Studies On Swelling And Stretching Of Cotton Yarns With Particular Reference To Their Structure And Tensile Properties

G.R.Poongodi [1], Y.C.Radhalakshmi [2], and V.Subramaniam [3]

[1] *Research. Scholar- Visveshwaraya Technological University, Belgaum, Karnataka.*;

[2]. *Scientist (C), CSR&TI, Mysore.*

[3] *Director, Department of Textile Technology, Jaya Engg. College, Chennai* .

Abstract

The processing sector in the textile field has a major responsibility of embellishing the properties of the textile fibres, yarns, fabrics. The chemical processing activities are dependent on various variables such as temperature, pH, time, concentration, etc. Innovative modifications to improve the strength of yarns by any means were being the study area for many researchers. This work was also conducted to develop methods and techniques for improving the performance of cotton yarns. It would be interesting to study the effect of swelling in alkali and subsequent stretching on the yarns characteristics for they compared with the swelling of conventional yarns and compact yarns in sodium hydroxide and stretching them to different levels with a view to studying the effects of these treatments on structural and tensile properties of the yarns.

Keywords : *Swelling, Stretching, Minimum twist of cohesion, Decrystallisation,Wickability.*

1. Introduction

Development of stronger yarns by any modifications which would increase the efficiency of the machines and also enhance the appearance and durability of the product is always welcome. The swelling behaviour of cellulosic yarns with various chemical reagents has been the subject of research for several years.The effect of varying degrees of stretch on physical properties of various cotton yarn during mercerization was studied and reported by main workers ***Panday And Nair***[(3)]. ***Kim*** et al also was also investigated the effect of stretch mercerization on cotton fibers in roving form.The mechanical properties of the yarns made from stretch mercerized rovings were compared with those of yarns made of untreated fibers and slack mercerized fibers. A study of effect of various chemical treatments and strain hardening on inter fibre cohesion property of cotton yarns has been carried out by ***Subramaniam et al*** .[(6)]

This paper is concerned with the effect of swelling and stretching treatments on conventional and compact yarns provided from cotton fibres. This study was conducted to develop methods and techniques for improving the performance of cotton yarns . A great deal of research was carried out on swelling and stretching of yarns in various media. With the introduction of new types of yarns such as compact yarns, it will be interesting to study the effect of swelling in alkali and subsequent stretching of conventional and compact yarns in sodium hydroxide on the yarn characteristics.

2. EXPERIMENTAL

2.1 Materials

- 30 Ne count regular and compact yarn.
- Sodium hydroxide pellets for preparing a mercerizing solution of 18% concentration.
- A custom built stretching device with a capability of stretching 4 leas simultaneously.

2.1.1 Fabrication of Stretching device

The stretching device consists of two square metallic plates, containing the hooks for fixing the lea, of which one is moveable and the other, a fixed one. There is a threaded central rod with a round handle at the top for rotating the rod. A metal scale is attached to this plate, for measuring the stretch being given.

Specifications of the instrument;

- Total height of instrument = 100 cm.
- Maximum gauge length= 90 cm.
- Top and bottom plate dimensions= 20cm*18cm
- Threaded rod diameter = 2.54 cm(1 inch)
- Bush diameter = 6 cm.

Figure-1: **Stretching Device**

2.2 Methods

2.2.1 Swelling and Stretching Treatment

The yarn samples(conventional and compact) in lea form were immersed in aqueous alkali solution of 18% concentration with a liquor ratio of 1:20 for 5 minutes at room temperature .After this swelling treatment, the yarns were subjected to subsequent stretching with the stretching device at various levels like 101% ,103% and 105%. The stretching was given to the yarns in alkaline condition for about six hours followed by washing and drying for about 10 hours in the stretched condition.

2.2.2 Test Methods

1. Yarn tenacity and elongation
2. Determination of crystallinity of fibres.
3. Minimum twist of cohesion.
4. Wickability.
5. Scanning Electron Microscope Analysis.

Tenacity and Elongation

Tenacity and breaking elongation of the treated and stretched samples were measured on Instron tensile tester at a gauge length of 250mm. The Strain rate was chosen as 40mm/min.The testing was carried out at an ambient conditions at 27 deg temp and 65% RH.

Crystallinity

The structural changes that occurred in the cotton fibers following stretch were investigated by X-ray diffraction studies.The cyrstallinity of the stretched yarns was calculated from X-ray diffraction techniques. The yarn sample was scanned by reflection method. The yarn was cut and made into fine powder passed through a 300 mesh and made into circular pellet weighting 100mg making use of special die. The powdered sample was scanned between 2ɵ angle 8^0 and 30^0.The cryastallinity was calculated using Segal's formula.

Minimum Twist of Cohesion

The cohesion phenomena in yarns merits serious consideration as it has a direct effect on the yarn's properties, particularly yarn strength. The minimum twist of cohesion, in twist per meter (tpm) is inversely proportional to the square root of the number of fibres in the cross section of the roving. The minimum twist of cohesion increases with micronaire index . An instrument based on Barella's technique was designed and fabricated. The instrument consisted of upper and lower jaws, and a specimen length of 25cm was fixed, and the tension was kept at 0.1 gm / Tex. The Minimum of Twist of Cohesion is given by the following expression .

MTC = (Number of turns present in the yarn) -- (Number of turns removed from the yarn) X 100 / (Number of turns present in the yarn).

Wickability

The effect of the above treatment on wicking property of the yarns were also Studied using vertical wicking test as per AATCC.

Scanning Electron Microscope

SEM photographs of fibres (both controlled and stretched) are shown in fig. The photographs serve as a proof for the swell ability of compact yarn is more than ring yarn.

3. RESULTS AND DISCUSSIONS

3.1.Discussions on ring yarn response to the treatment

The results show that compact yarns display a significant improvement in tenacity over conventional yarns following swelling and stretching treatments. It is seen that the elongation percentage slight increase on mercerizing, and on subsequent stretching there is a drastically reduction in it. There is no significant difference in reduction level of elongation percentage due to various levels of stretching.The inter fibre cohesion was found to be better in compact yarns than in conventional yarns. It is seen that the MTC value slightly increases on mercerization, on different levels of stretching the MTC values decreases. As MTC values decreases it indicates the improvement in inter fibre cohesion. The above graph reveals that as stretch % increases (at the level of 105%) there is positive sign in inter fibre cohesion. This supports the inference of previous strength parameter also.From X-ray studies it is interesting to note that there is a prominent drop in crystallinity % of cotton fibre of both conventional and compact yarns which shows decrystallisation has been taken place. This swelling and subsequent stretching treatment also enhances the wick ability property of cotton yarns to a distinct extent. It is been observed that that the wickabity of the yarn increases on Mercerization and further it is been enhanced on following stretching. From this it interesting to note that absorbency of yarns can be improved by this strain hardening phenomenon

3.2 Discussions on compact yarn response to the treatment

. It is seen that the elongation percentage slight increase on mercerizing, and on subsequent stretching there is a drastically reduction in it. There is no significant difference in reduction level of elongation percentage due to various levels of stretching. It is seen that the MTC value slightly increases on mercerization, on different levels of stretching the MTC values decreases. As MTC values decreases it indicates the improvement in inter fibre cohesion. The above graph reveals that as stretch % increases (at the level of 105%) there is positive sign in inter fibre cohesion. This supports the inference of previous strength parameter also. On different levels of stretching the MTC values decreases even below normal yarn level.It is been observed that that the wickabity of the yarn increases on Mercerization and further it is been enhanced on following stretching. From this it interesting to note that absorbency of yarns can be improved by this strain hardening phenomenon.

3.3. Comparison on ring and compact yarns response:

We see that while untreated samples of both compact and normal yarn have almost same elongation %, in mercerised samples, compact yarn has higher value and in mercerized and stretched samples at different levels than regular yarns.It is seen that the MTC value slightly increases on mercerization, on different levels of stretching the MTC values decreases. At various stretch levels and the values are high for regular yarn than that of compact yarn.

Observations:

Regular Yarn **Table:1**

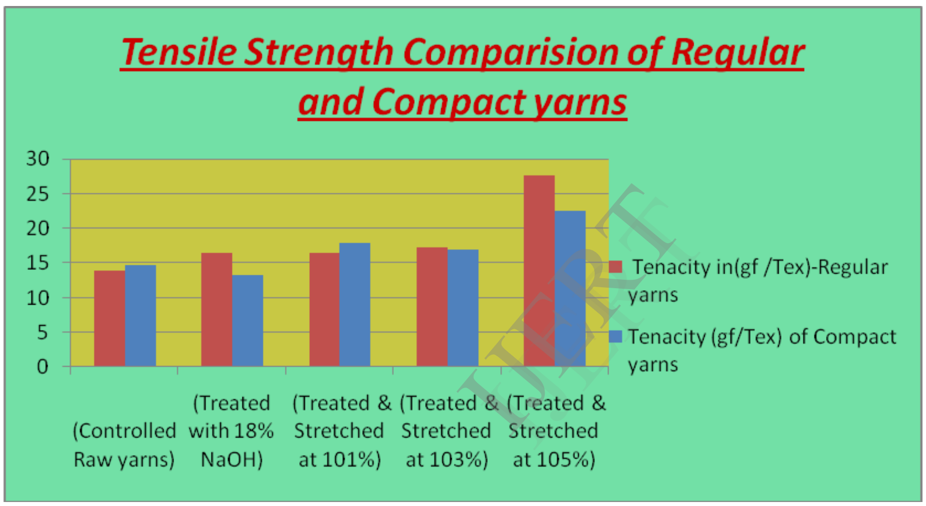
Type of yarn	Count in Ne (Tex)	Tenacity In g/Tex	Elongation in %	Intial Modulus g/Tex	MTC	Crystallinity %	Wickability Time mins fr 5cm height
R1 (Raw)	19.63	13.85	15.9	52.0	65	62.53	206.57
R2(Treated with 18% NaOH)	21.8	16.4	25.3	19.6	67	51.23	175.00
R3 (Treated & Stretched at 101%)	19.6	16.46	9.5	56.0	65	54.11	156.24
R4 (Treated & Stretched at 103%)	18.4	17.3	11	41.7	60	58.46	147.15
R5 (Treated & Stretched 105%)	17.8	27.6	9.7	81.0	49	52.96	138.06

Compact yarn **Table:2**

Type of yarn	Count in Tex	Tenacity In g/Tex	Elongation in %	Intial Modulus g/Tex	MTC	Crystallinity %	Wickability Time mins fr 5cm height
C1 (Raw)	19.6	14.64	15.3	21.19	60	64.12	197.46

C2(Treated with 18% NaOH)	24.6	13.25	24.5	21.9	63	53.78	174.48
C3 (Treated & Stretched at 101%)	19.6	17.93	10.2	72.9	54	52.96	150.44
C4 (Treated & Stretched at 103%)	18.4	16.9	8	90.1	52	51.92	144.00
C5 (Treated & Stretched at 105%)	17.8	22.49	8.3	81.0	47	50.87	137.33

Tensile Strength Comparison Chart :1



Minimum Twist of Cohesion – Regular yarns & Compact Yarns _Chart :2

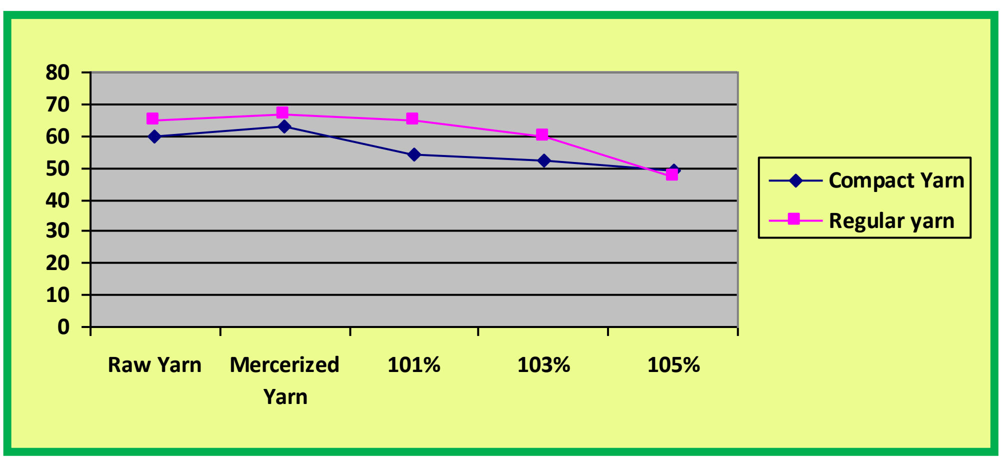


Chart:3

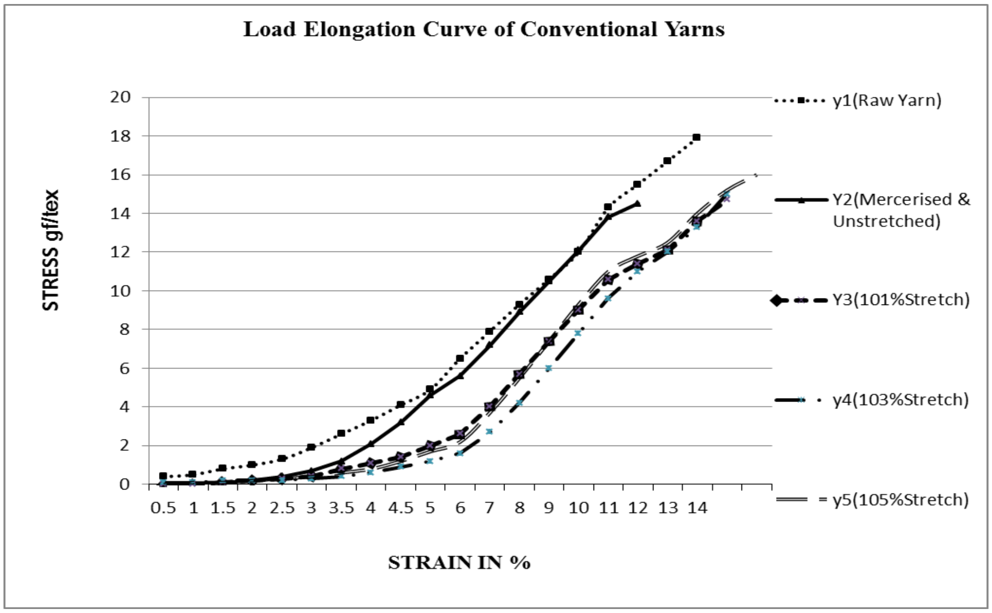


Chart:4

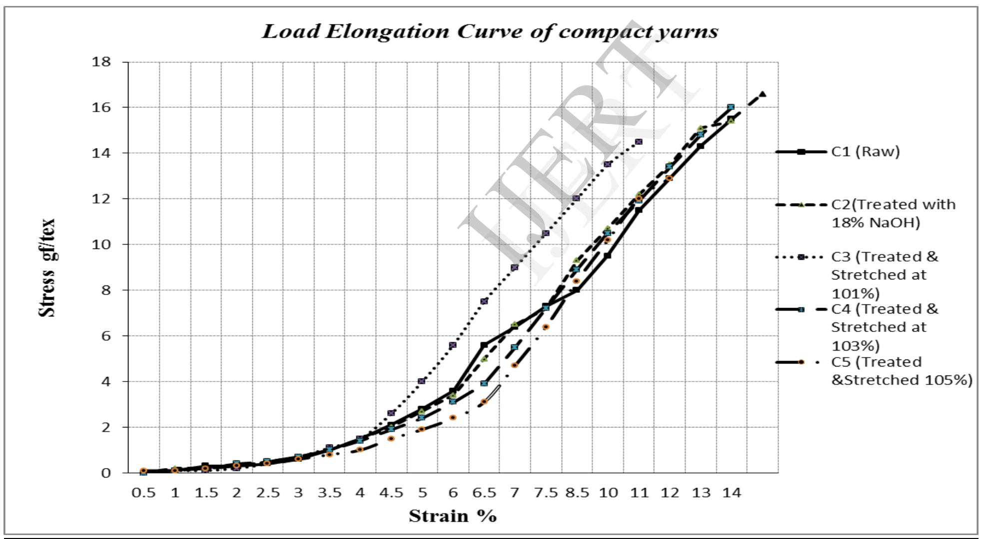


Chart:5

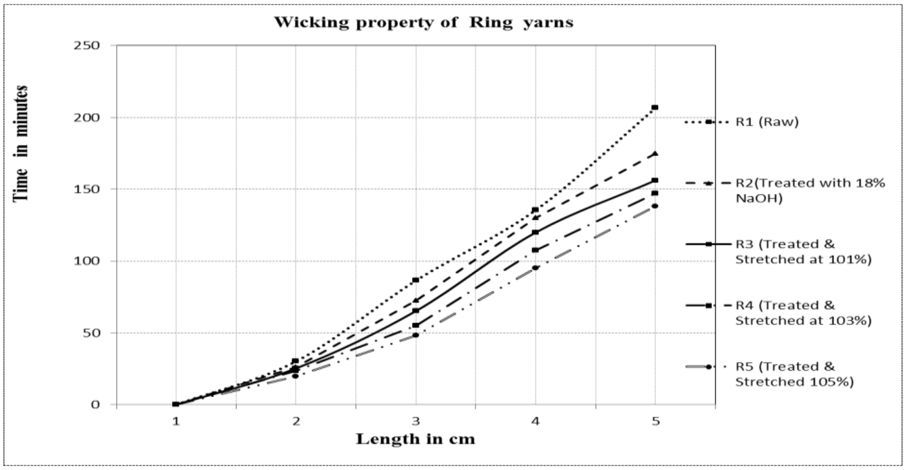
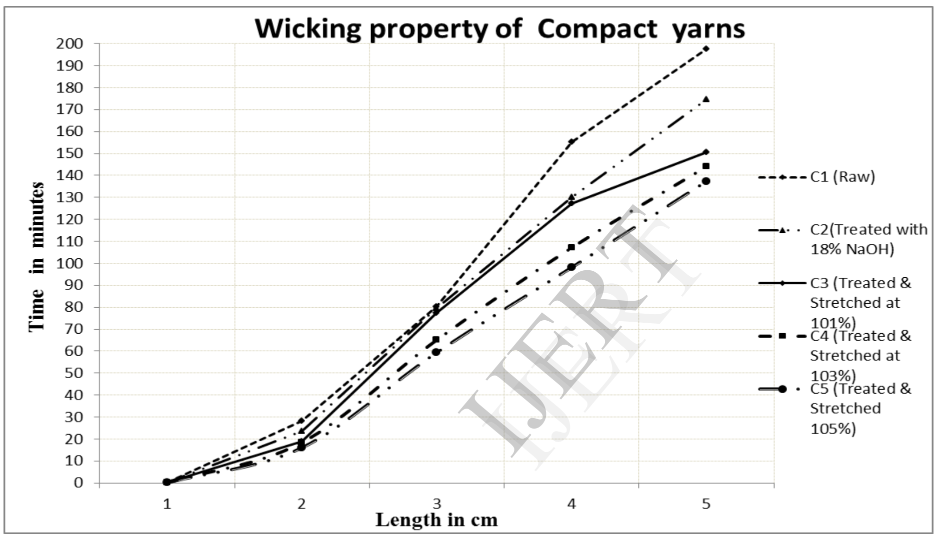
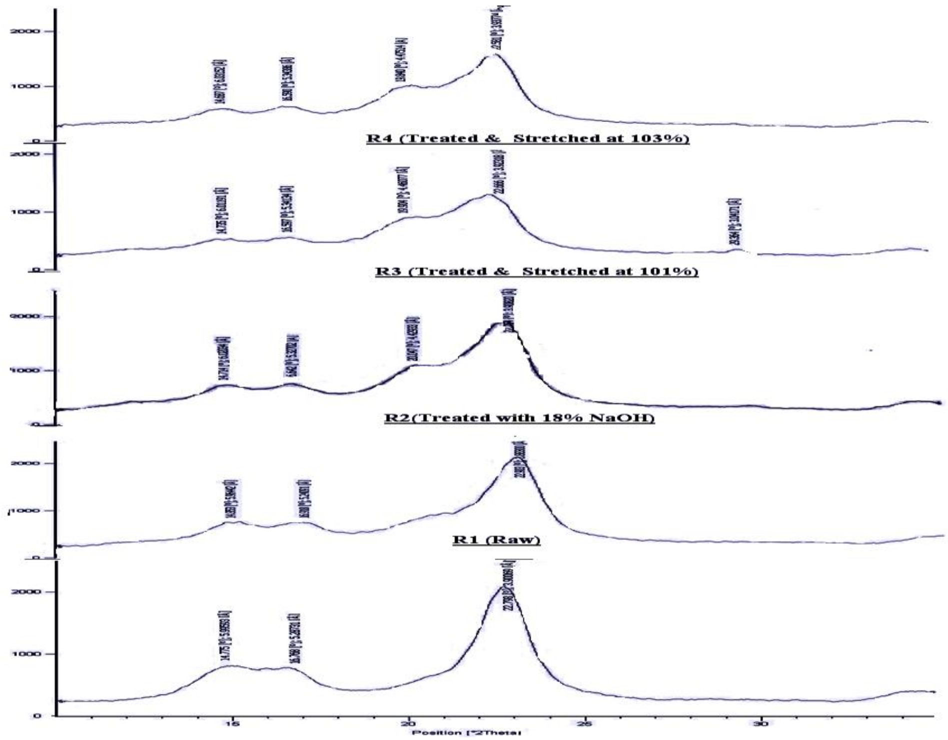


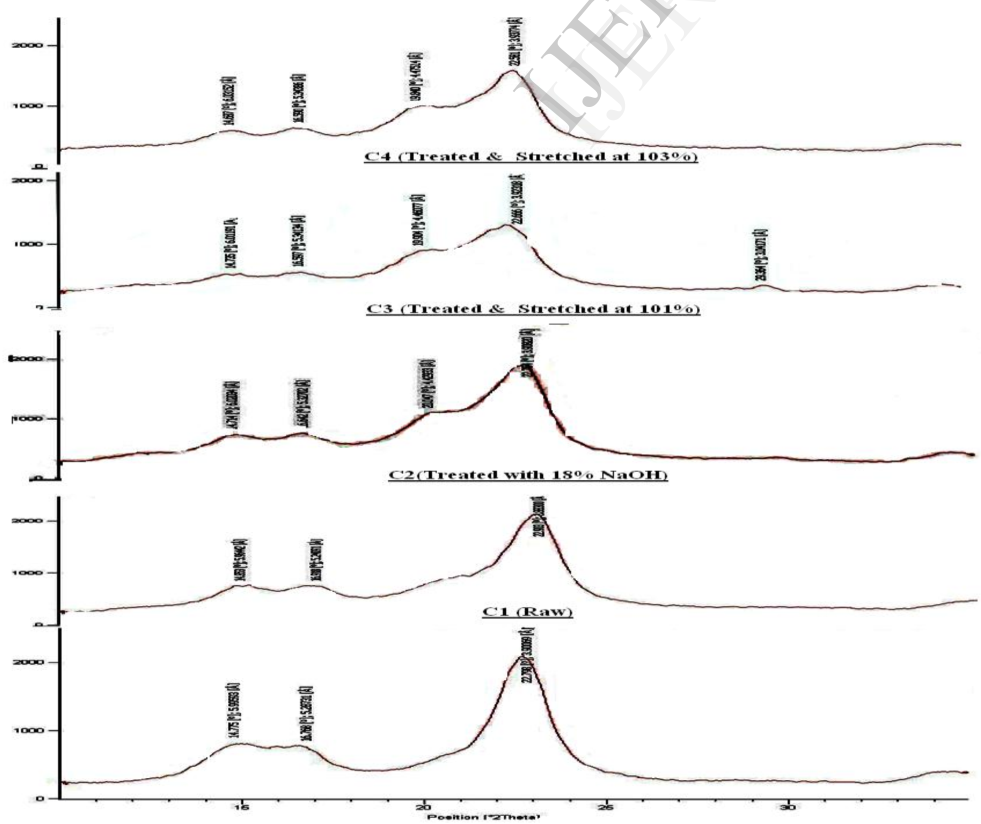
Chart:6



Impact of stretching on crystallinity in ring yarns **Chart: 7**



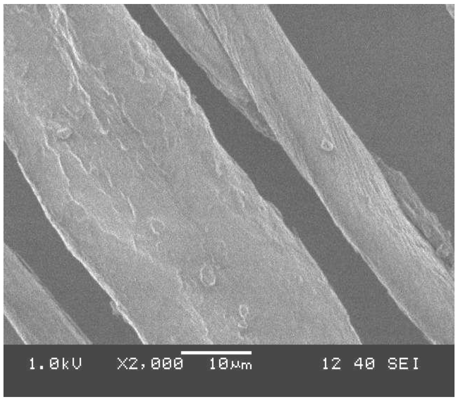
Impact of stretching on crystallinity in compact yarns **Chart: 8**



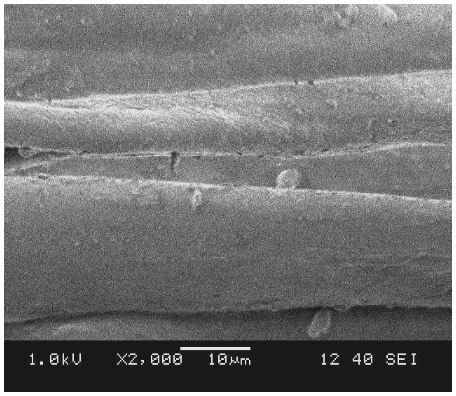
ISSN: 2278-0181
Vol. 2 Issue 2, February- 2013

SEM PHOTOGRAPHS – Compact yarns

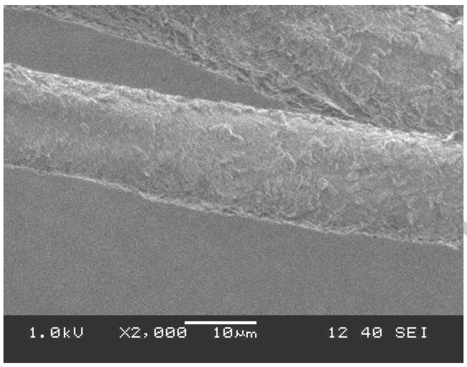
C1(Controlled,Untreated)



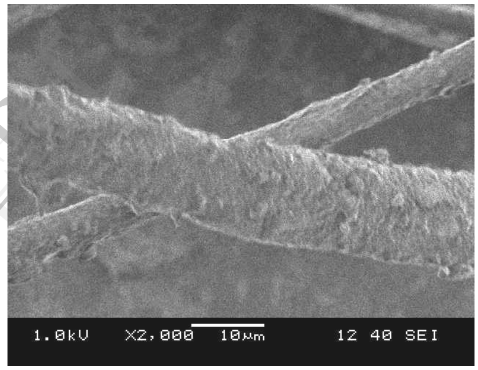
C2(Mercerised)



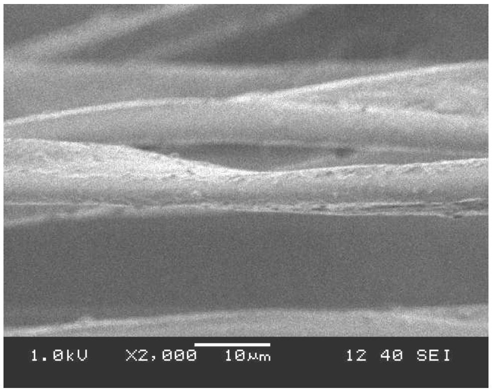
C3(Stretched 100%)



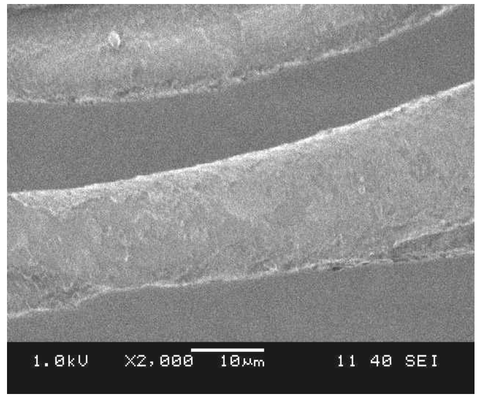
C4(Stretched101%)



C5(Stretched 103%)

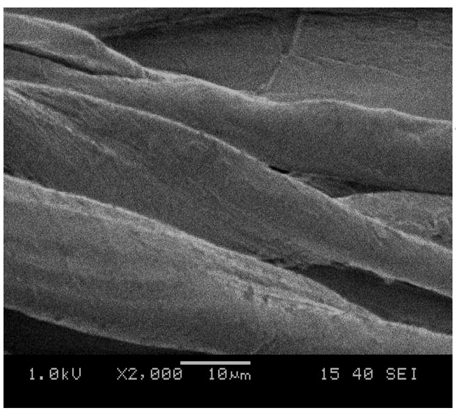


C6(Stretched104%)

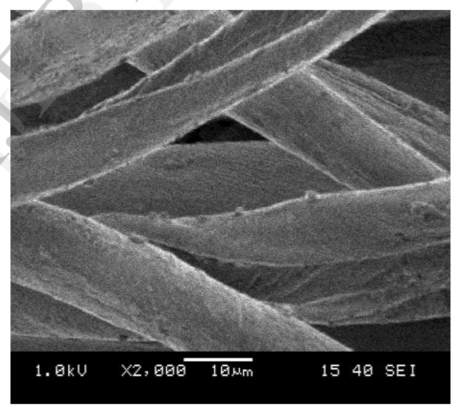


SEM PHOTOGRAPHS – Regular yarns

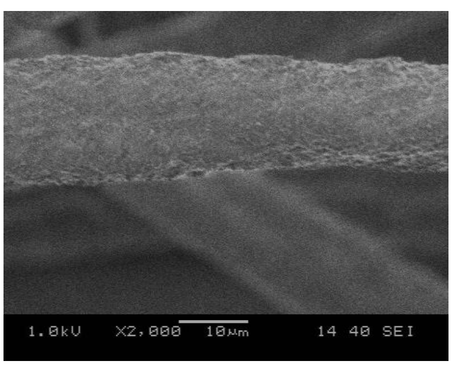
R1(Controlled,Untreated)



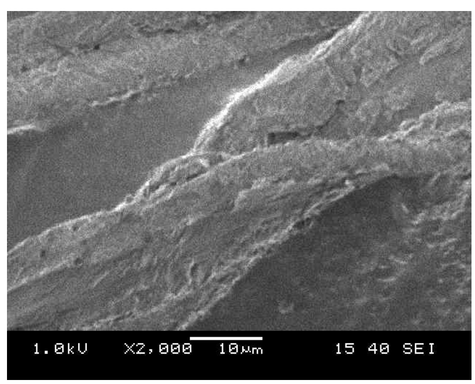
R2 (Mercerised)



R3(Stretched100%)

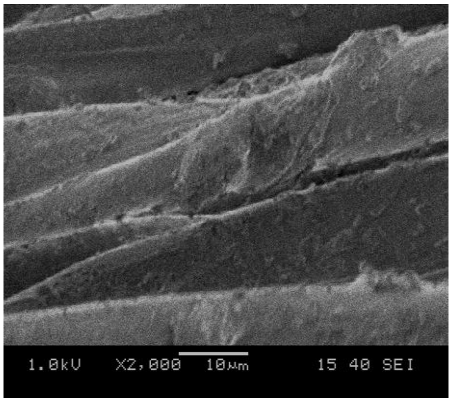


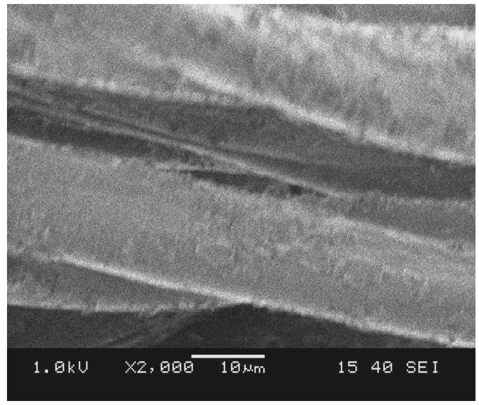
R4(Stretched 101%)



R5(Stretched 103%)

R6 (Stretched104%)





4. Conclusions

Compact yarns shrink more than normal yarns but at the same time are able to stretch back to the same length as that of normal yarns. The tenacity of both ring and compact yarn are seen to be improved on stretching. The result shows that as stretch increases there is a considerable increase in tenacity .The elongation % increases on mercerizing, and then decreases on stretching. In case of MTC values also the compact yarns shows much response to stretching treatments. The decrease in MTC values shows that there is betterment in inter fibre cohesion of the yarn structure. Decrystallisation has been taken place after stretching which elucidate there might be enhancement in absorbency property of yarns. The stretching treatment has a positive impact on wicking property of the yarns.

Reference :

1. Y.K. Kim,Tae Jin Kang ,A.M. Seyam ,Aly El-Shiekh (1984) 'Stretch Mercerization of Cotton Fibers' *Textile Research Journal*, Vol. 54, No. 5, 325-330
2. Muncheul Lee and Myung Sun Lee, Tomiji Wakida and Aya Hayashi, Susumu Okada and Yuichi Yanai (2002) 'Liquid Ammonia Treatment of Nylon 6 Fabric' *Textile Research Journal* ; 72; 539
3. S.N. Pandey ,P. Nair (1987) 'Mercerized and Crosslinked Cotton Yarns- Part II: Effect of Stretching During Mercerization on Physical Properties and Degradation of Crosslinked Yarns' *Textile Research Journal*, Vol. 57, No. 9, 532-538
4. Tomiji Wakida, Kyoko Kida, Muncheul Lee, Soyeung Bae, Hiromu Yoshioka and Yuichi Yanai(2002) 'Dyeing and Mechanical Properties of Cotton Fabrics Treated with Sodium Hydroxide/Liquid Ammonia and Liquid Ammonia/Sodium Hydroxide' *Textile Research Journal* ;70; 328
5. L.M. Zhou, K.W.P. Yeung and C.W.M. Yuen(2002), 'Effect of NaOH Mercerization on the Crosslinking of Ramie Yarn Using 1,2,3,4-Butanetetracarboxylic Acid' *Textile Research Journal*; 72; 531
6. Dr.V.Subramaniam, N.Gokarneshan, N. Anbumani (2007), 'Influence of Chemical Treatments on Inter-Fibre Cohesion in Yarns', *AUTEX Research Journal*; Vol 7; No. 1.