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Research Article

Effect of Spinning Top Front Roller Rubber Cots Shore Hardness on Yarn Quality

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Abstract

Recent day's enhancement in the yarn quality is a main challenge in front of the textile technologist. Ring frame rubber shore hardness plays vital role in deciding the fibre control throughout drafting at ring frame and Shore hardness is one of the main properties of top roller cot and varies for dissimilar types of fibre, application etc. In this research work the study has been conducted on the average grade cotton for 32s yarn count and then the effect of nine different spinning front line cots (Synthetic rubber cot) varying only in shore 'A' hardness (63, 65, 68, 72, 75, 80, 83, 85 and 90°) on 100% cotton ring spun yarn has been investigated. The change in cotton yarn properties like, unevenness %, Imperfection levels (in all class), yarn strength, yarn hairiness, and yarn elongation with progressive change in shore 'A 'hardness has also been reported. The count and process parameter's from opening and cleaning machines that covers blow room & carding then breaker & finisher drawing, speed frame and up to ring spinning kept identical. As one progress from lesser shore hardness (63°) to higher shore hardness (90°) the yarn unevenness %, imperfection levels and hairiness gradually increases and also the yarn strength and elongation decreased. Finally, from the results revealed that the yarnis with best evenness, imperfection, hairiness, tenacity and elongation results is obtained in case of using 63° shore hardness because lower the degree of shore hardness, higher the softness of rubber compound and vice versa. Even though softer cots under normal spinning conditions produces better yarns with better mass uniformity IPI levels, hairiness, tenacity and elongation during the production of 32s yarn count on the other hand, the worst result has come when using shore hardness 90° at the front top rollers and hence from quality and working point of view 63 to 65° shore hardness is superior for cotton.

Keywords: Ring spinning; Shore 'A' hardness; Spinning front line cot; Cotton yarn; Yarn quality parameters; Durometer.

Introduction

The textile industry is primarily concerned with the production of yarn and cloth. Yarn is a product of substantial length and relatively small cross-section consisting of fibres or filaments with or without twist [1]. Yarn quality is essential to the economic success of spinning plants. International competition and market requirements dictate the necessity to produce quality yarns at an acceptable price [2-6]. In general yarn quality is influenced by Quality of raw material, Opening & cleaning operations at Blow room & Carding, Speeds & Settings kept at various stages of yarn production and its functions, Process control techniques and parameters kept at spinning, humidification, (temperature and humidity), labour force training and their skills and maintenance of production equipment and vital components.

Drafting is the most important and fundamental operation in spinning and it gives a very important effect to the yarn quality [7]. Drafting components have a significant influence on yarn quality and production costs in ring spinning (Especially spinning top roller covers i.e., cots and drafting aprons [8]. These are the main components of the drafting mechanism and certainly it has more influence on the quality of the yarn produced Cots are used in draw frame, comber, speed frame and ring frame, whereas aprons are used only in speed frame and ring

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frame. The purpose of cots is to provide uniform pressure on the fibre strand to facilitate efficient drafting and use of aprons help to have better grip and control on fibres particularly floating fibres [9].

A front line cot in ring spinning should also offer sufficient pulling force to overcome drafting resistance. Mathematically, Force of pulling required at front line cot Frictional resistance between fibres and Force exerted by the aprons on fibres [10-12]. The raw material Compounds on the basis of special rubber in the hardness range of approx. 63 to 90° Shore A hardness are used as coating raw materials [13]. The composition of the raw material determines the characteristics of the cot such as Shore ‘A’ hardness of the rubber cot, Resilience properties, low Compression set values and elasticity of the cot, Surface Characteristics like grip offered on fibre strands, Abrasion resistance, Tensile strength, Swelling resistance and Colour. These characteristics should fulfill the demands made on a top roller cover like Good fibre guiding, no lap formation, long working life, Good ageing stability and Minimal film formation.

Normally synthetic top roller cots are available in cylindrical form as shown in fig. 1 and the technical specifications of a top roller cot are i) Bare roller diameter BRD ii) Finished outer diameter FOD iii) Width or Length iv) construction like Alufit or PVC core and v) Shore ‘A’ hardness. Shore hardness is one of the main properties of top roller cot and varies for different types of fibre, application etc.

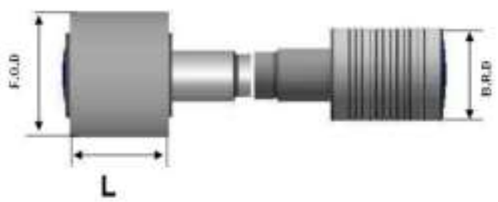

Fig 1. Technical specification of top roller cot

Hardness may be defined as the resistance to indention under conditions that do not puncture the rubber. It is called elastic modulus of rubber compound. These tests are based on the measurement of the penetration of the rigid ball into the rubber test piece under specific conditions. The measured penetration is converted into hardness degrees.

Generally, Shore hardness of a rubber cot is measured by using an instrument called ‘Durometer’ as shown in fig. 2 and the value is expressed in A scale. Cots are available in wide shore hardness ranging from 63 to 90° shore. A mathematical scale is used to convert the displacement data into hardness values within a range between 0 and 100 [14,15].

As per the ASTM (D 2240 Defines apparatus to be used and its sections such as diameter, length of the indenter, force of spring and D 1415–Defines specimen size), DIN, BRITISH and ISO Standards various test conditions have been laid for measuring. Shore a hardness of rubber products such as the specimen should be at least 6 mm in thickness, the surface on which the measurement made should be flat and the lateral dimension of the specimen should be sufficient to permit measurements at least 12 mm from the edges.

Fig 2. Durometer analog models

Top roller pressure, cots Ø, shore hardness of the cot and nipping length relationship is shown in fig. 3. As shown in fig. 3 that mathematically, Arc of contact or the nipping length made by top roller cot with fluted roller (I) is inversely proportional to the shore hardness of the rubber cot. In general, Lower the shore hardness higher will be the contact area with steel bottom roller better so that there will be positive control on fibre’s strand producing the yarn with better yarn evenness, lesser imperfection levels. Under Identical condition a cot measuring 63° Shore Hardness will make larger arc of contact with steel bottom than a cot measuring 90° Shore hardness [16].

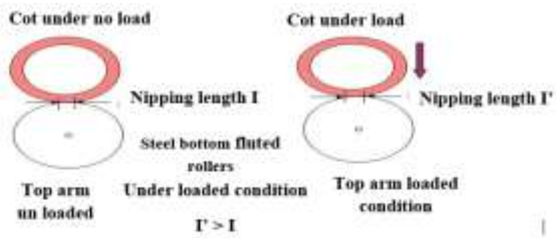

Fig 3. Shore Hardness and bottom roller contact area relationship

Materials and methods

Materials

To carry out this investigation 100% awash Ethiopian cotton was chosen as raw material with fibre parameters shown in table 1 and 32s Ne count carded yarn was produced at ring spinning and roller having different shore A hardness were used.

Table 1. Fibre parameters

Upper half mean length	29.03 mm	Elongation	6 %
Uniformity index	82.5%	Fibre micronaire	4.3 ug/inch
Short fibre content	8.4%	Trash content (w)	27 kg
Spinning consistency index	125%	Maturity ratio	0.86 %
Colour RD	77.6%	Neps /grams	108
+b (yellowness)	9.6%	Moisture content	5 %
Strength (gram /tex)	27.3	Raw material trash	4.5 %

Methods

The thesis work is designed to investigate the effect of top front roller spinning rubber cot shore hardness on yarn properties by collecting different data and samples. Cotton fibre is the most fibre for producing yarn with ring frame machines in Ethiopia and also Cotton yarn is one of the most popular linear textile products. Its various yarn properties are identified for this investigation.

Methods of testing yarn quality parameters

The yarn evenness was assessed in a standard testing atmosphere, that is, 65 ± 2 % relative humidity and 20 ± 2 °C temperature at Uster Tester 5 according to ASTM Standard D 1425-96 and tensile testing was done at Uster Tensorapid 4 as suggested in ASTM standard D 2256. Before testing, the yarns were conditioned for 24 hours in standard atmospheric conditions.

Methods of raw material processing

32s Ne carded yarn was produced in ring spinning by using the above sequence of machinery see in fig. 4, and Various process parameters like hank / count, speeds &setting, life of the individual elements like card wire, rings etc. kept identical throughout the study and the count and process parameter's from opening and cleaning machines that covers blow room & carding then breaker & finisher drawing, speed frame and up to ring spinning kept identical.

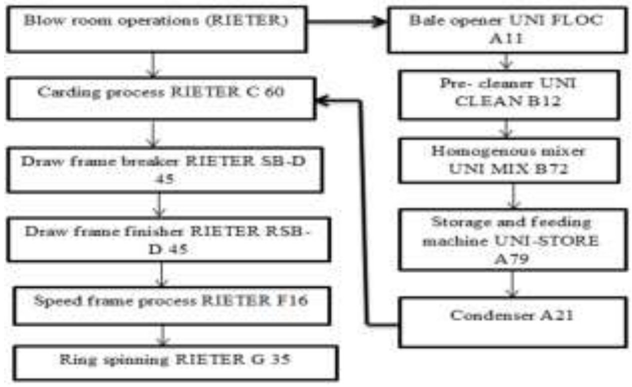

Fig. 4. Sequence of machinery for raw material processing carded Process

Method of cot mounting and buffing

For this investigation only Alufitt cot was chosen for both front and back line position. 9 top roller bare shells Were carefully selected for every Shore hardness (16 cots study in front line position) and mounting was carried in Vertical Pneumatic mounting machine and after mounting of cots grinding was carried in automatic double width grinding machine.

Method of cot selection

This research selected a nine different front top roller having different shore 'A' hardness values such as (63, 65, 68, 72, 75, 80, 83, 85 & 90°) but For back line position standard 83° Shore hardness cot was used throughout the study.

Results and discussion

At ring frame with machine parameters as shown in table 2 and 32s Ne carded yarn was produced by using different shore A hardness cot that ranged from 63° to 90° in front line at the back standard 83° was kept and around 45 Cops were collected in full stage with proper identification.

From Table 3 up to Figure 8 the present investigation summarized that, the effect nine different spinning front line cots (Synthetic rubber cot) varying only in shore A hardness (63°, 90°) on 100% cotton 32's ring spun yarn has been investigated. The change in cotton yarn properties like mass uniformity, unevenness percent, Imperfection levels (in all class), hairiness, strength and elongation with progressive change in shore hardness has also been reported.

Table 2. Machine parameters

Make of RF	G-35	Material processed	100% cotton
Drafting type	3/3	Pressure of presser arm	3 bar or 44 psi
Spacer size	3.5 mm	Total draft	40
Yarn count in Ne	32s	Break draft	1.09
Roving hank	0.8	Spindle speed	14000 (Avg)
Roving TM	1.3	Front roller speed	15.2 m/min
Bottom roller gauge	47 mm	RF-TM	4.14
Roller Diameter	32 mm	T.P.I	22.5

Effect of shore hardness on Yarn Evenness

Yarn evenness defined as the variation of mass per unit length can affect several properties of textile materials especially, the final appearance of the woven or knitted fabric and the irregularity or unevenness of a yarn is commonly defied as the variation in fineness along its length and more appropriately as the variation in mass per unit length along the yarn it is expressed as U% and CV%.

Test results of yarn evenness are shown in table 3. From Table 3 and fig. 5 summarized that, among the nine shore A hardness, yarn obtained front 63^{o} shows improvement in U (m) % and CV (m) %, of 32's yarn, this is due to the fact that lower shore hardness cot helps for increase in area of contact with the fluted bottom roller, which significantly shortens the uncontrolled area between apron to cot nipping point and also as shown in fig. 5 the graph shows that the shore A hardness values increase from lesser shore hardness (63°) to higher shore hardness (90°) the yarn U (m) % and CV (m) % gradually increases and Among the all shore A hardness the first front top roller used 63^{o} shows optimum quality because it produces less CV (m) % and U (m) % this is obtained due to lower the degree of shore hardness, higher the softness of rubber compound and vice versa. Even though softer cots under normal spinning conditions produces better yarns with better CV (m) and U(m) percentage.

Table 3. Test result of U (m) % and CV (m) %

Sl. No.	Shore A Hardness	Um, %	CVm, %
1	63°	13.68	17.45
2	65°	13.91	17.76
3	68°	14.19	18.15
4	72°	14.24	18.27
5	75°	14.38	18.38
6	80°	14.60	18.69
7	83°	15.01	19.14
8	85°	15.12	19.37
9	90°	15.36	19.75

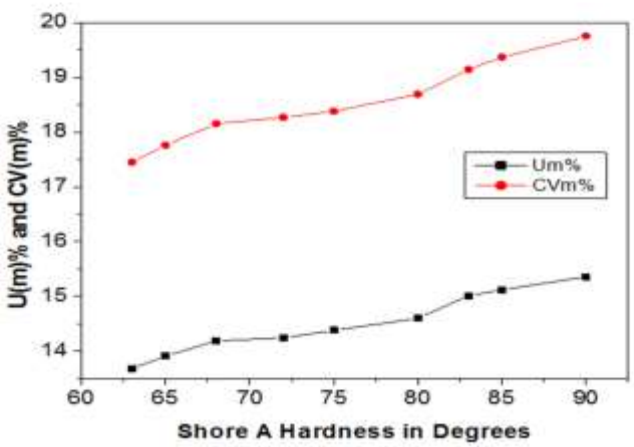

Fig. 5. Shows effects of shore hardness on U (m) and CV (m) %

Effect of shore hardness on yarn imperfection

The extremes of variation i.e. the thin places, thick places and neps are usually referred to as imperfection. The latest generation evenness tester provides imperfection values at different sensitivity levels but the values at certain sensitivity levels are considered to be standard in view of their importance with respect to fabric appearance as well as comparison with respect to standard values These standard sensitivity levels are hear is Thin-50%, thick+50% and neps+200% and sometimes called normal sensitivity levels.(As shown in table 4 that test result of yarn imperfection levels).

Table 4. Test result of normal imperfection levels

Sl. No.	Front	Normal Sensitivity Levels			Total
	SHORE A	Thin-50%/Km	Thick+50%/Km	Neps +200% /Km	
1	63°	65.0	418.0	494.4	977.4
2	65°	72.4	534.0	585.2	1191.6
3	68°	74.4	608.8	664.0	1347.2
4	72°	84.0	651.0	686.0	1421.0
5	75°	91.6	656.0	724.8	1472.4
6	80°	93.2	694.4	761.6	1549.2
7	83°	96.0	856.4	766.0	1718.4
8	85°	100.0	904.6	922.0	1926.6
9	90°	110.4	923.6	965.0	1999.0

From table 4 and fig. 6 summarized that, among the nine shore A hardness, yarn obtained at front used 63°, Shows improvement in Sum of Thin – 50%, Thick +50% & Neps +200% per Km of the produced 32’s yarn, this is due to the fact that lower shore hardness cot helps for increase in area of contact with the fluted bottom roller, which significantly shortens the uncontrolled area between apron to cot nipping point and also as shown in fig. 6 that the shore A hardness values increase from lesser shore hardness (63°) to higher shore hardness (90°) theSum of Thin – 50 %, Thick +50% & Neps +200% per Km of the produced yarn gradually increases. Among the all shore A hardness the first front top roller used 63^{o} shows optimum quality because it produces less Sum of Thin – 50 %, Thick +50% & Neps +200% per Km of the produced yarn. This is obtained due to Lower the degree of shore hardness, higher the softness of rubber compound and vice versa. Even though softer cots under normal spinning conditions produces better yarns with better Sum of Thin - 50 %, Thick +50% & Neps +200% per Km of the produced yarn.

Effect of shore hardness on yarn hairiness

Hairiness is characterized by the quantity of freely moving fibre ends or fibre loops projecting from a yarn and yarn hairiness significantly influence the characteristics of yarn, fabric appearance and working performance of spinning to its downstream processes. Test result of yarn hairiness is given in table 5.

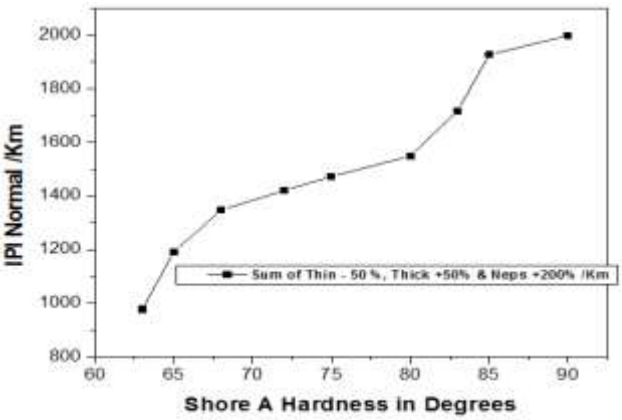

Fig. 6. Shows effects of shore hardness on normal imperfection levels

Table 5. Test result of yarn hairiness

Sl. No.	Shore A Hardness	Hairiness index (H)
1	63°	5.92
2	65°	6.09
3	68°	6.21
4	72°	6.23
5	75°	6.25
6	80°	6.43
7	83°	6.42
8	85°	6.51
9	90°	6.70

From table 5 and fig. 7 summarized that, among the nine shore A hardness, yarn obtained front 63° shows improvement in Hairiness index, of 32's yarn, this is due to the fact that lower shore hardness cot helps for increase in area of contact with the fluted bottom roller, which significantly shortens the uncontrolled area between apron to cot nipping point and also as shown in fig 7 that the shore hardness values increased from 60 to 90° the hairiness values also increased. Among the all shore hardness first front 63° shows optimum quality because it produces less hairiness index this is obtained due to Lower the degree of shore hardness, higher the softness of rubber compound and vice versa Even though softer cots under normal spinning conditions produces better yarns with better hairiness percentage.

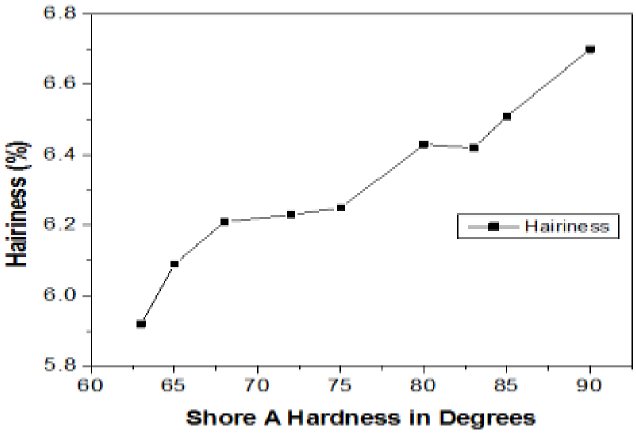

Fig. 7. Shows effects of shore hardness on yarn hairiness index

Effect of shore hardness on yarn strength and elongation

Tensile testing of yarns is used to determine the breaking force, elongation and toughness properties of the yarn. Test result of yarn strength and elongation is given in table 6.

Table 6. Test result of yarn elongation and tenacity

S. No.	Shore A Hardness	Elongation, (%)	Tenacity (CN/tex)
1	63°	5.05	14.37
2	65°	4.80	13.30
3	68°	4.65	13.15
4	72°	4.45	12.47
5	75°	4.33	12.38
6	80°	4.28	12.27
7	83°	4.10	11.96
8	85°	4.03	11.92
9	90°	3.93	11.75

From table 6 and fig. 8 summarized that, among the nine shore A hardness, yarn obtained at the front used 63° shore hardness shows improvement in tenacity (cN/tex) and elongation % of 32's yarn, this is due to the fact that lower shore hardness cot helps for increase in area of contact with the fluted bottom roller, which significantly shortens the uncontrolled area between apron to cot nipping point and also as shown in fig. 8 that the shore A hardness values increased from 63 to 90° the tenacity and the elongation values also decreased.

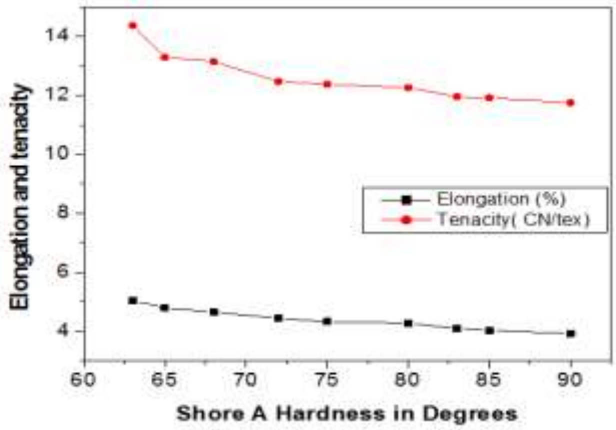

Fig. 8. Shows effects of shore hardness on elongation and strength

Among the all shore hardness first front 63° shore hardness shows optimum quality because it produces good elongation and strength this is obtained due to lower the degree of shore hardness, higher the softness of rubber compound and vice versa. Even though softer cots under normal spinning conditions produces better yarns with better elongation percentage and tenacity (CN /Tex).

From the data it was inferred that front line 63° gives optimum result in the production of 32's count carded yarn and The effect of nine different spinning front line cots (Synthetic rubber cot) varying only in shore A hardness (63, 65, 68, 72, 75, 80, 83, 85 & 90°) on 100% cotton 32s ring spun yarn has been investigated. The change in cotton yarn properties like mass uniformity, unevenness %, Imperfection levels (in all class), hairiness, elongation and tenacity with progressive change in shore hardness has also been reported.

Conclusions

Imperfection level, yarn unevenness % and hairiness usually increase with increase in shore hardness. This is due to the fact that lower shore hardness cot helps for increase in area of contact with the fluted bottom roller, which significantly shortens the uncontrolled area between apron to cot nipping point. Strength and elongation usually increase with decrease in shore hardness. This is due to the fact that lower shore hardness cot helps for increase in area of contact with the fluted bottom roller, which significantly shortens the uncontrolled area between apron to cot nipping point and lower the degree of shore hardness, higher the softness of rubber compound and vice versa. Even though softer cots under normal spinning conditions produces better yarns with better mass uniformity, IPI levels, hairiness, elongation and tenacity. Finally, From the above result, it is clear that yarn with the best evenness, imperfection, hairiness, tenacity and elongation results is obtained in case of using 63^{o} shore hardness because lower the degree of shore hardness, higher the softness of rubber compound and vice versa. Even though softer cots under normal spinning conditions produces better yarns with better mass uniformity IPI levels, hairiness, tenacity and elongation during the production of 32s yarn count on the other hand, the worst result has come when using shore hardness 90^{o}. This article purely deals with the mathematical relationship between shore hardness, yarn mass uniformity, imperfection levels, hairiness and tensile properties only. It doesn't incorporate other yarn quality parameters like long term irregularities, surface profile characteristics that include appearance, integrity.

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Conflicts of interest

Authors declare no conflict of interest.

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