross direction than machine direction in the strain vs Poisson's ratio plot. A higher value of R2 would mean that a higher percent of variation in the Poisson's ratio is due to the variation in the extension levels in cross direction.

Varying Gauge length and width

Furthermore, two SMS samples (sample 2 & 3) of 35 GSM & 50 GSM were selected for investigation to analyse the Poisson's ratio at various gauge lengths and widths. This was done to find out the influence of gauge length and width on Poisson's ratio. Four different gauge lengths 50mm, 100mm, 150mm & 200mm were selected with 50mm fabric width maintained constant at all gauge lengths. The test speed was maintained at 10mm/min. 5 fabric samples in both machine and cross direction were prepared and tested for contraction at the midline using different extension levels. The contraction was measured at 10 intervals of extension viz. (2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20%, 22.5% & 25%), Poisson's ratio calculated and plotted against extension as shown in Figures 12, 13, 14 &15.

In case of varying width, 25mm, 50mm, 75mm, & 100mm were selected with 50mm gauge length maintained constant and at same test speed of 10mm/min for four widths. 5 readings were taken both in machine and cross direction and samples prepared accordingly. The Poisson's value plotted against extension is seen in Figures 16, 17, 18 &19.

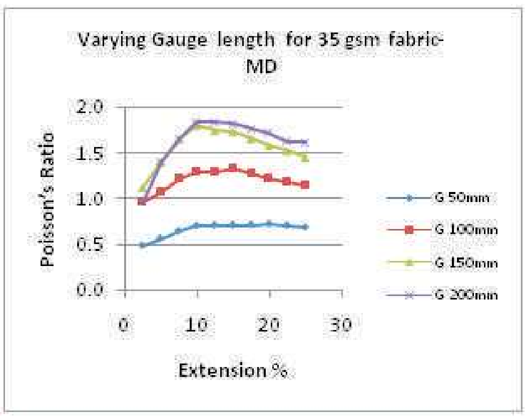


Figure 12

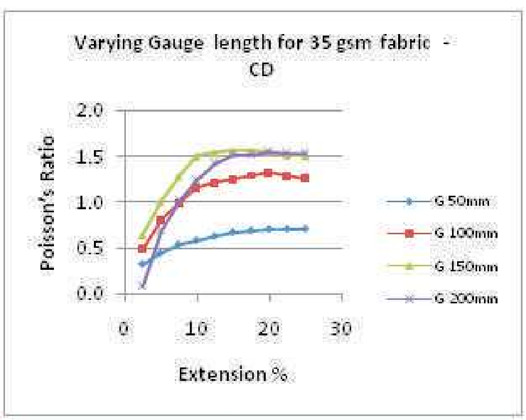


Figure 13

From Figures 12 to 15, it is clear that at varying gauge lengths the Poisson's ratio increases as the gauge length is increased at both the directions irrespective of GSM. A slight decrease is seen in Poisson's value above 10% extension level in both the GSM's at machine direction. In the case of cross-wise direction the graph flattens out above 10% extension for 35 & 50 GSM fabrics.

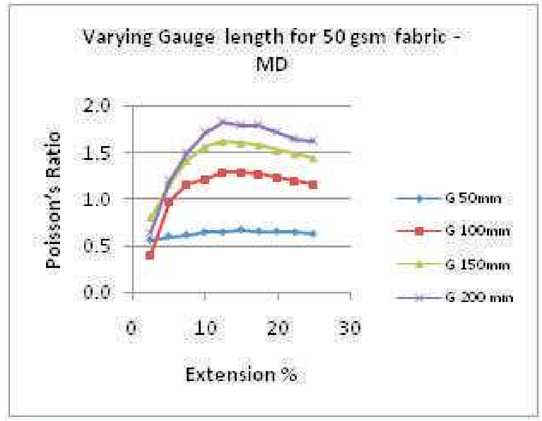


Figure 14

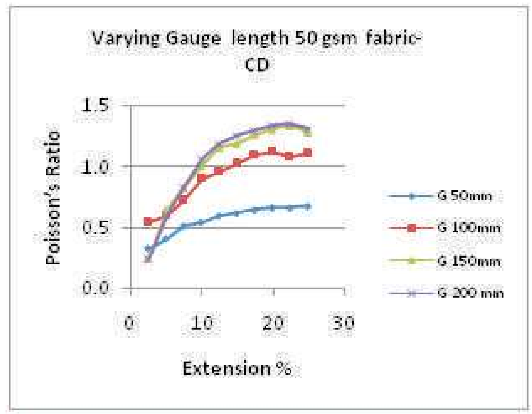


Figure 15

Figures 12 to 15 Change in Poisson's ratio at varying gauge length for 35 and 50 GSM SMS fabric

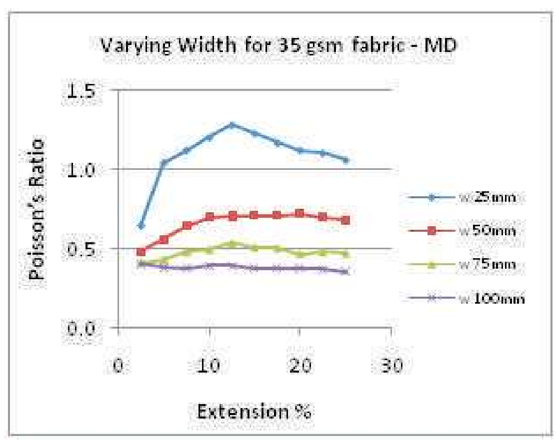


Figure 16

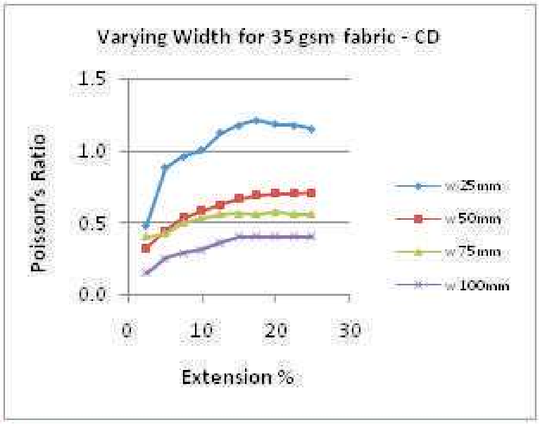


Figure 17

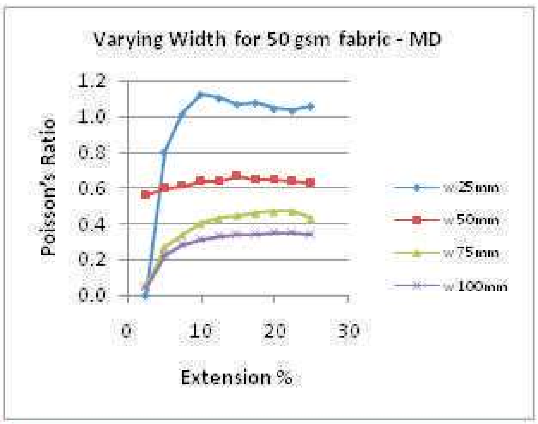


Figure 18

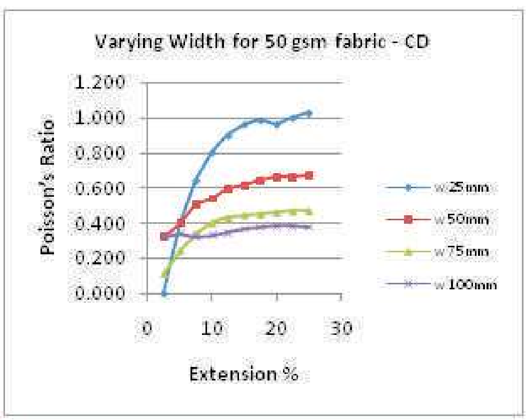


Figure 19

Figures: 16 to 19 Change in Poisson's ratio based on fabric width for 35 & 50 GSM SMS fabric

In the case of varying widths, as depicted in Figures 16-19, the Poisson's ratio is higher as the width decreases. This means that the contraction % is more pronounced in case of shorter widths. The graph shows that the Poisson's ratio remains stable at increasing extensions in the machine direction. In the cross direction the increase is gradual and flattens above 10% extension. This characteristic may be used in surgical gowns for better performance of the garment structure in real time use.

Conclusion

The tensile strength of the fabric in machine direction is almost double to that in the cross direction. The flexural rigidity and elongation values in cross direction are higher than machine direction for all the spun bonded fabric samples. With multiple layers, the flexural rigidity increases for the same GSM.

The Poisson's ratio is seen to change in the process of the extension of the fabric sample. The Poisson's ratio increases initially and then decreases slightly as the extension is increased in the machine direction. The graph flattens for cross direction after 15% extension for all the fabrics studied. It is inferred that as the number of layer increases for spun bonded fabric, the value of Poisson's ratio also increases when compared with fabrics of same GSM. The contraction level in machine direction is higher than the cross direction. In the machine direction the extension contributes much less and there may be other factors like binder film, melt structure, degree of orientation of fibrils, etc. influencing the Poisson's ratio.

In SMS fabrics the Poisson's ratio increases as the gauge length is increased at both the directions irrespective of GSM. Contraction % is more pronounced in the case of shorter widths & the Poisson's ratio increases as the width decreases.

Non-woven anisotropy and variation in tensile properties with the direction of extension is an important aspect observed in spun bonded non-woven studied. By analyzing those tensile, elongation, fabric bending and Poisson's ratio characteristics at two orientations (machine wise & crosswise) of the fabric, one could design the layout for medical products (surgical gowns) manufacture.

As the elongation values are higher and lower contraction (lower Poisson's ratio) is found in cross direction, the manufacture of surgical gown may be patterned accordingly to provide more comfort and stability during use for the surgeons. With the current COVID 19 pandemic this study could offer some insight into the various aspects to be considered in manufacturing coverall/bodysuits for physicians and patients.

CHARACTERISATION OF TEA BAGS & STRING USED IN DIP-TEA SACHET

Tea bags are becoming popular for brewing tea across the globe due to their simplicity and convenience. Although most of the teas across the world are brewed using tea bags, information regarding the impact of tea bag material parameters on tea bag infusion and brewed tea is slender. Hence, SITRA took up a study to characterize tea bags for their thickness, wettability, surface topography, pore size, porosity, and permeance towards understanding their influence on infusion kinetics.

Multiple studies carried out reveal the following striking facts regarding brewing by tea bags :

- a single plastic tea bag (made out of synthetic material) brewed at 95^0 C releases approximately 11.6 bn microplastics and 3.1bn nanoplastics (the latter are 150 times smaller than a hair, possibly small enough to permeate human cells)
- The National Institute for Occupational Safety and Health (NIOSH) labels tea bag sachets after extensive studies as a potential carcinogen, and has been shown to cause cancer in animals, impair fertility, and weaken immune function.
- Many paper bags, treated with a compound called epichlorohydrin, act as a pesticide.

Major tea brands available in sachets in the Indian market were identified & their products collected.

Investigation involved.

- physical characterisation of the string & sachet used
- chemical analysis - specific to migration study, pesticide residues, insecticides (chlorophenols), pH, formaldehyde, APEO, lubricants, etc.

Comparison were made of the sachets made of

- Filter paper
- PLA (corn, starch, maize etc.)
- Nylon/Silk
- Cotton/Muslin/Fabric, etc.

The study also aimed to investigate the Advantages & Disadvantages of

- Woven Vs Non-Woven
- Bio-degradable Vs Compostable
- Heat Sealable Vs Non-Heat Sealable Vs Ultrasonically sealed
- Bleached Vs Oxygen Bleached Vs Unbleached
- Chemical treatments – such as Epicholorohydrin, etc.
- Surface Coating – such as Synthetic Starch, etc.

Physical Parameters

S.no	Manufacturer	Air Permeability ($Cm^3/cm^2/sec$)	Bursting Strength (Kg/cm^2)	GSM (gms/m^2)	Thickness (mm)
1	A	59.7	0.144	16.92	0.089
2	B	126.6	0.200	13.00	0.081
3	C	126.3	0.120	12.41	0.079
4	D	131.1	0.100	13.47	0.080
5	E	130.0	0.154	13.24	0.088

S.no	Manufacturer	Count (Ne)(3-ply)	TPI (S -Twist)
1	Manufacturer A	6.73	8.27
2	Manufacturer B	6.58	8.76
3	Manufacturer C	7.54	6.76
4	Manufacturer D	5.69	3.18
5	Manufacturer E	6.55	3.64

Capillary Flow Porometer

Manufacturer	PORE SIZE ANALYSIS (in -house method)		
	Mean Flow Pore Diameter in microns	Bubble Point Pore (Maximum) Diameter in Microns	Minimum Pore Diameter in Microns
A	33.18	173.46	1.83
B	41.38	154.25	1.82
C	41.78	188.08	1.83
D	41.9	183.47	1.84
E	38.9	132.43	1.82

Chemical parameters:

S·no	Manufacturer	Chemical Composition
1	A	78.2% cellulose & 21.8% Polypropylene
2	B	82.9% cellulose & 17.1% polyester
3	C	100% cellulose
4	D	100% cellulose
5	E	100% cellulose

S.no	Manufacturer	Chemical composition
1	A	100% Cotton
2	B	100% Cotton
3	C	100% Cotton
4	D	100% Cotton
5	E	100% Cotton

Sachet extract's chemical characteristics

S.no	Manufacturer	PH at 28°C	Formaldehyde content (upto 16 PPM)
1	A	6.93	ND
2	B	7.13	ND
3	C	7.19	ND
4	D	7.74	ND
5	E	7.76	ND

ND - not detected

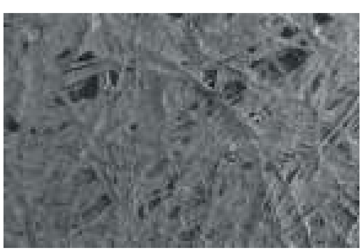
Stapling:

- While two major brands were staple-free, the other 3 were all stapled

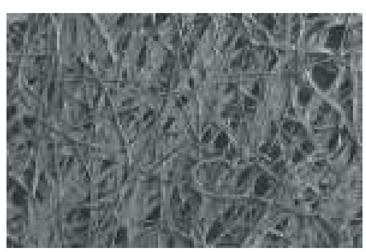
Toxicity of the extract of the teabag sachets is under investigation. Further, three varieties of tea bags sachets made from different materials viz., Nylon, PLA and nonwoven (spun bonded) will be analysed for various parameters and characterized physically and chemically.

SEM STUDY: Images at 150X

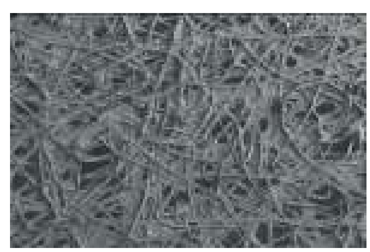
Sample 1: Assam green tea bag



Sample 2 AVT Green Tea bag



Sample 3: Lipton Green Tea bag



Sample 4: Organic India Green Tea bag

Sample 5: Tetley Green Tea bag

CHEMICAL PROCESSING

DEVELOPMENT OF ECO-CLOTHING BY GREENER REDUCTION PROCESS OF NATURAL INDIGO DYE (Sponsored by the Ministry of Textiles, Govt. of India)

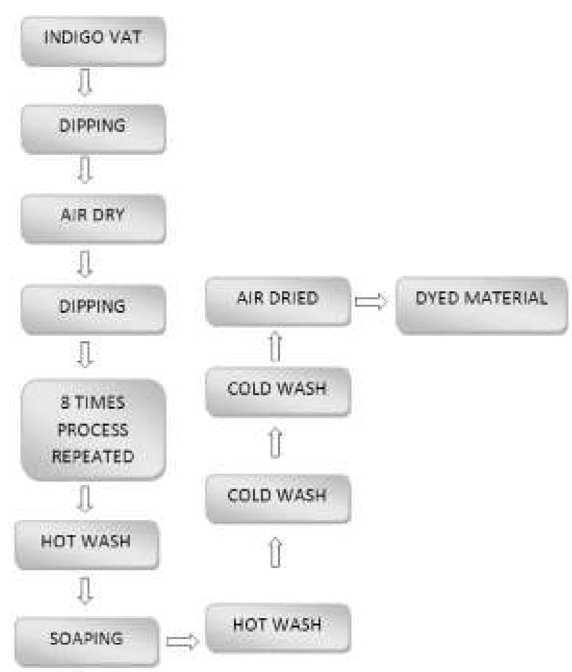
Natural dyes have been an integral part of human life since time immemorial. Presently there is an excessive use of synthetic dyes, estimated at around 10,000,000 tons per annum, the production and application of which release vast amounts of waste and unfixed colorants, causing serious health hazards and disturbing the eco-balance of nature. Since the mid-1980s, more interest has been shown in the use of natural dyes and a limited number of commercial dyes, and small businesses have started to look at the possibility of using natural dyes for coloration. Currently, the market for natural dyes is growing. thanks to the increased environmental awareness of consumers. Market opportunities especially exist in the green textile industry and Eco-fashion. In recent times, many commercial dyers and export- houses are reconsidering the possibilities of using natural dyes for dyeing and printing of textiles for high value global markets since natural dyes besides their eco-friendly behavior & social ethics, produce very uncommon, soothing and soft shades as compared to synthetic dyes. Among the natural colourants, Natural Indigo is the most important blue dye for textile colouration and is used persistently as a source of blue color. Almost 99% of indigo dye used by the industry is imported in synthetic form while a meager 1% of natural dye being developed in India.

The current project focuses on development of an eco-friendly reduction process of natural indigo dyes using greener reducing agents and also greener alkali sources to replace the conventional chemicals i.e., sodium dithionite or hydrose and caustic process which generates non-regenerable oxidation products and causes various problems in the disposal of the dye bath and the washing water. The colour value and the fastness properties of dyed fabrics, thus predicted were also evaluated.

Three different green reducing agents (RA1, RA2 & RA3) and three different Green alkalis (AK1, AK2 & AK3) were used, directly without further purification, for application on Ne 10 K yarns. Optimization of concentration of the green reducing agent and alkali was carried out by keeping the dye concentration at 5 gpl and changing one parameter at a time. The optimised recipe is a solution containing 5 g. of natural indigo dye which was reduced using green reducing agent (RA3) and green alkali (AK2) which were added to 1000 ml of water to prepare the natural indigo. This solution was left to stand for 2 hours at room temperature. Reduction potential and pH were measured at room temperature using a Hanna Instrument Model HI991003 ORP-pH analyser, USA which incorporated a platinum band electrode.

Hand dipping process: Fabric was dipped in the indigo vat at room temperature for 1 minute and exposed in air, and after the complete oxidation (Colour change) the 1st dipped yarn was again dipped in the same vat solution and thus total of 3 dips, 6 dips & 9 dips were made. Further, all the dyed yarns were washed with neutral soap and neutralised using sodium bicarbonate (0.5 gpl) and the dyed samples were rinsed and dried in open air for further evaluation. After the optimization process, some of the garments were dyed with the optimised recipe.

Process flow chart



Dyed fabrics were tested for color fastness to washing according to the ISO method IS 105-C10/B (2), where neutral pH soap was employed. Dyed fabrics were tested for color fastness to light according to AATCC Test method 16-2004 as per blue wool scale 2(10 hours).

Dyed fabrics were tested for color fastness to rubbing (dry and wet rub) according to the ISO 105 X12-2016.

The dyed samples were evaluated for their colour strength by determining the K/S values using a Gretag Macbeth 7000 eye (USA) Computer Colour Matching System. Average of four readings, taken at four different sample areas, were used to get the reflectance values based on which the Kubelka Munk function (K/S) was evaluated. $K/S = (1-R)^2 / 2R$ where, R is the reflectance at complete opacity, K is absorption coefficient and S is the Scattering coefficient. Dyed fabrics were also evaluated in terms of CIE LAB colour space (L*, a* and b*) values using the Gretag Macbeth 7000 eye (USA) system.

Selection of best suitable green reducing agent was carried out by dyeing the cotton yarns, keeping the indigo dye concentration and green alkali constant for the 3 dip, 6 dip and 9 dip processes. Figure 20, Figure 21, and Figure22 shows the K/S values of dyed cotton yarns using the three different green reducing agents. From the figures, it is clear that, RA3 green reducing agent shows the highest K/S value as compared to RA1 & RA2 in all the three stages of dyeing process. Thus, RA3 was selected for the greener reduction purpose for natural indigo dye. Similarly, three different alkali were employed for the pH control of indigo reduction process namely AK1, AK2 & AK3 and the dyeing experiment was conducted by keeping the dye concentration and above selected green reducing agent constant. The K/S values of 9 dip dyeing process is shown in Figure 23 which reveals that green alkali AK2 showed the highest K/s value as compared to AK1 & AK3.

Table 24 shows pH & ORP values of natural indigo dye reduction process (VAT TIME) and Table 25 shows colour fastness to washing of natural indigo dyed cotton garment.

Table 24 pH & ORP values of natural indigo dye reduction process (VAT TIME)

Minutes	ND+RA3+AK1		ND+RA3+AK2		ND+RA3+AK3	
	pH	ORP (-mv)	pH	ORP (-mv)	pH	ORP (-mv)
Initial	12.02	-650	12.41	-680	12.2	-707
5	12.00	-690	12.32	-717	12.38	-733
10	12.00	-700	12.32	-730	12.36	-742
20	12.02	-730	12.32	-743	12.37	-752
30	12.02	-728	12.33	-748	12.39	-756

Table 25 Colour fastness to washing of natural indigo dyed cotton garment

Parameters	8 Dip Garment Solid		6 Dip Tie & Dye using RA3		6 Dip Tie & Dye using RA 2		Oeko-Tex Limit for Baby Wear
Colour Fastness to Washing	CC: 4 SF: 4-5		CC: 4 SF: 4-5		CC: 4 SF: 4-5		CC: 3-4
Colour Fastness to Light (20 h)	3-4		4-5		4-5		NA
Colour Fastness to Rubbing	Dry	4	Dry	4	Dry	3-4	FAST
	Wet	3-4	Wet	3-4	Wet	3-4	
Remarks	Dark Blue		Dark Blue		Slight Light Blue		Pass

CC- Change in colour, SF- Staining on Adjacent Fabrics

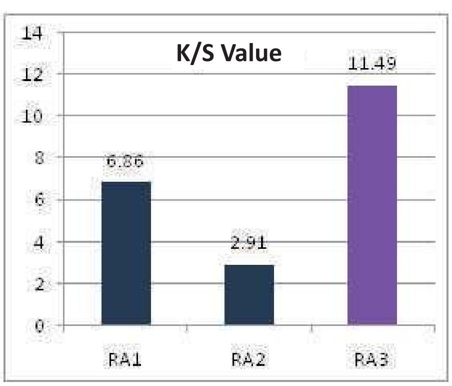


Figure 20 K/S value in 3 Dip Process

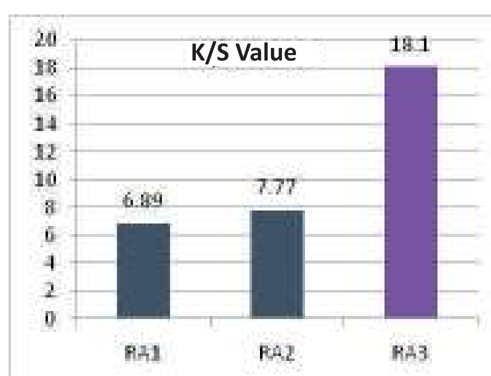


Figure 21 K/S value in 6 Dip Process

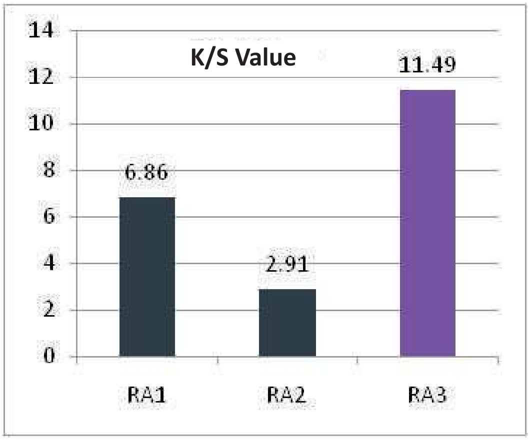


Figure 22 K/S value in 9 Dip Process

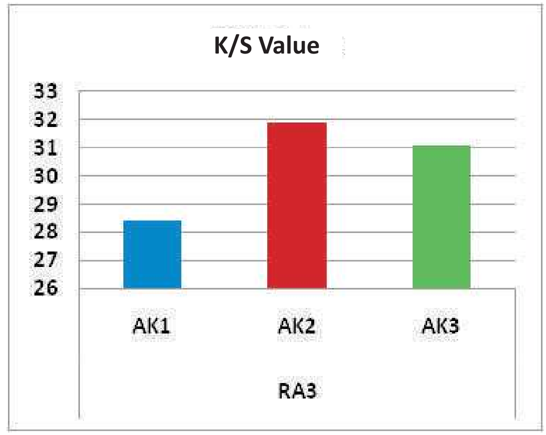


Figure 23 K/S value in 9 Dip process

It is evident from Table 25 that after washing, in all 3 cases, the fastness was excellent and no staining took place on the adjacent fabrics. Further, the yellowing nature of indigo was arrested due to the after treatment process (mainly washing process). The light fastness was in the range of 4, which is acceptable. Further, the whole process resulted in good wet rubbing fastness property which was in the range of 3-4. All over, best results were obtained using the optimized recipe combination of natural indigo dye, RA3 reducing agent and AK2 green alkali.

The dyed garments are shown below:

The SITRA developed natural indigo innovative technology was applied on Slasher dyeing machine in the dye house of the industrial partner. Based on the above study, the following recipes were taken to study the feasibility of commercialization. Natural indigo process being applied in Slasher dyeing machine is the first of its kind in the world.

Table 26 Recipe of industrial trail

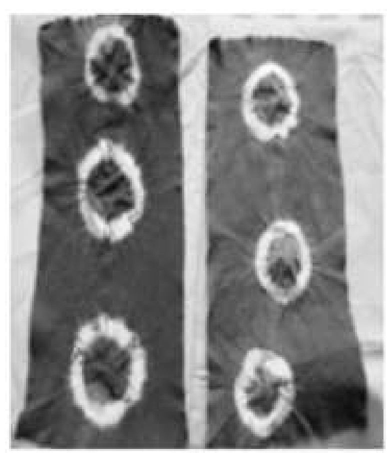
S.NO	VAT CON., GPL	INDIGO DYE	REDUCING AGENT	ALKALI
1	5 gpl	Natural Indigo powder	Green Reducing Agent (RA3)	Green Alkali(AK2)

Trials were taken using 2500 meters of yarn which included Ne 10 K, Ne 16 RSSL and Ne 30 C, in a Slasher dyeing machine. Natural Indigo, Green reducing agent (RA3) and Green alkali (AK2) were used; all chemicals used directly without further purification (Table 26).

1500 litres of water was taken for preparation of stock vat. Green alkali was added first (AK2- 450kg) followed by Natural indigo (150 kg) and finally the green reducing agent (450 kg-RA3). After adding all chemicals, vatting was allowed for 1hr. Stock vat 5gpl was dosed to machine in the 8-10 compartments of the machine.

Solid Garment Dyeing

Tie & Dye



Tie & Dye Fabric

pH & ORP values of natural indigo dye reduction process (vat time)

Minutes	ND+RA3+AK2	
	pH	ORP (-mV)
Initial	13.7	-900
Circulation	12.9	-750
Running	12.7	-740

Pretreatment
⇩
Washing
⇩
Dyeing
⇩
Washing } Repeated 6 to 10 bath
⇩
Pre-Drying
⇩
Sizing
⇩
Yarn Splitting
⇩
Yarn Accumulator
⇩
Take up Weavers Beam

Commercially developed natural indigo dyed samples produced based on the above process were tested for colour fastness properties. Details are as follows :

Table 27 Colour fastness to washing of natural indigo dyed cotton garment

K/S Value

PARAMETERS	10s carded yarn	10s slub yarn	16s RSSL yarn	30s combed yarn
Colour Fastness to Washing	CC: 4 SF: 4-5	CC: 4 SF: 4-5	CC: 4 SF: 4-5	CC: 4 SF: 4-5
Colour Fastness to Light (20 h)	3-4	4-5	4-5	4-5
Colour Fastness to Rubbing	Dry 4	Dry 3-4	Dry 3-4	Dry 4
	Wet 3-4	Wet 4	Wet 3-4	Wet 3-4
Remarks	Dark Blue	Dark Blue	Medium Blue	Dark Blue

CC : change in colour
SF : staining on adjacent fabrics

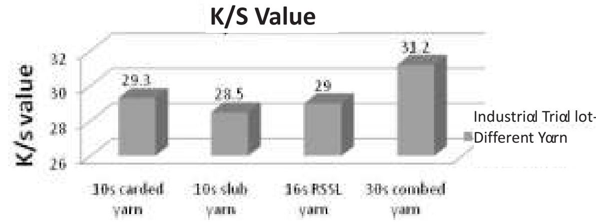


Figure 24 K/S Value of different type of yarns in the industrial trials

Table 27 and Figure 24 show that in all the 4 cases, the fastness was excellent after washing and no staining took place on the adjacent fabrics. Further, the yellowing nature of indigo was arrested due to the after treatment process (mainly washing process). The light fastness was in the range of 4, which is acceptable. Further, the whole process resulted in good wet rubbing fastness property which was in the range of 3-4. The best results were obtained using the optimized recipe combination of natural indigo dye, RA3 reducing agent and AK2 green alkali. The dyed fabric samples are shown below:

Difference between conventional denim and GRIN denim technology

Conventional Denim Dyeing Process	GRIN Denim Technology
Synthetic Indigo dyes	Synthetic/ Natural Indigo dyes
Hydrose as reducing agent	100% Greener & Biodegradable reducing agent
Caustic Soda as Alkali	Greener Alkali
Corrosive effects on ETP	No corrosive effects
Affects ETP microbes	Does not affect microbes
Toxic H_2S gas produced in ETP	No Toxic gases produced
Less Stable system, i.e., reducing agent & alkali is required	Highly Stable system i.e., No reducing agent & alkali is required
Non-Eco-friendly process	100% Eco-friendly & Sustainable process

Promotion of developed natural indigo product

SITRA'S green reduction of Indigo dyeing (GRIN) technology was launched in Textile fair "WEAVES" at Texvalley, Erode.

DEVELOPMENT OF METHODS FOR COST EFFECTIVE AND IMPROVED FASTNESS IN DYEING FOR PRODUCTION OF KOVAI KORA COTTON SAREES

The Department of Handlooms & Textiles, Coimbatore approached SITRA to find out the suitable method of dyeing 20-22 denier silk warp yarns and to get required fastness property of dyed yarn like washing fastness, wet and dry rubbing fastness, perspiration and light fastness. KOVAI KORA has acquired the Geographical Indicator Tag recently and the Department of Textiles, Government of Tamilnadu wanted to improve the said product's marketability. During the period 1980 to 2015 AD, Kovai Kora Cotton Sarees were very popular among the general public as well as celebrities for the variety of colours and the brightness which they offer. These sarees were essentially made of Vat dyed Cotton yarns of various counts in the Weft and 20-22 denier Kora Silk yarns in the were dyed different classes of dyes. There are more than 10 popular shades in which these Kora silk yarns are being dyed by the artisans. Of late, this product has lost its market share due to the infusion of synthetic sarees and also due to its poor fastness properties. The table below describes the fastness properties of majority of the silk dyed yarns in the Kovai Kora Cotton sarees :

Parameter / Fabric	Colour Fastness to			
	Washing	Perspiration		Artificial Light
		Acidic	Alkaline	
Change in Colour	2	2	2	3 (10 hours exposure)
Staining on	.			
Wool	2	1-2	1-2	NA
Acrylic	2-3	2	2-3	NA
Polyester	2	2-3	2-3	NA
Nylon	2	1-2	1-2	NA
Cotton	1-2	1	1-2	NA
Acetate	2	2	2	NA

Colour Fastness to Rubbing

Fastness against	Fastness rating
Dry Rubbing	1-2
Wet Rubbing	1

It can be seen from the above that the fastness properties of Silk yarns are well below average which is the main reason for the decline in demand for these sarees. Given the scenario, the Department of Handlooms and Textiles, Government of Tamilnadu felt that there was need to improve the Silk yarn dyeing process adopted for ages by the artisans in order to make it suitable for the present day's requirement. Hence, the project was assigned to SITRA to study the existing practices and suggest suitable improvements in the process.

As per their request, SITRA team visited silk yarn dye houses at seven places in and around Sirmugai and observed that the process being adopted for colour fixation of cold dyeing with acid dye for silk warp is not satisfactory. To fulfill the demand of the Department of Handlooms and Textiles, Coimbatore division, SITRA has developed a suitable method for kovai kora silk yarn with acid dyes. Based on the dyeing trials taken in the chemistry laboratory - SITRA, bulk dyeing trials were done at a few units in and around Sirumugai. The details are given below.

Process Sequence:

(MLR – 1:20) Wetting (non ionic Wetting agent) -1g/lit at cold for 10min

↓

Single Bath degumming and dyeing
Sodium bicarbonate -2gm/lit
Imerol XNI -1g/lit
Dissolved Acid Dye required –X %

↓

Warp Kora yarn is dipped and squeezed by hand for 10 times (5 to 10 min)

↓

The temperature of the bath is raised to 70˚C and Impregnated Hank is introduced in the dye bath and dyed at 70˚C for 20minutes at the end of dyeing 1cc/lit of Acetic Acid is added to exhaust residual dye from the dye bath

↓

The Dyed hank is rinsed in cold water twice

↓

Scrooping with 1cc/lit Acetic Acid at cold for 5 minutes

↓

Finished with 5g/lit Softener at cold for 5 minutes

↓

Squeezed and Dried in Shade

List of shades developed using different acid dyes and their % shade (owf)

S. No	Colour	Dye Name	% Shade (owf)
1	Turquoise Blue	Acid Turquoise Blue AS	2.0%
2	Lemon Yellow	Acid Yellow 4GN	0.8%
3	Parrot Green	Acid Yellow 4GN	2.0%
		Acid Turquo ise Blue AS	0.66%
4	Magenta	Acid Red 3BN	1.0%
5	Sun Orange	Acid Orange GS	1.0%
6	Red	Acid Red 5BN	2.0%
7	Rose	Acid Red 3BN	0.4%
8	Dark Coffee Brown	Acid Navy R	4.0%
		Acid Red 3BN	2.0%
		Acid Orange GS	0.4%
9	Jade Green	Acid Turquoise Blue AS	2.0%
		Acid Yellow 4GN	0.66%

The single yarn strength of grey yarn and partial degummed dyed silk yarn was determined as per SITRA's in-house method using UTR 4 machine.

The colour fastness to perspiration (acid and alkali) was evaluated according to ISO 105-E04: 2013.

Dyed yarns were tested for color fastness to washing according to the ISO Method, ISO 105-C10/A (1). Dyed yarns were tested for colorfastness to washing according to ISO Test Method, ISO 105-C10:2006. Dyed yarns were tested for colorfastness to light according to AATCC Test Method 16-2004 for 10 hours exposure. The samples were compared with the standard scale of blue wool and graded.

The dyed yarns were tested for colour fastness to rubbing (dry & wet) according to the ISO method, ISO 105-X12:2016.

RESULTS & DISCUSSIONS

Single Yarn Strength

Colour	Value	Time to break (in seconds)	B-Force gF	Elong. %	Tenacity gF/den	B-Work gF.cm
Grey Hank Yarn	1/50 Mean	1.07	72.70	17.90	3.63	473.0
Turquoise Blue	1/50 Mean	1.10	93.73	18.29	4.69	615.4
Lemon Yellow	1/50 Mean	1.29	74.67	21.69	3.73	552.9
Parrot Green	1/50 Mean	1.26	72.87	21.03	3.64	530.4
Magenta	1/50 Mean	1.25	91.83	21.07	4.59	656.7
Sun Orange	1/50 Mean	1.25	90.63	21.07	4.53	662.3
Red	1/50 Mean	1.40	91.85	23.64	4.59	749.8
Rose	1/50 Mean	1.34	85.51	22.51	4.28	653.5
Dark Coffee Brown	1/50 Mean	1.26	93.78	21.23	4.69	688.8
Jade Green	1/50 Mean	1.42	88.55	23.82	4.43	716.0

Colour fastness to perspiration

Colour	Turquoise Blue		Lemon Yellow		Parrot Green		Magenta		Sun Orange		Red		Rose		Dark Coffee Brown	
	AL	AC	AL	AC	AL	AC	AL	AC	AL	AC	AL	AC	AL	AC	AL	AC
Change in colour	4	4	4	4	3-4	4	4	4	4	4	4	4	4	4	4	4
Staining on	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wool	3-4	3-4	4	4-5	3	4	3-4	4	4	4	4	4	4	4-5	3	3-4
Acrylic	4	4-5	3-4	4-5	3-4	4	4	4	4	4	4	4	4	4-5	3-4	4
Polyester	3-4	3-4	3-4	4-5	3-4	4	4	4	4	4	3-4	4	4	4-5	3-4	4
Nylon	3-4	3-4	3-4	4-5	3-4	3-4	3-4	3-4	3-4	4	3	3-4	3-4	4-5	3	3-4
Cotton	3-4	4	3-4	4-5	3	4	3-4	4	3-4	4	3	4	3-4	4-5	3	3-4
Acetate	4	4	4	4-5	4	4	4	4-5	4	4	4	4	4	4-5	3-4	4

Note: AL-Alkaline, AC-Acidic

Colour fastness to washing +

Colour	Turquoise Blue	Lemon Yellow	Parrot Green	Magenta	Sun Orange	Red	Rose	Dark Coffee Brown	Jade Green
Change in colour	4	4	4	4	4	4	4	4	4
Staining on	.	.	.	.	.		.	.	.
Wool	3-4	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Acrylic	4	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Polyester	3-4	4-5	4-5	4-5	4-5	4	4-5	4	4
Nylon	3-4	4-5	4	4-5	4	4	4-5	4	4
Cotton	3-4	4-5	4-5	4-5	4-5	4	4-5	4	4
Acetate	4	4	4-5	4-5	4-5	4	4	4	4

+ Staining: 5- No staining, 4-Slightly stained, 3-Noticeably stained, 2 - Considerably stained, 1 - Much stained.

Colour fastness to light*

Colour	Turquoise Blue	Lemon Yellow	Parrot Green	Magenta	Sun Orange	Red	Rose	Dark Coffee Brown	Jade Green
Light Fading	4	4-5	4-5	4-5	4-5	4-5	4-5	4	4

**Blue Wool Scale Rating :1-Poor,8-Excellent*

Colour fastness to rubbing@

Colour	Turquoise Blue	Lemon Yellow	Parrot Green	Magenta	Sun Orange	Red	Rose	Dark Coffee Brown	Jade Green
Dry	4-5	4	4-5	4-5	4	4	4-5	3-4	4
Wet	4	4	4	4	4	3-4	4-5	3-4	3-4

@Grey Scale Rating :- Change in Colour: 5-No change, 4-Slightly changed, 3-Noticeably changed, 2 - Considerably changed, 1 - Much changed

The method, (Single bath partial degumming and dyeing with Sodium bicarbonate) developed by SITRA has yielded good strength of dyed yarn when compared to grey silk yarn and in addition to better fastness property to all agencies as given above.

ANTIOXIDANT COSMETOTEXTILES: DURABLE NANO-ENCAPSULATED VITAMIN E FINISHES ON TEXTILE FABRICS AND ITS CONTROLLED RELEASE STUDY (Sponsored by the Department of Science & Technology (DST) – WOSA, Govt. of India)

Textile materials are often permeable and through contact with the skin can act as a delivery system. Thus, intelligent fabrics are useful for *in vivo* applications. "Cosmetotextiles" is the emerging term that has been coined to designate textiles with cosmetic properties. It involves the use of textile materials to deliver a wide range of micro and nano-encapsulated ingredients such as aloe vera, Vitamin E, gallic acid, retinol and caffeine to provide various cosmetic benefits such as moisturizing, firming or slimming effects. Vitamin E can be absorbed through all the skin layers to the cell membrane, offers healthy glow to the skin and speeds up the cell regeneration. It is also used in several childhood diseases, such as for prevention of retinopathy of prematurity (ROP), growth retardation, fat malabsorption (e.g., cystic fibrosis, cholestatic diseases).

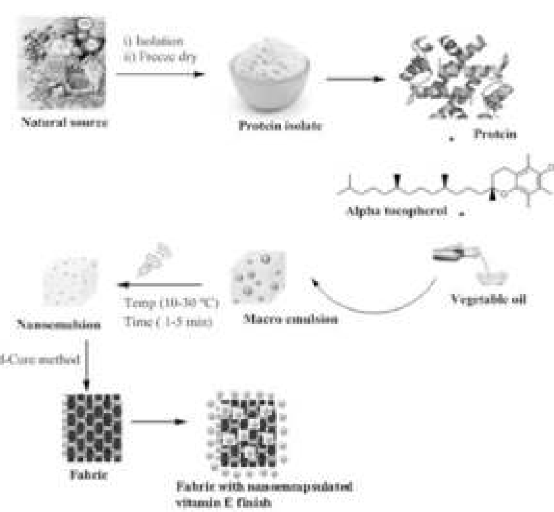
Oral dosage and topical creams and lotions may be the preferable route for the vitamin E supply. But, the risk is some of the oral vitamin E products may contain excipients, such as polyethylene glycol, propylene glycol, or polysorbate 80 which have been associated with adverse drug reactions in children. Further, expensive cosmetics are selectively applied on a few areas of the human body and not on the whole skin. Hence, the supplementation of vitamin E through fabric may be considered as a perfect choice. In cosmetic textile ?eld, micro and nano-encapsulation techniques containing vitamins are being applied in order to improve safety and durability of functional materials. Nano-carriers with increased surface area and lipid carrier ability would result in higher stability and higher drug loading capacity. Nanocapsules containing vitamin E for underwear, towels, T-shirts and bedding, those have direct contact with the skin; the release of vitamin E to the skin will be sustained for a longer period of time.

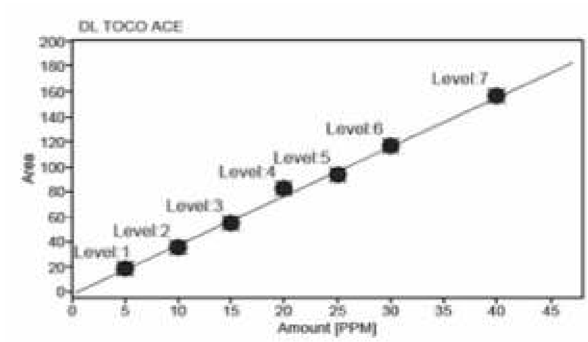
The main objective of the project is to replace the non-biodegradable polymer and costly carrier molecules (used as encapsulating agents) by eco-friendly and readily available raw materials, thus ensuring customer wellness through eco-friendly means.

The present work is on the nano-encapsulation of vitamin E from natural and commercial sources, the application of nano-formulation on the textile fabric by Pad-Cure method, evaluation of anti-oxidant property of finished fabric and vitamin E release study. Premature babies of very low birth weight (<1.5 Kg) might be deficient in vitamin E. This project will develop the vitamin E nano-encapsulated fabric to these infants which might reduce the risk of some complications, such as those affecting the retina. The present approach for the nano encapsulation is through readily available natural sources. Protein-based nanocarriers have gained lots of interest mainly because they are generally recognized as safe (GRAS), and readily biodegradable, as well as they have nonantigen nature, great source of nutritional requirement, plentiful sustainable sources and significant binding capacity. Hence, easily available and biodegradable protein based nano formulation will be applied as vehicles to entrap and deliver vitamin E. The evaluation of anti-oxidant activity and vitamin E release study of finished fabric will be carried out and feasibility of commercialization will also be studied.

The delivery of vitamin E through fabric can be achieved by micro or nano-encapsulation technology. The major benefit of nano-encapsulation which arise from their larger surface area and higher reaction rates, results in higher solubility, enhanced bioavailability and controlled release. The hydrophobic nature of vitamin E and its addition to nano formulation is a challenging task. Various nanoencapsulation techniques including nanoemulsions, nanostructured lipid carriers (NLCs), nanosuspensions, solid lipid nanoparticles (SLNs), Nanosized liposomes, biopolymer nano particles and micelles made of proteins, polysaccharides and their complexes or conjugates have been studied in the past few years. For the encapsulation of lipophilic vitamin E the addition of emulsifier (oil/water) is often required hence our approach is based on the oil in water nano emulsion method. The morphology of the nanoparticles will be evaluated by FE-SEM analysis and antioxidant activity of nano particles will be evaluated by ABTS radical cation (ABTS+) decolorization assay. Prepared nano emulsion will be applied on the fabric by Pad-Cure method. The characteristics of finished properties such as air permeability, fastness to washing and rubbing and moisture regain will be performed. The ABTS+ scavenging activity and release study of vitamin E from the finished fabric will also be evaluated.

Schematic representation of the methodology





Calibration curve for DL-α-tocopheryl acetate

HPLC analysis of α-tocopherol and α-tocopheryl acetate was performed while the UV-Vis spectroscopic analysis and antioxidant activity of α-tocopherol and α-tocopheryl acetate are in progress.

CHARACTERIZATION OF NATURAL DYES: INDIGO DYE, FRUIT EXTRACT OF TERMINALIA ARJUNA AND THESPESIA POPULNEA

There is great demand for natural dyes in the present times due to resurgence of natural dyes (ND) in the dyeing industry. Dyes are available from various sources (plant, animal and synthetic), however identification and standardization of natural dye are two major issues. The determination of purity, method of extraction and different sources of the dyes are the important factors of the dyes. There are no testing protocols available for natural dyes in the literature among ISO, DIN, ASTM, BIS or others. Therefore, there is a need to develop easy methods for identification of natural dyes based on simple chemical test and chromatographic methods which would also reveal the purity content and provide chemical information having good repeatability and reliability. Some methods are known in the literature but they are not very specific.

The methods available for identification of natural indigo dye currently are, Kit method (Preliminary test); Chromatographic tests which include Thin Layer Chromatography (TLC) (Mandatory test); High Performance Thin Layer Chromatography (optional test) and High Performance Liquid Chromatography (optional test) and Spectroscopy tests which include UV-Visible Spectroscopy (optional test), FT-IR Spectroscopy (optional test) and NMR Spectroscopy (optional test).

Kit test

Based on the solubility of the chemical components present in the dye stuff, the kit test has been used to differentiate natural and synthetic indigo dye. Three different kit tests were evaluated. In the first test, water is used as a solvent, natural indigo shows better solubility in water as compared to synthetic indigo. In the second test water and Dichloromethane (DCM) have been used in the binary system, natural indigo found to be more soluble in aqueous layer when compared to the organic layer. The solubility of natural and indigo dyes was evaluated in different organic solvents is another kit test. The colour change, in particular, inorganic solvents can be used to differentiate the natural and synthetic dye. Among the three kit methods, use of organic solvents was found suitable for the identification of natural dye. The natural dye shows purple colour in solvent which indicates the presence of natural impurity and the blue colour in synthetic dye indicates the absence/very low concentrations of natural impurities.

Colour change in natural and synthetic indigo

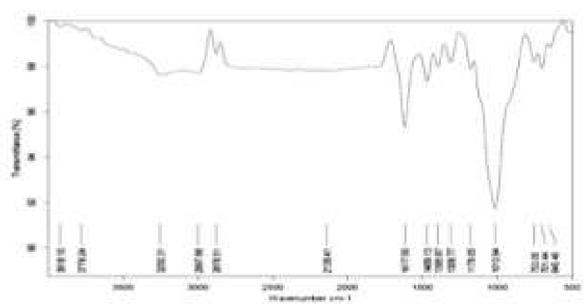
Thin layer chromatography

TLC of natural and synthetic indigo

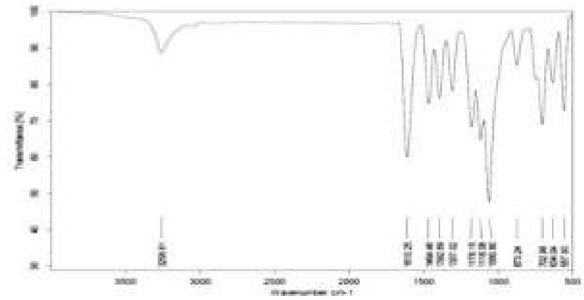
Thin layer chromatography (TLC) is a method used to reveal the purity content and provide chemical information having good repeatability and reliability. The TLC was performed for natural and synthetic indigo dyes for the differentiation. 0.01 g of indigo dye samples were dissolved in dichloromethane and used for spotting on the TLC plate and then eluted using suitable eluent system for indigo dyes. The spots were visualized in visible light. The clear blue and purple spot can be identified in the natural indigo dye, which indicates the presence of the colour component indigotin (blue spot) and the natural impurity (purple spot).

FT-IR Spectroscopy

Non-destructive analysis of indigo dye in textile samples was carried out using FT-IR. Detection of indigo in various samples was performed. This work shows the possibility of both vibrational and analytical methods to identify indigo directly in plant tissue, commercially available pigments and cotton textiles.



FT-IR spectrum of natural indigo dye



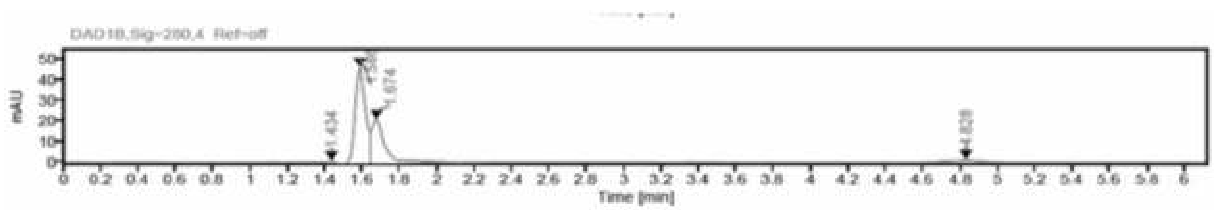
FT-IR spectrum of synthetic indigo dye

The sharp peak at 3258 cm-1 and broad peak at 3250 cm-1 indicates the presence of natural impurities and glycosidic linkages in natural dye. Small peaks around 1750 cm-1 are found in natural indigo. Sharp peaks are observed in finger print region of synthetic indigo FT-IR spectrum whereas broad signals are found in the natural indigo spectrum.

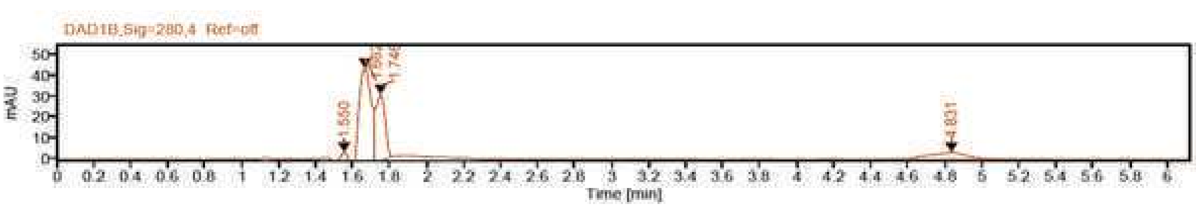
High Performance Liquid Chromatography (HPLC)

Identification of compounds by HPLC is a crucial part of chromatographic analysis. The natural and synthetic indigo dyes were dissolved in suitable solvent and then analyzed by HPLC. The following conditions were used to perform the analysis.

Column: C18, 150 X 4.6mm, Flow rate: 1.0 ml/min, Detector: DAD, Detection wavelength: 280 nm, Pump pressure: 15 MPa, Mobile phase: Isocratic (Methanol: Ethyl acetate)



HPLC chromatogram of natural indigo dye



HPLC chromatogram of synthetic indigo dye

Wavelength (dye)	RT	Peak area	Remarks
280 nm (Natural Indigo)	1.434	5.40	The peaks at RT 1.434 & 1.586 indicate natural dye.
	1.586	178.85	
	1.676	115.40	
	4.828	14.83	
280 nm (Synthetic Indigo)	1.550	23.45	The RT at 1.550 indicates synthetic dye.
	1.662	210.08	
	1.746	114.92	
	4.831	43.40	

The HPLC analysis of dye extract from the dyed fabric and the analysis of natural and synthetic indigo are in progress using UV-VIS spectroscopy.

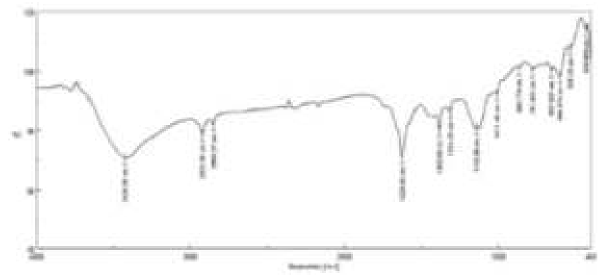
Characterization of fruit extract of Terminalia arjuna and Thespesia populnea

The extracted dyes were analyzed for phytochemical composition, such as total phenol, tannin and flavonoids. The phenolic compounds present in plants are good sources of natural dye. The phytochemical analysis of dye extract was carried out using FT-IR and GC-MS. The colour components in the plant extract of Terminalia arjuna and Thespesia populnea were identified by GC-MS analysis. The interaction between the colour component, mordant and fabric was studied.

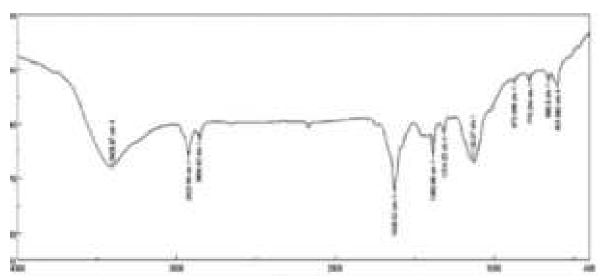
FT-IR analysis

Fourier Transform Infrared (FTIR) Spectroscopy is a widely used method for spectral analysis of solid, liquid or gas materials by absorption or emission. The molecular structures have correlation with the peak positions shown in an infrared spectrum. The functional groups present in a compound are confirmed by IR spectrum. The extracted dyes were analyzed using FTIR at the frequency range of 4000 to 400 cm-1.

The FTIR spectroscopy in Figure 1 (a) and (b) are of the natural dyes extracted from the fruits of Terminalia arjuna and Thespesia populnea. The broad peak at 3426 cm-1 could be hydroxide (–OH) and amine function groups stretching frequency corresponding to phenols, carboxylic acid in Gallic acid-based tannins. The sharp peaks at 2926 cm-1 and weak peaks at 2650 cm-1 may be C-H function group stretching frequency corresponding to aldehyde and allylic respectively. The strong, sharp peak at 1626 cm-1 may be C=C function group stretching frequency corresponding to unsaturated alkene and aromatic ring system. The medium and weak peaks at 1383 cm-1 and 1314 cm-1 may be –CH3 function group bending frequency and then 1143 cm-1 may be C–OH function group stretching frequency corresponding to phenols, carboxylic acid in Gallic acid-based tannins.



FT-IR Spectra of Terminalia Arjuna

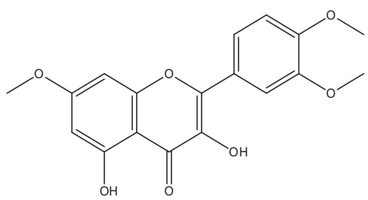
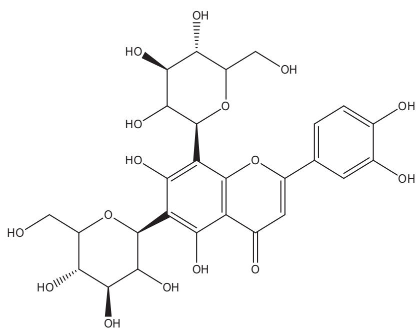


FT-IR Spectra of Thespesia populnea

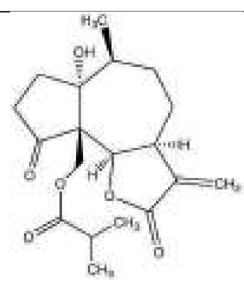
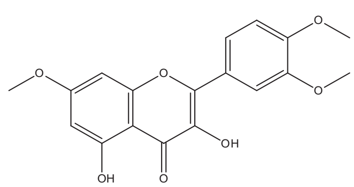
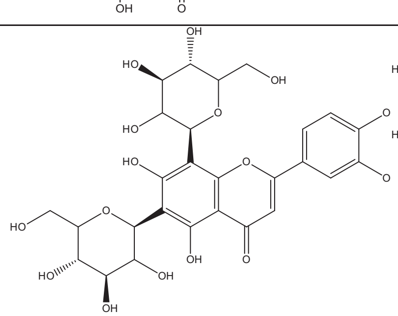
GC-MS analysis

The dyes extracted from the fruits of Terminalia arjuna and Thespesia populnea were analyzed using GC-MS for the phytochemical analysis. The dyes were dissolved in methanol at a concentration of 5mg/mL and then analyzed using GC/MS. From the library matches, the colour compounds were determined.

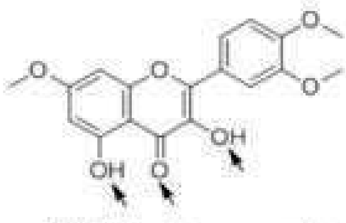
Terminalia Arjuna fruit extract colour constituents identified by GC MS

S. No	Chemical Structure	Chemical name	Common name	Category based on chemical nature and functional group
1		2-(3,4-dimethoxyphenyl)-3,5-dihydroxy-7-methoxy-4H-1-Benzopyran-4-one	7,3',4'-trimethoxy quercetin	Flavanoids
2		2-(3,4-dihydroxyphenyl)-6,8-di-α-D-glucopyranosyl-5,7-dihydroxy-4H-1-Benzopyran-4-one	Lucenin 2	Polyphenols

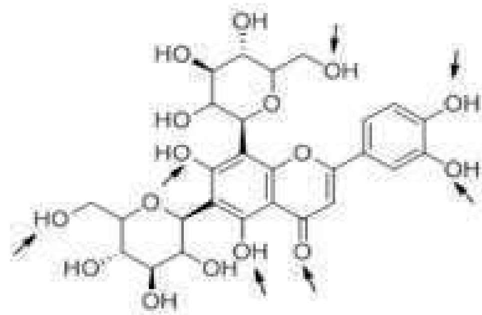
Thespesia populnea fruit extract colour constituents identified by GC MS

S. No	Chemical structure	Chemical name	Common name	Category based on chemical nature and functional group
1		(3aS,6S,6aR,9aR,9bR)-6a-hydroxy-6-methyl-3-methylene-2,9-dioxododecahydroazuleno[4,5-b]furan-9a-yl isobutyrate	Isochiapin B	Sesquiterpenoids
2		2-(3,4-dimethoxyphenyl)-3,5-dihydroxy-7-methoxy-4H-1-Benzopyran-4-one	7,3',4'-trimethoxy quercetin	Flavanoids
3		2-(3,4-dihydroxyphenyl)-6,8-di-α-D-glucopyranosyl-5,7-dihydroxy-4H-1-Benzopyran-4-one	Lucenin 2	Polyphenols

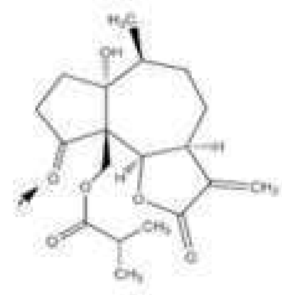
The active sites present in the colour components were identified and the formation of complex was drawn with the chemical structure. The active sites are highlighted using arrow mark.



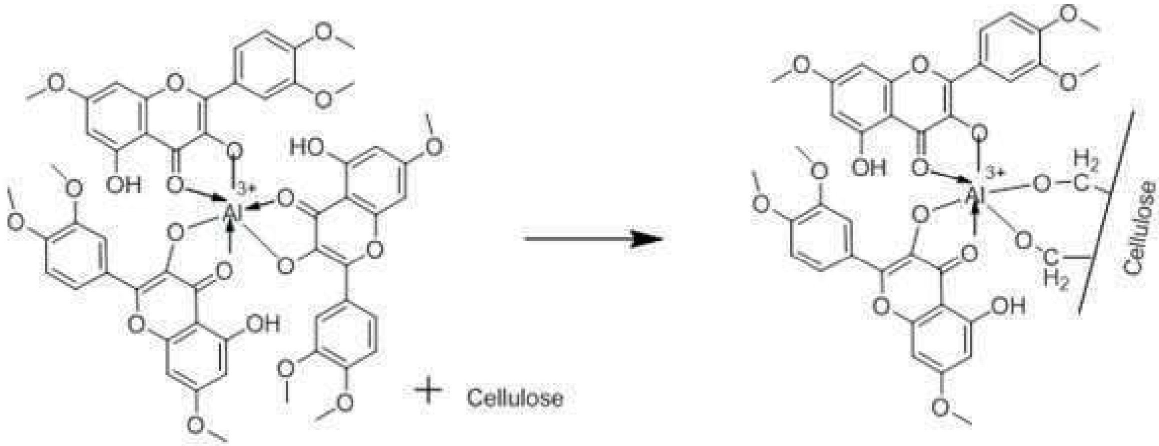
7,3',4'-trimethoxy quercetin



Lucenin 2



Isochiapin B



metal-flavanoid complex

metal-flavanoid-fibre complex

The identification of colour components in the natural dyes will pave a way to select the appropriate natural mordant for the dyeing of textile materials using natural dyes

STUDY ON IDENTIFYING THE USAGE OF MIXED SALT OBTAINED FOM EFFLUENT TREATMENT PLANT FOR DYEING

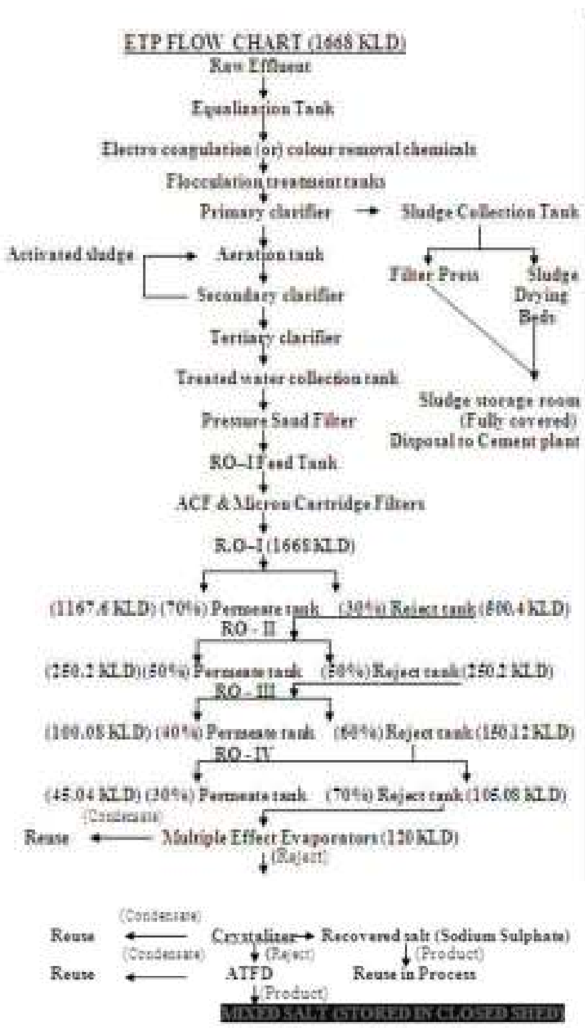
Disposal of mixed salt is an environmentally sensitive problem. It is also a mounting global issue as sludge production will increase subsequently with the increase in number of waste water treatment plants and the evolution of more stringent environmental quality standards. Mixed salt is often regarded as the major problem of water pollution control in terms of their immediate impact of nature and potential for pollution. With a few environmentally unfriendly disposal routes like land disposal and direct disposal to the sea having been phased out, the challenge facing sludge management is to find cost-effective and advanced solutions while responding to environmental, regulatory and public pressures. Recycling and use of wastes are the preferred options for sustainable development, rather than incineration or land filling. But sometimes it is not straight forward because of sensitivities and contaminants like heavy metals, etc. Considering the above, the present study focuses on usage of mixed salt for dyeing applications.

Objectives and Methodology of the study

- Ø To study and identify the usage of mixed salt from agitated thin film dryer (ATFD) rejection of individual Effluent Treatment Plants (IETP) and Common Effluent Treatment Plant (CETP).
- Ø To find out the possibilities of usage of contaminated salt for dyeing as an exhaustion agent.

- Ø To test and evaluate the quality parameters of mixed salt and commercial salt.
- Ø To dye the fabric using mixed salt and commercial salt in different shade categories
- Ø To evaluate the dyed samples using computer colour analysis.
- Ø To study the feasibility for commercialization based on the evaluation results.

Process flow chart of ETP plant



Mixed salt samples were analyzed for various physico-chemical and organic parameters according to standardized method. 100 % cotton Ready for Dyeing (RFD) single jersey knitted fabric samples were dyed using mixed salt and G.salt with the same recipe separately. The dyed samples were evaluated for K/S value and color difference value using spectrophotometer.

Reactive Vinyl sulphone dyes used were

- Tulactiv. Yellow CC
- Tulactiv.Red.CC
- Tulactiv Blue CC
- Tulactiv Black XLN
- Tulactiv Navy CC

The chemicals used were

- Anhydrous Glauber's salt (Na_2SO_4) – Exhausting agent
- Mixed Salt - Exhausting agent
- Sodium carbonate (Na_2CO_3) – Fixing agent
- Soap oil – Soaping agent
- Acetic acid (CH_3COOH) – Neutralizing agent

while parameters of the RFD fabric were as follows :

- Absorbency : 3 sec
- Whiteness Index : 68
- pH – 6-6.5

The required amount of dye was pasted with a small amount of water and addition of warm water for complete dissolution of dye. Then the solution was made to the required volume (which is required for stock solution). When the dye became completely soluble, it was checked by spotting on filter paper.

Dye baths were set with required amount of dye solution and water as per material to liquor ratio (MLR) of 1:8, Fabric samples were introduced into bath at room temperature. Dyeing was started at room temperature. The pH was maintained at 6 to 6.5. Then, after 10 minutes salt was added and ran for 10 more minutes at 60^{0}c. Then soda ash was added as per the requirement and dyeing was carried out at 60^{0}c for 30mins to 60mins. After complete fixation, the dyed samples were washed, neutralized and soaped.

Sequence of dyeing process

RFD Fabric is loaded at RT with Dye and water

⇩

Run at room temperature at 10 min

⇩

Salt Addition (Qty as per shade)

⇩

Run at 60^{0}C temperature for 10 min

⇩

Soda Addition (Qty as per shade)

⇩

Run at 60^{0}C for 30 min to 60 min (Time as per shade)

⇩
Washing at room temperature
⇩
Neutralization (Using Acetic Acid)
⇩
Soaping at temperature of 90^{0}C
⇩
Hot wash at temperature of 70^{0}C
⇩
Cold wash at room temperature
⇩
Dry the Fabric

Determination of performance properties

Assessment of colour is more than a numerical expression. Usually, it is an assessment of the colour difference (delta) from a known standard. CIE LAB (L*a*b*) and CIE LCH (L*C*h) are used to compare the colours of two objects.

DL* = difference in lightness/darkness value (+ = lighter - = darker)
Da* = difference on red/green axis (+ = redder - = greener)
Db* = difference on yellow/blue axis (+ = yellower - = bluer)
DC* = difference in chroma (+ = brighter - = duller)
DH* = difference in hue
DE* = total colour difference value

K/S Value is an important parameter of modern colorimetry, which can indicate the depth of the color of dyed fabric surface. K/S (Absorption coefficient (K) and Scattering coefficient (S) is a value used to determine the depth of color of a dyed fabric. K/S values are used in textile applications to control the color process parameters in dyeing and finishing of fabrics.

Characterization of mixed salt and Glauber's salt

The physico-chemical parameters of mixed salt and glaubers salt have been analyzed and compared with each other. The results of the analysis are given in adjacent table.

Mixed salt contains Sodium chloride 55 % and sodium sulphate 29% and it is contaminated with calcium and magnesium ion. The total hardness of mixed salt was 200 mg/L (@1% Solution). Total organic carbon of 14.63 mg/kg was present in mixed salt. Other metal parts are

Physico-chemical parameters results

PHYSICO-CHEMICAL PARAMETERS	MIXED SALT	GLAUBER SALT
Sodium Chloride (%)	55.28	1.32
Sodium Sulphate (%)	29.2	97.66
Moisture Content (%)	4.34	0.03
Total Hardness 2% solution (mg/L)	200	ND (LOD 1)
Calcium (mg/kg)	778	ND (LOD 1)
Magnesium (mg/kg)	472	ND (LOD 1)
Total Hardness (1% solution) (mg/L)	200	
Sulphate (mg/kg)	197272	659845
Total Organic Carbon (mg/kg)	14.63	1.53
Insoluble Matters (%)	0	0
Iodine (mg/kg)	ND (LOD 2)	ND (LOD 2)
Potassium (mg/kg)	971	781
Iron (mg/kg)	ND (LOD 0.5)	ND (LOD 0.5)
Aluminum (mg/kg)	ND (LOD 0.01)	ND (LOD 0.01)
Total Chromium (mg/kg)	ND (LOD 0.42)	ND (LOD 0.42)
Manganese (mg/kg)	ND (LOD 1)	ND (LOD 1)
Nickel (mg/kg)	ND (LOD 0.86)	ND (LOD 0.86)
Barium (mg/kg)	ND (LOD 3)	ND (LOD 3)
Titanium (mg/kg)	ND (LOD 3)	ND (LOD 3)
Copper (mg/kg)	9.93	9.4
Lead (mg/kg)	ND (LOD 0.16)	ND (LOD 0.16)
Reactive Silica (mg/kg)	ND (LOD 0.02)	ND (LOD 0.02)
Cobalt (mg/kg)	ND (LOD 0.74)	ND (LOD 0.74)
Strontium (mg/kg)	ND (LOD 3)	ND (LOD 3)
Vanadium (mg/kg)	ND (LOD 0.01)	ND (LOD 0.01)
Molybdenum (mg/kg)	ND (LOD 0.01)	ND (LOD 0.01)
Digestion	Done	Done
Oil and Grease	ND (LOD 3)	ND (LOD 3)
Electrical Conductivity	140.1	106.5
TDS (mg/L) (1% Solution)	9880	8720
Oxidation-Reduction Potential Value (ORP) (Mv)	-94	79
Colour	TO BE CHECKED	TO BE CHECKED
Turbidity(NTU)	3.38	1.08

ND (LOD) – Not detected (Limit of Detection)

not detected in mixed salt. The TDS detected was around 9880 mg/L. The ORP value of -94 shows that the mixed salt in solution may have some reducing impurities which may cause reduction in colour yield. Hence, a mild oxidizing agent needs to be added in the dye baths to prevent reduction damage to dyes. The mixed salt colour was found to be slightly yellowish and its turbidity value was found to be 3.38 NTU.

Cotton knitted fabric samples were dyed with Vinyl sulphone dyes with G.Salt and mixed salt (Table 28). Fabrics dyed using mixed salt and G.salt respectively were measured for colour difference, strength of colour and K/S value (Figure 25).

Table 28 Dyeing plan of different shades

COMPARISON OF G.SALT AND MIXED SALT - DYEING PLAN									
Trial No.	Category	DYES NAME	% SHA DE	Salt (gpl)	Soda (gpl)	Caus tic	Temp	Tim e	**Check points**
1	Self shade - Light	Tulactiv Yellow CC	0.5	20	10	_	60^{0} C	30	1)Absorb ency of Fabric 2)Dye bath PH 3) Soda bath out PH 4) Before Soap Ph
2	Combination (Dark)	Tulactiv Yellow CC	0.58	60	10	1	60^{0}C	60	
		Tulactiv Red.CC	1.75						
		Tulactiv Navy CC	4.1						
3	Combination (Dark)	Tulactiv Yellow CC	0.8	60	10	1	60^{0} C	60	
		Tulactiv Red.CC	0.62						
		Tulactiv Black XLN	4.16						
4	Self shade - Medium	Tulactiv Red CC	2	40	10	_	60^{0} C	45	
5	Self shade - DARK	Tulactiv Black XLN	6	60	10	1	60^{0} C	60	
6	Self shade - DARK	Tulactiv Navy CC	6	60	10	1	60^{0} C	60	
7	Combination(Light)	Tulactiv Yellow CC	0.25	30	10	_	60^{0} C	30	
		Tulactiv Red.CC	0.25						
		Tulactiv Blue CC	0.25						
8	Self Shade - Turquoise	Turquoise Blue (HE)	3	40	15	_	80^{0} C	40	
9	Combination(Medium)	Tulactiv Yellow cc	0.9	50	15	_	60^{0} C	60	
		Tulactiv Red.cc	3.1						

K/S value and computer colour analysis of Dyed sample

The above dyed samples were taken, measured for their colour difference, Strength of dye and K/S value by using Macbeth 7000A Spectrophotometer

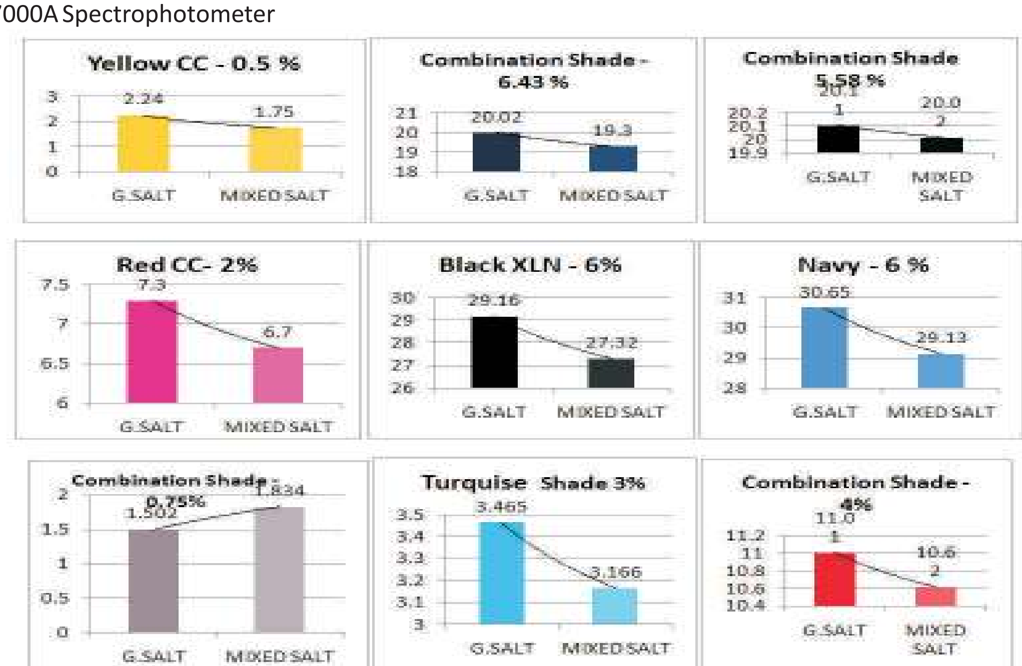
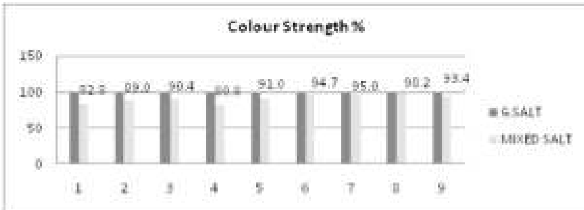


Figure 25 K/s Value of dyed samples in mixed salt and G.salt- comparison chart

Computer colour analysis



The K/s value and Colour difference results are shown in Figure 25 and Table 29. From Figure 25 It may be observed that the K/s value was lower in mixed salt sample compared to the G.Salt. From Table 29 it is observed that the total colour difference value (DE*) of mixed salt dyed smples was more than 1 and all samples are lighter. The colour strength was lower by 80 %. At higher water hardness, the decrease in colour strength and K/s values may be due to the detrimental effect of heavy metal salts on dyeing. The metal salts may have reacted with the reactive dyes and inhibited the exhaustion and fixation of dye on the fabric.

Findings

Ø Water hardness has detrimental effect on dyeing of textiles. For all shades studied with mixed salt, the strength of colour value was low. The effect of mixed salt was different for different shades. This may be due to varying affinity of the dyes with cotton material.

Ø Mixed salt can be used and utilized for dyeing as a exhaustion agent for medium and dark shade with the addition of 20 % of mixed salt and also by adding suitable sequestering and oxidizing agent.

Ø The usage of mixed salt quantity may vary from one Individual Effluent treatment plant (IETP) to another IETP and also between one Common Effluent Treatment Plant (CETP) and another CETP due to different processes involved in each. Usage of mixed salt was for dark and medium shades in industrial bulk trials was standardized and found successful.

Ø This is strongly not recommended for light and sensitive shades. The hardness of water is one of the most important factors which affects the dyeing process and causes the shade variation problem.

Table 29 Colour ΔE and colour strength value of mixed salt dyed samples

Trial No	Dyes Name	Percentage of Shade %	DL*	Da*	Db*	Dc*	DH*	DE*	% Strength
01	Tull Yellow CC	0.5	2.27L	0.67R	0.52B	0.06D	-0.85	2.39	82.81
02	Tull Yellow CC	0.58	1.24L	0.09R	-0.448	0.44B	0.07R	1.32	89.01
	Tull Red CC	1.75							
	Tull Navy CC	4.1							
03	Tull Yellow cc	0.8	1.41L	-0.05G	-017Y	0.03D	-0.07R	1.29	90.42
	Tull Red.cc	0.62							
	Tull Black XLN	4.16							
04	Tull Red cc	2	2.55L	-0.73G	-1.54B	-0.74D	-1.53D	1.87	80.78
05	Tull Black XLN	6	0.95L	-0.13G	-0.85B	0.14B	-0.24B	1.0	91.00
06	Tull Navy CC	6	0.45L	0.05R	-0.16B	-0.15B	0.07R	0.62	94.70
07	Tull Yellow CC	0.25	0.61L	0.14R	-0.70B	0.14B	-0.70B	0.94	94.97
	Tull Red CC	0.25							
	Tull Blue CC	0.25							
08	Turquoise Blue	3	0.11L	0.33R	-0.27Y	0.07	0.42B	0.44	98.18
09	Tull Yellow CC	0.9	0.64L	-0.89G	-0.43B	-0.99D	-0.10B	1.14	93.37
	Tull Red CC	3.1							

DEVELOPMENT OF WATER FREE DYEING TECHNIQUES BY USING SUPERCRITICAL CARBON DI-OXIDE (SC-CO_2)

Textiles are usually coloured to make them attractive for aesthetic appeal. There are two ways of adding colour to a textile substrate-printing and dyeing. Printing adds colours to the surface in discrete places, whereas dyeing completely covers the substrate with colour. Dyeing is the process of imparting colors to a textile material through a dye (colour). In textiles, wet processing industry require large amount of water for dyeing fabrics with various kinds of dyes. The textile industry is believed to be one of the biggest consumers of water. Water is used as a solvent in many pretreatment and finishing processes, such as washing, scouring, bleaching and dyeing. Waste stream generated in this industry is essentially based on water-based effluent generated in the various activities of wet processing of textiles. In the end, waste water contains large quantities of chemicals, salt and alkali, and becomes chemical waste, which is difficult to treat and leads to large amounts of untreated wastewater directly being dumped in water bodies such as lakes, rivers and others, leading to damage to the aquatic environment. On an average, 100–150 litres of water is required to process 1 kg of textile material.

Various techniques were adopted to address the reduction of usage of water viz., low liquor dyeing machine, high coloration dyes, salt less dye, etc., however they had shortfalls such as being non-eco friendly and high cost. Water recycling is a global challenge to the textile wet processing industry because of the high cost involved in the effective effluent treatment plant using membrane filtration technology. We must protect the environment from adverse effects of the effluent

Many of the textile processing units have shut down because of these problems. The textile wet processing industry is today interested in newer technologies which can address both effluents as well as using an eco friendly process. Hence, the elimination of water and chemicals would be a real breakthrough for the textile dyeing industry. Water free dyeing technology using supercritical carbon dioxide (SC-CO_2) can be a solution to the problem.

Difference between conversational dyeing and supercritical dyeing

CONVENTIONAL DYEING	SUPERCRITICAL CO2 DYEING
High volume of water required for dyeing. High concentrate chemicals are used like dispersing agent, leveling agent etc. Effluent treatment cost high	No water required for dyeing. No need auxiliary's chemicals. No waste water at all.
High energy requirements	Only 20 percent energy requirement
Dyeing, washing, Drying time – 4-5 hrs per batch.	Only 3 hrs (No need for drying)

The objectives of the project are

- Ø To develop a water free dyeing technique by using Supercritical carbon di-oxide.
- Ø To study the feasibility of dyeing of synthetic and cotton materials without water and to get uniform, reproducible interaction between Dye molecules and whole surface of Textile material.
- Ø To develop a method of natural dye extraction by using SC-CO_2

When carbon dioxide is heated to above 31.1^{o}c and is pressurized above 73.8 bar, it becomes supercritical, a state of matter that can be seen as an expanded liquid, or a heavily compressed gas. In short, above the critical point, carbon dioxide has the properties of both liquid and gas. In this way, supercritical CO_2, has liquid-like densities, which is advantageous for dissolving hydrophobic dyes, and gas-like low viscosities and diffusion properties, which can lead to shorter dyeing times compared to water. Carbon dioxide is preferred over other fluids because when compared to other fluids, the critical temperature and pressure is attained at lowest point. Carbon dioxide is the most investigated and used gas in the supercritical fluid process. It is a naturally occurring, chemically inert, physiologically compatible, relatively inexpensive and readily available gas for industrial consumption.

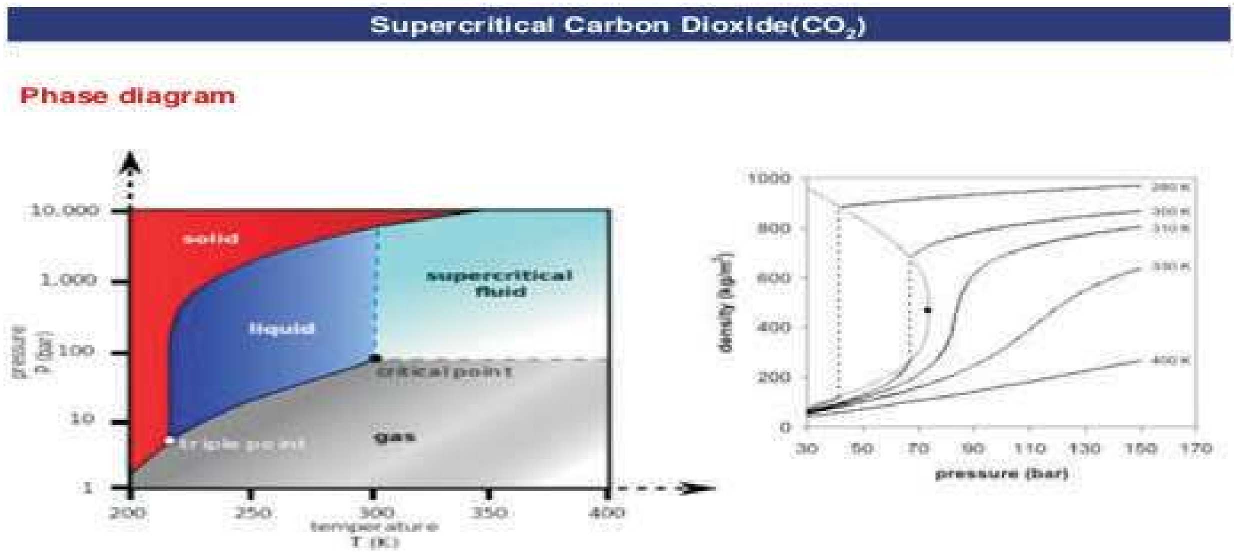


Figure 26 CO2 Pressure-temperature & density pressure phase diagram

Figure 26 shows the areas where carbon dioxide exist as a gas, liquid, solid or as a SCF. The curves represent the temperature and pressure where two phases coexist in equilibrium (at the triple point, the three phases coexist). The gas-liquid coexistence curve is known as the boiling curve. If we move upwards along the boiling curve, increasing both temperature and pressure, the liquid becomes less dense due to thermal expansion and the gas becomes denser as the pressure rises. Eventually, the densities of the two phases converge and become identical, the distinction between gas and liquid disappears, and the boiling curve comes to an end at the critical point. The critical point for carbon dioxide occurs at a pressure of 73.8 bar and a temperature of 31.1˚C.

Replacing water with Supercritical carbon dioxide is found to offer major environmental advantage for the textile dyeing industry. The vessel used in the extraction of flavours, perfumes, oil etc., is modified and made suitable to use SC-CO_2 for textile dyeing applications. Dyeing textiles using supercritical carbon dioxide as dye solvent instead of water has been the topic of discussion in various forums. The dedicated prototype SC-CO_2 vessel set-up was developed by Deven Supercritical Pvt Ltd is subjected to study the water free dyeing (Figure 27).

Initially, 100 % polyester woven fabric (GSM – 70 and filament yarn) was used for the study. Specially designed dyes for polyester from Colourtex for SC-CO2 dyeing. Coranger PE dyes and Dianix from DyStar were used in the experiment.

- Ø Coranger Yellow PE-3205
- Ø Coranger Yellow Brown PE-3325
- Ø Coranger Orange PE-3330
- Ø Coranger Red PE – 3499
- Ø Coranger Red PE -3447
- Ø Coranger Blue PE – 3648
- Ø Coranger Navy Blue PE – 3658
- Ø Coranger Violet PE-3529
- Ø Dianix Rubine S2G 150

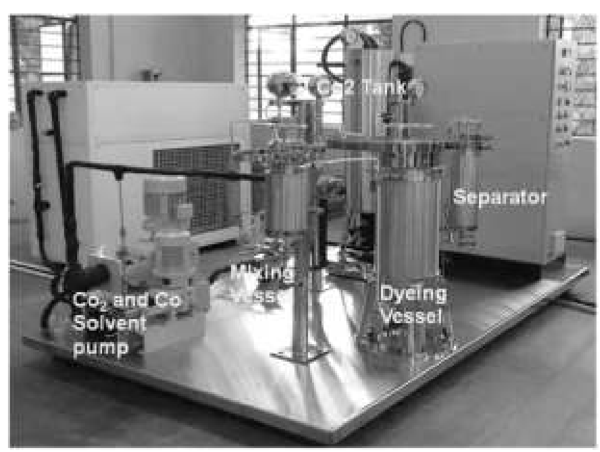


Figure 27 Supercritical Fluid Dyeing Pilot Machine

The SC-CO_2 textile dyeing system (Figure 28) includes various sub-systems viz. CO_2 gas cylinder, condenser, chiller, high pressure carbon dioxide and co-solvent pump, pre-heaters, dye mixing vessel, dyeing vessel, separator, CO_2 flow meter and control panel. These machines are developed to withstand the pressure of 300 pressure bar and 120°C temperature.

There are three components in the SC- CO_2 dyeing process: the gas, dyestuff and fiber polymer. The dyestuff dissolved in the SC- CO_2 is transferred to, absorbed by and diffused into the fabric. During the dyeing of fabrics, CO_2 loaded with dyestuff penetrates deep into the pore in the capillary structure of fabrics. This deep penetration provides effective coloration of textile materials. A further advantage of this dyeing technique is that the dye can be easily separated from CO_2 after depressurization.

The dyeing takes place in following steps:

- Ø Dissolution of dye in SC- CO_2
- Ø Transport of SC- CO_2 to the fibers
- Ø Adsorption of dye on fibre surface and finally
- Ø Diffusion of dye into the fibre takes place

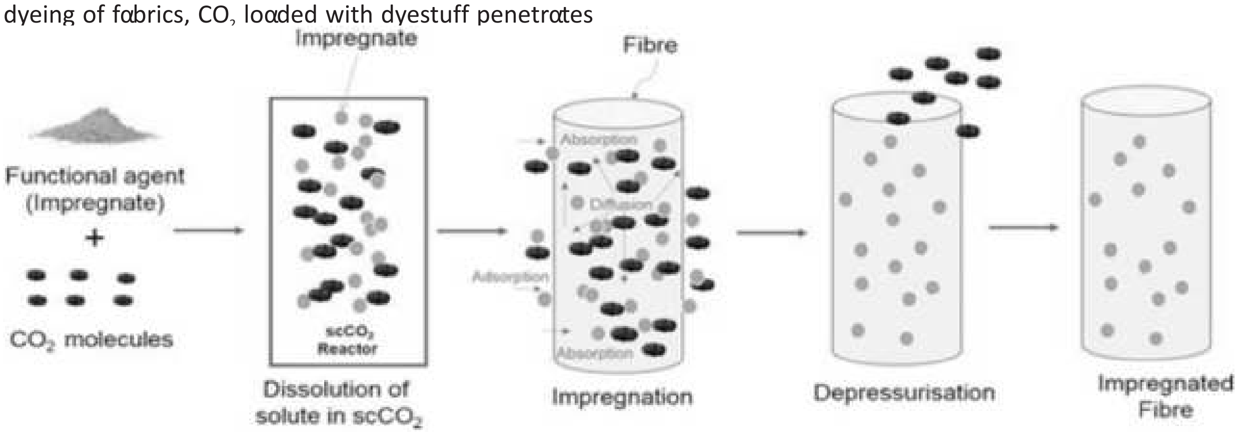
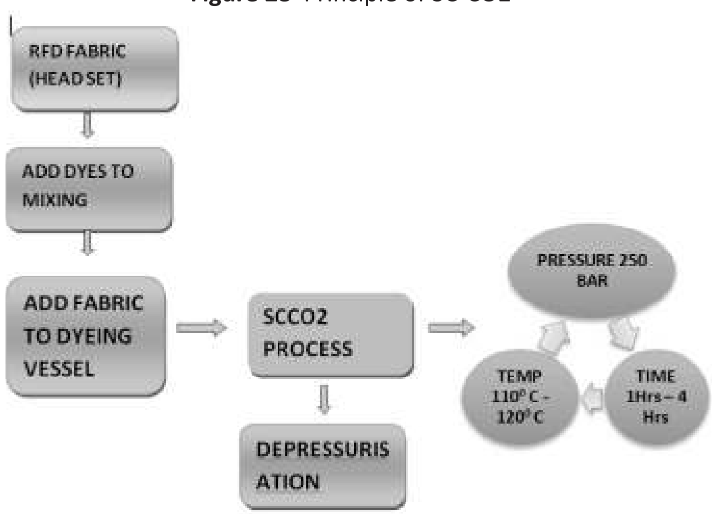


Figure 28 Principle of SC-CO2



SC- CO_2 dyeing was carried out in the dyeing pilot machine set-up for dyeing fabrics using disperse dyes and SC- CO_2 dyes for dyeing polyester fabric. Disperse dyes being non polar in nature is soluble in the supercritical carbon dioxide. Extensive dyeing trails were conducted to optimize the dyeing conditions and methodology using various methods and combinations (Table 30). The dyes were placed in the dye mixing vessel of known quantity and the polyester fabric was placed in the dyeing vessel. Polyester fabric was rolled on the textile holder. The vessels were tightly closed and experiment was carried out. After the reaction time of dyeing, the SC-CO_2 textile dyeing system was depressurized and the dyed fabric was removed. The dyed fabric was dried and does not require any reduction clearance to wash off any dyes on the surface. The fabric was then evaluated for their various properties.

Experiments

Table 30 Details of experiments

SAMPLE No.	DYES NAME	% OF SHADE	SC-CO_2 PROCESS			REMARKS
			PRESSURE (BAR)	TEMP (^0C)	TIME (MINS)	
01	Rubine S2G	2	150	100	60	Fabric more uneven & 50% dyes kept in mixing vessel. Fastness poor
02	Yellow Brown PE	2	200	110	60	Fabric uneven
03	Yellow Brown PE	2	250	110	120	Fabric uneven
04	Yellow Brown PE	2	250	120	180	Fabric slightly uneven and fastness improved when compared to 60 mins process
05	Yellow Brown PE	2	250	120	180	CO_2 passed top to bottom and bottom to top. Process carried out circulation mode.
06	Orange PE	2	250	120	240	Levelness and Fastness accepted limit.

The SC-CO_2 dyeing was carried out at pressure varying from 150, 200 and 250 bar and temperature varying from 100, 110 and 1200C. Duration taken for dyeing was also optimized varying from 1,2,3,4 hours. Based on these trails optimum dye solubility at a known pressure and temperature was derived.

The dyeing was carried out with respect to its flow rate of SC- CO_2, duration of dyeing, temperature and pressure for dyeing, fixations of dyes on substrate, repeatability of dyeing process, fastness properties of the dyed samples, etc. The variables are given in Table 30.

Determination of performance properties

Dyed fabrics were tested for color fastness to washing according to the ISO method IS 105-C10/B (2), where neutral pH soap was employed. Dyed fabrics were tested for color fastness to light according to ISO 105 B02 (10 hours).

Dyed fabrics were tested for color fastness to rubbing (dry and wet rub) according to the ISO 105 X12-2016.

Dyed fabrics were tested for color fastness to sublimation according to the IS 975:1988. (1500C -30 seconds). Fastness to sublimation is probably the most important requirement of dyed polyester, apart from fastness to light. The migration behavior and wet fastness of disperse dyes on polyester are closely involved with their response to heat treatments.

The dyed samples were evaluated for their color strength by determining the K/S values using a Gretag Macbeth 7000 eye (USA) Computer Color Matching System. Averages of four readings, taken at four different sample areas, were used to get the reflectance values based on which the Kubelka Munk function (K/S) was evaluated. K/S = (1-R) 2/ 2R where, R is the reflectance at complete opacity, K is absorption coefficient and S is the Scattering coefficient. Dyed fabrics were also evaluated in terms of CIE LAB color space (L*, a* and b*) values using the Gretag Macbeth 7000 eye (USA) system.

Optimization of various parameters for carrying out dyeing using SC-CO_2

The various dyeing trials were conducted using varying temperature, pressure, duration of dyeing process etc. Disperse dyes were selected which were found soluble in carbon di-oxide solvent for the study. Dyeing was carried out using these dyes for optimization of process of dyeing using SC- CO2 media.

- Ø Coranger Yellow PE-3205
- Ø Coranger Yellow Brown PE-3325
- Ø Coranger Orange PE-3330

The parameter studied were 1) pressure from 150 to 300 bar 2) temperature from 100 to 120 degree celcius 3) duration from one, two and three and four hours of dyeing process. This study was necessary to establish the optimum parameters for carrying out polyester dyeing using SC-CO_2. The variables studied are mentioned in Table 31.

Table 31 Various Variables studied for SC-CO_2 Dyeing

Variables		
Pressure (in bar)	Temperature in °C	Duration of dyeing (mins)
150	100	60
200	110	60
250	110	120
250	120	180
250	120	240

Colour fastness properties were evaluated and results are shown in Table 32.

From Table 31, it may be observed that fastness properties were improved when the temperature, pressure and time were increased. Dyeing in sample no 01 was more uneven and fastness properties were low. Sample 05 and sample 06 were polyester fabrics where the dyeing was more even and the fastness properties were within acceptable limits. Higher evenness and shade reproducibility were achieved at higher temperature (120°C) and higher pressure (250 bar). K/s values (Figure 29), shows that the colour shade in polyester fabric changed with an increase in dyeing temperature, time and pressure.

K/S Value

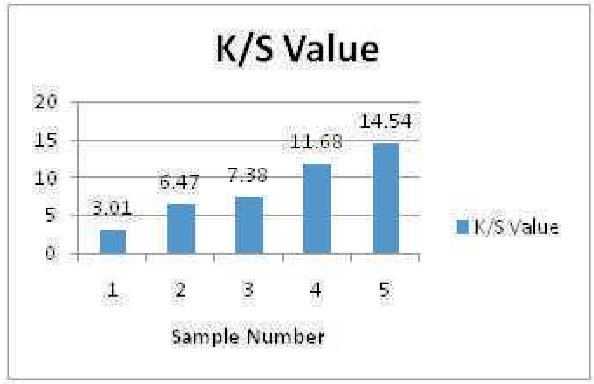


Figure 29 K/S Value

Specific observation

- Ø Selection of RFD fabric is important for evenness, before dyeing and the fabric should be free from added impurities
- Ø Shade depth, fastness properties and fabric shade evenness are achieved by increasing the pressure (250 bar), temperature (120°c) and duration(180-240 mins).
- Ø SC-CO_2 circulation direction is important for evenness of fabric. (In/Out and Out/In). That is achieved by running the fabric in both directions.

Advantages of water free supercritical CO_2 dyeing

Table 32 Results of fastness properties

Sample no	Variables (Pressure, Temp, Time)	Colour fastness					
		Washing		Light	Rubbing		Sublimation
		CC	SF		Dry	Wet	
01	150,100,60	2-3	2	2	2	2	3
02	200,110,60	2-3	3	3	2	2	3
03	250,110,120	3-4	4	3-4	3	4	3-4
04	250,120,180	4-5	4-5	4-5	4-5	4-5	4-5
05	250,120,180	4-5	4-5	4-5	4-5	4-5	4-5
06	250,120,240	4-5	4-5	4-5	4-5	4	4-5

CC : Change in colour SF : Staining on adjacent fabrics

- Zero discharge: No waste water, No environment pollution.
- SC CO_2 swells polymer matrix: Faster dye diffusion in the matrix.
- SC CO_2 has negligible surface tension: Efficient wetting of Textile
- Surface with faster penetration in voids.
- SC CO_2 has low viscosity: Efficient circulation of dye solution.
- SC CO_2 has high diffusivity: Faster rate of mass transfer.
- No damage of the fibre or fabric.
- Significantly shorter process and dyeing times.
- Efficient process: Lower dye consumption and it can also be reused (No wastage)
- CO_2 is non-toxic, non explosive, Generally Regarded As Safe (GRAS)
- Many post treatments of textile material are eliminated.

Summary of Findings

Concept of water free dyeing of polyester fabric is achieved by using SC-CO_2. Present project is an ongoing project, below activities are planned to be carried out.

- To develop more colours and evaluate their properties of dyed fabrics.
- To study the possibilities of dyeing cotton using SC-CO_2
- To develop a method for extraction of natural dyes by using SC-CO_2

DURABLE NON- FLUORINATED FUNCTIONAL TEXTILES USING FUMED SILICA SOLS (Sponsored by DST-SERB)

Today, modification of textile surface for hydrophobicity have drawn a lot of interest in both academic research and industry because of their claims such as protective coatings against corrosion, window snow, buoyancy enhancing, and for many other purposes. Commercially, surface hydrophobicity can usually be achieved by changing the surface tension of the textile material using long chain fluoro chemicals. The potential for fluorine free chemicals to replace fluorine began garnering attention around 2012, partially due to the chemical costs factor and partly due to an enhanced public awareness for environmentally friendly green products. Currently, although the hydrophobic surfaces are successfully applied in phenomenal ways on textile surface, their applications are limited by low durability in practice. These man-made hydrophobic surfaces can be easily damaged because they show very less resistance to mechanical contact on their surfaces, leading to loss of their hydrophobicity easily. Furthermore, application of these hydrophobic surfaces is still limited for their low adhesion on substrates. To resolve the problem of mechanical durability, researchers studied the hydrophobic metal/polymer composite surface possessing both mechanical durability and easy repairability. Generally, researchers have two approachable directions for imparting the hydrophobic surface preparation, one is top-down approach which includes plasma treatment, lithographic and template-based technique and the second is bottom-up approach such as chemical deposition, layer-by-layer (LBL) deposition, hydrogen bonding, sol-gel method and colloidal assemblies. Recently, sol-gel process has gained more attention due to its unique advantages such as low temperature processing, functionalization of fibre surfaces and high homogeneity of final products. Research studies have focused on the use of silicon alkoxides such as tetraethoxysilane (TEOS) (Fig 30) as a precursor in sol–gel preparation.

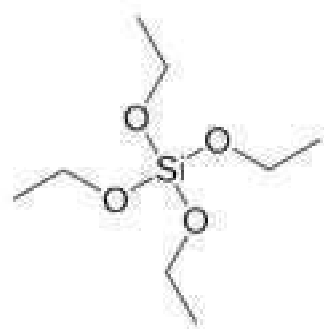


Figure 30 Tetraethylorthosilicate

The major benefit of TEOS is the compatibility range with other additives and also it's usefulness in controlling size distribution in mixture. But, the high cost of TEOS is a major hindrance for the commercial usage of this hydrophobic finish on fabrics. Due to this reason, there is a great need to prepare sols using low cost precursors. No major work is carried out on alternative silane crosslinkers for such Nano silica sol preparation. Further, due to Biocidal Product Regulation 528/2012, no major on alternative non-toxic biocides in combination of nano-silica work has been reported.

This present study focuses on developing fluorocarbon-free low surface-tension coatings and improvement to meet the required water repellent specifications using HDTMS and different carboxylic acids namely citric acid and salicylic acid as the precursors to prepare silica sol using hydrophilic fumed silica along with eco-friendly binder in two stage padding methodology and also single stage padding process. In-order to compare the effect of low cost carboxylic acid cross linker, commercial TEOS formulation was carried out and the results compared. Pad-dry-cure method was employed and the surface modification of the coated fabrics was evaluated by SEM images. Further, the water contact angle and spray test on the cotton woven fabric was evaluated.

Cotton fabric samples (20s Count, 160 GSM) were desized, scoured and bleached by conventional method. Hexadecyltrimethoxysilanes (HDTMS), Tetraethylorthosilicate (TEOS). Citric acid and Salicylic acid were purchased from Merck Life Science Pvt. Ltd. CAB-O-SIL @ Untreated Fumed Silica (M-5) was purchased from fumed silica manufacturing company "Cabot Sanmar Limited", Mettur, Salem District, Tamilnadu, India. Ethanol, HCL and other chemicals were employed from the laboratory. All chemicals were used directly without further purification.

Formulation for single stage application was developed using 0.2 % wt of CAB-O-SIl (Untreated fumed silica M5), ethanol and deionized water (0.5:1 in v/v) via mechanical stirring (1,000 rpm) for 18-24 hours at room temperature. Second, carboxylic acid (namely citric acid and salicylic acid) of 20gpl concentration and TPK paste 0.5% v/v were added to the different dispersion of silica under mechanical stirrer at 400 C for half an hour. On the other hand, in order to validate the functionality of fumed silica, scheme 1 & 2 were carried out using commercial TEOS and silane additives namely hexadecyltrimethoxysilanes (HDTMS) along with TKP 0.5% v/v for the coating of textile fabric (Table 33). For two stage application, only the silane additive (HDTMS) was padded separately.

Hydrophobic surface treatment on cotton woven fabrics

Cotton fabrics were immersed in silica hydrosols for 3 min, and then padded with a wet pickup of 70–80%. After that, samples were dried at 105°C for 5 min and cured at 150°C for 3 minutes in "WERNER MATHIS" drying & curing chamber. The ?nal treated cotton fabrics were referred as Sample S1–S6, respectively, according to the silica hydrosol used.

Evaluation of the treated cotton woven fabric

The water contact angle (WCA) was measured using a high resolution video contact angle instrument (Biolin Scientific Ltd.) at room temperature. The WAC was determined 60 seconds after a water droplet of 10µL was placed on the fabric. All reported contact angle values were taken from three measurements at different positions of the samples. Surface morphology of sample was observed using scanning electron microscopy (SEM CARLZEISS instruments)

Results and discussions

Water Contact Angle

From Table 34 it is clear that the cotton fabric samples treated scheme TEOS+HDTMS+TPK without fumed

Table 33 Scheme employed for the preparation of silica Sol water repellent formulation

Scheme	Silica Nanoparticles	Hydrophobic Additives	Silane Crosslinkers	Polycarboxylic acid crosslinkers*	TKP Natural Thickener
1	-		√	-	√
2	√	√	√	-	√
3	-	√	-	√	√
4	√	√	-	√	√

**Citric acid and Salicyclic acid were selected as per the previous work.*

silica sol hydrolyzed in HDTMS using TEOS as crosslinker and TKP has the highest CA of 131.0˚, and it reduced to118.2˚ when the application was carried out by separate application of silane additive, indicating that the coating bonding is better when formulation was made in single bath. With the addition of nano fumed silica, the water contact angle was lesser in the case of single stage process, where silica agglomerisation took place. When employed in two stage process, the water contact angle increased, indicating that the silica sol treatment using HDTMS & TEOS increases the WCA of the fabric. The fabric treated with silica sol using other carboxylic acids namely citric acid and salicylic acid and HDTMS showed an acceptable water CA of 125.6˚ and 125.6° respectively. Among the carboxylic acids used, salicylic acid showed the highest water contact angle by two stage process. The fumed silica addition has increased the water contact angle in both the methods.

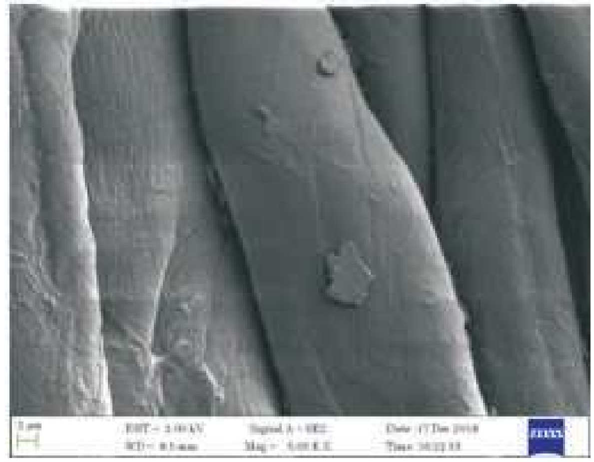
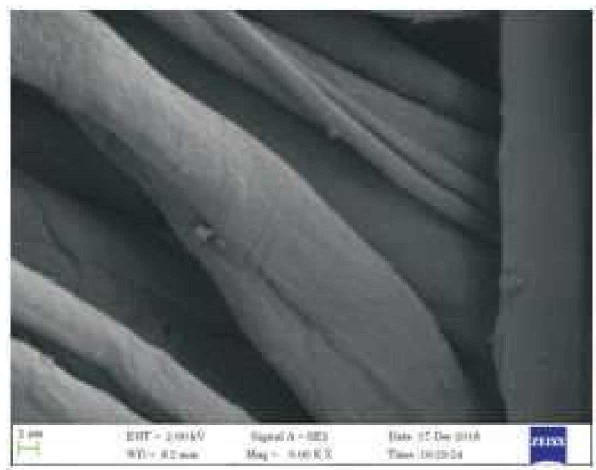


Figure 31 TEOS + HDTMS+TKP

Surface morphology of fabrics

Figures 31 to 36 represents SEM images of treated cotton fabrics by single stage application method. A clear and smooth coating surface of the silica film layer interconnecting the fibers are visible in Figure 32, Figure 33, Figure 34, Figure 35, Figure 36 and uneven coating on the commercial formulation sample can be seen from Figure 31. Figure 37 to 42 represent the SEM images of treated cotton fabric by two stage application method where silane additive was padded separately. A clear and smooth coating surface of the silica film layer interconnecting the fibers are visible in Figure 37, Figure 39, Figure 40, Figure 41 and Figure 42 and uneven coating on the commercial formulation sample with TKP can be seen from Figure 38.



Figue 32 Nano Silica+TEOS+HDTMS+TKP

Table 34 Water Contact Angle of the cotton fabric sample treated with all Schemes by single stage and two stage application methods with and without fumed silica using Citric acid and salicylic acid as carboxylic acid cross linker along with HDTMS

	Single Stage Method	**Two Stage Method**
Sample Code	**Contact angle (Deg)**	**Contact angle (Deg)**
TEOS + HDTMS+TKP	131.36±0.24	118.22±0.21
Nano+ TEOS + HDTMS+TKP	125.27± 0.35	127.85±0.14
Citric acid + HDTMS+TKP	112.70±0.56	128.83± 0.18
Salicylic acid+ HDTMS+TKP	118.08±0.33	125.64±0.26
Nano + Citric acid + HDTMS+TKP	125.64±0.25	125.50±0.23
Nano+Salicyclic acid+HDTMS+TKP	125.64± 0.21	129.17±0.28

Figure 33 Citric acid + HDTMS+TKP

Figure 34 Salicyclic+HDTMS+TKP

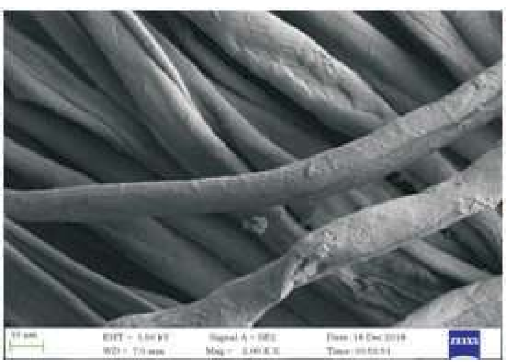


Figure 35 Nano Silica+Citric acid + HDTMS+TKP

Figure 36 Nano silica+Salicyclic +HDTMS+TKP

Figure 37 TEOS + HDTMS+TKP

Figure 38 TEOS+HDTMS+TKP

Figure 39 Citric acid + HDTMS+TKP

Figure 40 Salicyclic+HDTMS+TKP

Figure 41 NanoSilica+Citric acid + HDTMS+TKP

Figure 42 Nano Silica+Salicyclic + HDTMS+TKP

Water Spray Rating Test (AATCC 22 Method)

It measures the resistance of fabrics to wetting by water. It is especially suitable for measuring the water-repellent efficacy of finishes applied to fabrics. Evaluation is accomplished by comparing the wetted pattern with pictures on a standard chart. Each Spray test presented was the average of three fabric specimens and the results are given in Table 34.

All over, irrespective of the treatment methods, all the treated samples showed good spray test rating. The acceptable range in the textile industry market is rating above 80. In case of eco-friendly formulation, the addition of nano silica has improved the rating from 80 to 90 in the both the application methods.

Findings

Environmental problems have caused reorientation of thinking and promoted research for replacement of conventional technologies.

- The fumed silica particle based formulation was developed successfully to coat on the woven fabrics, the water repellency (hydrophobic nature) of coated fabric is at par with the results of fabric commercial formulations chemicals.
- Commercial TEOS cross linker is successfully replaced with low cost carboxylic acids. The highest water contact angle was obtained when salicylic acid was used as the cross linker during the silica sol preparation for the hydrophobic coating on the cotton fabric.
- One more formulation also made using natural thickener (TKP) was very efficient and the coating was even and resulted in good water repellency
- The study demonstrated with the surface treatment using fumed silica nano particle, low cost cross- linker and silane additive is a promising alternative to perfluorochemicals for achieving hydrophobic surface.
- The durability was good up to 10 laundry washes.

Table 34a Water spray rating test results

DESCRIPTION	RATING (0 to 100) for Single Stage Process	RATING (0 to 100) Double Stage Process
Untreated Cotton	0	0
TEOS + HDTMS+TKP	90	80
Nano+ TEOS + HDTMS+TKP	90	90
Citric acid + HDTMS+TKP	80	80
Salicylic acid+ HDTMS+TKP	80	80
Nano + Citric acid + HDTMS+TKP	90	90
Nano + Salicyclic acid + HDTMS+TKP	90	90

OPERATIONAL STUDIES

COSTS, OPERATIONAL PERFORMANCE AND YARN QUALITY (35TH STUDY): INTER-MILL SURVEY OF KEY FACTORS (OCTOBER-DECEMBER 2019)

This report is thirty-fifth in the series of studies in which 104 mills had participated. Though the CPQ study was launched 23 years ago (1997), it continues to attract a large number of mills, particularly mills having multiple units (group mills), spread all over India. Many participants vouch that these studies have helped them to trim their input costs and improve the performance. This clearly depicts the uniqueness and usefulness of this study.

The mills have been ranked based on contribution, i.e. yarn sale value less the sum of clean raw material cost, salaries and wages cost and power cost which ultimately decides the profitability (contribution minus overheads and stores costs = operating profit). Analysis of the 35th CPQ study has been completed and the reports have been dispatched to all the participant mills. The following are some of the main findings of the study.

Table 35 shows that the average contribution earned by the participant mill is at Rs 3410 per spindle per year, which amounts to about 9.5% of yarn sales. However, the average of the top 20% mills among the participants is noticed to be more than two times the all mills' average, which is mainly due to a higher yarn sales turnover (62% higher).

Table 36 shows that the manufacturing of value added yarns had resulted for the huge differences in yarn sales turnover between all mills' average and top 20% mills. The productivity level with respect to production per spindle and spindle utilisation maintained by the top 20% mills is also comparatively higher than the all mills' average.

Comparison with last study (October – December 2018)

Table 37 shows the comparison of the common mills that had participated in both 34th and 35th CPQ studies. Seventy six mills had participated in both the studies, ie. in 2018 and 2019.

Table 35 Summary of the mills' performance in 35th CPQ study

Parameter		All mills’ average	Top 20% mills’ average
Yarn sale value (YSV)	- Rs/spindle/year	24310	39500
	- Rs/kg	243	268
Raw material cost (RMC)	- Rs/kg	143	158
	- Rs/spindle/year	15180	24830
	- As % of sales	60.6	61.0
Salaries & wages cost (SWC)	- Rs/spindle/year	2660	2800
	- As % of sales	15.0	7.3
Power cost (PC)	- Rs/spindle/year	3060	3790
	- As % of sales	14.9	9.4
Contribution*	- Rs/spindle/year	3410	8080
	- Rs/kg	32	65
	- As % of sales	9.5	22.3
Prodn. /spindle/8 hrs. (adj. to 40s) in grams		105	114
Spindle utilisation (%)		89.67	95.81
Average count (Ne)		49s	37s

'*' Contribution = YSV – (RMC + SWC + PC)

Table 36 Summary of the mills' performance in 35th CPQ study

Type of yarn	All mills' average	Top 20% mills' average
Export	18	41
Combed	64	73
Hosiery	24	45
Doubled		
- Ring	2	4
- TFO	6	10
- Eli-twist	1	3
Compact	38	36
Gassed	1	3
Slub	1	1
Core spun	-	1
Melange	1	5
100% cotton	73	77
100% non-cotton	7	7
Cotton/MMF blends	20	16

The analysis shows that in the 4th quarter of 2019, mills on the whole had registered about 20% reduction in the contribution when compared to the 4th quarter of 2018. During the 4th quarter of 2019, the yarn sale value had registered a decrease of 12% when compared to the same quarter of 2018. The raw material cost, had also witnessed a reduction of 14% in terms of Rs per spindle per year and a 11% reduction with respect to Rs per kg of yarn. When compared to the 4th quarter of 2018, salaries and wages cost had increased by 3% in the 4th quarter of 2019. However, the power cost had remained the same among the common mills.

Further analysis shows that out of the 76 common mills, only close to 30% of the mills (22 mills) registered an increase in the contribution (by Rs 1080 per spindle per year) with the increase ranging from Rs 60 to Rs 3210 between mills (Figure 43). The increase in the contribution in the 22 mills was mainly due to reduction in input costs viz. RMC, salaries & wages cost and power cost which had offset the decrease in sales turnover (by Rs 246 per spindle per year). The remaining mills recorded a reduction of Rs 1550 per spindle per year in the contribution ranging from Rs 70 to Rs 6490 between mills. In these mills, the decrease in the RMC value by Rs 2080 per spindle per year was not enough to offset the reduction in sale value (by Rs 3420 per spindle per year) and increase in other input costs (by Rs 210 per spindle per year).

Figure 43 Differences in the contribution between the two studies
(Q4 of 2018 and Q4 of 2019)

Table 37 Comparison of costs and operational parameters between the two studies

Parameter		Common mills' (76) avg. 34th study (Oct. – Dec. 2018)	Common mills' (76) avg. 35th study (Oct. – Dec. 2019)
Yarn sale value (YSV)	- Rs/spindle/year	26870	23730
	- Rs/kg	258	235
Raw material cost (RMC)	- Rs/kg	158	140
	- Rs/spindle/year	17410	14970
Salaries & wages cost (SWC)	- Rs/spindle/year	2580	2670
Power cost (PC)	- Rs/spindle/year	3070	3070
Contribution	- Rs/spindle/year	3810	3020
Prodn. /spindle/8 hrs. (adj. to 40s) in grams		105	106
Capacity utilisation (%)		92.4	88.6
Average count (Ne)		48s	49s

AN INTER-MILL STUDY ON FIBRE TO YARN CONVERSION COST: 8TH STUDY

This study is based on the conversion cost particulars that were collected from mills in the 35th CPQ (Costs, Operational performance and Yarn quality) study, covering the data for the fourth quarter of 2019 (October – December). Out of 104 mills that had furnished data in 35th CPQ study, more than half of them had furnished the count-wise conversion particulars covering all the elements of cost. Remaining mills had not furnished the requested data. The data provided by the mills were scrutinised and wherever required, clarifications were obtained from them.

This report, being the eighth in the series, covers the conversion cost particulars of as many as 154 different counts and varieties of yarns. A detailed analysis has been made for 12 different counts for which 4 and above mills (in each count) had furnished the relevant data. In addition, the trend in the movement of conversion cost between 2010 and 2019 has also been covered.

Overall conversion cost in 2019

Table 38 shows the conversion cost particulars for 12 different counts and varieties of yarns.

It can be seen from Table 38 that the average conversion cost, in terms of per kilogram of yarn was found to increase as the count becomes finer, i.e. as low as Rs 53.7 in 24s CH to a high of about Rs 165.8 in 80s C-Comp. Counts. Between mills, the conversion cost varied considerably in all the counts, i.e., Standard Deviation (SD) ranging from as low as 4 to more than 31 with the overall difference being high at 13. Such a huge variation in the conversion cost between mills is largely due to the differences in the operational parameters like production rate, labour productivity, capacity utilisation, energy consumption, etc. and cost parameters such as wage rate, staff salary, power cost per unit, stores and packing materials cost, interest commitment and investment on plant and machinery and partly because of the in-correct method of estimation of yarn cost.

In terms of per kilogram per count, the conversion cost did not show any clear trend between counts. The conversion cost averaged at Rs 1.96 per kg per count with the cost ranging from Rs 1.56 to Rs 2.59 between counts, i.e. average ±0.52 paise. However, in terms of per spindle per shift, it showed a declining trend as the count became finer i.e. in 24s CH, it was around Rs 13 whereas in 80s, it was only about Rs 8.

Table 38 Count-wise conversion cost

Period: October – December 2019

S. no.	Count	Conversion cost/kg of yarn (Rs)				Conv. cost/ kg/ count (Rs)	Conv. cost/ spl./ shift (Rs)@	No. of mills
		Avg.	Min.	Max.	Std. Dev.			
1.	60s C	131.1	111.6	146.9	12	2.19	8.3	6
2.	40s C- Comp.	73.8	56.4	94.4	16	1.85	11.0	4
3.	50s C-Comp.	79.1	67.1	92.9	11	1.58	8.3	4
4.	60s C-Comp.	115.5	91.3	186.7	25	1.93	8.4	13
5.	61s C-Comp.	112.6	105.2	117.5	5	1.85	8.0	5
6.	80s C-Comp.	165.8	134.4	220.3	31	2.07	7.7	6
7.	24s CH	53.7	45.7	58.2	5	2.24	13.0	4
8.	30s CH	62.0	55.0	67.1	5	2.07	12.0	5
9.	40s CH-Comp.	62.5	53.1	67.3	6	1.56	9.7	4
10.	30s CH-Ex.	54.2	39.0	67.4	10	1.81	11.4	5
11.	30s CH-Comp.-Ex.	55.4	51.5	59.9	4	1.85	13.3	4
12.	56s P/C-K	145.0	97.2	169.3	29	2.59	10.8	5

'@' $\frac{\text{Conversion cost/kg of yarn x Prodn./spl./8 hours (g)}}{1000}$

Conversion cost and profit margin

Profitability of a spinning mill is decided by its commercial performance on the one hand and conversion cost on the other. The difference between yarn selling price (YSP) and raw material cost (RMC) is a measure of commercial performance which is also known as net output value (NOV). Average NOV, conversion cost and net profit/loss for the 12 counts pertaining to the period October to December 2019 are given in Table 39 and count-wise average YSP and RMC are given in Table 40.

It can be seen from Table 39 that during October to December 2019, 7 counts managed to earn profit whereas the rest of the counts registered a net loss. Compact and compact hosiery counts (both domestic and export) were found to be more beneficial. Since, the external factors that tend to affect the commercial parameters viz., YSP and RMC, on most occasions, are not under control of the managements, the mills must give top priority to optimise the conversion cost on a regular basis towards earning a reasonable profit margin.

Component-wise conversion cost

Tables 40 and 41 show the component-wise average conversion cost for all the 12 counts in terms of per kg of yarn and as a % of YSP respectively.

Table 39 Count-wise conversion cost and profit margin

S. no.	Count	Amount (Rs/kg of yarn)			As a % of YSP		
		NOV	Conver-sion cost (CC)	Net profit (NOV-CC)	NOV	Conver-sion cost (CC)	Net profit (NOV- CC)
1.	60s C	100.6	131.1	(-) 30.5	38.2	49.7	(-) 11.6
2.	40s C- Comp.	78.7	73.8	4.9	35.6	33.4	2.2
3.	50s C-Comp.	89.3	79.1	10.2	34.8	30.8	4.0
4.	60s C-Comp.	111.7	115.5	(-) 3.8	40.6	42.0	(-) 1.4
5.	61s C-Comp.	117.9	112.6	5.3	43.5	41.6	2.0
6.	80s C-Comp.	193.6	165.8	27.8	51.2	43.9	7.4
7.	24s CH	51.1	53.7	(-) 2.6	27.4	28.8	(-) 1.4
8.	30s CH	55.3	62.0	(-) 6.7	28.9	32.4	(-) 3.5
9.	40s CH-Comp.	68.7	62.5	6.2	31.3	28.5	2.8
10.	30s CH-Ex.	87.8	54.2	33.6	44.7	27.6	17.1
11.	30s CH-Comp.-Ex.	63.7	55.4	8.3	27.9	24.2	3.6
12.	56s P/C-K	57.2	145.0	(-) 87.8	36.2	91.7	(-) 55.5

Note: (-) sign indicates loss

Table 40 Component-wise conversion cost per kg of yarn
(Amount: Rs/kg of yarn)

S. no.	Count	YSP (a)	RMC (b)	Conversion cost							Net profit (a-b-c)
				SWC	Power	Stores & packing	Admn. OH	Int.	Dep.	Total (c)	
1.	60s C	263.6	163.0	34.1	48.1	10.0	7.5	18.5	12.9	131.1	(-)30.5
2.	40s C- Comp.	220.9	142.2	13.0	30.9	9.1	3.2	6.4	11.2	73.8	4.9
3.	50s C-Comp.	256.6	167.3	16.9	27.6	11.9	4.0	7.6	11.1	79.1	10.2
4.	60s C-Comp.	275.1	163.4	28.9	40.7	13.3	8.2	10.3	14.1	115.5	(-) 3.8
5.	61s C-Comp.	270.8	152.9	24.9	42.5	11.9	12.8	7.8	12.7	112.6	5.3
6.	80s C-Comp.	378.1	184.5	45.4	61.4	16.6	8.5	14.8	19.1	165.8	27.8
7.	24s CH	186.5	135.4	15.6	18.0	6.7	2.9	5.5	5.0	53.7	(-) 2.6
8.	30s CH	191.6	136.3	16.6	21.3	6.8	3.7	7.4	6.2	62.0	(-) 6.7
9.	40s CH-Comp.	219.4	150.7	18.2	21.3	7.8	2.4	5.7	7.1	62.5	6.2
10.	30s CH-Ex.	196.4	108.6	12.0	20.5	7.4	3.0	4.2	7.1	54.2	33.6
11.	30s CH-Comp.-Ex.	228.7	165.0	9.7	19.7	7.1	3.1	7.2	8.6	55.4	8.3
12.	56s P/C-K	158.2	101.0	47.2	31.8	5.2	7.5	50.9	2.4	145.0	(-)87.8

Table 41 Component-wise conversion cost as a % of YSP

S. no.	Count	RMC (a)	Conversion cost							Net profit (100-a-b)
			SWC	Power	Stores & packing	Admn. OH	Int.	Dep.	Total (b)	
1.	60s C	61.8	12.9	18.2	3.8	2.8	7.0	4.9	49.7	(-)11.6
2.	40s C- Comp.	64.4	5.9	14.0	4.1	1.4	2.9	5.1	33.4	2.2
3.	50s C-Comp.	65.2	6.6	10.8	4.6	1.6	3.0	4.3	30.8	4.0
4.	60s C-Comp.	59.4	10.5	14.8	4.8	3.0	3.7	5.1	42.0	(-)1.4
5.	61s C-Comp.	56.5	9.2	15.7	4.4	4.7	2.9	4.7	41.6	2.0
6.	80s C-Comp.	48.8	12.0	16.2	4.4	2.2	3.9	5.1	43.9	7.4
7.	24s CH	72.6	8.4	9.7	3.6	1.6	2.9	2.7	28.8	(-)1.4
8.	30s CH	71.1	8.7	11.1	3.5	1.9	3.9	3.2	32.4	(-)3.5
9.	40s CH-Comp.	68.7	8.3	9.7	3.6	1.1	2.6	3.2	28.5	2.8
10.	30s CH-Ex.	55.3	6.1	10.4	3.8	1.5	2.1	3.6	27.6	17.1
11.	30s CH-Comp.Ex.	72.1	4.2	8.6	3.1	1.4	3.1	3.8	24.2	3.6
12.	56s P/C-K	63.8	29.8	20.1	3.3	4.7	32.2	1.5	91.7	(-)55.5

Note: for Tables 6 and 7: (-) ve sign indicates net loss;
SWC: Salaries and wages cost; OH: Overheads

An analysis of the data that is furnished in Tables 40 and 41 reveals the following.

Component-wise conversion cost also showed an increasing trend as the count become finer. For example, the salaries and wages cost in 24s CH averaged about Rs 15.6 per kg of yarn where as in the fine counts (80s), it was almost 3 times higher at about Rs 45 per kg of yarn. The power cost which was around Rs 18 per kg of yarn in 24s count was more than 3 times higher at about Rs 61 per kg of yarn.

Another interesting observation is that amongst the 6 cost components, power cost was found to be the largest component with a share of 34% followed by salaries and wages cost (25%). The interest cost stood at 3rd place (15%) followed by stores and packing materials cost (10%), depreciation cost (10%) and administrative overheads (6%) (Figure 44).

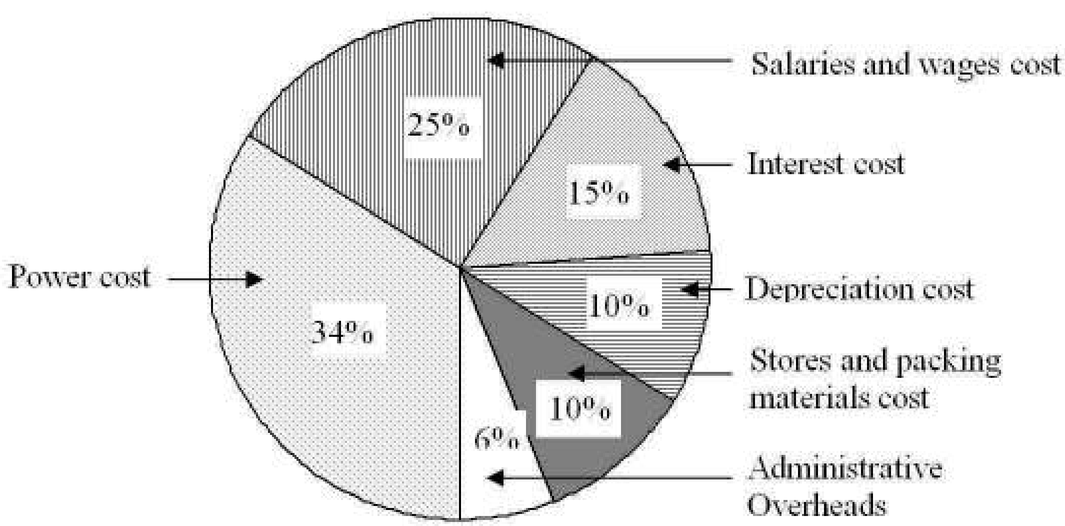


Figure 44 Components of cost in a spinning mills

Trend in the movement of conversion cost between 2010 and 2019

The year-wise average conversion cost in terms of Rs/count/kg between 2010 and 2019 is shown in Table 42 along with the range.

Table 42 Average conversion cost between 2010 and 2019

Year	CPQ study no.	Conversion cost (Rs/count/kg)	
		Avg.	Range
2010	25	1.60	1.40 - 1.70
2013	29	2.10	1.85 - 2.30
2014	30	2.00	1.70 - 2.30
2015	31	2.00	1.70 - 2.30
2016	32	2.10	1.96 - 2.35
2017	33	1.98	1.66 - 2.23
2019	35	1.96	1.56 - 2.59

The above table shows that between 2010 and 2013, the overall conversion cost had increased by about 30% and since then it was found to be hovering around Rs 2 per kg. The movement of conversion cost in terms of Rs per kg of yarn for 3 popular counts, for which there were sufficient representation of mills in all the 7 studies, also shows a similar trend (Figure 45).

The above figure shows that between 2010 and 2013, the conversion cost in terms of Rs/kg had witnessed an increase in the range of 18% to 43% between counts.

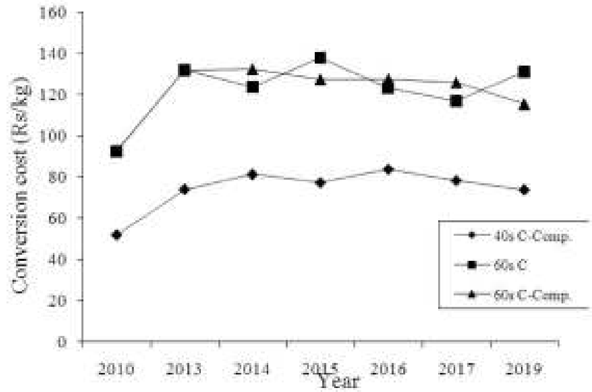


Figure 45 Movement of conversion cost between 2010 and 2019

An analysis of the component-wise conversion cost for the above counts during the period 2010 to 2019 shows that since 2013, the mills have been able to maintain the conversion cost at the same level (Table 43).

PRODUCTIVITY CONVERSION FACTORS

Based on the revised eighth edition of SITRA norms for spinning mills - 2019, a separate publication has been brought out by SITRA which covers productivity conversion factors for different counts and types of yarns. This edition replaces the previous edition of SITRA's publication 'How to assess a spinning mill's productivity?' that was released in 2010, (Vol. 55, No. 1, April 2010). In this edition, the conversion factors are given separately covering up to ring frames and automatic cone winding departments.

Table 43 Changes in the component-wise conversion cost between 2010 and 2019 (Rs/kg of yarn)

Year	Salaries & wages			Power			Stores & packing			Admn. O.H, Int. & Dep.			Total		
	40s C - Comp.	60s C	60s C- Comp.	40s C- Comp.	60s C	60s C- Comp.	40s C- Comp.	60s C	60s C- Comp.	40s C- Comp.	60s C	60s C- Comp.	40s C- Comp.	60s C	60s C- Comp.
2010	9.5	15.8	14.2	19.4	35.4	36.6	6.0	6.4	7.7	17.0	34.7	34.5	51.9	92.3	93.0
2013	12.3	27.3	23.0	32.0	54.3	55.0	7.7	10.1	12.3	22.0	40.3	41.5	74.0	132.0	131.8
2014	14.6	27.2	26.1	29.6	48.0	51.9	8.1	10.5	12.3	29.0	38.0	42.1	81.3	123.7	132.4
2015	12.0	28.6	22.9	32.7	58.2	54.5	6.6	10.8	12.9	26.0	40.2	37.2	77.3	137.8	127.5
2016	17.1	32.5	23.9	32.1	49.0	51.6	9.4	13.4	16.4	25.2	28.3	35.7	83.8	123.2	127.6
2017	14.8	28.9	31.6	28.3	41.2	47.2	9.9	11.1	15.1	25.3	35.7	32.0	78.3	116.9	125.9
2019	13.0	34.1	28.9	30.9	48.1	40.7	9.1	10.0	13.3	20.8	38.9	32.6	73.8	131.1	115.5

A major change in this new publication is derivation of the conversion factor after including the comber and its preparatory machines. Hence, the preparatory department tenter HOK conversion factor for combed counts given in the publication is inclusive of tenter categories pertaining to draw frame (breaker/pre-comber/finisher), lap former and comber. Similarly, separate conversion factors are provided for polyester cotton carded (PC-K) and combed (PC-C) yarn manufacturing as the PC-C process requires additional man power and machines for producing combed cotton fleece component that is required to be blended with polyester.

In automatic cone winding, for the first time conversion factors are also provided for ancillary operatives such as cone carriers, fitters, assistant fitters, cleaners and sweepers, who are employed in the department.

A beta version of the assumptions made with respect to productivity and process parameters of synthetic and blended yarns are also provided as a separate chapter in this publication along with the work assignments for different categories of operatives.

COST REDUCTION IN SPINNING MILLS – A CASE STUDY

The ultimate aim of any industry or a firm is to generate good profits through managerial excellence, achieved through commercial and operational prudence. However, generating profits is just like walking on a tightrope balancing tough globalized competition and increases in input costs. Mills must exercise a strict control in their expenditure pattern and take various cost control measures towards increasing their profit margin. This can be achieved by exploring the possibilities of selecting the profitable product-mix, consider modernisation of their machinery towards improving productivity, etc., in addition to various cost saving measures.

Exploring the right product-mix is always tough but a continuous activity, as the same acts as a nectar attracting more competitors to try it if found to offer a decent profit. Modernisation, of course a long-term measure, requires a huge amount of money towards capital investment and one has to wait for a long period to get paid-back for their investment. Hence, the best immediate solution to achieve faster recovery without much investment would be to focus on controlling input costs.

SITRA has been offering its various consultancy services to the mills and one such is guiding mills on how to control the input costs without making any major investment. After a detailed study at the mill level, the reports provided by SITRA highlight the expected savings by way of improvement in machine/labour productivity, yarn realisation & waste control, increase in yarn sale value due to quality consistency/quality up-gradation and implementation of energy saving measures.

The findings discussed below are based on a case study mill where suggestions were offered towards controlling the input cost. Anticipated savings that the mill could incur with the implementation of necessary measures is also covered.

Profile of the mill

The mill is about 25 years old with an installed capacity of around 35,000 spindles. It is equipped with modern hi-tech machines in almost all the departments. Nearly one-half of the ring frames are fitted with auto-doffers. It has been manufacturing 100% cotton carded and combed yarns (both warp and hosiery) in the count range of 16s to 61s.

Production per spindle

Overall production per spindle per shift of 8 hours (adj. to 40s) achieved by the mill was about 95 g which is 18% lower than the SITRA standard (116 g). Lower production per spindle was mainly due to spindle speeds (12% lower) and machine efficiency (6% lower).

Lower spindle speeds were mainly due to below average condition of ring frames. This in turn was due to critical components in ring frames such as rings, spindles, pressure hoses, etc., that were working beyond their useful life in most of the ring frames. Lower machine efficiency was mainly due to a higher pneumafil waste (Mill: 3.0%; Std.: 1.5%), higher ends down (Mill: 1.7%; Std.: 1.0%), higher doffing time (Mill: 7.1 min. per doff; Exp.: 3.0 min. per doff), high restarting breaks (Mill: 9.8%; Std.: < 5%), premature doff, lower cop content, etc.

Scope for improvement

During the study in the mills, major deficiencies, not attended to for a long time, were found with respect to the maintenance of machines, particularly in ring frames. A physical inspection revealed top arm load variations along with variations in top roll diameters in most of the ring frames. In addition, deviations were noticed with respect to ABC ring centering, lappet gauge and traveller clearer setting in ring frames. A large number of spindles were noticed without spindle buttons/lock resulting in more wobbling/vibrations while running. By correcting the above issues with replacement of critical components and following proper maintenance practices, it should be possible for the mill to improve the ring frame performance and hence the increase in overall spindle speed by 7%.

Regarding machine efficiency, more pre-mature doffing was noticed along with more top and bottom clearances (>12 mm). This ultimately reduces the average cop content and results in frequent doffs, particularly in the case of coarser counts. In addition to the above, the average machine downtime for doffing was noticed to be 50% higher than the expected time meant for doffing.

Higher pneumafil waste in ring frames (>3.0%) was noticed due to high re-starting breaks and low tenter efficiency. The end breakage in ring frames was noticed to be at the expected level for the mill's tenter assignment. However, the pneumafil waste was high by about two times, which clearly indicates poor patrolling by tenters. A random study on ends down in ring frames also show 70% greater number of ends down when compared with the expected level.

Re-starting breaks were also noticed to be about twice the standard in manual doffing ring frames, which was mainly due to wrong doffing method. Most of the doffers were noticed not performing simultaneous doffing and donning of ring frame cops and leaving a spindle gap of 5 to 8 between doffing and donning. This leads to more re-starting breaks. In auto-doffer ring frames, the re-starting breaks were noticed to be under control (less than 2.0%). Doffing rate of ring frame doffers was found to be at the required level (avg.: 80 cops per minute). However, lack of work co-ordination and wrong doffing practices were noticed to be the major reasons for high doffing loss. It was suggested to impart scientific training for the tenters and doffers for the correct method of working. In addition, it was recommended to periodically monitor their performance and take corrective actions for deviations, if any.

By implementing the suggestions as discussed above and with maintenance of required RH% and temperature in the ring frame department, the mill would be able to achieve a substantial increase in the overall spindle speeds along with improvements in overall machine efficiency, totally amounting to about a 12% increase in overall ring frame production rate.

Spindle utilisation

The average spindle utilisation maintained by the mill for the recent one year period was low at 86%, ranging from 64% to 98% between months. The sluggish market condition and absenteeism were reported to be the major causes for the loss in spindle utilisation. To address the former, it was suggested to give more importance for the marketing, since this is the era of smart and judicious marketing. A clever marketing strategy would be helpful to nullify the ups and downs of the market and also play a vital role for maintaining a long term association with the customers. Regarding worker absenteeism, it has been suggested to follow proper individual counselling of the workers along with frequent motivational programs towards ensuring their morale and commitment.

Hence, by concentrating more on exploring marketing potential and following good HR practices, the mill can avoid major losses, resulting in achieving a consistent utilisation level of 98% and above.

Savings due to higher machine productivity

By implementing the measures that have been suggested for improving the machine productivity (both production per spindle and spindle utilisation), the mill is expected to achieve an improvement in machine productivity by about 20%, resulting in an overall saving of about Rs 94 lakhs per annum.

Labour productivity

a) Up to ring frames

The labour productivity was noticed to be just one-half of the standard (Mill HOK: 20.5; Std.HOK: 10.2). The productivity was found to be lower in all the departments ranging from 10% to 77% between various categories of operatives. Lower work assignment and incorrect work methods and practices by operatives in most of the departments were noticed to be the major cause for the low labour productivity.

b) Automatic cone winding

The labour productivity in automatic cone winding machines was about 40% lower than SITRA standard (Mill HOK: 3.5; Std.HOK: 2.1). This was mainly due to lower winding on speed, lower machine efficiency and marginally due to low drum assignment. High red light faults (>2.4%) with prolonged duration of red lights (160 sec.) and high cop rejections (Avg. 22%; Range: 16% to 28%) were some of the reasons for low machine efficiency.

Scope for improvement

As per the detailed study made by SITRA, it was noticed that the mill can reduce 31 operatives per day with the implementation of team work, imparting multi skill and use of proper materials handling equipment with required automations. Also, it was suggested to impart scientific training to the operatives for correct work methods and practices in all the departments. Apart from the above, suggestions were given towards maintaining the end breakage rates in various departments at a minimum level and also provided solutions for achieving higher package contents.

In automatic cone winding, it was advised to ensure the red light faults at below 2% and their duration also to be maintained below 1.5 minutes (90 seconds). It was also suggested to maintain a uniform cop content in ring frames having the same spindle lift and ring diameter.

The operative reduction that would be sought with the implementation of the suggestions is given in Table 44.

By achieving a production rate of about 106 g (adj. to 40s) with 98% spindle utilisation and engaging the operatives as per the suggestion, the mill was given the target of achieving 15.5 HOK (up to ring frames), which means that the labour productivity would increase by about one-third from the prevailing level.

Savings due to higher labour productivity

Savings due to reduction of 31 operatives per day would be Rs 73 lakhs per annum

Table 44 Optimisation of production operatives

Department/category	Reduction per day
Preparatory	
- Blow room tenter	3
- Can carrier	3
- Sweeper	3
Ring frames	
- Doffer	6
- Jobber	3
Automatic cone winding	
- Reliever jobber	3
Packing	5
Maintenance operatives	5
Total	31

Hard waste

The hard waste obtained in automatic cone winding was high at 0.91% based on automatic cone winding feed (i.e. 0.60% based on cotton consumption). The major causes of hard waste were noticed to be wrong work practices and higher cop rejections. The cop rejection maintained by the mill in automatic cone winding was very high at 22% ranging from 16% to 28% (Std.: 5%). The clearer cuts level were by and large comparable with the expected level.

Nearly 75% of the cop rejections were noticed to be at less than 1/4th stage which in turn was due to wrong work practices by the ring frame tenters and doffers. The remaining 25% was noticed to be due to poor cop quality resulting due to below average condition of the ring frames.

By imparting scientific training to the ring frame tenters, doffers and winding tenters on correct work methods and also by improving the quality of ring cops by an improved ring frame, it should be possible to maintain the hard waste at 0.5% level based on automatic cone winding feed (i.e. 0.3% based on cotton consumption).

Saving due to lesser hard waste

A reduction of 0.3% hard waste would mean a saving of about Rs 16 lakhs per annum.

Overall anticipated savings

Immediate savings (as given below) expected by implementing the various measures suggested would be about Rs 183 lakhs per year.

Areas for cost reduction	Expected savings per annum (Rs in lakhs)
Increasing in the machine productivity	94
Optimisation of operatives	73
Hard waste reduction	16
Total anticipated savings	183

Long term measures

While suggesting short term measures, the mill was advised to plan for long term measures such as modernisation and exploring diversified products towards achieving continuous improvement and sustainability in the market. In a manufacturing sector like textiles, modernisation as well as (product) diversification has to go hand-in-hand. Some of the long term measures that were suggested include,

- Replace the existing ring frames with modern high-tech ring frames.
- Achieve work assignments on par with the SITRA standard.
- Make provision for automatic bobbin transport, individual spindle monitoring system and automatic cop transport to winding (link coners).

Conclusions

It has been observed during mill level consultancy studies in many mills, that there is a good scope to reduce the input costs without major investments and by exercising good control over the following.

- Incidence of wastes, particularly hard waste, sweep waste and invisible loss.
- Ring frame machine efficiency.
- Employment of operatives strictly as per suggestions.
- Worker absenteeism.
- Maintenance of machinery.
- Energy conservation.

ONLINE SURVEY OF YARN SELLING PRICE AND RAW MATERIAL COST

Towards keeping the mills informed about the trend in the movement of count-wise yarn selling price (YSP) and raw material cost (RMC) between months, SITRA conducts a monthly online survey on RMC and YSP since April 2013. The findings of this survey report helps the mills to compare their RMC, YSP, net out-put value (NOV) as well as their yarn quality and productivity level with other mills every month. This unique survey covers almost 250 different counts and varieties of yarns. As on March 2020, SITRA has successfully completed 84 studies with the overwhelming participation of as many as 80 mills from different parts of the country covering the following parameters.

Yarn selling price (YSP) (Rs/kg) Raw material cost (RMC) (clean material cost) (Rs/kg of yarn) Net output value (NOV) (Rs/kg of yarn & Rs/spl./8 hrs.) TCI (techno-commercial index) OTCI (overall techno-commercial index) RMC as a % of YSP Yarn realisation (%) Production/spindle (rotor)/8 hours (g)	Yarn quality - Count CV% - Strength CV% - CSP - U% - Imperfections/1000 m - Hairiness Index

The participant mills enter their data on count-wise average RMC, YSP, yarn realisation and production per spindle pertaining to almost 10 major counts in the web portal "www.rmcysp.sitraonline.org" between 1st and 7th of every month. Between 7th and 20th of every month, the entered data is verified. On 21st of every month, a survey report covering the data of all the participating mills on count-wise YSP and corresponding RMC, NOV, yarn quality, yarn realisation and production per spindle is being uploaded in the above web portal along with data base supported queries. Apart from the above, trend in the movement of average YSP, RMC and NOV of popular counts is being uploaded every month.

Market Performance Evaluation Index (MPEI) (April 2019 – February 2020)

SITRA has formulated an index viz. MPEI (Market Performance Evaluation Index) towards tracking the movement of commercial efficiency (Net out-out value i.e. yarn selling price – clean raw material cost) based on 12 popular cotton counts ranging from 30s to 100s. This index is being estimated from the data provided by the mills in SITRA's monthly online survey on raw material cost and yarn selling price and clearly portrays the trend in the movement of commercial efficiency between months.

The current fiscal year started with a MPEI of 83 points in April 2019 (Figure 46). During the month, yarn selling price index remained at the average level (YSPI: 99), whereas the raw material cost index was 15 points higher (RMCI: 115).

In the subsequent 4 months, the commercial efficiency was noticed to follow a downtrend due to further reduction in yarn selling price with substantial increase in the raw material cost (Figure 47). In August 2019, the yarn selling price had witnessed a reduction of 4 points (YSPI: 95) from that prevailed in April 2019. Similarly, the raw material cost (RMCI) was also not in favour and noticed to be high at 117. This has resulted in overall reduction in MPEI by 11 points in August 2019.

In September 2019, the MPEI had witnessed a low value of 69 points, which is considered to be the record low value during the past 2 years. During this month, the yarn selling price had declined by 7 points (YSPI: 92) from that prevailed in April 2019.

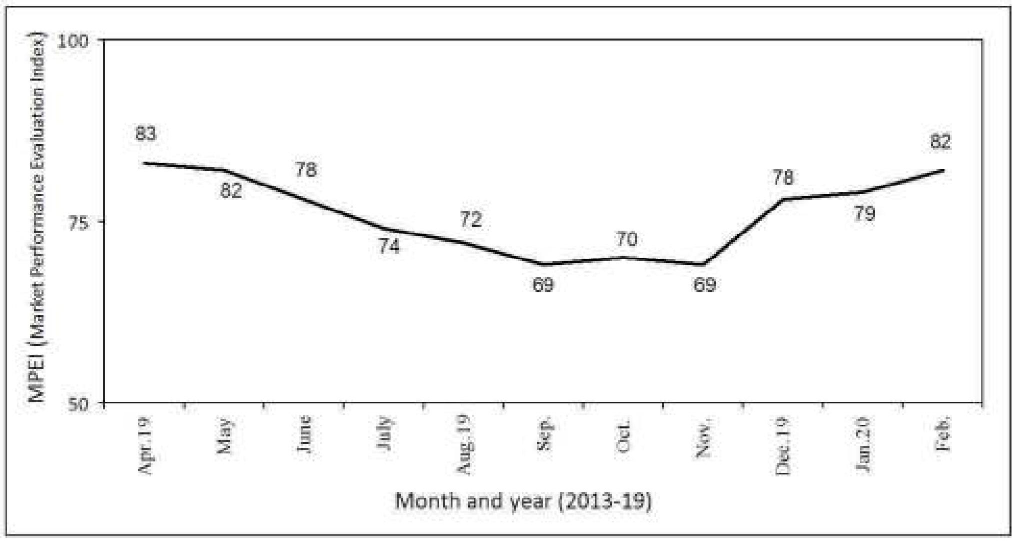


Figure 46 Market Performance Evaluation Index (MPEI)

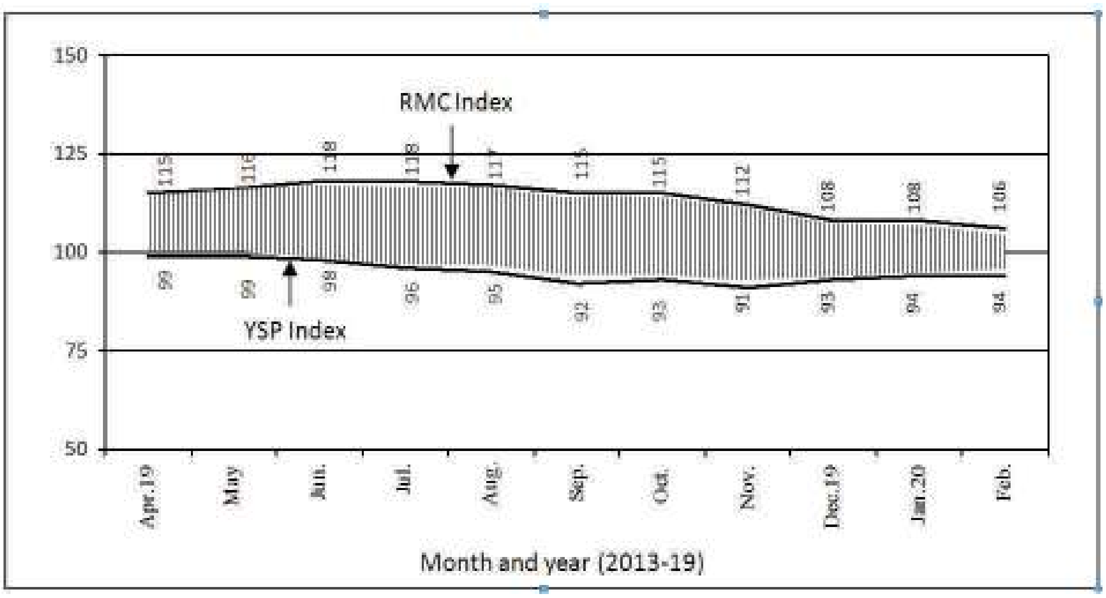


Figure 47 Yarn selling price index (YSPI) and Raw material cost index (RMCI)

In the next two months, the MPEI was found hovering around the same level and remained at the same 69 points in November 2019. In November, the yarn selling price index had further reduced to 91 points. However due to arrival of new crop, the raw material cost had shown a reduction of 3 points (RMCI: 112) leading to maintain the MPEI at the same level, in spite of reduction in yarn selling price.

The above trend was noticed to continue in December also in which the RMCI had further reduced by 4 points (RMCI: 108). Due to the substantial reduction in the raw material cost after arrival of new crop, the yarn selling price (YSPI) had also responded with a decline of 2 points and remained at 93 in December 2019. Hence, in December 2019, MPEI was noticed to recover by 9 points (MPEI: 78) from that prevailed in the previous month.

In January 2020, no significant change was noticed in the raw material cost and yarn selling price and hence the MPEI was noticed to remain at 79 points. In February 2020, there was an improvement in MPEI by 3 points thereby showing a positive trend for the three months. This was mainly due to reduction in raw material cost by two index points with the yarn selling price index remaining at the same level in comparison with the previous month.

Raw material cost (RMC), yarn selling price (YSP) and net out-put value (NOV) of a few popular counts during the past 7 years (April 2013 – March 2020)

The trend in the movement of RMC, YSP and NOV of a few popular counts during the past 84 months (April 2013 to March 2020) is shown in Figures 48 to 56.

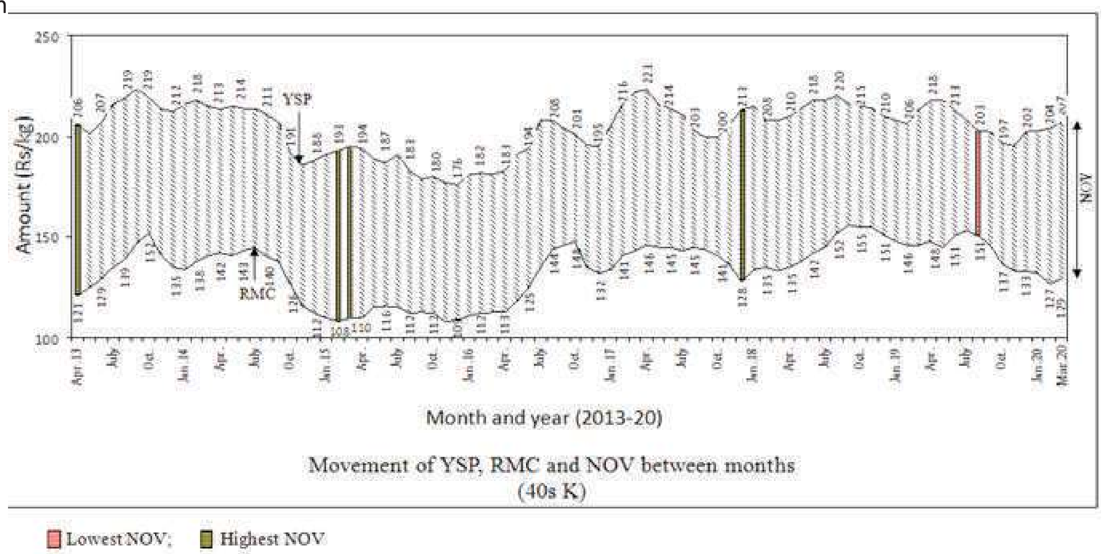


Figure 48 Movement of YSP, RMC and NOV between months (40s K)

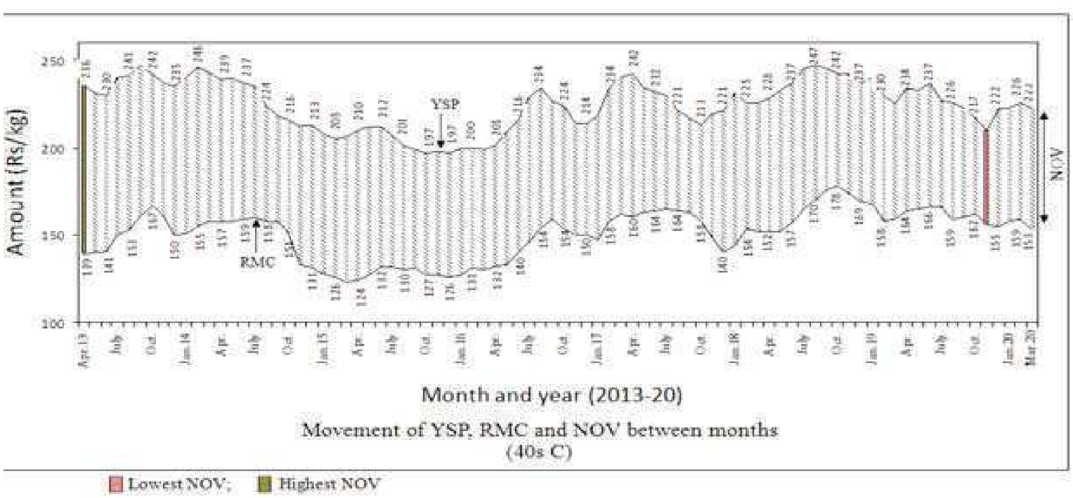


Figure 49 Movement of YSP, RMC and NOV between months (40s C)

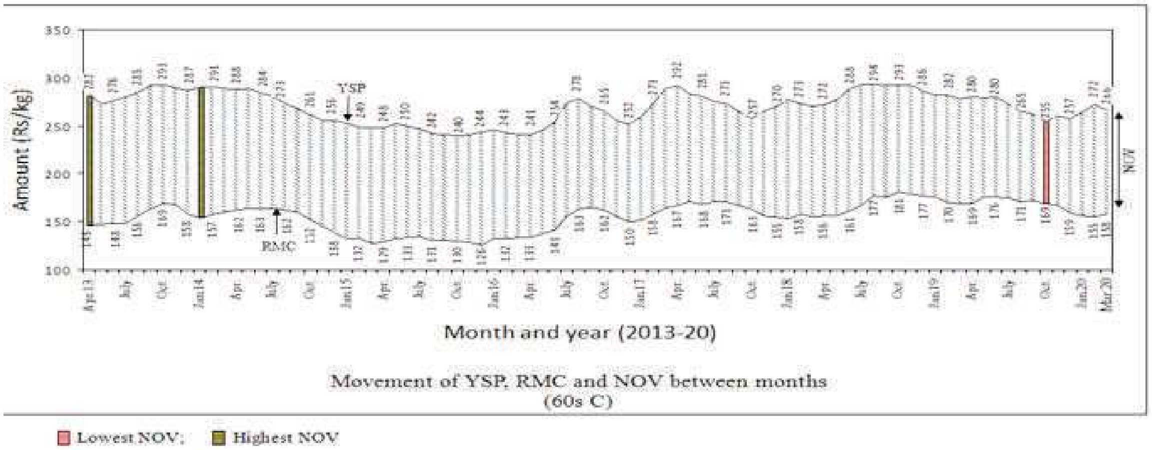


Figure 50 Movement of YSP, RMC and NOV between months (60s C)

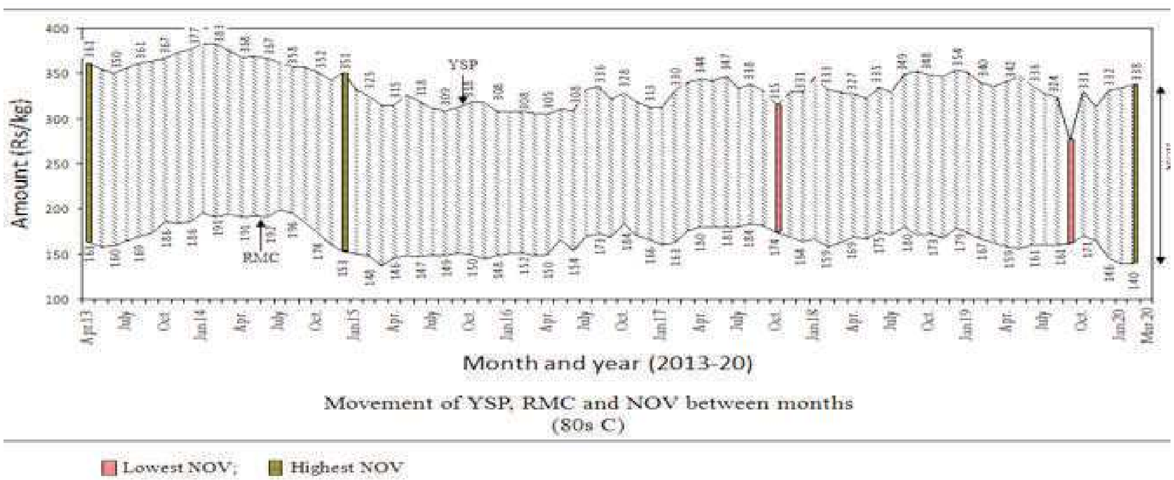


Figure 51 Movement of YSP, RMC and NOV between months (80s C)

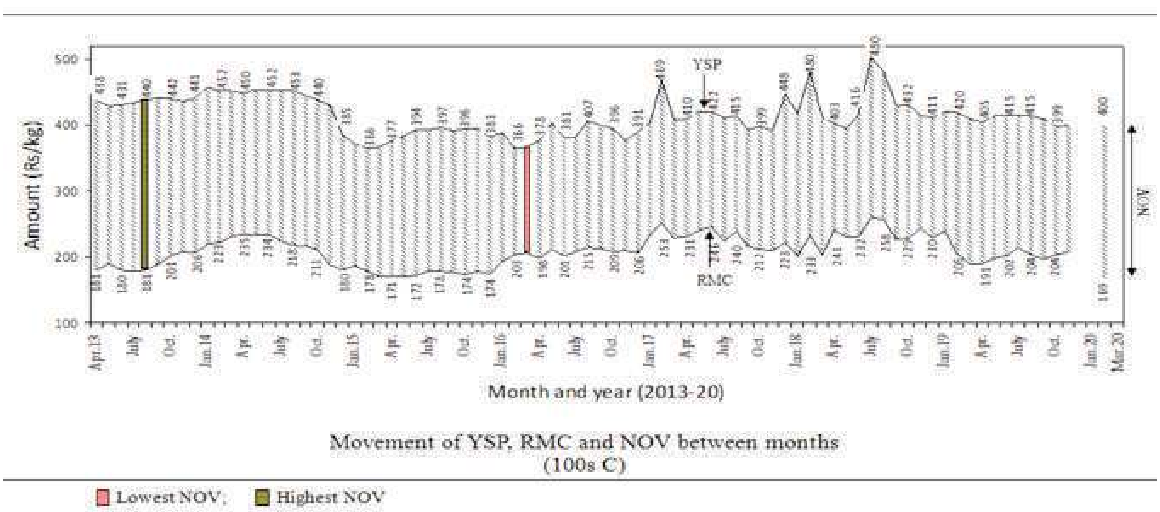


Figure 52 Movement of YSP, RMC and NOV between months (100s C)

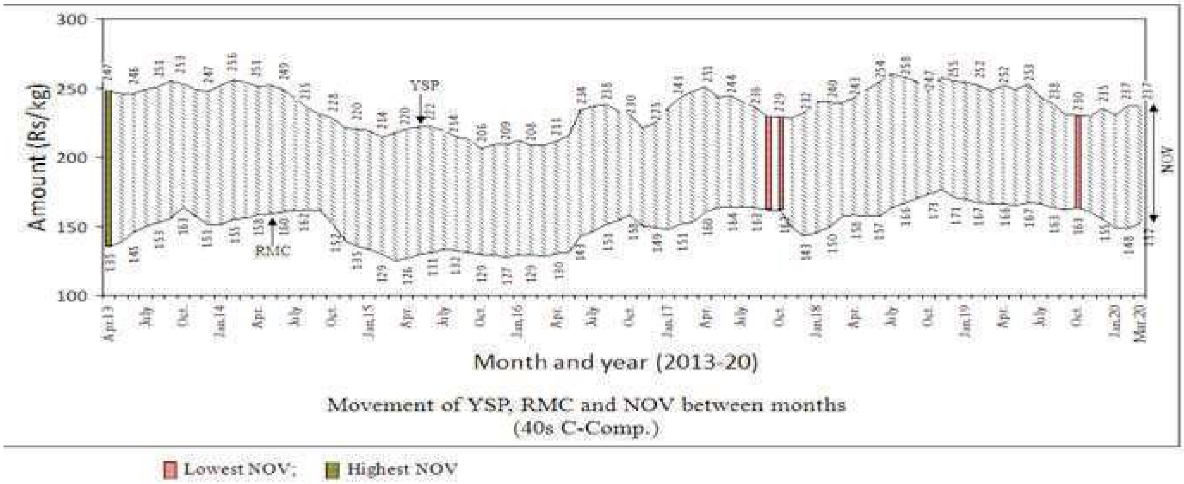


Figure 53 Movement of YSP, RMC and NOV between months (40s C-Comp.)

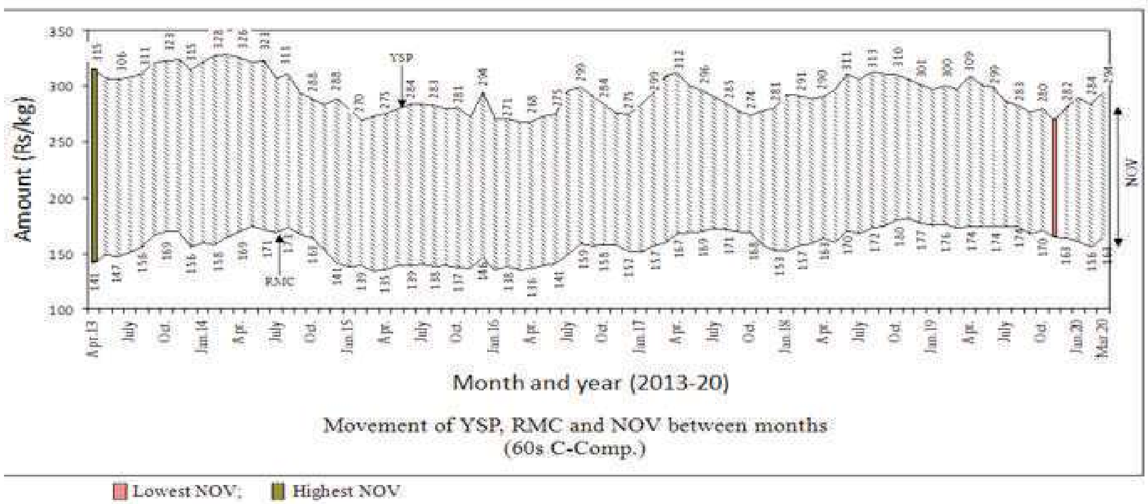


Figure 54 Movement of YSP, RMC and NOV between months (60s C-Comp.)

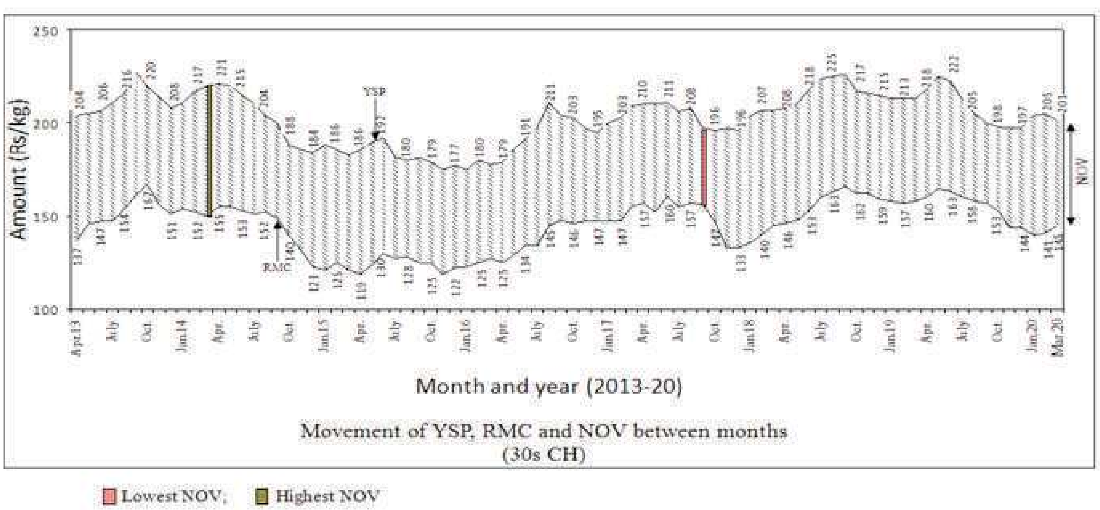


Figure 55 Movement of YSP, RMC and NOV between months (30s CH)

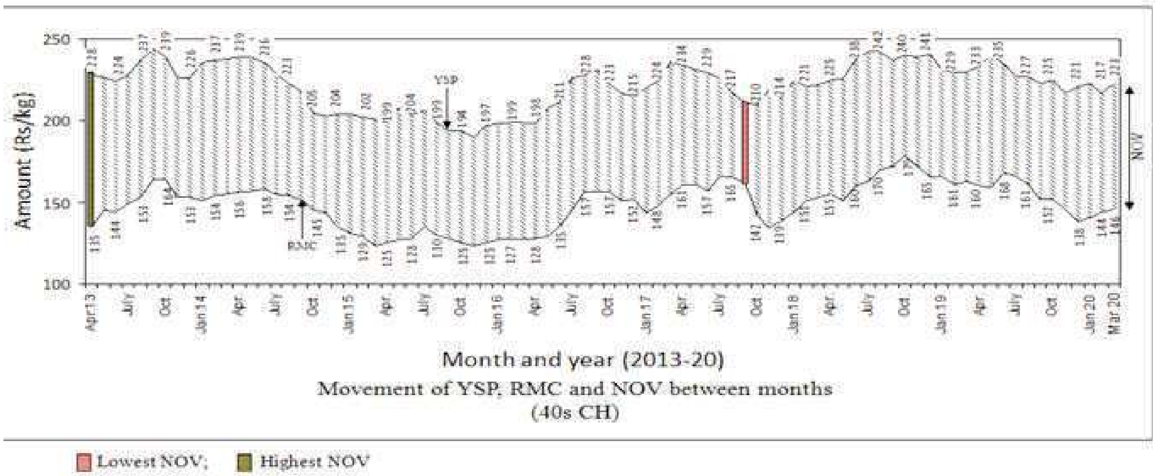


Figure 56 Movement of YSP, RMC and NOV between months (40s CH)

MEDICAL TEXTILES

DEVELOPMENT OF A COMFORT INDEX PARADIGM FOR TEXTILE STRUCTURES
(Sponsored by Ministry of Textiles, Government of India)

With increasing requirements of garment comfort, more and more studies have started focusing on comfort properties of fabrics. Scientific design and development of surgical gown, sportswear with wearing and functional comfort and bed linens with skin sensory comfort enhance not only the well-being and health of the real user, but also in human performance.

Clothing comfort is classified under three broad categories a) Aesthetic comfort b) Thermo-Physiological comfort and c) Tactile comfort/Sensorial comfort. Aesthetic comfort is the subjective perception of clothing by visual sensation, which is influenced by color, style, garment fitting, fashion compatibility, fabric construction and finish. Thermo physiological comfort is defined by heat, water vapour and air transfer through the clothing system in order to maintain the thermal equilibrium between environment and human body. The tactile comfort is related to mechanical interaction between the clothing material and human body/ skin.

At present, there is no comprehensive comfort index available for the determination of comfort of fabrics. This index will be useful in selecting the appropriate clothing for wearer with respect to different applications and under different environmental conditions. This research work is to develop a comfort index for textile materials with the instruments available at SITRA for the measurement of the comfort properties which include both thermo-physiological comfort and tactile comfort (Sensorial comfort).

Twelve commercially available nonwoven fabrics such as SMS, SMMS, SSMMS, laminated spun bond and one Viral Barrier of different aerial density (g/m2) were evaluated using FTT (Fabric Touch Tester) for this research work.

Sportswear

Eight interlock double-jersey plaited structured fabrics of different profiled cross-sectional in the non-skin contact filament and circular cross-sectional in the skin contact filament were evaluated for sportswear application. In these fabrics, the non-skin contact layer was of 100 % structurally modified full dull polyester textured yarns (1.03 dpf) with different cross sections, whereas the skin contact layer is made up of 100% semi dull partially oriented yarn (POY) polyester textured micro denier filaments (0.52 dpf) with k value of 1. The loop length (2.2 mm) and tightness factor (1.3 tex/mm) were normalized to construct the plaited-fabrics with varying stitch densities. The filament and fabric specifications are detailed in the Table 45.

Table 45 Filament specifications used to produce interlock double-jersey plaited structured fabrics

Sample code	Aerial density (g/m^2)	Stitch density	Shape of the filament cross section	Non-roundness factor, k	Filament diameter (µm)	
			Non-Skin	Non-Skin	Non-Skin	Skin
S1	139	2208	circular	1	14	9
S2	167	2808	Plus	1.29	14	9
S3	146	2420	Plus	1.19	15	9
S4	187	3185	Plus	1.13	13	10
S5	169	2756	Plus	1.29	14	10
S6	141	2254	circular	1	15	9
S7	159	2544	W	1.18	18	10
S8	144	2436	T	1.29	14	9

The filament diameter and non-roundness factor were analyzed using FESEM. The pore size analysis, air permeability, moisture regulatory property, moisture vapour transmission rate and tactile property of samples before and after (20) washings were conducted.

Bed Linens

Forty six satin woven structured fabrics of different EPI, PPI, cover factor, yarn count, aerial density (g/m^2) and fiber composition such as 100% cotton, 60% lyocell / 40% cotton, 40% lyocell / 60% cotton and 70% lyocell / 30% cotton were sourced from a leading manufacturer and the study conducted as shown in the Table 46. The tactile property, moisture vapour transmission and air permeability tests have been completed.

It has been observed from this study that an increase in knitted fabric GSM, thickness and stitch density results in decreased moisture vapour transmission property of the fabric. With an increase of fibre shape factor, (non roundness) the overall moisture management property of the fabric gets better, while air permeability as well as water vapour transmission reduces to a certain extent. As the pore size of the fabric increases, there is an increase in moisture vapour transmission (r= 0.63) and air permeability (r=0.54). Also, it is observed that the air permeability and moisture vapour transmission properties of the 20 washed samples are reduced due to reduced pore size; but there is no significant change in the moisture management properties of the washed samples. Since the different profiled fibres are used in the skin contact layer, the absorption rate (%/sec) is 2 times higher than the non skin contact layer (circular cross-section). Also the increased shape factor (non –roundness) of the fibre results in an increase the OMMC of the fabric due to an increase in fibre specific surface area and also increase in the wicking rate through the fabric.

The Qmax value is used to assess the surface warm / cool sensations of a garment and indicates the instantaneous thermal feeling sensed when there is initial contact of the material with the skin surface. A higher value of Qmax denotes that there is a more rapid movement of heat from the body to the fabric surface resulting in a cooler feeling fabric. In this study, it is shown that Qmax is better when the fabric thickness is less, GSM and stitch density are lower with correlation values of 0.68, 0.51 and 0.43 respectively. Further, Qmax increases with an increase in water vapour transmission rate with a positive correlation of 0.50.

The thermo physiological properties such as thermal and water vapour resistance for samples before and after washing are to be evaluated. A study needs to be conducted on the practical significance in fabric comfort, and based on which a Total Clothing Comfort Index (TCCI) for the sportswear textile will be formulated. In the case of bed linens, the thermal resistance property and functional properties such as

Table 46 Fabric specifications

S. No	Composition	EPI	PPI	Warp Cover factor	Weft Cover factor	Cloth Cover factor	Thread Count	Warp count	Weft count	Areal density g/m^2
1	100% Cotton	225	296	25.16	29.60	28.16	521	80	100	134
2		237	152	26.50	19.62	27.55	389	80	60	135
3		225	296	25.16	29.60	28.16	521	80	100	134
4		225	294	25.16	29.40	28.14	519	80	100	134
5		230	288	25.71	28.80	28.07	518	80	100	131
6		230	222	25.17	21.91	27.38	452	84	103	114
7		230	222	25.17	21.91	27.38	452	84	103	114
8		230	222	25.35	21.91	27.42	452	82	103	119
9		230	222	25.38	21.92	27.43	452	82	103	115
10		230	222	25.32	21.87	27.41	452	83	103	114
11		230	222	25.29	22.02	27.42	452	83	102	116
12	60%Lyocell / 40%Cotton	238	204	26.59	23.00	27.75	442	80	79	127
13		239	122	26.30	12.40	27.05	361	83	97	95
14		238	220	26.16	21.92	27.60	458	83	101	117
15		235	255	25.86	25.21	27.79	490	83	102	125
16		240	280	27.23	28.11	28.00	520	78	99	132
17		240	218	26.60	19.71	27.59	458	81	122	110
18		235	122	25.94	15.47	27.08	357	82	62	113
19		240	122	25.94	13.73	26.95	362	86	79	102
20		205	160	26.60	17.66	27.48	365	59	82	126
21		202	120	25.93	11.79	26.80	322	61	104	107
22		210	192	26.46	19.01	27.50	402	63	102	121
23		205	190	25.77	17.09	27.13	395	63	124	113
24		206	236	26.10	21.18	27.54	442	62	124	124
25		206	234	26.53	21.07	27.64	440	60	123	124
26		220	119	24.09	15.09	26.20	339	83	62	106
27		218	156	24.16	19.88	26.89	374	81	62	118
28		238	294	25.94	26.36	27.88	532	84	124	124
29		235	148	26.14	18.92	27.40	383	81	61	126
30	70% Lyocell,30% Cotton	200	152	25.88	16.58	27.14	346	60	84	126
31		235	198	25.86	21.59	27.51	433	83	84	127
32		206	119	26.96	11.79	27.40	325	58	102	112
33		237	152	26.30	19.67	27.49	389	81	60	126
34		232	120	25.76	13.29	26.82	352	81	82	104
35		235	120	26.49	15.09	27.30	355	79	63	116
36		240	102	26.06	12.91	26.96	342	85	62	106
37		210	102	27.72	13.29	27.85	312	57	59	119
38		205	160	27.06	17.71	27.65	365	57	82	124
39	40% Lyocell-60% Cotton	185	138	23.69	17.88	26.44	323	61	60	121
40		184	114	23.31	12.72	25.44	298	62	80	98
41		186	174	23.74	19.44	26.70	360	61	80	119
42		220	119	24.09	15.09	26.20	339	83	62	106
43		218	156	24.16	19.88	26.89	374	81	62	118
44		224	115	24.65	12.65	26.16	339	83	83	92.5
45		222	120	22.02	13.38	24.88	342	102	80	84
46		220	194	21.87	21.66	26.61	414	101	80	104

drape, crease recovery, tear and tensile strength for these samples are to be evaluated.

EFFECT OF ANTIMICROBIAL COATED MEDICAL TEXTILES ON THE NORMAL SKIN FLORA

Antimicrobial substances were originally used in textiles to prevent rotting. Nowadays, with an active life style and increasing concern on self-hygiene, the application of antimicrobial agents is extended to textiles that are used in outdoor, health care, hygiene, sport and leisure. In the case of health care sector, the antimicrobials are generally used as liquid to remove/eliminate infection causing pathogens in skin antisepsis and disinfection. Recently, antimicrobial coated fabrics are being used to develop curtains, wound dressings, surgical gowns, drapes, sutures, hernia mesh etc in health care sectors. Though these materials have good market potential as they combat against microbial infection and assist save the patients from pathogens, its usage in feminine hygiene products such as sanitary napkin, tampons, wipes, diaper etc needs to be studied carefully before the development. Some of these products, unlike health care products, have contact with the vaginal canal which is rich in vascular network and produces mucus. As a mucus membrane, the vagina secretes and absorbs fluids at a higher rate than skin and also protects against and washes away harmful microorganisms. Hence these products, if functionalized with antimicrobial compounds or deodorizer, will rapidly get absorbed by the mucous membrane and enter into the circulatory system without metabolizing it and putting the user at greater risk of potential chemical exposures. Moreover, the absorbed chemicals disturb the normal flora of the vagina. But so far, there is only a limited study to prove the hazards associated with the usage of antimicrobial / deodorizer coated hygiene products at national as well as international level. Hence in the present study, an attempt has been made to study the effect of antimicrobial coated hygiene products such as sanitary napkins and wet wipes on the normal flora of vagina and skin cells.

- Sanitary napkin and wet wipes impregnated with herbal products, metallic antimicrobial compounds and alcohol.
- Different brands of sanitary napkin and wet wipes have shown more than 90 % bactericidal activity against vaginal (Staphylococcus sp., Streptococcus sp., Lactobacillus sp., Klebsiella sp., Bacillus sp.) as well as normal skin flora (Streptococcus sps,Staphylococcus aureus, Bacillus cereus and Klebsiellapnuemoniae).
- Further cytotoxicity studies have also shown mild to severe toxicity when tested on skin cells.

From the present study, it is observed that sanitary napkins and wet wipes when impregnated with antimicrobial compound, not only kill microorganisms but also damage the skin cells.

DEVELOPMENT OF FACIAL SHEET MASK FOR DERMATOLOGICAL APPLICATIONS

The study aims to fabricate multifunctional, biodegradable, eco and skin friendly, nonwoven tissues using electrospinning of polymers for the production of facial beauty masks and advanced skin medications. Polysaccharides (cellulose, starch, chitin and chitosan) which are biodegradable, skin-friendly and obtained from renewable resources are used for the study. Herbs are encapsulated in these polymers and electrospun for the production of facial masks. Facial masks were also checked for cytotoxicity. The facial mask thus produced will promote skin nutrition and moisture, anti acne, anti-lesion, hypoallergenic and other desirable cosmetic effects.

Plant extracts were tested for their activity against the test organisms on the MH agar and Blood agar by agar well cutting method. 24hrs bacterial log phase cultures were serially diluted upto 10-5 and were swabbed over the surface using sterile cotton swab. Wells were made with the gel puncture and 10-50µl of herbal extracts were loaded onto the well. Plates were incubated at 37ºC for 24hrs.

The plant extracts were tested for their activity against Candida albicanson SD agar by agar well cutting method. 48hrs fungal culture was swabbed over the surface using sterile cotton swab. Wells were made with the gel puncture and 10-50µl of herbal extracts were loaded onto the well. Plates were incubated at 24ºC for 48 hrs.

The incubated plates were examined for the interruption of growth over the inocula. The size of the clear zone was measured to evaluate the inhibitory action of the herbal extracts.

Zone of Inhibition (mm) = (T-D)/2
Where, T is the size of the zone
D is the size of the well.

Antimicrobial susceptibility testing-Minimum inhibitory concentration

The minimum inhibitory concentration of the extract was calculated according to the concentration given in Table 47. About 1ml Nutrient broth was kept as control. All the tubes and control were incubated at 37˚C for 24hrs. After incubation, MIC was determined based on turbidity, using UV visible spectrophotometer.

Screening of medicinal plants for anti-oxidant activity
Ferric reducing antioxidant power assay (FRAP assay)
Procedure

About 200µl, 400µl, 600µl, 800µl and 1000µl of each plant extracts were taken in 5 test tubes. It was then made up to 1ml using 1% DMSO. Then 2.7 ml of FRAP reagent was added to each test tube. Exact duplicates were made. A blank was prepared by adding 2.7ml FRAP reagent in 1ml 1% DMSO. All the tubes were kept in dark incubation for 30 mins and color change was measured in a spectrophotometer at 593 nm.

Calculation

$$\text{FRAP of a Sample} = \frac{\text{control - sample}}{\text{sample}} \times 100\ (\mu M)$$

The phytochemical analysis of the extracts were assessed for the presence of alkaloid, flavonoid, tannin, saponin, phenol, glycoside, terpenoid and coumarin according to the standard procedures.

Peel off mask and hydrogel sheet mask were formulated. The test samples (Peel-off masks and Hydrogel masks combined with extracts) were tested for antimicrobial activity using ASTM E 2149 test method and the results were evaluated using the formula

$$\text{Percentage reduction (CFU/mL)} = \frac{B - A}{B} \times 100$$

where
A: CFU/mL of the treated flasks after 1 h contact time.
B: CFU/mL of the inoculum flasks after 1 h contact time.

The plant extracts were screened for their antibacterial activity using various solvents and the results are given below in Table 48.

The minimum inhibitory concentration of the selected plants extracts were assessed by tube dilution method and the results are tabulated in Table 49.

Table 49 Antioxidant activity assessed using FRAP assay

Test Organisms	Antimicrobial susceptibility testing Minimum inhibitory concentration (mg/ml)				
	Plant extracts				
	C. zeylan-cium	*C. longa*	*O. vulgare*	*Melaleuca* oil (µl/ml)	*A.barbadensis* (mg/ml)
S. aureus	0.168	-	0.145	9	-
Strep. pyogenes	0.168	0.123	-	7	-
P. aeruginosa	0.196	-	-	5	-
E. coli	0.196	-	0.125	1	-
K. pneumoniae	0.168	-	-	2	-
C. albicans	0.084	-	0.124	2	-

Table 47 Steps involved in determining the minimum inhibitory concentration of the plant extracts.

Eppendorf tubes	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Volume of broth(ml)	1ml	0.9ml	0.8ml	0.7ml	0.6ml	0.5ml	0.4ml	0.3ml	0.2ml	0.1ml	0
Volume of solution (µl)	0	50	100	150	200	250	300	350	400	450	500
Concentration (%)	0	1	2	3	4	5	6	7	8	9	10
Bacterial culture (µl) (1 x 10^{-5}CFU)	1	1	1	1	1	1	1	1	1	1	1

Table 48 Minimum inhibitory concentration – tube dilution method

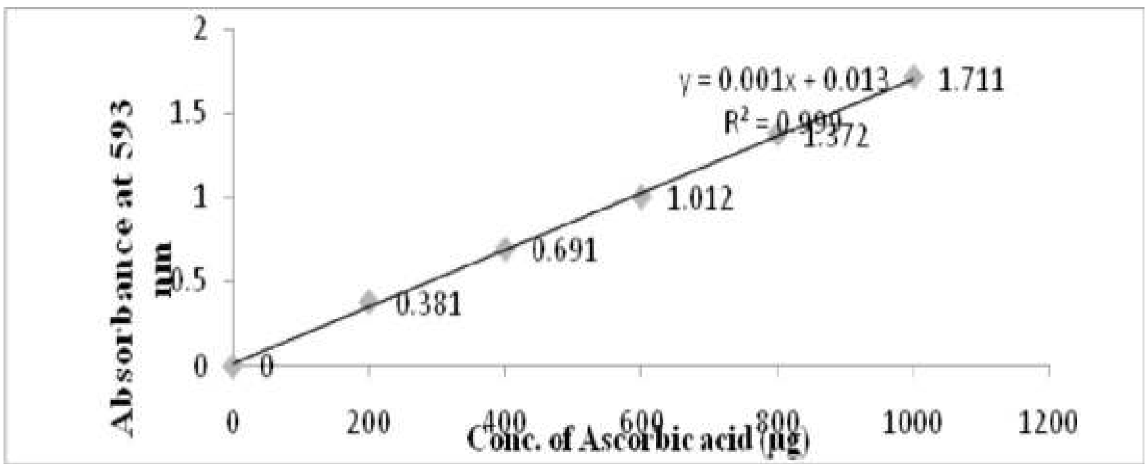
S. No.	Test Organisms	Antimicrobial activity (Zone of Inhibition in mm)				
		Curcuma longa	*Cinnamomum zeylancium*	*Origanum vulgare*	*Melaleuca* oil	*Aloe barbadensis*
1	*Staphylococcus aureus*	–	9	6	10	–
2	*Streptococcus pyogenes*	3.5	9	–	16	–
3	*Pseudomonas aeruginosa*	–	4.5	–	3.5	–
4	*Candida albicans*	–	33.5	6	36	–
5	*Escherichia coli*	–	9	2.5	18.5	–
6	*Klebsiella pneumoniae*	–	7	–	19.5	–

The antioxidant activity of the selected extracts were assessed using FRAP assay and the results are tabulated in Table 50.

Table 50 Antimicrobial activity of Plant extracts - Agar Well diffusion method

Sample Conc.(µg/ml)	FRAP (mM)			
	Standard (Ascorbic acid)	*C. longa*	*C. zeylancium*	*O. vulgare*
200	215	302.45	691.28	257.75
400	415	374.22	729.50	262.45
600	568	459.51	854.80	277.16
800	830	527.75	882.45	281.87
1000	1056	551.28	964.24	321.87

The extracts showed excellent antioxidant activity.



Phytochemical constituents	Extracts of Plant				
	C. zeylancium	*C. longa*	*O. vulgare*	*A. barbadensis*	*Melaleuca* oil
Alkaloids	+	+	+	+	+
Flavonoids	+	+	+	+	+
Saponins	+	+	+	+	+
Coumarins	-	-	+	-	-
Terpenoids	+	+	-	-	+
Phenols	+	+	+	-	-
Glycosides	-	+	+	-	-
Tannins	+	+	+	-	-

The phytochemical analysis showed the presence of alkaloids, flavonoids, saponins, phenol and tannin in the plant extracts.

Assessment of Antibacterial Activity - ASTM E 2149-10

(2013a) revealed that the hydrogel mask and the peel off mask showed 99.99% antibacterial activity against Escherichia coli and Staphylococcus aureus

ASTM E 2149-10 (2013a) for samples placed in Staphylococcus aureus

Test Organism: *Staphylococcus aureus*										
Dilution: 1 X 10^{-5}										
Time Duration	24 H									
Test Parameters	Hydrogel Mask					Peel-off Mask				
	10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}
Trail 1	66	3	1	-	-	98	17	3	-	-
Trail 2	50	7	1	-	-	95	21	1	-	-
Average	58	5	1	-	-	96.5	19	2	-	-
CFU /mL										
Formula used	$\text{Percentage Reduction} = \frac{B - A}{B} * 100$									
Bacterial Reduction (%)	99.9%									

ASTM E 2149-10 (2013a) for samples placed in E. coli

Test Organism: *E. coli*										
Dilution: 1 X 10^{-5}										
Time Duration	24 H									
Test Parameters	Hydrogel Mask					Peel-off Mask				
	10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{0}	10^{-1}	10^{-2}	10^{-3}	10^{-4}
Trail 1	99	14	3	-	-	101	9	-	-	-
Trail 2	108	21	-	-	-	117	16	-	-	-
Average	103.5	17.5	1.5	-	-	1	12.5	-	-	-
CFU /mL										
Formula used	$\text{Percentage Reduction} = \frac{B - A}{B} * 100$									
Bacterial Reduction (%)	99.9%									

MEDICAL TEXTILE PRODUCTS IDENTIFIED BY INMAS FOR WOUND HEALING AND RADIO PROTECTIVE EQUIPMENT BASED ON TEXTILES – A DRDO SPONSORED PROJECT

This project aims to develop the medical textiles products for defence agencies. SITRA has developed the products and submitted the same to defence for further evaluation. The following products which were developed at SITRA were identified for defence applications.

a) Blood absorptive gauze
b) Blood absorptive packing gauze
c) Natural polymer based wound dressings
d) Multi layer wound care products

a) Blood absorptive gauze

To improve the blood and body fluids absorbing capability, non medicated cellulose material with super absorbent polymer is used as a core material. This core material is sandwiched between the hydrophilic and hydrophobic nonwoven layers. The hydrophilic layer helps to absorb the body fluids and hydrophobic layer acts as liquid barrier layer to avoid further liquid leakage from the core.

b) Blood absorptive packing gauze

To treat the deep wounds, SITRA has developed wound care products which contain naturally available bleached cellulose material packed into a hydrophilic bag. After inserting the bag into the wound bed, it absorbs the liquid and the fibres get swollen. Hence, the gauze bag also gets bulged. Due to this, a pressure is created inside the wound bed which compresses the blood vessels and helps to avoid further hemorrhage.

c) Natural polymer based wound dressings

The naturally identified polymer is coated over the cotton gauze using pad dry cure method. This product improves the wound healing ability in terms of providing antibacterial activity over the wound bed.

d) Multilayer wound care products

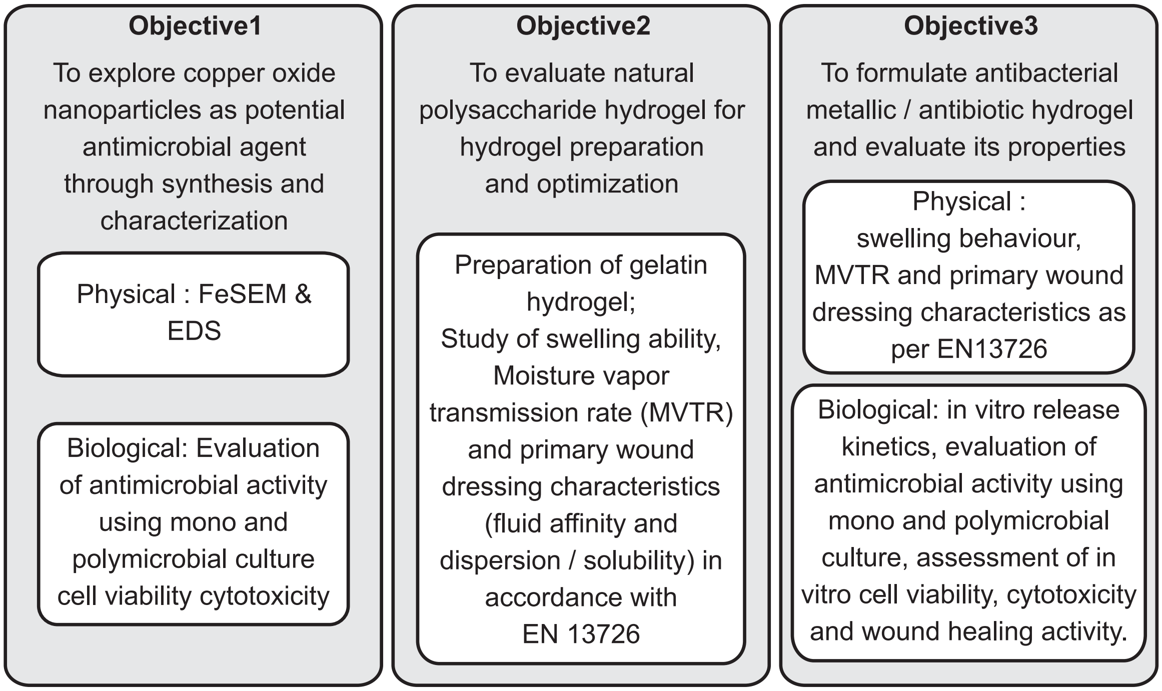
The wound care products have four different layers. The first layer (wound contact layer) has non adherent property with wound bed. The next layer is made using mechanically extracted fibre which has natural antibacterial activity. Another layer has odour absorbing capability. The back layer acts as a protective layer against further injury.

DEVELOPMENT AND CHARACTERIZATION OF METALLIC HYDROGEL FOR WOUND HEALING APPLICATIONS

Chronic wounds which include venous ulcer, diabetic and pressure ulcer are a global problem as they lead to substantial morbidity and mortality. These wounds are complex in nature in terms of both pathophysiology and optimal treatment. Considering the significant burden that they place on many healthcare systems around the world, it is surprising that more is not known about this costly medical challenge. Its prevalence is increasing steadily around the world and in India, though there is no data available on the prevalence of chronic wound, an epidemiological study shows its prevalence as 10.5 for every 1000 individuals. These wounds are a major cause of grief and concern among the affected and also contribute significantly to their overall diminished quality of life (MacLellan 2000). In spite of the availability of ample dressings for the treatment of chronic wounds, the research on exploring new materials/formulations for chronic particularly for infected wound is still on. This is mainly due to the threat on the development of resistance against antimicrobial agents. More recently, hydrogels have been investigated for wound dressing applications as they are cool, do not stick on the wound bed and also conform to the wound site. Some of the commercially available hydrogel wound dressings include IntraSiteTMgel (Smith & Nephew); TegagelTM (3M); Curasol® gel (Healthpoint); NuGel® (Johnson & Johnson) and from other large range of wound care companies. Based on its wide application in the areas of drug delivery, contact lenses, corneal implants and substitutes for skin, tendon, cartilage etc, hydrogel has been explored for further wound dressing developments and modifications.

When considering hydrogel for biomedical applications, the selection of base material for its preparation is extremely important. Gelatin based hydrogel has been widely studied for various biomedical applications as they are biocompatible, biodegradable and possess multiple functions. Gelatin is abundantly present in nature and easily processed into various forms and shapes, and it is inexpensive. Gelatin is extracted from type I collagen, having triple helix structure with the molecular weight of 95 kDa. Gelatin assists in the controlled delivery and release of bioactive agents. Gelatin-based hydrogels are able to protect biomolecules from degradation and release them over extended time periods .

In the case of wound dressing applications, gelatin provides warm and moist environment for rapid wound healing and also prevents the proliferation of bacteria in the wound. They are non-toxic and cause no inflammation, promote cell adhesion and proliferation. Gelatin is soluble in water at 37 ˚C, exhibits amphoteric behaviour and non-immunogenic. Moreover, gelatin is one of the main extracellular matrixes in many tissues and has great capacity of modification at the amino acids level. All these properties indicate that the gelatin hydrogel will not adversely interfere with the biological system that it comes into contact with when applied topically. Hence, in the present study, the combination of hydrogel and metals has been studied for their ability to treat infection and improve the healing by using copper oxide nanoparticles as an antimicrobial agent and gelatin as a carrier.



From this study, it is summarized that the hydrogel developed in the study can be used for treating moderately exudating infected wounds after further confirmation through appropriate in vivo models and clinical trials. Specifically, it is found that,

- Gelatin, a natural hydrophilic polymer has the compatibility with copper oxide nanoparticles and formed rigid gel with appreciable strength and resistance to water.

- Further, the incorporation of nanoparticles was found to have greater influence on the physical properties of gelatin hydrogel.

- The behaviour of gelatin in terms of swelling ability, gel content, reswelling, and drug release varied based on the concentration of nanoparticles.

- There was no significant difference observed in terms of antibacterial activity of copper nanoparticles in powder and after incorporation in hydrogel matrix and exhibited a strong bactericidal activity against all the tested organisms.

- In contrast to antibacterial activity, the nanoparticles in powder form at higher concentration showed cytotoxicity on L929 cells.

- But the toxicity was found nullified after incorporating in the gel matrix and also assisted in the proliferation of L929 mouse fibroblast cells.

SERVICES TO MILLS

Besides R&D work, SITRA has been offering technical and consultancy services which are well received by its member mills as well as non-members. Recent years have witnessed a marked increase in the utilisation of many of the services, primarily testing and training, by the non-members as well. The services availed by the mills during 2019 -20 are presented in Table 51. The onset of COVID-19 during the last quarter of the year had its impact, resulting in significant reduction in utlisation of most services during that period. However, there was significant surge in the requests received for testing of PPEs during that period.

Table 51 SITRA's services availed by textile mills during 2019 - 20

Type of service	Member units	Non members
Fibre, yarn and fabric testing (including PPE)	142	2188
Consultancy services	33	117
CPQ study and Online surveys	69	57
Training: Executives, supervisors and operatives	47	168
Accessories testing & instrument calibration	33	87

Testing of fibres, yarns and fabrics continued to the most sought-after service this year as well, with as many as 142 member mills, representing 71% of SITRA's membership, sending their samples for analyses. Apart from the member units, as many as 2188 non-member units, also utilised this service. This primarily included many units which sent their PPE samples for testing from all over the country. The number of samples received from the mills, including PPE samples was 81197 (Table 52).

With its continuous commitment to mills of ensuring speedy testing of test samples, without in any way compromising on the test standards which insist on preconditioning of samples, SITRA established during the year the "Rapid Conditioning System" to condition and prepare the pre-opened cotton fibres quickly for High Volume cotton testing. This system ensures that samples received from mills can be quickly pre-conditioned and sent for testing. Mills desirous of receiving quick test reports for their fibre samples can now opt for new service, "Rapid testing facility" by SITRA.

Spinning mills continue to patronise the "Costs, Operational Performance and Yarn Quality" study (CPQ) which covers key areas of a mill's functioning. This study, initiated by SITRA more than 2 decades ago, has received good appreciation from mills this year as well, with as many as 103 mills availing this service.

In April 2013, SITRA initiated the monthly online survey of raw material cost and yarn selling price which provides data to participant mills on their position vis-a-vis other participants on a monthly basis. Every year, this service has been receiving good response from the mills and during 2019-20, close to 60 mills on an average participated in the surveys conducted each month.

Table 52 Testing services offered by SITRA during 2019 - 20

Material	Commercial		Project and Others	
	Samples	Tests	Samples	Tests
Fibres	36517	130479	289	729
Yarns	16201	36891	561	1056
Fabrics	1751	3190	118	140
Chemical testing	12845	16285	295	622
CoE tests	13883	16994	75	150
Total	81197	203839	1338	2697

The training programmes offered for the managerial, supervisory and operative personnel were utilised by 47 (around 23%) of the member units while 168 non-member units also availed this service. Further details regarding the training programmes are given in the section under 'Training and development programmes" and labour training.

The consultancy services offered by different departments of SITRA for various operational and other technical/techno-economic problems were utilised by 33 (16%) member units and 117 non-member mills. Some of the important assignments that were handled by SITRA during the year, are listed below.

- Techno-economic viability study
- Yarn realisation study
- Machinery valuation
- Modernisation study
- Quality audit
- Assessment of laboratories for compliance to ISO/IEC 1705:2017
- Water consumption and time study of soft flow dyeing machines
- Energy Audit
- Water consumption audits
- A study on the technical feasibility of establishing dyeing units
- Work and Performance Study in weaving
- Performance audit
- Troubleshooting of ETP operations

Details of the individual consultancy services that were offered to the mills during the year are presented in Annexure V.

COMPUTER AIDED TEXTILE DESIGN CENTRES

Established in the year 1995, and with addition of 3 more centres, as a part of the PSCs, these are currently 4 centres functioning under SITRA's control without any financial assistance from the Ministry. The CAD system facilitates the creation of numerous designs quickly which can be varied or changed instantly depending upon the requirement of the customers. Computerised card punching, an intermediate technology, which will reduce the cost in both handloom and powerloom sectors, is also offered by the CAD centres. Table 53 depicts the various services of these centres that were utilised by the decentralised weaving sector.

Table 53 Services offered by the CAD centres during 2019 - 20

S.No.	Type of service	No. of services
1.	Designs development /graph printouts	508
2.	Training programmes (persons trained)	3 (10)

POWERLOOM SERVICE CENTRES

To cater for the requirements of the decentralised powerloom sector, SITRA has set up powerloom service centres at various places of powerloom concentration. The first of its kind was established at Somanur three decades ago. Since then, six more centres have been established and all these 7 centres are sponsored by the Ministry of Textiles, Government of India. The centres are located in Tamil Nadu at Karur, Komarapalayam, Palladam, Rajapalayam, Salem, Somanur and Tiruchengode. SITRA also operates a textile service centre at Chennimalai for the benefit of both handloom and powerloom units in that region.

The PSCs (Powerloom Service Centres) have conducted a number of interactive sessions with powerloom entrepreneurs under the TUF scheme. Various consultancy services like cluster development programme, machinery buyer-seller meet, exposure visits with Association & Society members to best practices following units at various places in India, entrepreneur development programmes, etc., were offered during the year. The centres also carried out many machinery inspections under the credit linked capital subsidy scheme. Weaving units are also continuously getting the service of the centes for various aspects like new project report preparation, machinery valuation, techno-economic viability study, project appraisal, textile extension study tour, etc.

Many units in Coimbatore, Erode, Namakkal and Salem districts that have installed rapier looms in recent times have immensely benefitted from the various services offered by the centres.

The buyer-seller meets have created a good platform for manufacturers and have contributed to the huge volume of Indian poplin and cambric fabrics exported from these units.

Efforts taken by the SITRA powerloom service centres to implement the welfare schemes, under the Group Insurance scheme of Government of India, have benefitted about 11,798 workers engaged in weaving, twisting, warping and sizing units.

The various services rendered by these powerloom service centres are given in Table 54.

Table 54 Services rendered by the powerloom service centres (2019 - 20)

S. No.	Type of service	No. of services
1.	Consultations	95
2.	New designs development	198
3.	Yarn / cloth / chemical samples testing	31,224
4.	Training programmes (persons trained)	76 509
5.	Liaison / request visits	2,928
6.	Number of looms inspected	21,810
7.	Number of special works	82*

** Seminars / TUF meetings / Talks*

KNITTING DIVISION

SITRA undertakes knitting trials and suitably advices the spinning mills in the region to produce the required quality yarns. Apart from the above service, the knitting division is rendering several other important services like testing the knitted fabric, technical consultations, identification of the causes for the defects, sample development, machinery valuation, etc., In addition to the above, the knitting department is conducting seminars focusing on the latest trends in the knitting industry and providing training at various levels. The following services were offered during 2019 -20.

- Ø Testing of various quality parameters of knitted fabrics and garments
- Ø Fabric faults, cause and remedial measures
- Ø Consultancy services
- Ø Conducting training programmes
- Ø Preparing technical feasibility reports
- Ø Machinery valuation and inspection

Karl Mayer warp knitting and warping machines are available at SITRA for mills/parties for samples development as well as product development in medical textiles.

The various services offered by the division in the year under review are given in Table 55.

Table 55 Services offered by the knitting division (2019 - 20)

S. No.	Type of service	No. of services
1	Testing	5256
2	Samples knitting on FAK machine	1,687
3	Knitting performance of yarn	250
4	Other testing services	539
5	Fabric observation	1018
6	Defect Analysis	1762
7	Consultancy	364

DEFECT ANALYSIS WING

SITRA established during the year 2016 a separate wing for "Defect Analysis" which enables mills to send their yarn and fabric (woven and knitted) samples for analysis of defects. Fabrics can be analysed for both weave/knit faults as well as wet processing faults. Based on the analyses carried out, mills receive reports indicating the maximum possible evidences for the root cause of the problem in the sample(s) sent for analyses.

Ø Defects analysis

The various defects that can be assessed include contamination, stain, shade variation- barre or bands in knitted and woven fabrics or patches, colouration effects, blend irregularities, stress failure, holes due to chemical, mechanical or biological damage, etc.

Ø Re-engineering and design evaluation

Mills can guided on re-engineering and design evaluation of woven and knitted fabrics (Both warp and weft knitted fabrics).

Ø Sewability

Samples sent by mills would be evaluated for the performance of sewing threads / needles on different sewing machines that are available with SITRA.

Ø Appearance / Performance of woven and knitted fabrics

Details of the running performance of the yarns during knitting and details of grey fabric appearance like thick places, thin places, long thin places, long thick places, slubs and contaminations using SITRA method as well as on a 4 Point System of inspection method.

During the year, 1,762 samples were tested for various parameters such as Spirality, Ends and picks per Inch, CPI/WPI, Weight per unit area, Shrinkage and Yarn Twist.

WEAVING CENTRE

SITRA's weaving centre is fully equipped with different types of shuttleless weaving machines like, Sulzer Projectile P700 HP, Picanol GTX Plus Rapier, Toyota JAT 710 Air-jet and Dornier LWV 4/E Air-jet machines to provide the following services to the textile industry to meet the global competition.

- Preparation of project proposals, model project reports and technical feasibility study reports for weaving units.
- Entrepreneur Development Programme for new entrepreneur to start weaving units.
- Conducting weavers' and maintenance training programmes on shuttleless weaving machines
- Consultancy services and liaison visits
- Product development and sample weaving
- Yarn performance study in shuttleless weaving machines
- Woven fabric defect analysis
- Management development programmes & Supervisory development programmes
- Training programme on fabric quality inspection and cloth analysis

The major activities of the division during the year include 2 technical consultancy assignments, 21 sample weavings and conducting 4 different training programmes wherein 145 persons were trained.

TEXTILE CHEMISTRY DIVISION

SITRA's Textile Chemistry division, with nearly 4 decades of experience, has the skilled manpower and expertise in chemical processing, effluent treatment, chemical testing, consultancy, training, etc., to meet the ever increasing demands of today's industries. The laboratory accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL) and meets the requirements of ISO / IEC 17025:2017 and its test reports are valid across the globe. The department's eco testing, water analysis and fibre & wet processing laboratories are equipped with State-of the-art testing equipment to carry out testing on various matrices namely,

Ø Textiles (Fibre, yarn and fabric)
Ø Textile accessories
Ø Technical textiles
Ø Medical textiles
Ø Bio-degradability of chemicals
Ø Packing materials
Ø Water (Drinking water, construction water, bore well water, mineral water, etc)
Ø Waste water / Effluent (general and as per TNPCB norms)
Ø Industrial water

The lab has increased the number of parameters under the scope of accreditation by more than 67 % compared to the previous cycle of accreditation which means increased range of testing of the products and improved recognition in the global market. Now, majority of the quality control tests required by buyers are included in the NABL scope of accreditation. Water testing to test drinking water, construction water, bore-well water, surface/river/ground water, water from purifiers, water from treatment plants, sewage water, effluent water, industrial water, etc. have also received NABL Accreditation in the year 2020. The lab is also equipped with facilities required to carry out the tests required for organic certifications like Eco mark in India, Global Organic Textile Standard (GOTS), Global Recycling Standard (GRS), etc. and pre-requisite testing for OekoTex certification.

The department carried out preliminary testing of samples of fibre, yarn, fabric, garments, textile auxiliaries, lubricant oils, sizing chemicals, polythene bags, wax rolls, effluents for different mills/exporters to meet Oeko-tex, ECO PASSPORT and GOTS certification/regulation.

The water lab of the Chemistry division has now facilities required to test most of the testing requirements of the following products:

- Ø Potable drinking water as per IS 10500: 2012
- Ø Packaged drinking water as per IS 14543: 2016
- Ø Water for textile industry as per IS 201:1992
- Ø Laboratory grade water as per ISO 3696
- Ø Packaged Natural Mineral Water as per IS 13428, etc.

During the year, the laboratory received NABL Accreditation for additional parameters of Water /Waste Water testing to test Drinking water, construction water, borewell water, surface /river/ground water, water from purifiers, water from treatment plants, sewage water, effluent water, industrial water, etc.

Analytical Instruments

The lab is equipped with state-of the art instruments to test the harmful substances in the textile materials, residues in water, etc. The following are the major instruments available with the laboratory:

- Ø High Performance Liquid Chromatography (HPLC – DAD / FLD)
- Ø Liquid Chromatography with Mass Spectrometer (Triple Quadrapole) (LC-MS/MS)
- Ø Gas Chromatography with Mass Spectrometer (GC-MS)
- Ø High Performance Thin Layer Chromatography (HPTLC)
- Ø Fourier Transform Infra Red Spectrometer (FTIR)
- Ø Inductively Coupled Plasma Mass Spectrometer (ICP-MS)
- Ø Gas Chromatography mass spectrometer – Triple Quadrapole (GC-MS/MS)

Further, the lab is equipped with state-of-the art instruments viz., UV-Vis spectrometer, Atomic Absorption Spectrometer (AAS), Total Organic Carbon analyser (TOC), etc. for testing of eco parameters. The lab carries out testing of various samples as per national and international standard test methods such as AATCC, ASTM, IS, ISO, BS EN ISO, DIN, APHA, OECD, EN, etc.

Recent addition of GC-MS/MS

With a view to strengthen the analytical lab, a latest state-of-the art GC-MS/MS (GC: 8890 B and MS: 7000 D) from Agilent has been added to the analytical lab. This instrument will help the lab to carryout finite analysis such as Pesticides Residues in Textiles, drinking water, waste water, etc and Volatile Organic Compounds in Textile, water and food matrices, etc. Most of the eco parameters which are required for GOTS, Oeko-tex and water testing as per BIS can now be performed at SITRA.

The department conducts training programmes on various aspects of testing, quality control, general analysis, instrumental analysis to mill technicians, international participants, students, research scholars, etc. During the year 2019-20, the department conducted 6 different training programmes and a total of 61 persons were trained.

Staff of the department are also empanelled by NABL as assessors to carry out assessment of testing laboratories as per ISO/IEC 17025 Standards. During the year, 8 assessments were carried out.

The staff of the division have also offered consultancy services to processing mills on wide-ranging areas. During the year, 94 consultancy were offered to textile mills, Government bodies and chemical suppliers on various areas such as water consumption audits, technical troubleshooting, process optimization, technical feasibility study, dyeing with natural dyes, etc. Tamilnadu Pollution Control Board (TNPCB) has recognized SITRA's textile chemistry department for carrying out water consumption studies at processing units.

SITRA TEXTILE TESTING AND SERVICE CENTRE, TIRUPUR

In order to cater for the requirements of the knitting industry, textile processing units, export houses etc., in the region, SITRA had established a sample collection centre at Tirupur in the year 2005. Samples collected at the centre are brought to SITRA the same day. In many cases, results are reported to the customers within 24 hours, thus reducing considerably the turnaround time. Based on customers' feedback, SITRA has upgraded the centre into an extension service centre and has completed the process of setting up a laboratory with essential instruments for physical and chemical testing of knitted fabric / garments, water effluent, chemicals etc. During the year 2015, the centre had moved to a spacious building to accommodate more instruments. With additional instruments added during the year, the centre has been able to reduce the turnaround time of sending samples to SITRA and carry out testing for water / effluent testing, fibre identification & blend analysis, etc. The number of tests carried out by the centre during the year was 2769, which was marginally higher than the number of previous year (2723).

SITRA TEXTILE TESTING AND SERVICE CENTRE-CHENNIMALAI

In order to cater for the requirements of the handloom and power loom weavers, textile processing units in SIPCOT and regions like Perundurai, Erode, etc., SITRA has established a Testing and Service Centre at Chennimalai. Samples collected at the centre are brought to SITRA the same day. In many cases, results are reported to the customers within 24 hours. The Centre carries out testing of testing Yarn CSP, fabric analysis for design, identification of fibre, blend analysis, etc. The number of tests carried out by the centre during the year was 1053, which was more than 25% increase over the previous year (845).

CENTRE OF EXCELLENCE FOR MEDICAL TEXTILES

The Centre of Excellence for medical textiles was established at SITRA under Mini Mission I of Technology Mission on Technical Textiles (TMTT), promoted by Office of the Textile Commissioner, Ministry of Textiles, Government of India during the year 2010. The centre is actively involved in various activities such as prototype development, pilot scale production, testing and evaluation, training and seminars, standards formulation, incubation services, information resources, research and development, technical consultancy and Detailed Project Reports for new ventures. It has technical collaboration with various reputed institutes in India and abroad.

The centre has been equipped with several high-tech testing instruments for measuring various parameters for medical textile products. It has also developed many equipment on its own like the Synthetic Blood Penetration Resistance Tester (SBPRT), Bacterial Filtration Efficiency tester, Viral Penetration Resistance Tester(VPRT), Dry Microbial Penetration Resistance Tester, compression bandage pressure measurement system and Particulate Filtration Efficiency tester. SITRA is involved in the testing of PPE since Feb, 2020 to assist the Goverment of India and the manufacturers with the selection of right fabric for the development of PPE to combat COVID 19. SITRA was the only lab approved by Ministry of Textiles, Govt. of India for testing and certification of PPE. During the year, the division tested 13883 samples involving 16994 tests.

The centre's activities also include development of many medical textile products like Bifurcated vascular graft, 3D compression bandages for Lymphedema, spunlace non-woven wound dressings for malodour wounds, breathable surgical gowns treated with nano finishes, barbed - bi-directional surgical sutures, hospital bed linens with enhanced thermal properties for coma patients, hernia mesh, clinical heart patch fabrics, insole liner for diabetic shoes, etc. During the year, the centre developed wet wipes of different types, curcumin loaded wood pulp and chitosan coated gauze for different customers.

The department had prepared several DPRs as part of its activity to help new entrepreneurs in setting up of technical textile units. It was involved in the development of specifications / standards, apart from the development of prototypes. During the year, 10 such prototypes were developed. The department also offered consultancies on 13 different assignments.

Another activity of the department includes training of personnel from industry as well as fresh entrepreneurs on avenues in medical textiles. During the year, the department trained 145 persons under 23 different programmes.

Formulation of standards for various medical textile products is another mandate of the division. The division, in collaboration with the Bureau of Indian Standards,(BIS) is actively involved in the formulation of the standards. During the year, it has contributed to the drafting of the following standards.

1) IS 17334 : 2019 Medical Textiles: Surgical Gowns and Surgical Drapes Specification (Published)
2) IS 16549, Surgical drapes, gowns and clean air suits, used as medical devices, for patients, clinical staff and equipment — Test method to determine the resistance to wet bacterial penetration [First revision of IS 16549]

3) TXD 36 (14814) Medical Textiles – Adhesive Incise, Pre-Operative Adhesive And Transparent Drapes - Specification
4) TXD 36 (14816) Medical Textiles – Disposable Shoe Covers - Specification
5) TXD 36 (14822) Medical Textiles – Abdominal Binder- Specification
6) TXD 36 (14823) Medical Textiles – Dressing, Shell Compressed - Specification
7) TXD 36 (14824) Medical Textiles – Dressing, Wound Care Occlusive With Flexible Foam Padding For Optimum Healing - Specification
8) TXD 36 (14826) Medical Textiles – Anti-Embolic Stockings For Post Operative Use Up to Thigh Medium – Specification
9) TXD 36 (14827) Medical Textiles – Pressure Garments – Specification
10) TXD 36 (14828) Medical Textiles – Napkin Absorbent, Dental, Disposable – Specification
11) Doc: TXD 36 (14483), Textiles – Determination of antifungal activity of textile products — Part 1 : Luminescence method
12) Doc: TXD 36 (14484), Textiles — Determination of antifungal activity of textile products — Part 2: Plate count method
13) Doc: TXD 36 (14485), Textiles — Determination of antiviral activity of textile products
14) Reusable Sanitary Pad/Napkin — Specification

The division has also been involved in the drafting of the following international standard:

- IWA 32:2019 Screening of genetically modified organisms (GMOs) in cotton and textiles

Staff of the department are also registered with the Bharathiar University, Coimbatore to guide students for their M.Phil and Ph.D. in Medical Textiles.

SITRA participated in three conferences organized by various associations towards dissemination of the services offered by the division and saw it as an opportunity to encourage entrepreneurs in both Medical and Technical Textiles fields

- ☐ TEX - NEXT – 2019 organised by the Madurai District Tiny & Small Scale Industries Association held at MADITSSIA Hall , Madurai during 18 to 21 July, 2019.
- ☐ TEX FAIR - 2019 & FARM TO FINISH EXPO, 19 conducted by SIMA and held at Codissia Trade Fair Complex, Coimbatore on 12th August, 2019.
- ☐ TECHNOTEX – 2019 conducted by FICCI / MoT held at Bombay Exhibition Centre, Goregaon during 29 to 31 August, 2019.

SITRA MICROBIOLOGY AND BIO-TECHNOLOGY LABORATORIES

Towards providing diversified services under chemical testing, SITRA had started the microbiology testing facilities as an extension of its chemical laboratory in the year 2009. This NABL accredited laboratory is now under the CoE-Meditech and is well equipped to test samples as per international test standard of ASTM, AATCC,APHA and IS and has the facility to test samples for bacterial filtration efficiency, anti-bacterial activity assessment of textile materials : parallel streak method, anti-bacterial finishes on textile materials: assessment of testing for antibacterial activity and efficacy on textile products, anti-fungal activity, assessment on textile materials: mildew and rot resistance of textile materials, anti-microbial activity assessment of carpets, determining the anti-microbial activity of immobilized anti-microbial agents under dynamic contact conditions, anti-microbial susceptibility tests, methods of sampling and microbiological examination of water, heterotrophic plate count, ETO Sterilization, resistance of materials used in protective clothing to penetration by blood-borne pathogens using Phi X174 bacteriophage penetration as a test system, textile fabrics-determination of antibacterial activity-Agar diffusion plate test and determining the activity of incorporated anti-microbial agent(s) in polymeric or hydrophobic materials. Cytotoxicity, anti cancer activity and anti oxidant studies etc. During the year 2019-20, a total of 1030 samples were tested by the microbiology laboratory and 579 samples by the biotechnology laboratory.

TEXTILE ACCESSORIES TESTING

SITRA offers testing service to evaluate the quality of spinning and weaving accessories / spares as per BIS standards. Moreover, training is imparted to the mill technicians on aspects like evaluation of quality characteristics, sampling procedures, etc. A total of 2,582 samples from 373 units covering various accessories like Carton Boxes, Paper Cones, Rings & Travellers, Tubes, Paper Cores and Kraft Papers, etc., were tested during the year under review which is marginally lower than the numbers compared to the previous year.

SITRA CALIBRATION COTTONS

SITRA has been involved in the supplying calibration cottons to help mills in calibrating their High Volume Testing equipments. Currently available cottons include LL5 (Long), SL5 (Short), LM4 (Low Mic) & HM4 (High Mic). The response to the cottons continued to be good this year as well with enquiries from mills all over India, and about 500 packets being sold

CALIBRATION AND PERFORMANCE CERTIFICATION FOR INSTRUMENTS

Calibrating testing equipment and maintaining their reports is a requirement as per quality systems like ISO and TQM. Many mills are seeking SITRA's help to get a "Calibration Certificate" for their textile testing and quality control instruments. SITRA's certificates are rated as equivalent to the national standards of the National Physical Laboratory (NPL), New Delhi. During the year under review, as many as 170 spinning, weaving and knitting units availed the service of SITRA to receive calibration certificates for 4069 textile testing and quality control instruments. Testing the performance of instruments developed by SITRA and manufactured by its licensees is another important service rendered by SITRA.

TRAINING SERVICES

1. STAFF TRAINING

During the year under review, SITRA offered 16 different training programmes which include 7 functional programmes, 8 in-house programmes and 1 international training wherein a total of 466 persons were trained. The details of the various programmes are given in Table 56.

A. Functional Programmes

SITRA's 40th management development programme

The management development programme organised every year by SITRA, attracts young entrepreneurs interested in understanding the various aspects of textile mill management.

This intensive 45 days programme covers all the major aspects of mill management - material management, financial management and cost control, production and productivity, statistics and quality control, energy management and maintenance, personnel management etc. Six young executives attended this programme which was held during October-November 2019.

Training Programme on Functional skills for quality control

A 3-day training programme for the technicians working in quality control / testing laboratories, merchandisers, exporters, etc. was conducted in May 2019. Totally 7 participants attended this programme which covered topics like sampling techniques, testing of construction parameters of woven and knitted fabrics, colour theory & computer colour matching, colour fastness, inspection of garments and specific tests for garments, care label instructions, eco parameters, etc. Apart from the theoretical sessions, participants also had the opportunity to have practical demonstrations at the laboratories.

Interactive programme on defects analysis in wet processing

SITRA, in association with Tirupur Exporters' Association, Tirupur conducted a one-day workshop with an aim to enlighten the technicians and supervisors in the industry regarding the necessary care to be taken on various aspects like process and quality control in wet processing, exercising proper process and quality control measures at various stages of supply chain and processing towards reducing defects and effective treatment of textile effluents and disposal of sludge. The programme also dealt with actual case studies of defects in industry which have been handled by and rectified by SITRA. Forty four participants attended the programme.

Training Programme on “Process optimization strategies for producing synthetic fibres and blends in cotton spinning system”

Optimising the process variables is the key to spin synthetic fibres and their blends in a cotton spinning system. Many of the cotton spinning mills have been weary of embracing this recent trend to produce synthetics and blends in their existing systems, as they are still apprehensive about the process and the technology. By ensuring that key control measures are in place, it would be possible for mills to be successful in this venture with overall benefits of limiting off-specification production, increased productivity and lower costs.

This two-day programme which was held on 26th and 27th September, 2019 shed light on the key issues associated with synthetic fibres, their influence on processing and ultimately the yarn quality, importance of maintaining control systems to achieve the desired

Table 56 SITRA's Training and development programmes 2019-20

S. no.	Name of the programme	Duration (in days)	Number of		
			A	B	C
	Functional programmes				
1.	Management Development Programme	45	1	6	6
2.	Training programme on Functional skills for quality control	3	1	5	5
3.	Interactive programme on defects analysis in wet processing	1	1	42	44
4.	Training Programme on "Process optimization strategies for producing synthetic fibres and blends in cotton spinning system"	2	1	11	17
5.	Training programmes on "Functional skills in testing & quality control for lab technicians"	4	1	7	31
6.	Training programme on "Yarn Realisation and Waste Control"	2	1	40	57
7	"Industrial energy audit" for TNAU students	3	1	1	34
	In-house programmes				
8.	Technical Awareness programme M/s. Sri Kannapiran Mills, Coimbatore	2	1	1	15
9.	Technical Awareness Programme M/s. Rieter India Ltd, Coimbatore	2	1	1	20
10.	Technical Awareness Programme M/s. Voltas Ltd, Coimbatore	2	1	1	20
11.	Training programme for defect analysis M/s. Kikani Exports, Coimbatore	1	1	1	7
12.	Refresher training programme M/s.Premier Lab, Tirupur	1	1	1	2
13.	Refresher training programme M/s.Best Corp, Tirupur	4	1	1	2
14.	Training programme for Foremen and Fitters	10	1	1	20
15.	Training programmes in medical textiles	1-10	23	51	145
	International programmes				
16.	68th International Training Programme	45	1	21	41
	Total	-	**38**	**191**	**466**

Note : A - Batches B - Orgnisations C - Participants yarn quality, right work practices that can reduce wastes and reduce downtime, apart from the importance of testing and statistical quality control of in-process material. A total of 16 participants attended the programme.

Training programmes on “Functional skills in testing & quality control for lab technicians”

A 4-day training programme for the technicians working in quality control / testing laboratories, merchandisers, exporters, etc., was conducted in January 2020. Totally 31 participants attended this programme which covered topics like sampling techniques, testing of construction parameters of woven and knitted fabrics, colour theory & computer colour matching, colour fastness, inspection of garments and specific tests for garments, care label instructions, eco parameters, etc. Apart from the theoretical sessions, participants also had the opportunity to have practical demonstrations at the laboratories.

Training programme on 'Yarn realisation and waste control”

The two day training programme held during 5th and 6th March, 2020 aimed to enlighten participants on the importance of waste control and good supervision and proper maintenance of machinery towards reducing wastes. Some of the specific topics covered were raw material quality evaluation - cotton and synthetics, optimization of waste extraction, Invisible loss and its control in spinning mills, estimating the expected yarn realisation for the existing working conditions based on SITRA's formula and compare it with norms, step by step analysis of the causes for deviation and means of initiating corrective action. Fifty seven participants attended the programme.

B. IN-HOUSE TRAINING PROGRAMME

Technical awareness programme.

At the request of M/s. Sri Kannapiran Mills, Coimbatore, SITRA conducted a two day training programme which had specific focus to educate their executives on topics such type of yarn faults, classification yarn faults, yarn clearer basic principles, clearer setting optimization. Fifteen executives of the company attended the two day programme held during May 2019.

Technical awareness programme

At the request of M/s. Rieter India Private Ltd, Maharasthtra, SITRA conducted a two day training programme for their service engineers towards sensitizing them on the various technical issues in spinning mills and the trouble shooting mechanisms for the same. Twenty service engineers of the company attended the two day programme held during 6th November to 7th November 2019.

Technical awareness programme

At the request of M/s. Voltas India Ltd, Coimbatore, SITRA conducted a two day training programme for their service engineers, covering various technical issues in spinning mills and the trouble shooting mechanisms for the same. Twenty service engineers of the company attended the two day programme held on 15th and 16th October, 2019.

Training programme for foremen and fitters

At the request of M/s. R S B cottex Ltd, Gujarat, SITRA conduct one week training programme for their foremen and fitters. The focus of the programme was to highlight key technical areas such as textile process, machinery audit, maintenance critical areas from blowroom to winding, deliberation on special tools and gauges, importance of inventory cost control, etc. Twenty participants attended the programme.

Training programme on defect analysis

At the request of M/s. Kikani Exports Ltd, Coimbatore, SITRA conducted a 3-day training programme for their executives. The focus of the programme was various technical issues like defect analysis - types and their mode of occurrence, fiber, yarn and wet processing faults, etc. Seven participants attended the programme.

Refresher training programmes on textile testing

At the request from M/s Premier Lab, Tirupur, SITRA conducted a one day refresher training programme for their executives on 1s February, 2020. A similar programme of 4-days duration was conducted for M/s. Best Corporation, Tirupur during March, 2020. The particiants wre provided hands-on training on the various testing equipment and standards to be followed therein.

C. INTERNATIONAL TRAINING PROGRAMME

International training, a regular feature of SITRA's training activity since 1974, and more than 1690 participants from 69 countries have so far been benefited out of SITRA's expertise in textiles. The participants taking part in such programmes are sponsored by the Ministries of External Affairs and Economic Affairs, Govt. of India, under their sponsoring schemes viz., ITEC (Indian Technical and Economic Co-operation Plan).

ii) SITRA's 68th International training programme

The 68th batch of this programme, being held during October-November, 2019 was inaugurated by Dr. Prakash Vasudevan, Director, SITRA on 3rd October, 2019. Forty one participants from different 19 countries, Bangladesh, Bhutan, Botswana, Egypt, Ethiopia, Guatemala, Iraq, Kenya, Myanmar, Namibia, Philippines, Rwanda,South Sudan, Sudan, Tanzania, Tuvalu, Uruguay, Uzbekistan, and Zimbabwe attended the Programme. The participants were sponsored by the Ministry of External Affairs, Govt. of India, under its sponsoring scheme ITEC (Indian technical and economic co-operation plan). The Valedictory function of the programme was held on November 11, 2019. Participants received their course completion certificates during the valedictory function.

2. LABOUR TRAINING

SITRA has been regularly conducting training programmes for the textile mill workers for the past 36 years. Many mills have utilized SITRA's services in this area this year as well, with as many as 231 shop floor workers being trained during the year. All the training programmes (13 batches) were organized at mills' premises in the respective regional languages (Table 57).

(I) Pre-employment and retraining programmes

Pre-employment training for new entrants and retraining programmes for the experienced workers were conducted in 5 mills, covering 156 operatives in 9 batches. Significant improvement was achieved in key elemental timings, incidence of waste, production rate and quality of output in all the programmes. Details of the operatives training programmes for spinning mills conducted in 2019 -20 are shown in Table 58.

Table 57 Training programmes offered for shop floor workers in 2019-20

S. no.	Type of programme	Number of		
		Mills	Batches	Partici-pants
1.	Operatives training	5	9	156
2.	NBCFDC	3	4	75
	Total	8	13	231

Table 58 Break-up of operatives training programmes for spinning mills (2019-20)

S. no.	Tenting jobs	Number of		
		Mills	Batches	Partici-pants
1.	Speed frame	1	1	15
2.	Ring frames	4	8	141
	Total	5	9	156

Training under National Backward Classes Finance Development corporation(NBCFDC)

The National Backward Classes Finance & Development Corporation (NBCFDC), under the Ministry of Social Justice and Empowerment, Government of India aims to improve and develop the economic activities for the members of Backward Classes living below the poverty line by offering assistance to institutions by leveraging their strength to enhance the skill of individuals under different job roles in various sectors. Two outstation mills availed SITRA's services to train their operatives under the scheme. Totally, 75 operatives were trained in 4 batches for a period of 45 days for the tenting jobs in spinning and autoconer. The training programmes were conducted in Tamil.

ANCILLARY SERVICES FOR TEXTILE MILL OPERATIVES

1. Aptitude tests for selection of operatives

Since the jobs in textile mills are mostly semi-skilled, repetitive and monotonous, it is of utmost importance to select only those individuals who would have these characteristics and would desire to do these jobs. By doing so, mills can not only ensure more productivity but also greater commitment and involvement amongst the employees.

SITRA's aptitude tests are exclusively designed to meet the specific requirements of assessing the ability or aptitude of employees to do the expected activities in the various departments of a textile mill. These tests are being effectively used by around 200 member mills for the selection of employees and they are appreciative of the effectiveness of these tests. The tests measure whether an individual has the capacity or latent ability to learn and perform a given job if adequate training is provided. The use of aptitude tests is advisable for fresh applicants who have little or no experience and may be used by the mills interested in selecting employees for whom training will result in greater performance. The tests are designed to cover the operatives for preparatory, spinning and weaving departments. Most of the jobs in these departments involve I) Visual acuity eg., ability to note end breakages, ii) Two hand coordination for working at machines eg., operations like piecing and knotting, iii) Finger dexterity eg., operations like piecing and knotting iv) Eye and hand coordination for operating the state-of-the-art machines and v) quick reaction time to respond to emergencies at the work place. All these psychophysical attributes are measured by using the three tests in the SITRA Aptitude Test Kit.

Since 2005, SITRA has included another sub-test to the Kit - colour blindness. Many times, it is observed that operatives suffering from colour blindness are unable to distinguish the subtle differences in colour variations as also identify the basic colour combinations. In order to ensure the best fit of operatives with the job, it is essential to screen out persons with this defect. During the year 2019-20, 11 aptitude test kits were purchased by the textile mills.

2. Multimedia DVDs on work methods

SITRA had earlier come out with a CD, for the benefit of spinning mill operatives, providing the work methods for spinning mill operatives. Modernisation has brought in many new machinery in the industry and it was pertinent that SITRA come out with a revised version in line with the times. Hence, a new version of multimedia training materials, in DVD format, was released by SITRA some years back. Like the earlier version of VCDs released by SITRA, this DVD version also will serve as a handy tool for spinning mills to educate operatives on the right ways and means of working in spinning mills. All departments from mixing to reeling are covered. The highlight of the DVD is the option available to users to select any of the 5 languages voice-over namely, Tamil, Telugu, Malayalam, Kannada and Hindi. An English version of the DVD is also available separately.

Departments covered: Mixing, blowroom, carding, combing, drawing, speedframe, ring spinning, open end spinning, manual cone winding, auto cone winding, ring doubling, two for one twisting and reeling.

During the year 2019-20, 7 DVDs were purchased by the textile mills.

CONFERENCES AND SEMINARS

1. SITRA's 32nd Technological Conference

SITRA's technological conferences are held with the objective of disseminating the fruits of its R&D work for the benefit of the industry. The 32nd edition of the conference was held at SITRA on 31st July, 2019. Dr.K.V.Srinivasan, Chairman, Council of Admniistration, SITRA inaugurated the conference. Shri P.Nataraj, Chairman, SIMA, delivered the Keynote address where he sought to highlight the issues faced by the textile industry and thanked SITRA for offering its services that would mitigate them. He observed that the papers discussed in the conference are a reflection of SITRA's efforts to address some of the areas that are relevant to the industry in the region.

SITRA scientists presented the following seven papers during the Conference

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1. Studies on yarn contraction of cotton yarns in conventional and compact ring spinning systems
2. A study on effect of surface modification in apron on yarn quality
3. Staffing pattern in Spinning Mills
4 Case studies in defect analysis of woven and knitted fabrics
5. Development of a reliable quantitative method for determination of sugar content in cotton fibres and measures to minimize the stickiness

6. Study of energy consumption in ultra modern spinning Mills

7. Impressions of ITMA-2019.

The forenoon session, which witnessed the presentation of the first 3 papers, was chaired by Mr.A.Kanthimathinathan, President, Patspin India Ltd., Palakkad and the afternoon session of the other 4 papers was chaired by Shri. Kamatchisundaram, Vice President, Voltas Limited, Textile Machinery Division, Coimbatore.

The conference also witnessed the official release of SITRA's most-sought-after monograph "SITRA Norms for Spinning Mills" and 3 different Apps developed by SITRA meant to provide convenience to technicians using SITRA's services. Also, 12 staff of SITRA received awards for completion of 25 year of service on the occasion.

The conference was attended by 145 delegates.

2. Seminar on "Towards zero defects in wet processing"

SITRA, in association with SITRA-Powerloom Service Centre, Karur & The Karur Textile Manufacturer Exporters' Association, conducted a Seminar with an aim to enlighten the technicians and supervisors in the industry regarding the necessary care to be taken on various aspects like process and quality control in wet processing, exercising proper process and quality control measures at various stages of supply chain and processing towards reducing defects and effective treatment of textile effluents and disposal of sludge. The Seminar also dealt with actual case studies of defects in industry which have been handled by and rectified by SITRA.

Sixty even participants took part in the seminar which was held at Karur Textile Manufacturer Exporters' Association, Karur on 10th April, 2019.

MOUs SIGNED

During the year, Memorandums of Understanding were signed with the following organisations/ Institutions/agencies:

a) M/s. MAK India Ltd., Coimbatore, MAK India Limited, an established business house with commitments for bringing about environment friendly solutions to the industry for the objective of partnering with SITRA, for study, analysis, conducting trials and work out possible industrial adaptation and commercial viability of application of various technologies, inventions, solutions and research works carried out by SITRA.

b) M/s. WWF India, New Delhi, a NGO with a mission to ensure use of sustainable renewable natural resources, for utilising SITRA for conducting water quality testing of samples taken from water basins.

c) Nehru Arts and Science College, Coimbatore, an educational institution, for regular conducting of Training programmes and workshops for their students.

d) M/s Siva Texyarn Limited, Tirupur, a textile manufacturing across all verticals, for utlising the services of SITRA's NABL accredited laboratories for testing of their materials covering fibres to finished materials.

PATENTS FILED

1) Process of manufacturing breathable viral resistant film and laminates, Patent application no: 201941033758 Dt. 22.8.2019

2) Development of transdermal patch for selected cardiovascular drugs, Patent application no: 201941034173. Dt. 24.8.2019

NEW LAUNCH

Process launch of 100% Green & sustainable technology for the manufacture of natural & synthetic indigo at 'Weaves' exhibition, Texvalley, Erode, 27 November 2019.

SITRA developed a breakthrough technology for greener reduction of indigo dye during dyeing process, aptly labelled as GRIN - "Green Reduction of Indigo Dye" under a Technical project sponsored by the Ministry of Textiles, Govt. of India and industrial collaboration with M/s K.G.Fabriks Limited. The development ensures processing denims using a 100% greener& biodegradable reducing agent and a green alkali for bulk production in continuous yarn slasher dyeing machines. The significance of this technology is that it does not call for any additional capital investments. Also, it can be used for the manufacture of denims using both synthetic indigo and natural indigo dyes.

In most industrial indigo dyeing processes, sodium dithionite (hydrose) is used as an agent since it has a powerful reducing property. However, it leads to generation of non-regenerable oxidation products and results in various problems in the disposal of the dye bath and the washing water. Till date, no commercial green & organic indigo dye reducing technology is available globally for replacing sodium dithionite & sodium hydroxide (Caustic) in all areas of vat dye applications.

This new process eliminates hazardous waste water completely by replacing the sodium dithionite or hydrose and caustic by using a green reducing agent and a green alkali. The process is not only pollution free but prospects for improved process stability, especially for vat dyes.

KG FABRIKS Limited, in collaboration with SITRA launched "Nature's Blue"- sustainable denim using Natural Indigo with the above GRIN Denim Technology developed by SITRA at 'Weaves' exhibition at Texvalley, Erode held during 27 - 30 November 2019.

COMMUNICATION

Library

SITRA library with its large collection of books and periodicals continued to attract many technicians from member mills as well as students from colleges and universities. During the year, more than 2400 visitors, which included technicians, students and outside specialists visited SITRA library for utilising its rich collection of books and journals. Three hundred and seventy nine publications have been added to the existing bank of more than 27,000 books on various technical subjects, apart from textiles and management. SITRA has also been receiving 111 Journals on varied aspects on textiles and allied disciplines.

Visitors

Dignitaries from various walks and industries, from India and abroad visited SITRA during the year. This included,among others, the Secretary, Director and Textile Commissioner, Ministry of Textiles, Govt. of India. The details of visitors are given in Annexure II.

Publications

1. Monograph on “SITRA Norms for Spinning Mills”

The 8th edition of “SITRA Norms for Spinning Mills”, was released during the SITRA's Technological Conference in July, 2019. The publication provides the combined norms for Quality & Waste, Productivity as well as General Norms that includes energy and costs among others (for cotton only).

Based on the analysis of data received from mills and after extensive discussions and expert confabulations, revisions were done on many of the norms given in the previous editions by taking into consideration the technological developments that have taken place in the process machinery. Certain sections were also newly introduced in this edition.

Some of areas that have been approached differently in this edition, compared to the previous ones, include

- Comber and its preparatory machines are included in HOK calculation and accordingly the conversion factors are being arrived at (Operatives engaged in the above departments were not included while arriving at the conversion factors till the previous edition).

- In automatic cone winding department, ancillary operatives have been considered for HOK estimation (Up till the previous edition, HOK was provided only for the tenter category).

Some of the aspects that have newly included are,

- As present day quality requirements are customer driven, Avant-garde method of grading quality levels has been introduced in place of the practice followed in previous editions of classifying quality levels as “Good”, “Average” and 'Poor”. Four percentile levels are given with quality levels suggested at 5 percentile points specifically be helpful for mills achieving superior quality using richer raw material.

- Standard HOK has been provided for a ultra modern spinning mill having latest generation machines with high level of automations.

Prediction formulas are given for yarn contraction for different count ranges with varying TM's, which were arrived at based on extensive studies carried out at SITRA on the yarn contraction levels for different level of TM's and different spindle speeds.

2. How to assess a Spinning Mill's Productivity

This revised edition covers the conversion factors pertaining to production per spindle and HOK up to ring frames and automatic cone winding departments. The conversion factors for the preparatory department that are provided in this publication are inclusive of comber and the preparatory departments for combed counts. In addition, separate HOK conversion factors are given for polyester/cotton carded and polyester/cotton combed varieties as the later requires additional man-power and machines for producing combed fleece component.

The publication also gives, for the first time, conversion factors for the ancillary operatives in automatic cone winding department namely cone carriers, fitters, assistant fitters, cleaners and sweepers .

Another important addition is the inclusion of SITRA norms for synthetics and blended yarns with respect to productivity, process parameters and work assignments. The above parameters are being dealt as a beta version in a separate chapter.

In all, SITRA brought out during the year, 23 publications which included 1 monograph, 4 research / inter-mill study reports, 12 online reports, 4 focus and 2 Etech letters (SITRA news publication) (Annexure III).

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SITRA scientists published 3 research papers in technical journals and presented 12 papers in conferences and seminars (Annexure VI).

ANNEXURE I

THE STAFF

DIRECTOR
Dr.Prakash Vasudevan, M.Sc. (Textile Engineering), Ph.D (Leeds)

SPINNING
Assistant Director and Head of Division:
(Addl. incharge of Weaving & Knitting division)
Mr.D.Jayaraman, M.Tech.

Senior Scientific Officers:
Mr. G.Nagarajan, M.Tech.
Mr. R.Soundararajan, B.E.
Mr. S.Balamurugan, M.Tech.

Scientific Officers:
Mr. M.K.Vittopa, M.Tech., A.M.I.E.
Mr. V.Vijayajothi, M.Tech.

WEAVING AND KNITTING
Senior Scientific Officer:
Mr. S.Sounderraj, M.Tech.

Scientific Officer:
Ms.C.Vanithamani, B.Tech.

LIAISON AND CONSULTATION
Senior Scientific Officer & Head of Division:
Mr. J.Sreenivasan, M.Tech.

Senior Scientific Officers:
Mr. N.K.Nagarajan, M.Tech., MBA.
Mr. P.Subash, M.Tech.
Mr. N.Ravichandran, M.Tech.

Scientific Officers:
Mr. G.Santhana Krishnan, M.Tech.
Mr. Sambhaji Shivaji Chavai, M.Tech.

TEXTILE ENGINEERING & INSTRUMENTATION
Principal Scientific Officer & Head of Division:
Mr. M.Muthukumaran, B.E.

Senior Scientific Officers:
Mr. M.Muthuvelan, B.E., PGDBA., M.B.A., M.Phil (Mgmt).
Mr. N.Vasanthakumar, B.Sc., A.T.I.

Scientific Officers:
Mr. G.Ilango, DME.
Mr. S.Chandirasoodan, M.Tech.

TEXTILE PHYSICS
Principal Scientific Officer & Head of Division:
Dr.R.Pasupathy, M.Tech., M.B.A., A.M.I.E, Ph.D

Scientific Officer:
Mr. M.Kumaran, M.Tech.

TEXTILE CHEMISTRY
Principal Scientific Officer & Head of Division :
(Addl. incharge of CoE- Medical Textiles division)
Mr. S.Sivakumar, M.Tech., D.T.P

TRAINING
Principal Scientific Officer & Head of Division:
(Addl. incharge as Administrative Officer)
Dr.K.Sajjan Rao, M.Sc., Ph.D.

CENTRE OF EXCELLENCE FOR MEDICAL TEXTILES

Senior Scientific Officers:
Dr. E.Santhini, M.Sc., Ph.D.
Mr. T. Sureshram, M. Tech.

Scientific Officers:
Mr. D.Veerasubramanian, M.Tech.
Dr. S.Radhai, M.Sc., M.Phil., Ph.D.
Mr. K.R.Muthukumar, M.Tech.

ADMINISTRATION
Principal Officer & Head - Finance and Cost Accounts:
Ms.K.Vadivazhaki, B.Com., A.C.A.

Principal Scientific Officer - IT:
Ms. R.Suganthi, M.Sc., M.C.A., M.C.S.D., Net 07, OCA & OCP.

Senior Officer & Head - HR:
Mr. R.Sivaram, MHRM, M.B.A.

Senior Officer - Stores:
Mr. M.Babu, B.E.

Officer & Secretary to Director:
Ms. N.Saradha Jayalakshmi, M.Sc., M.B.A.

Officer - Accounts:
Ms. K.Prabha, M.Com., PGDCA

ANNEXURE I (Contd..)

THE STAFF

Total staff strength as on 31st March 2020

Officers	*:....................31*
Scientific/Technical assistants	*:....................31*
Administrative staff	*:....................11*
Skilled/Semi skilled & maintenance services	*:....................14*
Technical assistants on contract	*:......................5*
Total	***:.............. ....92***

Powerloom service centres (Govt. sponsored)

Officers	*:......................2*
Scientific/Technical assistants	*:....................26*
Skilled/Semi skilled	*:......................1*
Total ..:	***...................29***

ANNEXURE II
VISITORS

- **Shri R.Ambalavanan**, Director General, CAG, Govt. of India
- **Ms.Celia B. Elumba**, Director, Philippine Textile Research Institute (PTRI), of the Department of Science and Technology (DOST) Govt. of Philippines.
- **Dr. Kannan Krishnan,** University of New Castle – Australia.
- **Shri Moloy Chandan Chakrabortty,** Textile Commissioner, Ministry of Textiles, Govt. of India
- **Shri Nihar Ranjan Dash**, Joint Secretary, Ministry of Textiles, Govt. of India
- **Shri Ravi Capoor**, Secretary , Ministry of Textiles, Govt. of India
- **Shri Sudhir Garg**, Joint Secretary, Ministry of MSME, Govt. of India
- **Mr. T.Rajkumar,** Chairman CITI

ANNEXURE III

SITRA PUBLICATIONS DURING 2019 - 2020

1. Research / Inter-mill study reports :

An inter-mill study on fibre to yarn conversion cost - 8th study- *N.K. Nagarajan.*

Costs, operational performance and yarn quality: Inter-mill study of key factors (34th study)
- *J.Sreenivasan, P. Subash and N.Ravichandran.*

Production pattern and product diversification in spinning mills- *N.K.Nagarajan and Sambhaji.S Chavai.*

How to assess a spinning mill's productivity? - *J.Sreenivasan, N.K. Nagarajan, P. Subash and Sambhaji S.Chavai.*

2. Focus:

Quality requirements for hosiery yarns - *D.Jayaraman, G.Nagaraj and S. Soundarraj.*

How to measure efficiency of an induction motor - *M.Muthuvelan and B.Harishankar.*

Quality evaluation of manmade fibres - *R.Pasupathy, D.Jayaraman and G.Nagaraj.*

How spinning mills can recover from covid - 19 catastrophe - *J.Sreenivasan, N.K. Nagarajan, and Sambhaji S.Chavai.*

3. Books:

SITRA Norms for Spinning mills

4. SITRA eTechletter:

2 issues

5. Other Publications:

Annual report 2018-19

ANNEXURE IV

SITRA DEVELOPMENTS

1. Machinery

Storage positive feed system for knitting machines
High speed reeling machine
High production cutting machine
High speed blending draw frame single delivery machine
"Spinfan" system for fancy yarns
SITRA - VOLKA ring frame
"Enerspin" drive system for ring spinning & doubling frames
SITRA "miniSPIN" - Miniature spinning plant for test runs
SITRA ENERCONER - Energy efficient drive control system for automatic cone winding machines
Energy and production information system for ring spinning frames "SITRA EnerInfosys"
Ener TFO
SITRA CIM
SITRA Microcontrol
Weavability Tester
High performance jute flyer spinning frame - SITRA Jute Flyspin
Micro controller based energy saving & information system for air compressors used in textile mills - SITRA PCRA ENERCOMP
SITRA PCRA Climocontrol

2. Fibre and Yarn Testing Instruments

Fibre bundle strength tester
Trash separator
Electronic twist tester
Electronic lea strength tester
Semi - Automatic twist tester
Motorised twist tester
Nep counter
SITRA motorised multi-board yarn appearance winder
Electronic load indicator for conventional lea strength tester (ELCONLEA)
SITRA rapid sample conditioner
SITRA- ABRATEST - Yarn abrasion resistance tester
Single yarn strength tester
Schnidt model yarn tension meter
Roving strength tester

3. Others

SITRAlised energy saving spindle tapes
SANTIMIT
Weft feeler mechanism to stop the loom for pirn changing
Energy efficient fans - SITRA excel fan
Infra colour dyeing machine
Shore hardness tester
Cyberscan bench top PH meter
Fabric stiffness tester
Drapemeter
Fabric thickness tester
MRG crimp tester
Fabric elongation tester
Fabric roughness/friction tester
UV Photocatalytic reactor
Self anchor suturing machine
CSP system and fabric strength tester
Fabric winding mechanism for powerlooms
Arterial prosthetic graft
SITRA pneuma kit
SITRA motor relay tester
Lab fabric dyeing machine
Soxhlet extraction mantles
Microprocessor based electronic balance
Launderometer
Crease recovery tester
Perspirometer
SITRA Enercool
Fabric compression tester
SITRA's Bacterial Filtration Efficiency Tester
SITRA's blood penetration resistance tester

SITRA may be contacted for the addresses of the Licensees

ANNEXURE V

LIST OF STUDIES / SERVICES RENDERED TO MILLS

Mills utilised SITRA's services and expertise for a wide range of their requirements. Some of the studies/services attended during 2019 - 20 were:

Water consumption and time study of soft flow dyeing machines (94), Water consumption audits (76), LCT testing(43), Fabrication of viscosity Cup (23), Sample Weaving – Product Development (21), Monthly inter-mill survey (12), Assessment of laboratories for NABL accreditation purpose (8), Energy audit (11), Quality audit (10), Machinery health audit to mMills through mobile App (10), Machiney audit (7), Machinery valuation (6), Method of calculation & 40s conversion factors list (6), SITRA's blow room openness tester(5), Natural Dyeing of cotton lining materials (5), Compressor air flow study (6), Technical consultancy for spinning mills (6), Openness tester study (5), Warp knitting sample development (4), Technical consultancy in weaving (2), Trouble shooting of ETP operation (2).

Apart from the above, the following studies were also undertaken: Yarn costing study, Work assignment study, Noise level study, Staff optimisation study, Air consumption on weaving machines, Diagnostic study, DPR (Detailed Project Report) for starting a new dyeing units, Technical Study of a weaving unit. Techno economic viability study of spinning mills, Mandatory Energy Audits, Technology transfer of the outcome of a research project, Internal audit of other laboratories, Compressed air consumption study, energy consumption study, technical feasibility of establishing a dyeing unit, trouble shooting of ETP in bleaching and dyeing units, Development of Eco-Clothing by greener reduction process of Natural Indigo dye, Fixing of Inlet Quality standards for the CETP's in Tamilnadu, Development of better fastness dyeing methods for kovai kora cotton sarees, Study of Identifying the usage of mixed salt for dyeing, Development of a suitable recipe for processing of Grey cotton fabrics with Metallic/ metal coated ZARI yarns, Sorting out the problem associated with burn-out style of printing on scoured polyester/viscose knit fabrics, Sorting out the problem associated with shade variation in hank yarn mercerization process, Removal of foul smell from Discharge print on 100% viscose dyed knit fabric, Removal of white patches on Polyester/Cotton dyed fabrics, Removal of Iron stain from bleached yarn (white) and melange yarn, Process optimization in dyeing of 100 % viscose knit fabric

ANNEXURE VI

PAPERS PUBLISHED IN JOURNALS AND PAPERS PRESENTED IN CONFERENCES

PAPERS PUBLISHED IN JOURNALS

Ketankumar Vadodaria, Abhilash Kulkarni, E Santhini and Prakash Vasudevan	Materials and structures used in meniscus repair and regeneration: A review	Biomedicine, 2019, 9(1): 11-22. (ISSN 2211-8039).
N. Sudhapriya et al.	Dyeing of textiles with natural dyes extracted from Terminalia arjuna and Thespesia populnea fruits	Ind Crops Prod, 2020, 148, 112303. Impact factor: 4.244
N. Sudhapriya, et al	p-TSA. H_2O mediated one-pot, multi-component synthesis of isatin derived imidazoles as dual-purpose drugs against inflammation and cancer	Bioorg chem, 2020, 102, 104046. Impact factor: 4.831

PAPERS PRESENTED IN SEMINARS /CONFERENCES

D.Jayaraman	"Sustainable ECO textiles"	Proceedings of Conference, held at Bharathiyar University, Coimbatore, on 27th February 2020
D.Jayaraman	"Career opportunity"	Programme conducted by department of physics, held at Sri Ramakrishna College of Arts and Science, Coimbatore, on 3rd April 2019
S. Sivakumar	"Role of Chemistry in Textile Industry"	UGC-DST CURIE sponsored workshop on "Industry-Institute Connect IIC 2019 held at Avinashilingam Institute for Home Science and Higher Education
M.K.Vittopa	"High Productivity Hand Operated Charkha Development"	5th Committee meeting on S&T held at Central office Mumbai on 19 November 2019
M.K.Vittopa	"Scope of banana fibre as a source of income in villages"	Vivekananda Institute of Biotechnology, Sri Ramakrishna Ashram, Nimpith, West Bangal on 19 February 2020
D.Jayaraman	Studies on yarn contraction in cotton yarns in conventional and compact ring spinning systems	SITRA's 32nd Technological Conference of SITRA, on 31th July, 2019
N.Ravichandran	Staffing pattern in Spinning Mills	
N.Vasantha Kumar	Study of energy consumption in ultra modern spinning Mills	
S.Sivakumar	Development of a reliable quantitative method for determination of sugar content in cotton -fibres and measures to minimize the stickiness	
S.Balamurugan	A study on effect of surface modification in apron on yarn quality	
S.Sounderraj	Case studies in defect analysis of woven and knitted fabrics	
D.Jayaraman, M.Muthukumaran S.Sivakumar	Impressions of ITMA -2019	

ANNEXURE VI (Contd.)

PAPERS PUBLISHED IN JOURNALS AND PAPERS PRESENTED IN CONFERENCES

Lectures delivered

Mr.M.Muthukumaran	"Energy Management in Spinning Industries"	Training program for Young Entrepreneurs in the theme of Textile Management Excellence held at LMW-Unit I, Training Centre, Coimbatore on 31.08.2019.
	"Energy Management in industries"	Lakshmi Electrical Control Systems Ltd., Coimbatore on 28.08.2019.
	"Energy Conservation – Compressor & Piping System"	Energy Conservation Week observed by Indo shell Cast Pvt. Ltd., Unit – II, Coimbatore on 28.12.2019.
	"Paradox of the Indian Power Sector"	Tamil Nadu electricity Consumers Association (TECA), head at Hotel Fairfield Marriott on 30.9.2019.
Ketankumar Vadodaria	Opportunities in Medical Textiles	Texnext 2019 Conference organized by Madurai District Tiny & Small Scale Industries Association on 19th July 2019.
N.K.Nagarajan	"Application of Industrial Engineering concepts in Apparel and Textile Technology"	Faculty Development Program (FDP) Kumaraguru College of Technology (KCT), Coimbatore on 27.11.2019 .
D. Veerasubramanian	Physical properties of textiles & its characterization	Faculty Development Program (FDP) Bharatiyar University, Coimbatore on 29th January 2020.
M.Kumaran	New fibres in textiles	Conducted by National institute of technical teachers training & research. Govt. of India, at SSM institute, Komarapalayam on 20.02.2020

ANNEXURE VII

MEMBERS OF COUNCIL OF ADMINISTRATION

Elected members

1. Mr.Sanjay Jayavarthanavelu, Chairman & MD, Lakshmi Machine Works Ltd., Coimbatore (Chairman)
2. Mr.E.Sathyanarayana, Managing Director, Sree Satyanarayana Spinning Mills Ltd., Tanuku (Vice-Chairman)
3. Mr. S.Dinakaran, Joint Managing Director, Sambandam Spinning Mills Ltd., Salem.
4. Mr. Durai Palanisamy, Managing Director, Shri Cheran Synthetic India Ltd., Pallipalayam
5. Mr. Gopinath Bala, Technical Director, Sri Venkatalakshmi Spinners (P) Ltd., Udumalpet.
6. Mr. Prashanth Chandran, Managing Director, Precot Meridian Ltd., Coimbatore.
7. Dr. K.V.Srinivasan, Managing Director, Premier Mills Pvt. Ltd., Coimbatore.
8. Dr. S.K Sundararaman, Executive Director, Shiva Texyarn Ltd., Coimbatore

9.. Mr. Thiyagu Valliappa, Executive Director, Sree Valliappa Textiles, Ltd, Bengaluru

10. Mr. J.Thulasidharan, Managing Director, The Rajaratna Mills Ltd., Coimbatore.

Permanent Members

11. The Managing Director, National Textile Corporation, Southern Regional Office, Coimbatore.
12. The President, Madura Coats Pvt. Limited, Bengaluru.
13. The Wholetime Director, The Lakshmi Mills Co. Ltd., Coimbatore.

Directors of the Textile Research Associations of India

14. Dr. Anjan Kumar Mukhopadhyay, Director, The Bombay Textile Research Association, Mumbai.
15. Dr. Arindam Basu, Director General, Northern India Textile Research Association, Ghaziabad.
16. Shri Pragnesh Shah, Director, The Ahmedabad Textile Industry's Research Association, Ahmedabad.
17. Dr. Prakash Vasudevan, Director, The South India Textile Research Association, Coimbatore.

Scientific / Technical Members

18. Dr. A.N.Desai, Retd. Director, The Bombay Textile Research Association, Mumbai.
19. Dr. J.Srinivasan, Professor and Head, Dept. of Fashion Technology, Kumaraguru College of Technology, Coimbatore.

Representatives of the Ministry of Textiles, Government of India.

20. The Additional Secretary & Financial Adviser, Ministry of Textiles, Govt. of India, New Delhi.
21. The Joint Secretary (R&D), Ministry of Textiles, Govt. of India, New Delhi.
22. The Textile Commissioner, Office of the Textile Commissioner, Govt. of India, Mumbai.

Representative of the Government of Tamil Nadu

23. The Commissioner of Handlooms and Textiles, Govt. of Tamil Nadu, Chennai.

Representative of the Tamil Nadu Handloom Weavers' Co-operative Society Ltd., Chennai.

24. The Managing Director, The Tamil Nadu Handloom Weavers' Co-operative Society Ltd., Chennai.

Representative of the Southern India Mills' Association

25. Chairman, The Southern India Mills' Association, Coimbatore.

Special invitees

`1. The Director, Ministry of Textiles, Govt. of India, New Delhi.

`2. The Chairman, Confederation of Indian Textile Industry, New Delhi.

`3. The Director, Central Leather Research Institute, Chennai (CSIR representative).

`4. Mr. Divyar S. Nagarajan, President, Dyers Association of Tirupur.

`5. Mr. Raja M. Shanmugam, President, Tirupur Exporters Association, Tirupur.

`6. Mr. Suresh Manoharan, Executive Director, Best Color Solutions (I) Pvt. Ltd., Tirupur.

7. Sri Harish Kapil Kumar, Technical Director, Sri Kumaran Mills Pvt. Ltd.,
8. Mr. Rohit Rajendran, Executive Director, Premier Spg&WvgMills Ltd.

ANNEXURE VIII

MEMBERS OF SUB-COMMITTEES

(A) Finance and machinery sub-committee

Shri Sanjay Jayavarthanavelu	Lakshmi Machine Works Ltd., Coimbatore.
Shri E.Sathyanarayana	Sree Satyanarayana Spinning Mills Ltd, Tanuku.
Dr. K.V.Srinivasan	Premier Mills Pvt. Ltd., Coimbatore.
Dr. Prakash Vasudevan	Director, SITRA, Coimbatore.

(B) Staff and awards sub-committee

Shri Sanjay Jayavarthanavelu	Lakshmi Machine Works Ltd., Coimbatore.
Dr. K.V.Srinivasan	Premier Mills Pvt. Ltd., Coimbatore.
Shri J.Thulasidaran	The Rajaratna Mills Ltd., Palani.
Dr. Prakash Vasudevan	Director, SITRA, Coimbatore

ANNEXURE IX

MEMBERS OF RESEARCH ADVISORY COMMITTEE

Members

1. Mr. Sanjay Jayavarthanavelu, Chairman cum Managing Director, Lakshmi Machine Works Limited, Coimbatore (Chairman)
2. Dr. Prakash Vasudevan, SITRA, Coimbatore (Director)
3. Dr. Anjan Kumar Mukopadhyay, Director, The Bombay Textile Research Association, Mumbai.
4. Dr. Arindam Basu, Director General, Northern India Textile Research Association, Ghaziabad.
5. Shri. S. Dinakaran, Joint Managing Director, Sambandam Spinning Mills Ltd., Salem.
6. Shri. Gopinath Bala, Technical Director, Sri Venatalakshmi Spinners Pvt. Ltd., Udumalpet.
7. Mr.M.N.Subramanian, Director, The Ahmedabad Textile Industry's Research Association, Ahmedabad.
8. The Textile Commissioner, Ministry of Textiles, GoI, Mumbai.
9. Shri. M.Muthupalaniappa, Vice President (Technical), representing Mr. T.Kannan, Thiagarajar Mills Ltd., Madurai.
10. Shri. Sethuramalingam, Chief General Manager, Eveready Spinning Mills, Dindigul.
11. Shri.Prashanth Chandran, Managing Director, Precot Meridian Ltd, Coimbatore.
12. Dr. K.V.Srinivasan, Managing Director, Premier Mills Private Limited, Coimbatore.
13. The Chairman & Managing Director, National Textile Corporation Ltd., New Delhi.
14. Chairman, The Southern India Mills' Association, Coimbatore.
15. The Commissioner of Handlooms and Textiles, Govt. of Tamil Nadu, Chennai.
16. The Director, Central Leather Research Institute, Chennai.
17. The Joint Secretary (R&D), Ministry of Textiles, Government of India, New Delhi.

Invitees

1. Dr.Anbu Kulandainathan, CSIR-Central Electrochemical Research Institute, Karaikudi.
2. Dr.J.Angayarkanni, Head, Dept, of Microbiology,Bharathiar University, Coimbatore
3. Shri.Ashok kumar, Technical Director, Saranya Spinning Mills Pvt Ltd., Namakkal.
4. Shri K.Balasanthanam, MD, Kongoor Textile Process, Tirupur.
5. Shri.C.B.Bhaskaran, Director, Eastern CETP, Angeripalayam
6. Dr.V.R.Giridev, Asst. Professor(Sr. Grade), Dept. of Textile Technology, AC College of Technology, Anna University, Chennai.
7. Dr.S.Gnanapoongothai, Vice-Principal, PSG Institute of Medical Sciences & Research, Coimbatore
8. Shri Kanthimathinathan, President, Patspin India ltd, Palakkad.
9. Shri.W.R.Kesavan, Director, Hydra Consulting Service Private Ltd., Coimbatore.
10. Dr.K.Kumaran, Head, Tamil Nadu Agricultural University, Mettupalayam.
11. Dr. Peer Mohammed, Professor and Head, AC Tech, Anna University, Chennai.
12. Shri S.Rajasekar, Joint Managing Director, Theni Gurukrishna Textile Mills Pvt Ltd., Theni.
13. Dr.R.Rajendran, Associate Professor, Dept. of Microbiology, PSG College of Arts & Science, Coimbatore.
14. Dr.R.Rajkumar, Chief Medical Officer, Kovai Diagnostic Centre, Coimbatore
15. Dr.A.Ramamoorthy, Coimbatore.
16. Dr.T.Ramachandran, Principal, Karpagam Institute of Technology, Coimbatore.
17. Dr.V.Sarveswaran, Sri Ramakrishna Hospital, Coimbatore,
18. Dr.M.Senthil Kumar, Associate Professor, PSG College of Technology, Coimbatore
19. Shri.Sri Hari Prasad, MD, Kadri Wovens, Unit of Kadri Mills, Perundurai.
20. Dr.J.Srinivasan, Professor, Dept of Fashion Technology, Kumaraguru College of Technology, Coimbatore.
21. Dr.V.Subramaniam, Director, Dept. of Textile Technology, Jaya Engineering College, Chennai.
22. Shri.T.R.Subramaniam, Director, Eastern CETP, Tirupur
23. Shri.K.Sudhakaran, Director, Eastern CETP, Veerapandi
24. Shri.Suresh Manoharan, Executive Director, Best Colour Solutions India Pvt. Ltd., Tirupur.
25. Shri.S.Thirumurugan, Marketing Manager, Ponpure Chemicals, Tirupur
26. Dr.Umamaheswari. K, Associate Dean, Dept. of Medical Nanotechnology, School of Chemical & Biotechnology, SASTRA.

ANNEXURE X

COMMITTEES IN WHICH SITRA STAFF REPRESENTED

Chairman, Hosiery Sectional Committee, TX 10, Bureau of Indian Standards, New Delhi.

Chairman, Medical Textiles Committee Tx 36, Bureau of Indian Standards, New Delhi.

Member, Advisory Committee for AIC NIFT TEA incubation centre for Textiles and Apparels.

Co-opted member of Governing Committee, NIFT - TEA.

Member, Sub-committee for manpower planning for the textile engineering industry constituted by India ITME Society, Mumbai.

Member, Project management Committee for Mini Mission III and Mini Mission IV of Jute Technology Mission.

Member, TX 0I & TX 05 Committees, Bureau of Indian Standards, New Delhi.

Member, Panel of Experts for the Constitution of Selection/ Assessment Committees in Textile Technology, National Institute of Science Communication.

Expert member, Board of Studies (BoS) in Textile Technology, Bannari Amman Institute of Technology (Autonomous), Sathyamangalam.

Member, Board of Studies in Textile Technology, PSG College of Technology, Coimbatore.

Member, Council of National Jute Board, Kolkata.

Member, All India Powerloom Board, Ministry of Textiles, Government of India, New Delhi.

Member, Advisory Committee & member, Staff Selection Board, Textile Technology Department, Kumaraguru College of Technology, Coimbatore.

Member, Council of Administration, SIMA Cotton Development & Research Association.

Member, Cotton Advisory Board, Ministry of Textiles, Govt. of India.

Member, Cotton Development & Research Association, New Delhi.

Member, Board of Examiners of Indian Institute of Handloom Technology, Salem.

Member, CII, Southern Region, Textile Sub-committee.

Supervisor, Ph.D & M.Phil. Programmes (Textile Technology), Anna University, Chennai.

Member, Board of Studies (BoS) in Textile Technology (TT) Karpagam University, Coimbatore.

Member, Confederation of Indian Industries (CII), Coimbatore zone.

Member, Board of Governors, Sardar Vallabhbhai Patel International School of Textiles and Management, Coimbatore.

Member, Cotton Selection/Purchase Committee, KVIC, Chitradurga.

Member, Technical Sectoral Expert Committee of Textile Sector under PAT Scheme of Bureau of Energy Efficiency (BEE), New Delhi.

Member Board of Studies (Bos) in Psychology, Bharathiar University, Coimbatore; PSG College of Arts & Science, Coimbatore; Govt. Arts College, Coimbatore; Sri Krishna College of Arts & Science

Member, Board of Studies (BoS) in Textile Technology and Textile Chemistry departments of Anna University, Chennai.

Member, Textiles Speciality Chemicals and Dyestuffs Sectional Committee, TXD 07, Bureau of Indian Standards, New Delhi.

Member - Board of Academic Affairs (BOAA) in Indian Institutes of Handloom Technology

ANNEXURE XI

SITRA MEMBER MILLS

Full Members

1 Acsen Tex P. Ltd.
2 Adwaith Textiles Limited
3 Amaravathi Spinning Mills
4 Amarjothi Spg. Mills Ltd.
5 Anna Co-op. Spg. Mills Ltd.
6 Annamalaiar Mills Private Ltd.
7 B K S Textiles Private Limited
8 B R T Spinnerrs Limited
9 Best Cotton Mills (P) Ltd
10 Cardwell Spinning Mills Limited
11 Chenniappa Yarn Spinners (P) Ltd
12 Chida Spg. Mills (P) Ltd.
13 Coimbatore Polytex Private Ltd.
14 D B V Cotton Mills (P) Ltd.
15 Eastman Spinning Mills (P) Ltd.
16 Emperor Textiles (P) Ltd
17 Ennar Spinning Mills (P) Ltd
18 G T N Industries Ltd
19 G T N Textiles Ltd.
20 G V D Textiles (P) Ltd
21 Gopalakrishna Textile Mills Pvt. Ltd
22 Harshini Textiles Ltd
23 Hindustan Cotton Spinning Mills
24 Jai Sakthi Mills
25 Jay Textiles -Unit II (Super Sales India Ltd.)
26 Jayalakshmi Textiles
27 Jayavarma Textiles (P) Ltd - Unit 2
28 JVS Exports
29 K K P Spinning Mills Ltd
30 Kallam Spinning Mills Ltd
31 Kaveri Yarns and Fabrics Ltd.
32 Kayaar Exports Private Limited
33 Kesharinandan knit fabrics P Ltd
34 L S Mills Ltd.
35 Lakshmi Machine Works Ltd.
36 Madura Coats Private Limited (4)
37 MAG Solvics (P) Ltd
38 Mallur Siddeswara Spg. Mills Pvt. Ltd.
39 Maris Spinners Ltd.
40 Marudhamalai Sri Dhandapani Spinning Mills
41 Narasu's Spg. Mills
42 National Textile Corporation (TN&P) Ltd. (16)
43 Prabath Spinner India
44 Prachidhi Spinners Pvt. Ltd,
45 Precot Meridian Ltd. (5)
46 Premier Mills Private Ltd.
47 Premier Spg. & Wvg. Mills Ltd.
48 S C M Textile Spinners
49 S P Spinning Mills Ltd.
50 S.A. Aanandan Spinning Mills (P) Ltd
51 S.P Apparels - Spinning Unit
52 Sahana Textiles
53 Salona Cotspin Limited
54 Sangeeth Textiles Ltd.
55 Saravana Polythreads (P) Ltd
56 Sarmangal Synthetics Limited
57 Saudagar Enterprise
58 Saurer Textiles Solution-CBE
59 Selvaraja Mills Pvt. Ltd.
60 Senthilkumar Textile Mills Private Limited, Erode
61 Seyadu Spinning mills
62 Shanmugappriya Textiles Ltd.
63 Shiva Mills Limited
64 Shri Cheran Synthetics India Ltd
65 Shri Govindaraja Mills Ltd. - B Unit
66 Shri Ramalinga Mills Ltd.
67 Shri Santhosh Meenakshi Textiles Private Limited
68 Soundararaja Mills Ltd.
69 Southern Spinners and Processors Limited
70 Sowmiya Textiles Private Ltd
71 Sree Ayyanar Spg. & Wvg. Mills Ltd - Unit I (2)
72 Sree Narasimha Textiles (P) Ltd.
73 Sree Satyanarayana Spg. Mills Ltd.
74 SRG Apparels
75 Sri Gomathy Mills Private Limited
76 Sri Kannapiran Mills Ltd.
77 Sri Kannattal Mills P. Ltd.
78 Sri Karthikeya Spg. & Wvg. Mills Ltd.
79 Sri Kumaraguru Mills Ltd.
80 Sri Kumaran Mills Limited.
81 Sri Lakshmi Saraswathi Textiles (Arni) Ltd.
82 Sri Mahasakthi Mills Ltd
83 Sri Muni Pachaiyappan Textiles (P) Ltd.
84 Sri Nachammai Cotton Mills Ltd.
85 Sri Ramakrishna Mills (CBE) Ltd.
86 Sri Ranga Textiles (P) Ltd.
87 Sri Shanmugavel Mills Pvt. Ltd.
88 Sri Sharadhambika Spintex P.Ltd
89 Sri Sivajothi Spg Mills P Ltd
90 Sri Varadaraja Textiles Ltd.
91 Sri Vasudeva Textiles Limited Unit III
92 Sri Venkatalakshmi Spinners (P)Ltd.
93 Sri Vignesh Yarns (P) Limited
94 Super Spg. Mills Ltd. (5)
95 T T Limited (Unit Tirupathi Spinning Mills)
96 The Banhatti Co-op. Spg. Mills Ltd.
97 The Bharathi Co-op. Spg. Mills Ltd.
98 The Kadri Mills (CBE) Ltd. (13)
99 The Lakshmi Mills Co.Ltd. (4)
100 The Palani Andavar Mills Ltd.
101 The Pondicherry Co-op. Spg. Mills Ltd.
102 The Pudukkottai District Co-op Spg Mills Ltd
103 The Rajaratna Mills Ltd. (2)
104 The Ramanathapuram District Co-operative Spg Mills
105 The Southern Textile Ltd
106 The Tamilnadu Handloom Weavers' Co-op.Society Ltd
107 The Tamilnadu Textile Corporation Ltd
108 Tirupur Textiles Private Ltd. (3)
109 Umayal Spinners (P) Ltd
110 Veejay Lakshmi Engineering Works Limited (2)
111 Veejay Syntex Pvt. Ltd.
112 Vijay Velavan Spinning Mills (P) Ltd
113 Vishnu Lakshmi Mills (P) Ltd
114 Viswabharathi Textiles Ltd.

Note: Figures in brackets indicate number of units

ANNEXURE XI (Condt..)

SITRA MEMBER MILLS

Associate Members

1 Br.Sheshrao Wankhede Shetkari Sahakari Soot Girni Ltd
2 Eurotex Industries & Exports Ltd.
3 Ginni Filaments Ltd
4 Gloster Jute Mills Ltd
5 Gujarat Heavy Chemicals Ltd. Unit : Sree Meenakshi Mills
6 Kangwal Textile Company Limited,
7 Loyal Textile Mills Ltd.
8 Maharaja Shree Umaid Mlls Ltd
9 Nagammal Mills Ltd.
10 Nagreeka Exports Ltd.
11 P B M Polytex Ltd. (2)
12 Pee Vee Textiles Limited
13 Pratibha Syntex Limited
14 PT. Indo Liberty Textiles
15 Rajapalayam Mills Ltd.
16 Reliance Industries Ltd.
17 Rieter India (P) Ltd
18 RSB Cottex
19 Sambandam Spg Mills Ltd.
20 Shetkari Sahakari Soot Girni Ltd.
21 Siddhi Industries Limited
22 Sree Valliappa Textiles Ltd.
23 Sri Jayajothi & Co Ltd
24 Sudiva Spinners Private Limited
25 Sumicot Limited
26 The Gobald Textiles Pvt. Ltd.
27 The Suguna Mills Pvt. Ltd.
28 Thiagarajar Mills Ltd. (2)
29 Vardhaman Yarns & Threads Limited
30 Vippy Spinpro Ltd
31 Voltas Ltd.

FINANCIAL STATEMENTS
AS ON
31st MARCH 2020

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

COIMBATORE - 641 014

Independent Auditor's Report

To
The Members of The South India Textile Research Association

Report on the Audit of Financial Statements

Opinion

1. We have audited the accompanying financial statements of The South India Textile Research Association ("the Association"), which comprise the Balance Sheet as at March 31, 2020 and the Statement of Income and Expenditure for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

2. In our opinion and to the best of our information and according to the explanations given to us the aforesaid financial statements give a true and fair view of the financial position of the Association as at March 31, 2020 in conformity with the accounting principles generally accepted in India:

   (a) in the case of the Balance Sheet, of the state of affairs of the Association as at March 31, 2020; and

   (b) in the case of the Income and Expenditure Account, of the Excess of Expenditure over Income for the year ended on that date.

Basis for Opinion

3. We conducted our audit in accordance with the Standards on Auditing (SAs) issued by ICAI. Our responsibilities under those standards are further described in the Auditor's responsibilities for the Audit of the Financial Statements section of our report. We are independent of the Association in accordance with the Code of Ethics issued by ICAI and we have fulfilled our other ethical responsibilities in accordance with the Code of Ethics. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Responsibilities of Management and Those Charged with Governance for the Financial Statements

4. Management of the Association is responsible for the preparation of these financial statements that give a true and fair view of the state of affairs and results of operations of the Association in accordance with the accounting principles generally accepted in India. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

5. In preparing the financial statements, management is responsible for assessing the Association's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the Association or to cease operations, or has no realistic alternative but to do so.

6. Those charged with governance are responsible for overseeing the Association's financial reporting process .

Auditor's Responsibilities for the Audit of the Financial Statements

7. Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

8. As part of an audit in accordance with SAs, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

   (a) Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.

   (b) Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Association's internal control.

   (c) Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by management.

   (d) Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Association's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report.

9. We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

Report on Other Requirements

10. Further, we report that:

   (a) We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purpose of our audit.

   (b) In our opinion, proper books of account have been kept by the Association so far as appears from our examination of those books .

   (c) The Balance Sheet and Statement of Income and Expenditure dealt with by this Report are in agreement with the books of account.

For PNRaghavendra Rao & Co.,
Chartered Accountants
Firm Registration Numbe r: 003328S

Sd/- Pon Arul Paraneedharan
Partner
Membership Number: 212860
UDIN: 20212860AAAAET9513

Coimbatore
September 28, 2020

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION
BALANCE SHEET AS AT 31ST MARCH 2020

Amount in "Rs."

Particulars	Schedule No.	2019-20	2018-19
LIABILITIES			
Corpus/Capital Fund	1	2,82,73,102	2,82,67,868
Capital Grant from Ministry	2	39,66,96,265	39,33,43,220
Reserves and Surplus	3	64,12,09,327	60,92,77,658
Current Liabilities and Provisions	4	3,19,07,014	1,76,22,357
TOTAL (A)		**1,09,80,85,708**	**1,04,85,11,103**
ASSETS			
Fixed Assets - Net Block	5 & 6	56,74,89,374	54,65,15,954
Investments	7	40,88,74,332	39,04,08,457
Sponsored Projects - Grant Receivable	8	2,14,07,108	1,67,35,356
Current Assets, loans, Advances etc	9	10,03,14,894	9,48,51,336
TOTAL (B)		**1,09,80,85,708**	**1,04,85,11,103**

"Vide our report of even date"
For P.N.Raghavendra Rao & Co.,
Chartered Accountants
Sd/-
(Pon Arul Paraneedharan)
Partner

UDIN: 20212860AAAAET9513

Place : Coimbatore
DATE: 28/09/2020

(Sd/-) Sanjay Jayavarthanavelu (Chairman)
(Sd/-) Prakash Vasudevan (Director)
(Sd/-) K V Srinivasan

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION
INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH 2020

Amount in "Rs."

Particulars	Schedule No.	2019-20	2018-19
INCOME			
Income from Services	10	9,36,87,982	8,10,44,748
Membership/Ministry Contribution	11	1,73,10,625	1,62,32,050
Sponsored Projects - Overhead Recoveries	12	7,67,186	15,83,574
Interest Income	13	30,48,536	31,71,949
Other Income	14	84,82,906	79,36,179
Closing Stock	15	10,24,671	-
TOTAL (A)		**12,43,21,906**	**10,99,68,500**
EXPENDITURE			
Establishment Expenses	16	8,32,26,674	7,60,09,361
Administrative Expenses	17	1,97,18,044	1,69,83,879
Repairs and Maintenance	18	75,71,491	79,90,728
Stores Consumed	19	47,21,958	33,85,968
Finance Charges	20	25,508	9,742
Sponsored Projects - SITRA Contribution	21	5,36,599	3,65,446
Depreciation	22	89,41,223	85,75,461
TOTAL (B)		**12,47,41,497**	**11,33,20,584**
Balance being excess of Expenditure over Income for the year		(4,19,591)	(33,52,084)
Appropriated from Corpus fund for R&D		2,20,296	2,33,966
Appropriated from Infrastructure Dev. & Maintenance Reserve		18,83,400	10,10,578
Appropriated from Staff Benefit Reserve (Payment of Terminal Benefits & Exgratia)		29,53,923	39,47,584
Paid from Sitra Employee Gratuity Scheme		19,17,407	21,33,199
Appropriated from Depreciation Reserve		8,00,859	6,20,736
Appropriated from General Reserve		-	3,25,920
Balance Surplus		**73,56,294**	**49,19,899**
Transfer to Staff Benefit Reserve		45,00,000	30,00,000
Transfer to Infrastructure Dev. & Maintenance Reserve		25,00,000	15,00,000
Transfer to General Reserve		**3,56,294**	**4,19,899**

"Vide our report of even date"
For P.N.Raghavendra Rao & Co.,
Chartered Accountants
(Sd/-)
(Pon Arul Paraneedharan)
Partner

Place : Coimbatore
DATE: 28/09/2020

(Sd/-) Sanjay Jayavarthanavelu (Chairman)
(Sd/-) Prakash Vasudevan (Director)
(Sd/-) K V Srinivasan

UDIN: 20212860AAAAET9513

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Schedules to Balance Sheet for the year ended 31.03.2020

Amount in "Rs."

Schedules	2019-20	2018-19
Sch - 1		
Corpus/Capital Fund		
Contribution from Member Mills	2,82,67,868	2,80,51,468
Add: Received during the year	3,10,580	2,16,400
	2,85,78,448	2,82,67,868
Less: Profit / (Loss) on Disposal of Assets	(3,05,346)	-
Total	2,82,73,102	2,82,67,868
Sch - 2		
Capital Grant from Ministry		
Cotton Textile Fund Committee	12,53,791	12,53,791
Council of Scientific and Industrial Research	22,69,513	22,69,513
MOT/Office of the Textile Commissioner - Spon Projects	11,56,54,538	11,25,55,515
Ministry of Textiles - Sponsored CAD Centre	48,82,780	48,82,780
Ministry of Textiles - Centre of Excellence - Meditech	21,38,45,815	21,35,91,793
MOT/Office of the Textile Commissioner - PLSC	5,87,89,828	5,87,89,828
Total	39,66,96,265	39,33,43,220
Sch - 3		
Reserves & Surplus		
General Reserve	24,67,39,317	21,26,04,964
Asset Stabilisation Reserve	3,18,96,843	5,90,67,102
Corpus fund for Research and Development Reserve	10,43,73,738	9,75,40,861
Infrastructure Development and Maintenance Reserve	6,65,13,697	6,49,13,589
Staff Benefit Reserve - SITRA	3,46,50,407	3,06,95,082
Staff Benefit Reserve - PLSC	1,90,84,951	1,51,44,302
Depreciation Reserve Invt.Interest	13,79,50,375	12,93,11,757
PLSC/CAD Centre Reserve	(60,00,817)	(67,91,193)
Less: Transferred to Sitra General Reserve	60,00,817	67,91,193
Total	64,12,09,327	60,92,77,658
Sch - 4		
Current Liabilities & Provisions		
Current Liabilities		
Unspent grant		
Unspent grant - SITRA	23,66,072	42,12,217
Unspent grant - COE	4,25,365	5,91,559
Advance from Debtors	76,72,235	54,33,302
Creditors for Purchases & Capital Goods	1,45,27,621	11,19,453
Creditors For Expenses	19,83,016	17,57,723
Total (A)	2,69,74,309	1,31,14,254
Provisions		
ISDS Provision for Expenses	-	3,95,468
Provision for Expenses -SITRA	34,77,693	25,49,965
Provision for Expenses - COE	10,92,796	4,43,675
Provision for Expenses - PLSC	3,62,216	11,18,995
Total (B)	49,32,705	45,08,103
Total (A + B)	3,19,07,014	1,76,22,357

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Schedules to Balance Sheet for the year ended 31.03.2020

Amount in "Rs."

Schedules	2019-20	2018-19
Fixed Assets		
Sch - 5		
Gross Assets		
Lands	7,83,712	7,83,712
Building - SITRA	3,70,33,494	3,47,27,334
Building - COE	8,51,76,526	8,51,76,526
Building - WIP	9,24,480	11,46,164
Plant and Machinery	17,01,59,613	14,38,32,940
Furniture & Fittings	80,48,192	80,00,752
Computer And Accessories	1,10,07,493	1,03,72,219
Library	32,47,521	30,89,489
Vehicle	14,89,840	14,89,840
Total	**31,78,70,871**	**28,86,18,976**
Sch - 6		
Fixed Assets under Sponsored Projects		
The South India Textile Research Association	7,31,53,124	7,28,85,051
Integrated Skill Development Scheme	2,42,91,138	2,42,91,138
Centre of Excellence - Meditech	22,70,02,901	22,67,32,518
Powerloom Service Centre	5,94,10,975	5,93,81,209
Total	**38,38,58,138**	**38,32,89,916**
Total Gross Block	**70,17,29,009**	**67,19,08,892**
Depreciation Reserve		
Depreciation Reserve - Building	1,94,76,588	1,72,78,219
Depreciation Reserve - Computer & Accessories	34,22,838	31,43,604
Depreciation Reserve - Furniture And Fixtures	29,59,963	27,85,852
Depreciation Reserve - Plant & Machinery	8,15,41,553	7,63,33,001
Depreciation Reserve - Vehicles	5,77,160	5,07,725
Depreciation Reserve - Library	12,15,173	9,24,504
Depreciation Reserve - ISDS	58,90,247	52,63,920
Depreciation Reserve - PLSC & CAD	1,91,56,113	1,91,56,113
Total	**13,42,39,635**	**12,53,92,938**
Net Block	**56,74,89,374**	**54,65,15,954**
Sch - 7		
Investments		
Depreciation Reserve Investment - SITRA	20,44,22,767	20,19,53,024
Corpus Reserve for Research and Development Investment	7,86,82,491	7,76,93,864
Infrastructure Development & Maintenance Reserve Investment	5,81,23,267	6,16,02,639
Staff Benefit Reserve Investment - SITRA	1,53,23,787	1,97,22,122
Staff Benefit Reserve Investment - PLSC	66,87,896	28,27,327
General Reserve Investment - SITRA	3,97,31,882	2,41,09,481
General Reserve Investment - PLSC	59,02,242	25,00,000
Total	**40,88,74,332**	**39,04,08,457**
Sch -8		
Sponsored Projects - Grant Receivable		
As per Schedule	2,14,07,108	1,67,35,356
Total	**2,14,07,108**	**1,67,35,356**

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION
Schedules to Balance Sheet for the year ended 31.03.2020

Amount in "Rs."

Schedules	2019-20	2018-19
Sch - 9		
Current Assets, loans, Advances etc		
Sundry Debtors		
Sundry Debtors	76,09,043	89,23,821
Total	**76,09,043**	**89,23,821**
Inventories		
Raw Materials	9,41,643	-
Finished Goods	10,24,671	-
Total	**19,66,314.00**	-
Cash & Bank Balances		
Cash on Hand	58,091	85,027
Cash at Bank	59,70,152	20,95,636
Cash at Bank Sponsored Project	28,65,696	56,73,564
Total	**88,93,939**	**78,54,227**
Loans & Advances		
Deposits - Others	36,73,265	26,89,404
Interest Receivable	5,26,64,084	4,02,08,779
Advances for Purchases and Others	1,03,52,626	1,95,83,442
GST Input Credit	27,42,696	29,45,472
Tax Deducted at Source	1,24,12,927	1,26,46,191
Total	**81845598**	**78073288**
Grand Total	**100314894**	**94851336**

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Schedules to Income and Expenditure Account for the year ended 31.03.2020

Amount in "Rs"

Schedules	2019-20	2018-19
Sch - 10		
Income from Services		
Testing and Investigation Fee	8,91,96,910	7,62,49,713
HRD Education Receipts	35,78,708	46,28,721
Publication Income	9,12,364	1,66,314
Total	**9,36,87,982**	**8,10,44,748**
Sch - 11		
Membership/Ministry Contribution		
From Ministry of Textiles	1,10,00,000	1,00,00,000
From Membership Contribution	60,37,713	60,05,941
From Technical Service Card Membership Fees	2,72,912	2,26,109
Total	**1,73,10,625**	**1,62,32,050**
Sch - 12		
Sponsored Projects - Overhead Recoveries	7,67,186	15,83,574
Total	**7,67,186**	**15,83,574**
Sch - 13		
Interest Income		
Interest Income from Investment and Advances	30,48,536	31,71,949
Total	**30,48,536**	**31,71,949**
Sch - 14		
Other Income		
Rent Receipts	27,54,775	28,37,783
Miscellaneous Income	24,05,790	41,92,744
Allocation of Expenses incurred by SITRA for PLSC	10,23,192	9,05,652
Allocation of Expenses incurred by SITRA for COE	22,99,149	-
Total	**84,82,906**	**79,36,179**
Sch - 15		
Closing Stock		
Finished Goods	10,24,671	-
Total	**10,24,671**	-
Sch - 16		
Establishment Expenses		
Salary and Other Allowances	7,69,64,399	7,25,49,849
Payment towards Terminal benefits	25,81,309	49,50,608
Sitra Contributory PF and other Funds	56,74,407	44,20,626
	8,52,20,115	8,19,21,083
Less: a) Allocated to Ministry Sponsored Projects	17,06,291	39,11,042
b) Allocatd to Internal Project from Corpus Fund for R&D Reserve	2,87,150	10,12,707
c) Allocated to ISDS	-	9,87,973
Total	**8,32,26,674**	**7,60,09,361**

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Schedules to Income and Expenditure Account for the year ended 31.03.2020

Amount in "Rs"

Schedules	2019-20	2018-19
Sch - 17		
Administrative Expenses		
Travelling Expenses	15,92,683	16,78,172
Printing & Stationery	9,78,171	8,30,233
Publication Expenses	9,78,743	1,42,982
Postage, Telegrams and Telephone Charges	11,84,910	12,35,424
Journals and Periodicals	2,43,163	4,91,774
Electricity Charges	69,87,686	71,20,428
Insurance	6,71,572	11,04,723
Rent, Rates and Taxes	9,54,392	6,03,759
Advertisement Charges	1,01,024	44,800
Training Course Expenses	5,21,332	5,37,330
Conferences, Seminars and Meetings	10,84,838	9,35,110
Professional Charges	7,20,987	6,50,282
Office Expenses	4,02,802	6,18,207
Testing expenses	6,06,918	8,54,092
Allocation of Expenses incurred by SITRA for COE	22,99,149	-
Provision for Doubtful Debts & Bad Debts Written off	3,89,674	1,36,564
Total	**1,97,18,044**	**1,69,83,879**
Sch - 18		
Repairs & Maintenance		
Maintenance of Motor Cars and Vehicles	42,140	60,806
Maintenance of Machinery	48,43,660	60,73,308
Maintenance of Building & Staff Quarters	26,61,767	16,17,681
Maintenance of Furniture and Office Equipments	23,924	2,38,932
Total	**75,71,491**	**79,90,728**
Sch - 19		
Stores Consumed	56,63,601	33,85,968
Less: Closing Stock of Raw material	9,41,643	-
Total	**47,21,958**	**33,85,968**
Sch - 20		
Finance Charges		
Bank Charges and Commission	25,508	9,742
Total	**25,508**	**9,742**
Sch - 21		
Sponsored Projects - SITRA Contribution	5,36,599	3,65,446
Total	**5,36,599**	**3,65,446**

"Vide our report of even date"

Place : Coimbatore
DATE: 28/09/2020

For P.N.Raghavendra Rao & Co.,
Chartered Accountants
Sd/-
(Pon Arul Paraneedharan)
Partner

(Sd/-) Sanjay Jayavarthanavelu (Chairman)
(Sd/-) Prakash Vasudevan (Director)
(Sd/-) K V Srinivasan

UDIN: 20212860AAAAET9513

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Schedules to Balance Sheet for the year 2019 - 2020

DEPRECIATION FOR THE YEAR 2019 - 2020

Schedule 22

Amount in "Rs."

S.No.	Name of the Asset	COST				DEPRECIATION				WDV	
		Value as on 01.04.2019	Additions During 2019-2020	Deletion During 2019-20	Value as on 31.03.2020	Depreciation As on 01.04.2019	Deletion During 2019-20	Depreciation for the year 2019-20	Depreciation As on 31.03.2020	Closing W.D.V As on 31.03.2020	W.D.V As on 31.03.2019
1	Land	7,83,712	-	-	7,83,712	-	-	-	-	7,83,712	7,83,712
2	Library	30,60,673	1,38,060	-	31,98,733	9,23,200	-	2,88,954	12,12,154	53,99,237	55,50,131
3	ISDS - Library	34,12,659	-	-	34,12,659						
4	Building	3,39,05,249	23,06,162	-	3,62,11,411	1,04,30,963	-	4,17,665	1,08,48,628	2,67,34,148	2,56,23,627
	Building WIP	11,46,164	3,68,188	11,46,164	3,68,188						
5	ISDS - Building Renovation	10,03,177	-	-	10,03,177						
6	Auditorium	5,03,235	-	-	10,59,527	2,23,590	-	4,558	2,28,148	8,31,379	2,79,645
	Dining Shed WIP		5,56,292								
7	Staff Quarters	2,37,543	-	-	2,37,543	1,16,895	-	1,967	1,18,862	1,18,681	1,20,648
8	Furniture	50,73,042	47,440	-	51,20,482	26,10,646	-	1,64,441	27,75,087	47,95,072	49,12,073
9	ISDS - Furniture	24,49,677	-	-	24,49,677						
10	Sitra Furniture at PLSC	27,685	-	-	27,685	18,077	-	321	18,398	9,287	9,608
11	Machinery	12,44,41,640	2,66,03,616	-	15,10,45,256	7,47,19,947	-	50,57,683	7,97,77,630	11,18,22,302	9,02,76,369
	Machinery WIP		-	-							
12	Sponsored Projects - Assets	4,05,54,676	-	-	4,05,54,676						
13	ISDS - Machinery	1,34,70,102	-	-	1,34,70,102	40,55,376	-	4,84,858	45,40,234	89,29,868	94,14,726
14	ISDS-PSC-Machinery	36,00,001	-	-	36,00,001	11,11,897	-	1,28,137	12,40,034	23,59,967	24,88,104
15	ISDS - Machinery Phase II	3,55,523	-	-	3,55,523	96,647	-	13,332	1,09,979	2,45,544	2,58,876
16	Sitra Machinery at PLSC	4,33,949	-	-	4,33,949	2,41,189	-	9,927	2,51,116	1,82,833	1,92,760
17	Computer	83,33,829	3,87,274	-	87,21,103	31,43,604	-	2,79,234	34,22,838	52,98,265	51,90,225
	ERP WIP	20,38,390	2,48,000	-	22,86,390	-	-	-	-	22,86,390	20,38,390
18	Motor Cars	13,78,119	-	-	13,78,119	4,59,787	-	64,926	5,24,713	8,53,406	9,18,332
19	Motor Cycles & Scooters	1,11,721	-	-	1,11,721	47,938	-	4,509	52,447	59,274	63,783
20	CoE Building Electrical Equipments	1,31,46,233	-	-	1,31,46,233	18,87,203	-	3,76,052	22,63,255	1,08,82,978	1,12,59,030
21	COE Building	8,51,76,526	-	-	8,51,76,526	50,55,743	-	13,22,447	63,78,190	7,87,98,336	8,01,20,783
22	COE Furniture & Fixtures	26,17,044	-	-	26,17,044	3,51,164	-	75,680	4,26,844	21,90,200	22,65,880
23	COE Assets	62,04,222	2,38,901	4,95,872	59,47,251	7,42,959	94,526	2,46,532	8,94,965	50,52,286	54,61,263
						-					
	Sponsored Projects -Assets					-					
24	UNDP Jute Project Machinery	1,32,01,739	-	-	1,32,01,739	-	-	-	-	1,32,01,739	1,32,01,739
25	COE Assets	22,67,32,518	2,70,383	-	22,70,02,901	-	-	-	-	22,70,02,901	22,67,32,518
26	Assets under Sponsored Projects - SITRA	1,91,28,636	2,68,073	-	1,93,96,709	-	-	-	-	1,93,96,709	1,91,28,636
27	PLSC Assets	5,93,81,209	29,766	-	5,94,10,975	1,91,56,113	-	-	1,91,56,113	4,02,54,862	4,02,25,096
	Total	**67,19,08,892**	**3,14,62,155**	**16,42,036**	**70,17,29,009**	**12,53,92,938**	**94,526**	**89,41,223**	**13,42,39,635**	**56,74,89,374**	**54,65,15,954**

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Schedules to Balance Sheet for the year 2019 -2020

Financial Status of Sponsored Projects : 01/04/2019 - 31/03/2020

Schedule 8 & 21

Amount in "Rs."

Sl. No	Name of Sponsored Project	Opening Balance 2019-20		Receipts			Expenditure as at 31.03.2020 Recurring & Non Recurring			Total Expenditure as at 31/03/2020	Balance as at 31/03/2020 IA / SITRA		Balance as at 31/03/2020 MOT	
		Industry	Ministry	MOT/IA Contribution	Revenue/ Appropriation	Total Receipts	Industry	SITRA	MOT		Unspent	Due	Unspent	Due
1	**Ministry of Textile Sponsored Research Projects**													
a	Development of Special wound care Dressing made of PVA/ chitosan	-	(36,221)	-	-	(36,221)	-	-	-	-	-	-	-	(36,221)
b	Design and Fabrication of an Instrument to Evaluate Resistance of Medical Face Masks to Penetration by High Velocity Stream of Blood from a Punctured Wound	-	(13,99,631)	-	1,141	(13,98,490)	-	-	-	-	-	-	-	(13,98,490)
c	Design and fabrication of an instrument to evaluate the characteristics of fluid handling capacity of wound care dressings	-	(15,01,368)	-	452	(15,00,916)	-	-	-	-	-	-	-	(15,00,916)
d	Development of a Heat and Moisture Exchange Filter	-	(14,44,851)	-	1,075	(14,43,776)	-	-	-	-	-	-	-	(14,43,776)
e	Development of Indigeneous Viral Barrier Fabric	(15,00,000)	(11,57,239)	-	1,427	(26,55,812)	-	-	-	-	-	(15,00,000)	-	(11,55,812)
f	Development of a Anterior Cruiate Ligaments (ACL) using Textile Matrices	-	(14,62,373)	-	1,132	(14,61,241)	-	-	-	-	-	-	-	(14,61,241)
g	Development of Nanoparticle based transdermal patches of selected cardiovascular drugs	-	(12,99,947)	-	1,139	(12,98,808)	-	-	-	-	-	-	-	(12,98,808)
h	Polyester Vascular Graft Implant- Process Optimization and Production Scale up	-	(18,27,994)	-	3,999	(18,23,995)	-	-	-	-	-	-	-	(18,23,995)
i	Development of Eco Clothing by greener reduction process of Natural Indigo Dye	2,81,491	2,46,684	4,32,000	-	4,32,000	5,15,617	97,534	6,53,471	12,66,622	1,00,340	-	-	(4,06,787)
		(12,18,509)	**(98,82,940)**	**4,32,000**	**10,365**	**(1,11,87,259)**	**5,15,617**	**97,534**	**6,53,471**	**12,66,622**	**1,00,340**	**(15,00,000)**	**-**	**(1,05,26,046)**

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Schedules to Balance Sheet for the year 2019 -2020

Financial Status of Sponsored Projects : 01/04/2019 - 31/03/2020

Schedule 8 & 21 — **Amount in "Rs."**

Sl.No.	Name of Sponsored Project	Opening Balance 2019-2020	Receipts		Expenditure Recurring		Capital -	Total Expenditure As At 31/03/2020	Refunded/Transfer to Reserve	Balance as at 31/03/2020			
			Funds Received during the year	Revenue / Appropriation	IA	MOT	MOT			IA / SITRA Unspent	IA / SITRA Due	MOT Unspent	MOT Due
1	Ministry sponsored powerloom service centre receipts	-	1,14,00,000		(3,11,84,065)	1,14,00,000	-	(1,97,84,065)	-	-	-	-	-
2	Tamilnadu Skill Development Programme Commissioner of Backward Classes	(1,78,780)	-	-	-	-	-	-	-	-	-	-	(1,78,780)
3	SITRA Integrated Skill Development Scheme - DPR-3	3,47,468	-	7,308	-	1,66,516	-	1,66,516	1,88,260	-	-	-	-
4	Samarth - Scheme for capacity building in Textile Sector	-	2,24,160	-	-	25,586	-	-	-	-	-	1,98,574	-
6	International Training Programme	(24,19,413)	56,59,860	-	-	83,29,239	-	83,29,239	-	-	-	-	(50,88,792)
7	**CoE Projects**												
i	Office of the Textile Commissioner												
	a) Development of Collagen coated hernia mesh	(2,40,000)	-	-	-	-	-	-	-	-	-	-	(2,40,000)
	b) Development of Moppings pads using non woven & Woven structure	(2,40,000)	-	-	-	-	-	-	-	-	-	-	(2,40,000)
ii	Design & Development of an instrument to assess the puncture resistance of surgical material by using sharp edged puncture probe/syringe needles	(5,08,377)	-	14,667	-	14,598	92,017	1,06,615	1,63,742	-	-	-	(7,64,067)
iii	Development of nanofibrous membrane for wound healing by controlled release of Indian Honey & Curcumin	(1,68,761)	-	892	-	32,376	-	32,376	-	-	-		(2,00,245)
iv	Dev of Novel, Biodegradable Adult Incontinence device	(1,18,057)	-	14,629	-	1,67,527	1,36,500	3,04,027	(4,07,455)	-	-	-	-
v	Dev of Total Comfort Index paradigm for textile structures	(8,08,713)	-	160	-	11,91,510	-	11,91,510	-	-	-	9,644	(20,09,707)
vi	To Identify the Potability of drinking water from Poor Sanitation - Foldscope Scheme	(11,500)	4,00,000	2,015	-	1,34,146	-	1,34,146	2,56,369	-	-		-
vii	Development of Leukodepletion Filter - Sree Chitra Tirunal Institute	3,37,500	-	5,648	-	2,09,213	-	2,09,213	-	-	-	1,33,935	-
viii	Medical Textile products identified by INMAS for wound healing and radio protective equipment based on textiles - DRDO	2,54,059	2,50,000	12,371	-	2,09,274	25,370	2,34,644	-	-	-	2,81,786	-

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Schedules to Balance Sheet for the year 2019 -2020

Financial Status of Sponsored Projects : 01/04/2019 - 31/03/2020

Schedule 8 & 21

Amount in "Rs."

Sl.No.	Name of Sponsored Project	Opening Balance 2019-2020	Receipts		Expenditure Recurring		Capital -	Total Expenditure As At 31/03/2020	Refunded/Transfer to Reserve	Balance as at 31/03/2020			
			Funds Received during the year	Revenue / Appropriation						IA / SITRA		MOT	
					IA	MOT	MOT			Unspent	Due	Unspent	Due
8	**SITRA DST & Inhouse Project**												
i	Durable Non-Fluorinated Functional Textiles using Fumed Silica Sols	2,25,964	4,35,654	14,130	5,654	9,16,277	-	9,21,931	-	-	-	-	(2,46,183)
ii	High Productivity hand operated charkhas development - KVIC	2,07,078	7,75,053	4,153		2,74,717	-	2,74,717	-	7,11,567	-	-	-
iii	Research & Development of Waterless Dyeing Process - M/s.Devan Supercriticals Pvt Ltd	25,00,000	-	-	-	-	-	-	25,00,000	-	-	-	-
iv	Warp Knitted Sewing Ring Fabric - Sree Chitra Tirunal Institute	2,51,000	-	2,226	-	-	-	-	-	2,53,226	-	-	-
v	Dev of Cost effective and better fastness dyeing methods for production of Kovai Kora Cotton sarees - Dept of Handlooms & Textiles	5,00,000	3,50,000	8,843	-	8,60,000	-	8,60,000	-	-	-	-	(1,157)
vi	Others - Grant												
	a) Coir Board	(9,500)	-	-	-	-	-	-	-	-	-	-	(9,500)
	b) NSTT Project	(3,79,631)	-	-	-	-	-	-	-	-	-	-	(3,79,631)
	c) National Accredation Lab	(23,000)	-	-	-	-	-	-	-	-	-	-	(23,000)
vii	Antioxidant Cosmetoextiles durable non encapsulated Vitamin E Finishes on Textile fabrics and its controlled release study	-	13,05,600	9,745	-	2,05,816	7,165	2,12,981	-	-	-	11,02,365	-
		(4,82,663)	**2,08,00,327**	**96,787**	**(3,11,78,411)**	**2,41,36,794**	**2,61,052**	**(68,06,151)**	**27,00,916**	**9,64,793**	**-**	**17,26,303**	**(93,81,062)**

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Centre of Excellence Medical Textiles
Balance Sheet as at 31st March 2020

Annexure

Amount in "Rs."

31.03.2019 Rs.	LIABILITIES	Rs.	31.03.2020 Rs.	31.03.2019 Rs.	ASSETS	Rs.	31.03.2020 Rs.
	CAPITAL GRANT				**FIXED ASSETS**		
20,86,18,778	Contribution from Ministry-Opening	21,35,67,864		22,67,32,518	- Ministry Grant	22,70,02,901	
49,73,015	Additions during the year	2,77,951	21,38,45,815	62,04,222	- Others	59,47,251	23,29,50,152
63,78,942	Interest Opening balance	-			**CURRENT ASSETS**		
16,28,442	Add: Earned during the year	24,064		9,36,203	Sundry Debtors		7,36,651
80,07,384		24,064		28,850	Loans & Advances		15,100
77,57,126	Less: Refund to MoT	-		6,65,126	Advances for Purchases & others		29,29,390
2,50,258	Transfer to Various Grant	24,064	-	16,54,368	Bank Balance		27,06,119
-					Investment		10,00,000
					Inventories		
					Raw Material		9,41,643
					Finished Goods		10,24,671
5,91,559	Unspent Grant		4,25,365		**SITRA - RESERVE ADJUSTMENT**		
				1,05,74,327	Asset Stabilization Reserve	1,07,93,256	
	RESERVES & SURPLUS			7,61,212	Staff Benefit Fund Reserve	9,78,178	
7,42,959	Depreciation Reserve	8,94,965		1,17,590	SITRA Group Gratuity Scheme	1,17,590	
1,13,77,884	Appropriation for Capital Expenditure	1,15,96,813		9,56,063	Infrastructure & Main. Reserve	9,56,063	
	Staff Benefit Reserve	5,00,000		2,94,711	Depreciation Reserve	5,52,382	
8,24,386	General Reserve - SITRA	5,19,040	1,35,10,818	23,86,776	General Reserve	23,86,776	
				17,51,578	Corpus Fund for R & D Reserve	19,99,628	1,77,83,873
	CURRENT LIABILITIES:						
3,37,69,078	Branch & Divisions	3,89,39,770		35,95,408	Sponsored Projects - Grant Receivable		49,54,019
5,25,778	Advance from debtors	20,70,526					
4,35,668	Creditors for Purchases & Capital Goods	7,41,028			**INCOME & EXPENDITURE ACCOUNT**		
4,43,675	Creditors for Expenses	10,92,796	4,28,44,120	49,41,010	Opening Balance	56,43,828	
					Less: Excess of Income over		
				7,02,818	ExpenditureIncome for the year	59,328	55,84,500
26,23,02,781	**Total**		**27,06,26,118**	**26,23,02,781**	**Total**		**27,06,26,118**

"Vide our report of even date"

For P.N.Raghavendra Rao & Co.,
Chartered Accountants
Firm Registration No:003328S

Place : Coimbatore
Date : 28.09.2020

(Sd/- Pon Arul Paraneedharan)
Partner
Membership.no.212860

Sd/- Sanjay Jayavarthanavelu
(Chairman)

Sd/-Prakash Vasudevan
(Director)

Sd/- K V Srinivasan

UDIN: 20212860AAAAET9513

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Centre of Excellence Medical Textiles

Income & Expenditure Account for the year ended 31st March 2020

Annexure

31.03.2019 Rs.	EXPENDITURE	Rs.	31.03.2020 Rs.	31.03.2019 Rs.	INCOME	31.03.2020 Rs.
92,07,512	Establishment Expenses	88,74,493		80,86,161	Testing & Investigation Fees	1,28,02,074
5,38,000	Add: Provision for Gratuity & Leave salary	5,34,000				
97,45,512		94,08,493		14,63,955	HRD Education Receipts	8,22,084
26,89,651	Less : Allocated to Sponsored Projects	7,68,491				
	Less: Paid from Group Gratuity Scheme			-	Ministry Contribution	16,50,000
	Transfer to Corpus fund for R&D Reserve					
3,68,271	(Internal Projects)	2,48,050				
66,87,590			83,91,952	-	Closing Stock	10,24,671
32,427	Training Course Expenses		21,762			
3,05,378	Travelling Expenses		6,31,388	5,37,264	Sponsored Projects - Overhead Recoveries	1,05,000
6,22,561	Stores Consumed		25,01,114			
-	Less: Closing Stock of Raw Materials		(9,41,643)	38,586	Interest Income	33,823
1,25,491	Building Repairs & Maintenance		62,370			
10,85,328	Maintenance of Machinery		7,97,434	2,85,000	Other Receipts	19,875
76,870	Printing & Stationery		54,576			
1,00,944	Office Expenses		2,83,032			
15,14,272	Electriciy Charges		8,16,954			
4,47,626	Insurance		1,89,796			
57,664	Postage & Telephone charges		51,703			
16,000	Professional Fees		59,500			
6,16,873	Testing Expenses		3,45,989			
	Allocation of Expenses incurred by SITRA for COE		22,99,149			
14,906	Sponsored Projects - IA Contribution		4,33,358			
2,31,174	Depreciation		3,74,402			
-	Excess of Income over Expenditure Income for the year c/o		**84,691**	**15,24,137**	Excess of Expenditure over Income Income for the year c/o	-
1,19,35,103	**Total**		**1,64,57,527**	**1,19,35,103**	**Total**	**1,64,57,527**

INCOME & EXPENDITURE APPROPRIATION ACCOUNT

31.03.2019 Rs.	EXPENDITURE	Rs.	31.03.2020 Rs.	31.03.2019 Rs.	INCOME	31.03.2020 Rs.
15,24,137	Excess of Expenditure over Income Income for the year c/o			-	Excess of Income over Expenditure for the year b/f	**84,691**
-	**Excess of Income Over Expenditure Transferred**		**5,59,328**	1,49,117	Appropriated from Depreciation Reserve-SITRA	2,57,671
-	Transferred to Staff benefit Reserve	5,00,000		3,25,920	Appropriated from General Reserve-SITRA	-
-	Transferred to General Reserve	59,328		1,17,590	Paid from Sitra Employee Gratuity scheme Fund-SITRA	-
				2,28,692	Appropriated from Staff Benefit Reserve-SITRA	2,16,966
				7,02,818	Excess of Expenditure Over Income Transferred	-
15,24,137			**5,59,328**	**15,24,137**		**5,59,328**

"Vide our report of even date"

Place : Coimbatore
Date : 28.09.2020

For P.N.Raghavendra Rao & Co.,
Chartered Accountants
(Sd/- Pon Arul Paraneedharan)
Partner
UDIN: 20212860AAAAET9513

(Sd/-) Sanjay Jayavarthanavelu
(Sd/-) Prakash Vasudevan
(Sd/-) K V Srinivasan

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Ministry of Textiles Sponsored Powerloom Service Centres

BALANCE SHEET AS AT 31st March 2020

Annexure

Amount in "Rs."

31.03.2019	LIABILITIES		31.03.2020	31.03.2019	ASSETS		31.03.2020
Rs.		Rs.	Rs.	Rs.		Rs.	Rs.
5,87,89,828	**CONTRIBUTION FROM GOVERNMENT AND GOVERNMENT DEPARTMENTS**	5,87,89,828		5,96,53,814	**FIXED ASSETS (AT COST)**		5,96,83,580
-	Add: Interest received from MOT funds	-	5,87,89,828	25,00,000	**Investments**		59,02,242
					ADVANCES AND DEPOSITS		
	PLSC/CAD CENTRE - GENERAL RESERVE			11,63,782	Sundry Deposits	11,63,782	
(83,33,484)	Closing Balance		(78,74,387)	6,87,121	ISDS - Salary & Other Expenses	-	
				2,28,078	Advances for Purchase & Others	1,77,937	
	STAFF BENEFIT RESERVE APPROPRIATION FOR TERMINAL BENEFITS					-	
				34,490	Tax Deducted at Source		
93,16,975	**Opening Balance**	1,19,85,696		1,59,311	Duties & Taxes	-	13,41,719
-	Add: Provision for Staff Benefit Expenses for the year	-					
30,00,000	Add: Transfer of Balance Surplus	5,00,000			**CURRENT ASSETS**		
3,31,279	Less: Staff Terminal Benefits Apportioned for the year	(88,641)		39,375	Cash on Hand	24,976	
1,19,85,696	**Closing Balance**	1,23,97,055	1,23,97,055				
				15,57,480	Cash at Bank	6,39,020	
	PSC RESERVE APPROPRIATION FOR CAPITAL EXPENDITURE			16,71,570	Provisions - Income	-	
18,73,570	Opening Balance	18,73,570		1,78,780	Grant Receivable	1,78,780	
	Add: Current year Utilisation	-	18,73,570	96,330	Sundry Debtors	1,49,488	9,92,264
	CURRENT LIABILITIES						
11,18,560	Creditors for Expenses	5,67,324					
435	Creditors for Purchase & Capital Goods	61,896					
25,35,526	Branches & Divisions	21,04,520	27,33,740				
6,79,70,131	**Total**		**6,79,19,806**	**6,79,70,131**	**Total**		**6,79,19,806**

"Vide our report of even date"

For P.N.Raghavendra Rao & Co.,
Chartered Accountants
Firm Registration No:003328S

(Sd/- Pon Arul Paraneedharan)
Partner
Membership.no.212860

UDIN: 20212860AAAAET9513

Place : Coimbatore
Date :28/09/2020

Sd/- Sanjay Jayavarthanavelu (Chairman)

Sd/- Prakash Vasudevan (Director)

Sd/- K V Srinivasan

THE SOUTH INDIA TEXTILE RESEARCH ASSOCIATION

Ministry of Textiles Sponsored Powerloom Service Centres

Income & Expenditure Account for the year ended 31st March 2020

Annexure

31.03.2019	EXPENDITURE	31.03.2020	31.03.2019	INCOME	31.03.2020
Rs.		Rs.	Rs.		Rs.
1,22,65,598	Salaries	1,20,73,166	1,14,00,000	Revenue Grant from Ministry	1,14,00,000
40,02,975	General office expenses	38,47,069	1,27,55,727	Income from Services	91,61,396
32,21,817	Rent, Rate & Taxes	31,74,635	1,71,796	Interest on Bank and other deposits	1,81,766
2,78,636	Spares, store & Consumbles	83,105			
19,09,196	AMC/Maintenance of Equipement	9,63,300			
26,49,301	Excess of Income over Expenditure for the year c/o	6,01,887			
2,43,27,523	**Total**	**2,07,43,162**	**2,43,27,523**	**Total**	**2,07,43,162**
35,13,718	**Balance Surplus**	9,59,097	26,49,301	Excess of Income over Expenditure for the year b/f	6,01,887
30,00,000	Transfer to Staff Benefit Reserve - PLSC	5,00,000	3,31,279	Appropriated from Staff Benefit Reserve - Provision for Terminal Benefits-PLSC	88,641
5,13,718	Transfer to PLSC/CAD Centre Reserve	4,59,097	5,33,138	Appropriated from Staff Benefit reserve for payment of Terminal Benefits - SITRA	2,68,569
35,13,718		**9,59,097**	**35,13,718**		**9,59,097**

"Vide our report of even date"

Place : Coimbatore
Date :28/09/2020

For P.N.Raghavendra Rao & Co.,
Chartered Accountants
Firm Registration No:003328S
(Sd/- Pon Arul Paraneedharan)
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