

SINGEING AND MERCERIZATION EFFECT OF 100% COTTON COMBED RING-SPUN ON SOME PROPPERTIES OF THE TWISTED YARN

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ABSTRACT

In this study twisted yarns were exposed to different preparations in order to determine the effect of such preparations on some properties at the same yarn count of the yarns. 100% cotton yarns Giza 86 no. 50/ 2 ring – spun combed yarn have been used without any preparation . The singeing process of the yarn was carried out using three speeds of singeing, 800 m/min - 900 m/min -1000 m/min and a mercerizing process under tensile using three degrees of concentration of NaOH: 26° Be - 30° Be - 34° Be then a singeing-mercerization process was carried out at the same singeing speeds and degrees of NaOH concentration in order to determine the effect of such preparations on the properties of tensile strength, tenacity and elongation as well as to measure the diameter of the yarn and the circular diameter of all of them at the same yarn count 50/2. One of the most important findings of the study is that singeing has given lower values for tensile strength, elongation and tenacity than the values recorded by the sample without any preparation. It also led to a decrease in yarn diameter and an increase in its circularity because of the removal of hairiness interlaced on the yarn surface. In the mercerization process, the results recorded the highest tensile strength and tenacity of the yarns in comparison to the rest of the samples due to the absorption of NaOH , the yarn diameter has decreased and its circularity increased. The singeing-mercerization process recorded a decrease in tensile strength, elongation and tenacity of the yarns in comparison to those mercerized only because the yarns were singed before mercerization. Yarn diameter also decreased and its circularity increased compared to control sample. It was observed an increase in the luster of singed-mercerized yarn compared to the mercerized only. There is no luster in the singed yarns only with no preparations, and all the yarns were yellowish in all treatments.

Keywords: *Circular Diameter, Mercerization, Singeing, Yarn Diameter, Yarn Properties.*

I. INTRODUCTION

Ring spun yarn is one of most widely applied yarns in textile industry [1] There are many preparing processes applied to ring spun yarns depending on the type of the used yarn , from theses preparing processes : singeing , [2,3] mercerization , dyeing ,sizing[4,5] and bulking process [6] However, microscopy analysis has shown that some fibers protrude from the stem of the yarn and these fiber called hairiness [1-3] Hairiness is removed by



singeing,[2,3,5,7] waxing, application of lubricant, enzyme treatment and sizing [7] During singeing process the yarn is passed through a gas or electric burner. Size of the flame and setting between yarn and flame must be carefully chosen to prevent scorching and damage to material [7 , 8] A few researches studied singeing processes and singeing fundamentals . Some of these researches makes a comparison between compact and combed ring spun yarn 100% cotton and another research studies the effect of yarn singeing on 100% viscose ring- spun yarn , most of them use the single yarn . All of these researches proved that there is an effect on some properties of yarn such as hairiness , where the hairiness and elongation decreases after the treatment [2,3,9] . while the tenacity increases in viscose [3] and the tensile strength decreases in the cotton compact [3] and ring – spun yarn [2 ,9] another researches studied fabric singeing , woven[5] and knitting [10,11] In woven the singeing process was applied before the desizing and bleaching processes then the fabric properties were measured [5] A research used the single jersey cotton polyester knit fabric but with different percentages in cotton polyester blended and applied the singeing process then compare the pilling grade measures after and before the singeing process [10] Another research used the single jersey cotton knit fabric in chemical and mechanical singeing and then compare the results of the fabric properties in the two processes [11] Mercerization was carried out in fiber , [12,13] yarn hank [4,9, 14,15,16] and fabric[5,17] using NaOH solution[12-17] it removes waxes ,oil , lignin and pectin from the surface [12,13] after mercerization hairiness was decreased [4 ,9] However, the yarns structural variants considerably influence the reduction in both short and long hairs through mercerization. [4] Lots of researches studied Mercerization process carried out in types of natural fibers like cotton[4,5,] , palm, coconut, sisal, banana, hemp... etc, then measured properties (mechanical , chemical) , [12, 13] from these researches the chemical treatment mercerization [12] and acetylation was used [13, 18] and compare the results before and after the treatments [12, 13,18] a research studied the fabric mercerization using NaOH , liquid ammonia and both of them together where the mercerization used firstly then the liquid ammonia to know the partial conversion of cellulose I to II or cellulose I to III using sum frequency generation (SFG) , X-ray diffraction (XRD) and infrared (IR) , it also studied the physical properties of the fabric and then compare the results for each treatment [17] a group of researches studied the mercerization of yarn whether it is ring , compact[14] O E rotor -spun[4,16] yarn and measure some properties of yarn before and after mercerization . [4,14,16] Most researches studied single yarn singeing only or single yarn mercerization only but this study concerned with twisted yarn singeing , mercerization and singeing- mercerization together and their effect on some twisted yarn properties and knowing its behavior in the mercerization and singeing processes .

2.1 Preparation of yarn samples:

100% cotton combed Giza 86 twisted yarn count 50/2 before and after all preparation .Three preparations were made to them, the process of singeing at three speeds and the process of singeing-mercerization at the same speeds of singeing and three degrees of concentration of NaOH, where the singeing process was carried out first and then the process of mercerizing and finally a mercerizing process only at the same concentration degree of NaOH used in the singeing-mercerization process together



2.1.1 The process of yarn singeing

The process of singeing the hair was carried out by passing the yarns on the direct flames of fire at speeds of 800 m /min -900 m /min -1000 m /min and the machine specifications were as follows:

Machine Model:	ssm Swiss
Machine speed:	1200 m / min
Pressure gas:	27
Pressure air:	12
Yarn count before singeing:	47.9 / 2
Yarn count after singeing:	50/2

The yarn count before singeing was calculated according to following equation:

$$\text{Single yarn count before singeing} = (100 - 4.2) \times \text{the yarn count after the singeing} \dots \dots \dots (1)$$

2.1.2 The process of yarn mercerization:

The yarn were treated with a solution of NaOH a concentration of 26 -30- 34 on a German machine geige model and mercerization specifications were as follows:

Tensile in the immersion stage:	124 cm - 132 cm
Immersion time:	7sec - 1 min
Tensile in the dimensions fixing stage:	132 cm - 136 cm
Time to fix dimensions:	5sec
Tensile the in the washing stage:	136 cm - 138 cm
Washing time:	2.30 min
NaOH concentration :	26° Be - 30° Be - 34° Be separately
NaOH heat degree:	15-18 ° C
The degree of washing:	90-110 ° C
Temperature of the drying oven:	90 -110 ° C
Ph:	7
Diameter of hank before mercerization:	141 cm
Diameter of hank after mercerization:	138 cm
Yarn count before mercerization:	49.30/ 2
Yarn count after mercerization:	50/2

The yarn count before singeing was calculated according to following equation:

$$\text{Single yarn count before mercerization} = (100 - 1.4) \times \text{the yarn count after the mercerization} \dots \dots \dots (2)$$

2.1.3 The process of yarn singeing - mercerization

Yarns from the singeing processes have been used at the same three speeds and then mercerizing was carried out for the singed yarns by using the same degree of concentrations of NaOH and the same specifications used in the two stages:

Yarn count before the singeing -mercerization:	47.20/ 2
Yarn count after the singeing -mercerization:	50/2

Singeing speed and degree of NaOH concentration were as follows:

800 m / min + 34° Be

900 m / min + 30° Be

1000 m / min + 26° Be

Single yarn count before singeing -mercerization = $(100 - 5.6) \times \text{count after the singeing -mercerization} \dots (3)$

Table 1: The properties of the twisted yarns

NO	Specification	Kind of preparation	Yarn count before preparation	Yarn count After preparation	Twist factor	Type spinning
1	control			50/2	4.5	100 % Cotton Ring- spinning Combed
2	800 m / min	Singeing	47.9/2			
3	900 m / min					
4	1000 m / min					
5	800 m /min + 34° Be	Singeing- mercerization	47. 2/2			
6	900 m/ min +30° Be					
7	1000 m /min+26° Be					
8	26° Be	mercerization	49.3/2			
9	30° Be					
10	34° Be					

2.3 Testing and Analysis

Tests were conducted on samples of yarn in the laboratory under standard conditions and a temperature of 20 ± 2 ° C and humidity $65 \pm 5\%$ according to the US ASTM specifications.

2.3.1 Tensile strength, elongation and tenacity

Tensile strength, elongation and tenacity were measured for the yarns before and after any preparations and the test was carried out on the 1,000 meters for each yarn by the device Uster 3

2.3.2 Diameter (2dØ) and shape (circular yarns)

Diameter and circular yarns were measured for the yarns before and after any preparations and the test was carried out on the 1,000 meters for each yarn by the device Uster 4

III. RESULTS AND DISCUSSION

3.1 The effect of singeing, singeing-mercerization and mercerization of twisted yarns on the tensile strength, elongation and tenacity.

i) Table 2 and Fig 1, 2 and 3 show the effect of the three preparation processes on tensile strength, elongation of yarn and tenacity. It was found that the singeing process has caused a decrease of tensile strength, tenacity and elongation of yarn maybe because the process of singeing hair on the surface of the yarn is carried out by exposing yarns to temperatures while passing on the fire flame directly at speeds of 800, 900 and 1000 m /min which affects the cotton material and making it tend to yellowing due to oxidizing part of cellulose and weakening the cellulose links which weakens the tensile strength, elongation and tenacity a little in comparison to the tensile strength, elongation and tenacity of the yarn before being subjected to singeing.

ii) It was found that the mercerization process only using the three concentrations of NaOH 26, 30, 34° Be recorded results of greatest tensile strength of the yarn in this process in comparison to the other processes and the unprepared yarn and was second in decrease of elongation after its decrease in the singeing process and the yarns in this process have luster. This is may be due to that mercerization make fibers swelled and therefore spread the crimps and twists so that the surface becomes regular and smooth increasing light reflection and causes luster. We find that the colour of mercerized yarns change to a yellowish colour as a result of exposure to the temperature of the drying oven and antioxidizing the cellulose. The absorption of NaOH in turn leads to breaking the links between the cellulose chains whereupon free chains re-arrange itself, and when NaOH is removed the chains form new links causing the cohesion of cellulose, which reduces the yarn elongation. Mercerization under tensile which spreads cellulose twists, that make hairs parallel toward the longitudinal axis of the fibres lending more tensile strength and tenacity.

iii) In the singeing-mercerization process, which was carried out in the same singeing degrees and concentration of caustic soda it was found that the results recorded decrease of tensile strength and tenacity after those recorded in the mercerization process and higher than that recorded in the singeing process and the yarn before preparation. This may be due to subjecting the same yarn to singeing process and then mercerization. In the singeing process, the tensile strength decreased because of the reasons previously explained, i.e. they entered mercerization with lower tensile strength and tenacity than those yarns that have entered mercerization without singeing them, so their strength and tenacity decreased lower than the strength and tenacity of the mercerized yarns without an increase in the tensile strength and tenacity for the reasons previously explained. For elongation, the results recorded the lowest percentage in all cases due to carrying out a singeing process and then mercerization that undermined the percentage of elongation at each process of two processes for the reasons previously explained. An increase in yarn luster at this process has been observed as a result of the removal of hairiness and mercerization.


Table 2: The results of testing the twisted yarns count 50/2

No	Specification	Kind of preparation	Tensile strength g.f	Elongation %	Tenacity g/ tex	2dØ Diameter mm	Shape circular diameter
1	Control		537.2	5.64	22.74	0.26	0.73
2	800 m /min	Singeing	507	5.14	21.46	0.24	0.8
3	900 m/ min		481.4	4.81	20.38	0.22	0.8
4	1000 m /min		515	5.06	21.82	0.22	0.8
5	800 m/min+ 34° Be	Singeing - mercerization	617.6	3.88	26.14	0.21	0.8
6	900 m/min +30° Be		626.3	3.99	26.51	0.22	0.8
7	1000 m/min +26° Be		647.3	4.12	27.40	0.25	0.76
8	26Be	mercerization	679.5	3.97	28.77	0.21	0.8
9	30° Be		639.7	4.01	27.08	0.21	0.8
10	34° Be		707.4	4.07	29.95	0.25	0.8

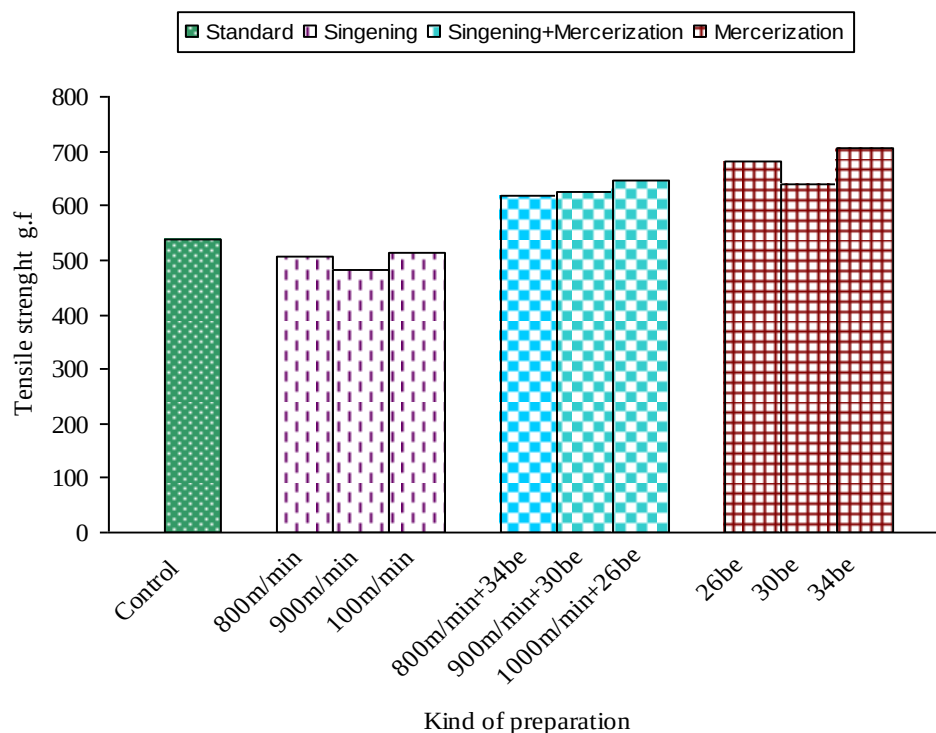


Figure 1. Effect of different preparations on the twisted yarn tensile strength g.f

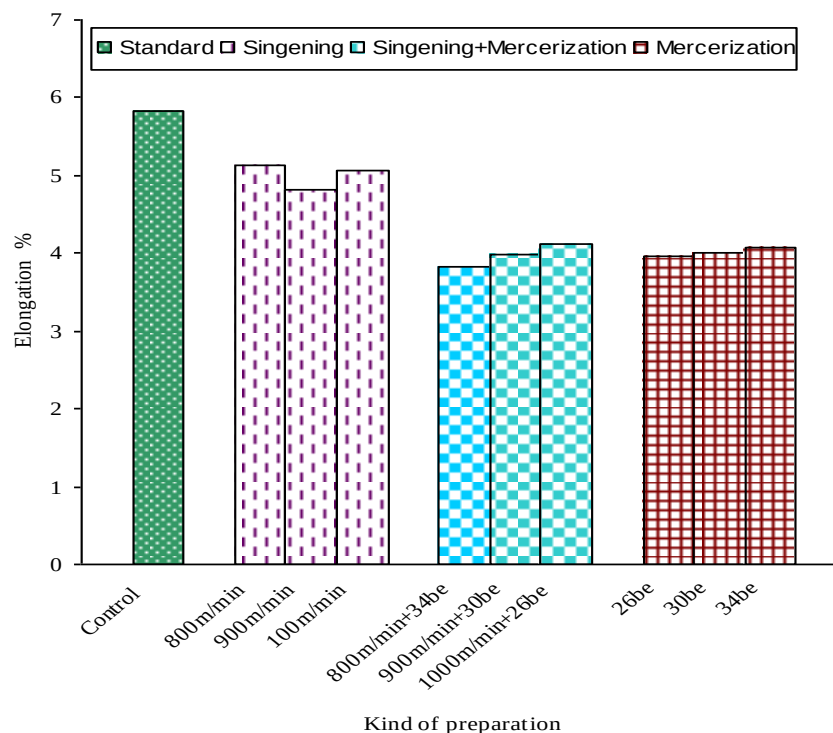


Figure 2 Effect of different preparations on the twisted yarn elongation%

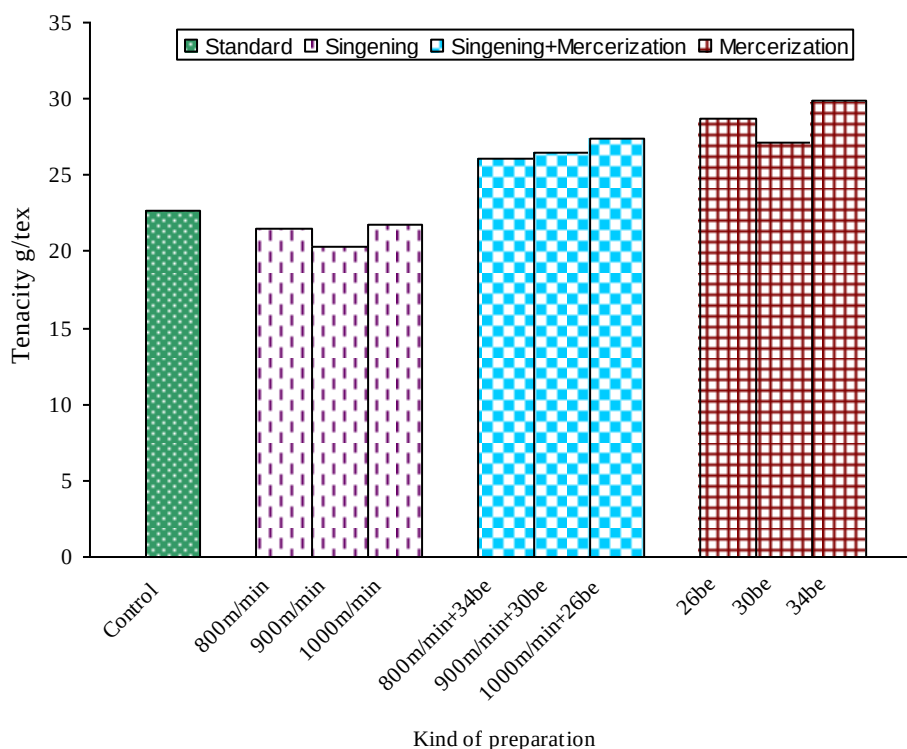


Figure 3 : Effect of different preparations on the twisted yarn tenacity g/ tex

3.2 The effect of the singeing, singeing-mercerization and mercerization on the yarn diameter and shape (circular diameter)

i) Table 2 and Fig. 4 show the effect of the different preparations on the yarn diameter. When singeing the yarns, we find that the samples recorded more decrease in yarn diameter of the sample than in the control sample and the likely the reason for this is the removal of hairiness around the yarn diameter during the singeing process and therefore the yarn diameter becomes less. It was found in the process of mercerizing the yarns that the samples recorded more decrease in yarn diameter than in the control sample. The reason for this decrease is due to the fact that the mercerization process took place under tensile leading to a decrease in the diameter; also getting rid of impurities and wax contributed to this decrease. In the singeing-mercerization process, the samples recorded a decrease than in the control sample as a result of the removal of hairiness and the tensile stress on the yarns during mercerization.

ii) Table 2 and Fig. 5 show the effect of the preparations on the circularity of the yarn diameter. We find that all the samples have been recorded 0.8 with the exception of one sample recorded which recorded 0.76, but all were higher than that of the control sample which recorded 0.73. The closer the value of the result to the one integer, the more the circularity of the yarn diameter. This is due to the fact that singing removes hairiness from the surface of the yarn which is intertwined with ends forming loops different in height along the yarn surface. In the mercerizing process, fibers become swelled causing fiber diameter inside the yarn to be more circular and

resulting in the circularity of yarn diameter. In the process of singeing-mercerization yarns tend to circularity for the same reasons.

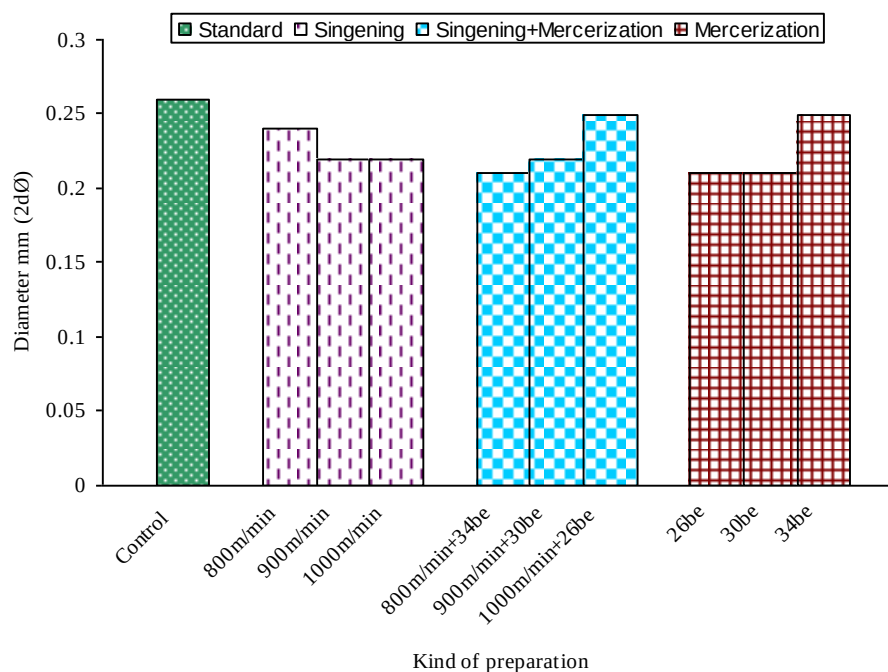


Figure 4: Effect of different preparations on the twisted yarn diameter mm (2dØ)

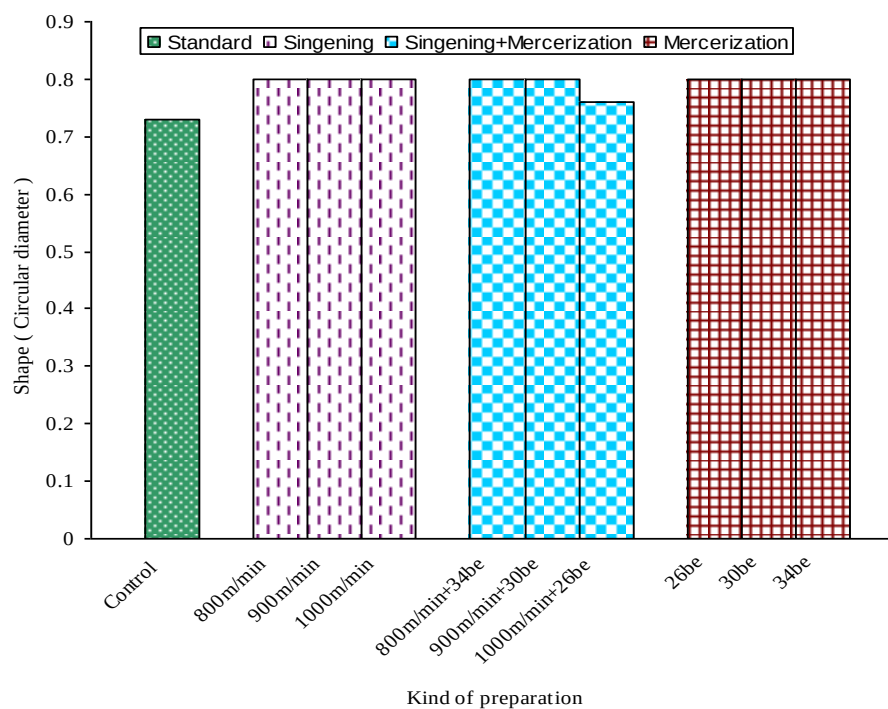


Figure 5: Effect of different preparations on the twisted yarn shape (circular diameter)



IV. CONCLUSION

Low tensile strength, elongation and tenacity of the twisted yarns in the process of singeing is due to yarn exposure to the heat of the flame directly leading to breaking some links lowering the tensile properties. Increase of the tensile strength, tenacity of the yarns and decrease in elongation in the mercerization process is due to the absorption of NaOH, restoring the order of the chains in the direction of the yarn axis which increases the cohesion of the cellulose, and so increases the tensile strength and tenacity and thus a reduction in elongation. Tensile strength, tenacity and elongation of the twisted yarn is lower in the process of singeing-mercerization than their counterparts in the mercerized yarns only. The reason for this is the passage of the yarns on the fire before mercerization where these properties decreased in the singeing process, so elongation becomes lower in mercerization while tensile strength and tenacity were more than they were in the singeing process, but still lower than in mercerization. Mercerized yarns recorded the highest values in terms of tensile strength and tenacity, followed by the singed mercerized. Yarns singed recorded the lowest values of tensile strength and tenacity and the highest values of elongation in all treatments of the yarns. Control sample recorded the highest value of elongation. Diameter of prepared yarns became lower than in the control sample because of the removal of hairiness by singeing and carrying out the mercerization under tension with the removal of wax and oils. More semi-circularity of all the yarns than in the control sample because of the removal of hairiness by singeing and the swelling of the fibers in mercerization. Yarn samples are more yellow than in the control sample due to heat in singeing and mercerization and cellulose oxidation. Luster of the singed-mercerized yarn than those mercerized only is due to the removal of hairiness in the singeing and the absorption of NaOH that led to the spread of twists. Control and singed samples have no luster. The behavior of the twisted yarn is the same as the single Yarn. Singeing – mercerization changes the values of the results from the singeing or mercerization.

REFERENCES

- [1]. Cheng, K P.S., and Yu, C., A study of compact spun yarns, *Textile research journal*, 73(4), 2004, 345-349.
- [2]. Xia, Z., Wang, X., Ye, W. and Xu, W., Experimental investigation on the effect of singeing on cotton yarn properties, *Textile research journal*, 79(17), 2009, 1610 – 1615.
- [3]. Ramachandran, T., Thirunarayanan, A., Influence of gas yarn singeing on viscose spun yarn characteristics, *IOSR journal of polymer and textile engineering*, 02, 2015, 34 – 38.
- [4]. Tyagi, G. K., Low stress properties of mercerized cotton ring- and OE rotor- spun yarns, *Indian journal of fibre and textile research*, 30, 2005, 290 – 294.
- [5]. Taskin, C., Ozguney, A. T., and Gurkan, P., Comparison of woven fabric properties from traditional and compact ring-spun yarns after dyeing processes, *Fibres and textiles in eastern Europe*, 15, 2007, 86-90.
- [6]. Algiurusamy R., and Das A., *Technical textile yarns industrial and medical applications* Woodhead publishing, 2010.
- [6]. Balasubramanian N., Hairiness of yarns: relative merits of various systems, [http:// www.Fibre2fashion.com](http://www.Fibre2fashion.com)



- [7]. Hussain , T. , Singeing fundamentals , <http://www.Fibre2fashion.com>
- [8]. Mohammed A., and Ibrahim A. , The effect of cotton yarns singeing and mercerization on the ratio of light reflection of the fabric , International journal of advance research in science and engineering ,04, 2015 ,116-121.
- [9]. Smriti , S. A. , and Islam , MD. A. , An exploration on pilling attitudes of cotton polyester blended single jersey knit fabric after mechanical singeing ,03 (1) , 2015, 18- 21.
- [10]. Hannan M. A. , Zakaria , M. ,and Bhuiyan A. H. , Comparative study of chemically and mechanically singed knit fabric , International journal of research in engineering and technology , 03 ,2014, 675 – 679 .
- [11]. Maheswaran N. , Kumar ,M. H. ,and Velmurugan, Characterization of natural fiber reinforced polymer composite , International journal of engineering sciences and research technology ,04(1) , 2015 , 362-370.
- [12]. Mokaloba N. , and Batane R. , The effect of mercerization and acetylation treatments on the properties of sisal fiber and its interfacial adhesion characteristics on polypropylene , International journal of engineering , science and technology ,06(4) , 2014, 83 – 97 .
- [13]. Dhamija S. and Manshahia M , Performance characteristics of mercerized ring- and compact- spun yarns produced at varying level of twist and traveler weight , Indian journal of fibre and textile research , 32 , 2007, 295-300.
- [14]. Jordanov I. and Mangovska B. Accessibility of mercerized , bioscoured and dried cotton yarns , Indian journal of fibre and textile research , 36 , 2011, 259 – 265 .
- [15]. Tyagi , G. K. , Goyal , A. and Dhanda K. , Frictional and mechanical properties of mercerized ring- and rotor- spun yarns , Indian journal of fibre and textile research , 29 , 2004, 357 – 361.
- [16]. Kafle K. , Greeson , K. , Lee , Christopher and Kim S. H. , Cellulose polymorphs and physical properties of cotton fabrics processed with commercial textile mills for mercerization and liquid ammonia treatments , Textile research journal ,. 84(16) , 2014, 1692 – 1699 .
- [17]. Bledzki , A. K. , Mamun A. A. , Luka-Gabor M. and Gutowski V. S. , The effects of acetylation on properties of flax fibre and its polypropylene composites , 2 (6) , 2008. 41