CHAPTER – 3

COMPARISON OF FABRIC PROPERTIES OF RING & COMPACT YARN FABRIC SUBJECTED TO HOT MERCERIZATION

3.1 Introduction:

Mercerization is an established chemical process for enhancing tensile strength, dyeability and lustre of cotton. The fabric properties are also influenced largely by the fabric geometry and the structure of the yarn used [10, 147, and 148]. The previous investigation deals with mercerization of cotton in the form of fibre and yarns manufactured by ring, rotor, and compact spinning technology. Omeroglus and Pillay, [145 and 146] while studying the response of open end and ring yarn, observed more increase in tenacity of rotor yarn as compared to ring yarn after mercerization.

Basal G & William Oxenham [142] have shown that the rate of fibre migration as well as amplitude of migration is higher in compact spun yarn. Fibre migration results in minimizing spinning triangle and higher packing density of compact yarn. Further research [146-148] has shown that compact yarn possess better yarn properties with respect to tenacity, elongation and hairiness.

In the present research work, an attempt has been made to compare fabric properties of compact and ring yarn fabrics, before and after hot mercerization.

3.2 Materials & Experimental Methods:

3.2.1 Materials:

Ring and Compact yarn of 40s (Ne) count were spun from same cotton mixing.
A]  Fabric:

Fabric samples of following specifications were manufactured.

Warp Count - 40° (Ring Yarn and Compact Yarn)
Weft Count - 40° (Ring Yarn and Compact Yarn)

Ends/Cm 35  Picks/Cm 25

Weight (gm.m⁻²) 92  Weave Plain

The Ring and Compact yarns used for fabric manufacturing were spun under identical conditions, keeping same fibre mixing, and spinning machine parameters. Similarly, weaving conditions, and machine parameters were maintained identical.

B]  Mercerization Frame:

A stainless steel frame having dimension of 440 mm x 440 mm was fabricated. Provision was made for easy handling and keeping the fabric stretched under tension. Fixed pins were provided on sides of the frame. Two trays were also fabricated. One tray was used for impregnating fabric in Sodium Hydroxide solution and other tray was used for collecting wash liquor during washing.

C]  Chemicals:

Following Laboratory Reagents were used.

Caustic Soda,
Acetic acid,
Sodium Carbonate,
Sodium Chloride,
Sulphuric acid,
Hydrogen peroxide,
Hydrochloric acid.

Commercial products: Amylase-Enzyme

3.2.2 Methods:

A] Processing Sequence

B] Preparation of Fabric:

- Desizing:
  Grey fabric was desized with 5 grams per litre enzyme at 60°C for 4 hours at 6.5 pH. Fabric was subjected to a hot wash (70°C) followed by cold wash.

Combined Scouring & Bleaching:

The desized fabric was subjected to combined scouring and bleaching using following recipe on the weight of fabric (owf).

- Sodium hydroxide - 2.00 %
- Sodium carbonate - 0.50 %
- Hydrogen peroxide (50%) - 1.50 %
- Peroxide stabilizer - 0.50 %
- Temperature - 85°C
- Time - 4 hours.

Fabric was given hot wash, cold wash.
**Hot Mercerization:**

The above fabric samples were mercerized using 24% Caustic Soda solution at 60°C, giving 2% stretch and impregnation time of 60 seconds. After hot wash and cold wash, fabric samples were neutralized.

**Dyeing:**

The fabric samples were dyed with Reactive Red HE 8B with (C.I.Red 152) for 0.5% shade using standard dyeing procedure in Rota dyer, keeping Material to Liquor Ratio (MLR) 1: 20. During dyeing 15 grams per litre salt and 10 grams per litre soda ash were added for exhaustion and fixation respectively. Dyeing was carried out at 80°C for 60 minutes.

### 3.3 Fabric Testing:

**Atmospheric conditions for conditioning and testing:** (IS: 6359:1971)

Prior to evaluation, the samples were conditioned to moisture equilibrium in the standard atmosphere at 65 ± 2 percent relative humidity and a temperature of 27°C ± 2°C for 48 hours.

#### 3.3.1 Tensile Testing: (IS: 1959:1985)

**‘Ravelled Strip’ Method of Fabric Tensile Strength:**

Tensile testing was carried on Instron 5565 for tensile strength and elongation. Sample size of 20 cm X 5 cm was used. The distance of 20 cm was kept between the jaws with minimum 20 threads in the strip along the direction of force applied. A speed of 300 mm per minute was used so that specimen breaks within 20 seconds. As the Machine was started upper jaw moved in upper direction and the specimen was broken. The recorded value of load and elongation was used to calculate the tensile strength of fabric in kgf. Total 10 readings were taken in warpway and weftway.
3.3.2 Abrasion Resistance: (ASTM D: 4966-98)

Abrasion is just one aspect of the wear and is the rubbing away of the component fibres and yarns of the fabric. The machines are based on the principles of two simple harmonic, motions working at right angles.

Abrasion resistance is measured by subjecting the specimen to rubbing motion in the form of a geometric figure. It is a straight line, which becomes gradually widening ellipse until it forms another straight line in the opposite direction and traces the same figure again under known conditions of pressure and abrasive action. Resistance to abrasion is evaluated.

Four specimens of 38 mm diameter are cut and fixed on the four circular specimen holders, which are mounted under load, on the brass plate subjected to multidirectional motion. The abradant cloth is fastened to each of the four blocks from bottom side. The fabric is mounted on the specimen holder and it rubs uniformly against the abradant surfaces from the top side. The estimation of wear that has taken place is found out. Five specimens from each sample are tested. After 5000 abrasions, loss in weight and thickness were measured. They are graded from 0 to 5 (5 shows excellent resistance and 0 for least abrasion resistance).

3.3.3 Pilling Resistance: (IS: 10971:1984)

Pills are bunches or balls of tangled fibres, which are held to the surface of a fabric by one or more fibres. Determination of pills was carried out with Eureka box tester. Four samples of 114 X 114 mm size were mounted on rubber holder and the machine was run for 18000 revolutions at the speed of 60 revolutions per minute. After 5 hours, samples were taken out and pills were counted on each specimen under the microscope. The rating was given by comparing with standard.
3.3.4 Air Permeability: (ASTM-D-737-96)

Air permeability is determined, at 1 cm of water head pressure. It is the volume of air in cubic centimeter passed per second through one square centimeter of fabric. The appropriate disc for the fabric to be tested is selected along with the valve disc and the fabric is cut to the size of template. The fabric is inserted between the measuring slot and clamp is closed. Machine is started slowly and the rate of air flow is increased gradually until the required pressure drop is indicated on the draught gauge. As the water pressure valve shows the value of 1 cm, the rate of flow of air is read off from Rotameter. The fabric testing area is 5.07 cm$^2$. An average of five reading divided by 5.07 gave the volume of air in cubic centimeter passed per second through one square centimeter of fabric.

3.3.5 Drape: (IS: 8357-1977)

A circular fabric is sandwiched between two horizontal disks (12.30 cm) diameter. The fabric is allowed to hang down freely under the action of gravity. A planner projection is recorded on an ammonia paper. The drape pattern obtained is cut along the outline and its area is determined gravimetrically. The drape coefficient is calculated as the ratio of projected area of the drape specimen to its theoretical maximum.

3.3.6 Crystallinity Index:

The radial intensity distribution of X-ray diffraction shows the prominent peaks which correspond to the X-rays reflected from (101), (101) & (002) planes. The presence of amorphous cellulose causes a reduction in the intensity of these peaks with simultaneous increase in background intensity. The crystallinity index measures the intensity maximum, at 002 plane and intensity minimum, at 18$^\circ$ corresponding to amorphous fraction.
**Crystallinity Index** = \( \frac{I_{002} - I_{am}}{I_{002}} \times 100 \)

\( I_{002} = \) Maximum Intensity of 002 lattice  \hspace{1cm} \( I_{AHM} = \) Intensity at 2\( \theta = 18^\circ \)

### 3.3.7 Light Fastness: (AATCC-16-1993)

Effective humidity is controlled to 65% by adding 3 ml solution of NaNO\(_3\) to the cell. A strip of dyed fabric sample, measuring 50 mm X 10 mm is mounted on top of the card board of size 110 mm x 50 mm. Staple standard samples supplied for comparison from 1 to 8, sequentially beneath it on the same card. The standard range 1 shows very low fastness. Each higher value denotes twice as fast as one below it. Exposed them to the Mercury Blended Tungsten Lamp [MBTL](500 Watts). The exposure is continued. The assessment in made between exposed and unexposed part of the sample after certain intervals till the rating of 4 which shows significant difference in the shade. This sample of numerical rating 4 is taken for observation to compare with the shades of Blue wool standard samples having contrast shade values from 1 to 8 on the same strip mounted below the above sample. Standard sample of grade 4 from Blue wool is maximum acceptable difference in shade between exposed and unexposed portion of the specimen. Higher the rating better is the light fastness.

### 3.3.8 Washing Fastness: (AATCC-110-1995)

A composite specimen fabric sample measuring 10 cm X 4 cm was washed in Laundro-o-meter using ISO 105-CO3 method. Wash liquor containing 5 grams per litre reference detergent, 2 grams per litre soda ash was used with Material to Liquor Ratio [MLR] 1:50 at 60\(^\circ\)C for 30 minutes. Samples were rinsed and dried. Changes are rated and recorded accordingly.
3.3.9 Rubbing Fastness: (IS 766: 1988)

The test specimen of 14cm x 5 cm was fixed on to the rubbing surface. In case of dry rubbing fastness, a dry piece of bleached cotton fabric was placed over the end of rubbing finger. The instrument was run for ten cycles with standard force.

In case of wet rubbing fastness, fresh dyed specimen was used along with wetted white cotton fabric as rubbing cloth. Rest procedure was repeated as described in dry rubbing fastness test. The samples were assessed for colour change and staining, using grey scale.

3.3.10 Barium Activity Number:

Specimens of 2 grams of mercerized cotton to be tested and unmercerized cotton were immersed in separate baths of barium hydroxide solution for 2 hours. The flasks were shaken at frequent intervals. After 2 hours, 10 ml of solution from each container was transferred, including the blanks and titrated against 0.1N hydrochloric acid, using phenolphthalein as an indicator.

Using the titration values, the ratio of barium hydroxide absorbed by a mercerized specimen to that absorbed by the unmercerized standard sample, is determined. Multiply this ratio by 100 to obtain the barium activity number.

3.3.11 Testing of Colour Absorption and scattering (K/S):

The development of the Kubelka-Monk equation in 1931 is as under.

\[
K/S = \frac{(1-R)^2}{2R}
\]

\[K = \text{absorption coefficient},\]
\[S = \text{scattering coefficient}\]
\[R = \text{reflectance},\]

This measures the reflectance of dyed textiles. The utility and application of this important equation has been critically reviewed by many researchers. The
reflectance values were measured using Premier scan colour matching system “Colour Eye 300” and chosen maximum wavelength and K/S values were calculated by built-in software of colour matching system.

3.3.12 Scanning electron microphotographs:

Electron microscope with magnification of X 500, 50µm was used to obtain the photographs of hot mercerized fibres from the Ring yarn mercerized fabrics and Compact yarn mercerized fabrics.

3.4 Results & Discussion:

Since the compact spinning technique is modified spinning method, geometry of yarn is different. In the chemical processing of fabrics, mercerization is an important operation, which improves physical & chemical properties to satisfy consumer demands. The effect of hot mercerization, on various physical properties of fabrics was studied. The results obtained are as follow.

3.4.1 Tensile Strength:

The fabric samples manufactured using compact yarn and ring yarn were subjected to hot mercerization and evaluated for tensile properties. The results obtained are shown in Table 3.1. From the data, it can be seen that both, ring yarn fabric samples and compact yarn fabric samples, show increase in tensile strength in warpway as well as weftway when subjected to hot mercerization process.
### Table 3.1

Comparison of Tensile Strength of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>Tensile Strength Warp (kgf)</th>
<th>Tensile Strength Warp (kgf)</th>
<th>Tensile Strength Weft (kgf)</th>
<th>Tensile Strength Weft (kgf)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unmercerized</td>
<td>Hot Mercerization</td>
<td>Unmercerized</td>
<td>Hot mercerized</td>
</tr>
<tr>
<td>A] Compact yarn</td>
<td>26.5</td>
<td>28.5</td>
<td>21</td>
<td>22.5</td>
</tr>
<tr>
<td>fabric</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% increase after</td>
<td>-</td>
<td>7.54%</td>
<td>-</td>
<td>7.14%</td>
</tr>
<tr>
<td>Hot Mercerization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B] Ring Yarn fabric</td>
<td>24</td>
<td>26</td>
<td>20</td>
<td>21.5</td>
</tr>
<tr>
<td>% increase after</td>
<td>-</td>
<td>8.33%</td>
<td>-</td>
<td>7.50%</td>
</tr>
<tr>
<td>Hot Mercerization</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Graph 3.1 - Comparison of Tensile Strength (kgf) of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric**
It can be seen from Table 3.1 and Graph 3.1 that the tensile strength of compact yarn fabric warpway is 26.5 kgf before hot mercerization & after hot mercerization it is increased to 28.5 kgf showing 7.54% increase in tensile strength. As regards to tensile strength of ring yarn fabric warpway, before hot mercerization, it is 24 kgf & after hot mercerization, it was found to be 26 kgf, showing increase in tensile strength by 8.33%. Thus, significant increase in tensile strength is observed after hot mercerization for both the ring yarn fabric as well as compact yarn fabric.

Similarly, tensile strength of compact yarn fabric weftway was 21.0 kgf before hot mercerization & after mercerization it increased to 22.5 kgf, showing 7.14% increase in tensile strength. As regards to tensile strength of ring yarn fabric weftway, before hot mercerization, it is 20 kg/cm² & after mercerization, it is found to be 21.5 kgf showing increase in tensile strength by 7.5%.

It has been found that after mercerization, tensile strength increases due to better orientation of crystals, deconvolutions, and swelling of fibres, causing reduction in air space and better binding of fibres. It also reduces weak links. Higher strength of compact yarn has also resulted in higher fabric strength before and after mercerization as compared to ring yarn fabric. Since in the weft direction numbers of threads are significantly lesser than warp threads, tensile strength in weft direction is lesser than that of in warp direction.
3.4.2 Tensile Elongation:

Table 3.2
Comparison of Tensile Elongation % of Unmercerized and Hot Mercerized Ring and Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>Warpway Elongation % before hot Mercerization</th>
<th>Warpway Elongation % after hot Mercerization</th>
<th>Weftway Elongation % before hot Mercerization</th>
<th>Weftway Elongation % after hot Mercerization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact yarn fabric</td>
<td>4.0</td>
<td>3.65</td>
<td>3.5</td>
<td>3.25</td>
</tr>
<tr>
<td>Ring Yarn fabric</td>
<td>4.5</td>
<td>4.15</td>
<td>4.2</td>
<td>3.9</td>
</tr>
</tbody>
</table>

Graph 3.2 - Comparison of Tensile Elongation % of Unmercerized and Hot Mercerized Ring and Compact Yarn Fabric.
It can be seen from Table 3.2 and Graph 3.2 that elongation of compact yarn fabric after mercerization is decreased from 4% to 3.65% in warp direction and from 3.5% to 3.25% in weft direction.

Similarly, elongation of ring yarn fabric after mercerization in warp direction has decreased from 4.5% to 4.15% and in weft direction 4.2% to 3.9%. Swelling and deconvolutions of mercerized fibres has decreased the elongation in both warp way and weft way direction for both ring yarn fabric as well as compact yarn fabric.
3.4.3 Crimp:

Table 3.3

Comparison of Crimp Properties of Unmercerized and Hot Mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>Crimp% Unmercerized Warp</th>
<th>Crimp% Mercerized Warp</th>
<th>Crimp% Unmercerized Weft</th>
<th>Crimp% Mercerized Weft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact yarn fabric</td>
<td>6.00</td>
<td>6.50</td>
<td>7.00</td>
<td>7.50</td>
</tr>
<tr>
<td>Ring Yarn fabric</td>
<td>5.00</td>
<td>5.50</td>
<td>6.50</td>
<td>7.00</td>
</tr>
</tbody>
</table>

Graph 3.3 - Comparison of Crimp Properties of Unmercerized and Hot Mercerized Ring & Compact Yarn Fabric.

It is observed from Table 3.3 & Graph 3.3 that compact yarn crimp percentage after hot mercerization has increased from 6.00% to 6.50% in warp direction and 7.00% to 7.50% in weft direction. This increase in crimp % is a result of deconvolutions due to mercerization. Similarly, in case of ring yarn the crimp has increased from 5.00% to 5.50% in warp direction and from 6.50% to 7.00% in weft direction.
3.4.4 Abrasion Resistance:

Table 3.4 [A]

Comparison of Abrasion Resistance (% Loss in Weight) of Unmercerized and Hot Mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>% Loss in Weight of Unmercerized Fabric</th>
<th>% Loss in Weight of Hot Mercerized Fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact yarn fabric</td>
<td>3.70</td>
<td>3.90</td>
</tr>
<tr>
<td>Ring Yarn fabric</td>
<td>5.60</td>
<td>6.16</td>
</tr>
</tbody>
</table>

Graph 3.4 [A] - Comparison of Abrasion Resistance (% Loss in Weight) of Unmercerized and Hot Mercerized Ring & Compact Yarn Fabric.
3.4.4 Abrasion Resistance:

Table 3.4 [B]

Comparison of Abrasion Resistance (% Loss in Thickness) of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>% Loss in Thickness of Unmercerized Fabric</th>
<th>% Loss in Thickness of Hot mercerized Fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact yarn fabric</td>
<td>2.20</td>
<td>2.31</td>
</tr>
<tr>
<td>Ring Yarn fabric</td>
<td>3.09</td>
<td>3.39</td>
</tr>
</tbody>
</table>

Graph 3.4 [B] - Comparison of Abrasion Resistance (% Loss in Thickness) of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric
Studies In Mercerization

The fabric samples were subjected to abrasion on Martindale Abrasion Tester. The results obtained after 5000 cycles are given in Table 3.4 [A] and Table 3.4 [B], Graph 3.4 [A] and Graph 3.4 [B]. While unmercerized Compact yarn fabric loses 3.7% fabric weight after being subjected to abrasion test. Hot mercerized fabric losses 3.9 % when subjected to abrasion. Thus, it can be seen that there is no significant increase in weight loss % in hot mercerized compact yarn fabric subjected to abrasion test.

Similarly, unmercerized Ring yarn fabric loses 5.6% weight while hot mercerized ring yarn fabric shows 6.16% weight loss when subjected to abrasion. As compared to compact yarn fabric, ring yarn fabric, both unmercerized as well as hot mercerized show more weight loss due to abrasion. It may be due to the fact that ring yarn is having more hairiness in comparison to compact yarn and during abrasion test fibre loss takes place.

As regards to loss in thickness due to abrasion, for compact yarn fabric, it increases from 2.20% for unmercerized to 2.31% for hot mercerized fabric sample. Similarly, for ring yarn fabric, loss in thickness after abrasion is 3.09% for unmercerized fabric and 3.39% for hot mercerized fabric.

In case of compact yarn, owing to higher mean migration of fibres, higher packing density of yarn and yarn geometry, it is found to give minimum loss in weight and thickness before and after hot mercerization when subjected to abrasion. The higher weight loss for ring yarn fabric may be due to reduced fibre binding and more hairiness as compared to compact yarn fabrics.
3.4.5: Pilling Resistance:

Table 3.5
Comparison of Pilling Resistance of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>Pilling Grade for Unmercerized Fabric</th>
<th>Pilling Grade for Hot mercerized Fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact yarn fabric</td>
<td>4.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Ring yarn fabric</td>
<td>3.00</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Graph 3.5 - Comparison of Pilling Resistance of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric
As shown in Table 3.5 and Graph 3.5 after subjecting the unmercerized and hot mercerized ring and compact yarn fabric to 18000 cycles pilling test, the fabric pilling grade for unmercerized and hot mercerized compact yarn fabric is found to be 4 and 5 respectively. This indicates that compact yarn fabric shows least tendency for pills formation and hot mercerization further improves resistance to pilling. Similarly in case of unmercerized and hot mercerized Ring yarn fabric, pilling grade is found to be 3 and 4 respectively.

It can be seen that, in the case of ring yarn fabrics, though hot mercerization process is able to improve the pilling grade, it is inferior to that obtained for hot mercerized compact yarn fabric.

Since more pills are formed on the surface of the unmercerized ring spun yarn fabric due to protruding fibres, which act as nuclei. After mercerization, fibres are deconvoluted, straighten-up, swell and there by packing increases due to which slight decrease in pilling tendency is observed after hot mercerization for compact yarn fabrics as well as for ring yarn fabrics.
3.4.6 Air Permeability:

Table 3.6
Comparison of Air Permeability of Unmercerized and Hot mercerized
Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>Air Permeability Unmercerized fabric (cm(^3)/sec/cm(^2))</th>
<th>Air Permeability Hot mercerized fabric (cm(^3)/sec/cm(^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact Yarn fabric</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Ring Yarn fabric</td>
<td>15.8</td>
<td>14.8</td>
</tr>
<tr>
<td>% decrease after Hot Mercerization</td>
<td>6.25 %</td>
<td>6.32 %</td>
</tr>
</tbody>
</table>

Graph 3.6 - Comparison of Air Permeability of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric

Studies In Mercerization
It can be observed from Table 3.6 and Graph 3.6 that air permeability for compact yarn unmercerized fabric and hot mercerized compact yarn fabric is 16 cm$^3$/sec/cm$^2$ and 15 cm$^3$/sec/cm$^2$ respectively. Similarly, air permeability for ring yarn unmercerized fabric and hot mercerized fabric is 15.8 cm$^3$/sec/cm$^2$ and 14.8 cm$^3$/sec/cm$^2$ respectively. The drop in air permeability after hot mercerization for both compact yarn fabric and ring yarn fabric could be attributed to the swelling of fibres after hot mercerization thereby reducing the air spaces available between the fibres and yarns.
3.4.7 Drape Coefficient:

Table 3.7
Comparison of Drape Coefficient of Unmercerized and Hot mercerized
Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>Drape Coefficient of Unmercerized fabric</th>
<th>Drape Coefficient of Hot mercerized fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact yarn fabric</td>
<td>48.12</td>
<td>55.53</td>
</tr>
<tr>
<td>Ring yarn fabric</td>
<td>45.15</td>
<td>54.82</td>
</tr>
</tbody>
</table>

Graph 3.7 - Comparison of Drape Coefficient of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric
It is observed from Table 3.7 & Graph 3.7 that drape coefficient for unmercerized compact yarn fabric is 48.12 which subsequently increase to 55.53. Similarly, for ring yarn unmercerized fabric drape coefficient is 45.15 and after mercerization, it increases to 53.82. It shows significant increase in drape coefficient after mercerization with compact and ring yarn fabric. In ring yarn fabric and compact yarn fabric, subjected to hot mercerization, swelling of fibres causes increase in diameter of fibres and yarn, thereby the distance between the threads is reduced which increases bending resistance or stiffness of fabric which could be attributed to increase in drape coefficient.
3.4.8 Crystallinity Index:

Comparison of Crystallinity Index of fibres and X-ray spectrographs from Unmercerized and Hot Mercerized Ring & Compact Yarn Cotton Fabric.

Graph 3.8- X-ray Spectrograph of fibres from compact Yarn Fabric after hot Mercerization

Graph 3.9- X-ray spectrograph of fibres from ring yarn fabric after hot Mercerization
Table 3.8
Comparison of Crystallinity Index of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>Crystallinity Index of Unmercerized Fabric</th>
<th>Crystallinity Index of Hot mercerized fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact Yarn fabric</td>
<td>71.00</td>
<td>50.67</td>
</tr>
<tr>
<td>Ring Yarn fabric</td>
<td>71.50</td>
<td>44.51</td>
</tr>
</tbody>
</table>

Graph 3.10 - Comparison of Crystallinity Index of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric
Table 3.8 and Graph 3.10 show Crystallinity Index of cotton fibres from compact yarn unmercerized and hot mercerized fabric and cotton fibres from ring yarn unmercerized and hot mercerized fabric. Crystallinity Index of cotton fibres from unmercerized compact yarn fabric is 71.00 which is reduced to 50.67 after hot mercerization. However, Crystallinity Index of cotton fibres from ring yarn unmercerized fabric is 71.50 which is reduced to 50.67 after hot mercerization. Crystallinity Index of cotton fibres from compact yarn fabrics is reduced after hot mercerization by 28.63 %. Ring yarn fabric crystallinity decreases after hot mercerization by 44.51 %. It shows lower value of crystallinity index after hot mercerization with ring yarn fabric, showing reduced crystallinity and higher amorphous region, as compared to compact yarn fabric.

It has long been recognized that cellulose is part crystalline and part amorphous. At higher concentration of sodium hydroxide dipole hydrates or solvated dipole hydrates are formed with smallest diameter (7.4\(^0\)A). These dipole hydrates are capable of penetrating the crystalline region of fibres and form hydrogen bonds. Thus, it induces important structural changes at intrafibrillary region and reduces the crystallinity thereby increasing amorphous region.

It can be observed from the X-ray spectrographs Graph 3.8 and Graph 3.9 that the intensity of reflection is more in case of fibres from compact yarn fabric, showing higher crystallinity as compared to fibres from ring yarn fabric after hot mercerization. This may be because of higher packing density of fibres in compact yarn fabric offer more resistance for penetration of mercerizing liquor as compared to ring yarn fabric.
3.4.9 Barium Activity Number (BAN):

Table 3.9
Comparison of Barium Activity Number (BAN) of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>Barium Activity Number (BAN) Unmercerized</th>
<th>Barium Activity Number (BAN) Hot Mercerization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact Yarn fabric</td>
<td>149</td>
<td>169.12</td>
</tr>
<tr>
<td>Ring yarn fabric</td>
<td>151</td>
<td>180</td>
</tr>
</tbody>
</table>

Graph 3.11 - Comparison of Barium Activity Number (BAN) of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric.
From the Table 3.9 and Graph 3.11, it can be observed that Barium Activity Number (BAN) of ring yarn without mercerization is 151 which increase to 180 after mercerization. Similarly in the case of compact yarn fabric the BAN increases from 149 to 169.12 after mercerization. Increase in BAN in ring yarn fabric after mercerization is 42%. Lesser increase in BAN for hot mercerized compact yarn fabric as compared to hot mercerized ring yarn fabric may be due to higher fibre packing density of compact yarn fabric resists the penetration of alkali to the core of yarn more in comparison to that of ring yarn fabric. Therefore, ring yarn shows higher absorption of Barium Hydroxide as compare to that of compact yarn fabric.
3.4.10 K/S Value:

Table 3.10
Comparison of Colour Absorption and scattering (K/S) Value of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact Yarn fabric</td>
<td>51.318</td>
<td>62.055</td>
</tr>
<tr>
<td>Ring yarn fabric</td>
<td>47.028</td>
<td>60.382</td>
</tr>
</tbody>
</table>

Graph 3.12 - Comparison of Colour Absorption and scattering (K/S) Value of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric.
Both the compact yarn fabrics as well as ring yarn fabrics were subjected to dyeing before and after hot mercerization. It can be seen from Table 3.10 and Graph 3.12 that the Depth of colour in terms of (K/S) value is 51.318 for compact yarn unmercerized fabric and (K/S) value is 62.05 after hot mercerization. Depth of colour in terms of (K/S) value for ring yarn unmercerized fabric is 47.08 and for hot mercerized fabric it is 60.382. It shows that (K/S) value for the compact yarn unmercerized fabric is higher by 12% as compared to ring yarn unmercerized fabric. Similarly, (K/S) Value of compact yarn fabric dyed after hot mercerization is 62.055 and (k/s) for ring yarn fabric is 60.382. It shows that compact yarn (k/s) value is higher by 14% than (k/s) value of ring yarn fabric dyed after hot mercerization. This clearly indicates that compact yarn fabrics have (7%) higher (k/s) value. Higher (k/s) in case of compact yarn fabric could be attributed to reduced hairiness and reduced scattering of light than those of ring yarn fabrics and excellent orientation of fibres to the yarn axis, in comparison to ring yarn fabric. After mercerization fibres swell and deconvoluted; therefore, light scattering from the surface is reduced in both the cases after hot mercerization. Thus, fibre arrangements in yarn structure play decisive role in reflectance and scattering values of the fabric.
3.4.11 Rubbing Fastness:

Table 3.11

Comparison of Rubbing Fastness of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact Yarn fabric</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Ring Yarn fabric</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Graph 3.13 - Comparison of Rubbing Fastness of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric
### 3.4.12 Washing Fastness:

**Table 3.12**

Comparison of Washing Fastness of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>Washing fastness of Unmercerized fabric</th>
<th>Washing fastness of Hot mercerized fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact yarn Fabric</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Ring yarn fabric</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

**Graph 3.14 - Comparison of Washing Fastness of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric**
3.4.13 Light Fastness:

Table 3.13
Comparison of Light Fastness of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric

<table>
<thead>
<tr>
<th></th>
<th>Light fastness of Unmercerized fabric</th>
<th>Light fastness of Hot mercerized fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compact yarn</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Fabric</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ring yarn</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Fabric</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graph 3.15 - Comparison of Light Fastness of Unmercerized and Hot mercerized Ring & Compact Yarn Fabric
It can be seen from Table 3.11, Table 3.12, Table 3.13 and Graph 3.13, Graph 3.14, Graph 3.15 that Dry Rubbing fastness, Wet Rubbing fastness, Washing fastness and Light fastness are remain same for both Ring & Compact Yarn Cotton Fabric mercerized as well as unmercerized.

3.4.13 Scanning electron micro photographs:

Scanning electron micro photographs of ring and compact yarn fabrics after mercerization are shown in the Figures 3.2 & 3.3. These figures clearly indicate that the compact yarn fibres are arranged parallel to the axis and are cylindrical while in the ring yarn, fibres are swollen but not much cylindrical and further, fibres are not found to be arranged parallel in ring yarn.

**Scanning electron micro photographs**

![Figure 3.1- Fibres from Hot Mercerized Compact Yarn](image)

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3.5. Conclusion:

Comparative study of the fabrics manufactured from ring yarn and compact yarn subjected to hot mercerization shows that:

1) Tensile Strength of compact yarn fabric is significantly higher as compared to ring yarn fabric.

2) Crimp percentage in case of both, compact and ring yarn fabrics, is increased.

3) Compact yarn fabric offers higher resistance to abrasion.

4) Drape coefficient shows stiffness has increased after mercerization with ring and compact yarn fabrics. Both ring and compact yarn fabric become stiffer after mercerization.

5) Air permeability is significantly reduced for both hot mercerized compact and ring yarn fabrics.

6) Hot mercerized compact yarn fabric shows better resistance to pilling as compared to that of hot mercerized ring yarn fabric.
7) Hot mercerized ring yarn fabric shows higher Barium Activity Number as compared to that of ring yarn fabric.

8) (K/S) values are significantly improved for both ring and compact yarn fabric after hot mercerization. Compact yarn fabric shows slightly higher (k/s) as compared to that of ring yarn fabric.

9) Rubbing Fastness, Washing Fastness and Light Fastness remain same after hot mercerization for both the compact and ring yarn fabric.