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EFFECT OF MECHANICAL FINISHING ON DIMENSIONAL STABILITY OF COTTON KNITTED FABRIC

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Abstract

Dimensional stability of cotton knitted fabric is a very crucial parameter which is important to maintain for dye house operations. Due to structural limitations dimensional change of cotton is much higher in case of knit fabric than the woven one. In exhaust dyeing the fabric needs to undergo mechanical finishing by different machines such as slitting, dewatering or squeezing, stenter or tensionless dryer and open or tube compactor. In this study the effect of squeezer machine, stenter and open compactor was investigated on different structure of knit fabrics such as single jersey, 1x1 rib and pique of different GSM. It is found that GSM of the fabric remains about 9.21, 7.32 and 7.29% lower than the target GSM in case of single jersey, 1x1 rib and pique fabric respectively after dewatering which is overcome after stentering and compacting. Lengthwise shrinkage is significant for all fabric structure. The shrinkage of single jersey, 1x1 rib and pique fabrics found ± 5% after subsequent stentering and compacting. The spirality remains about 3, 0-3 and 0% for single jersey, 1x1 rib and pique fabric, respectively.

Keywords: Dimensional stability, GSM, shrinkage, stentering, compacting.

Introduction

Weft knitted fabric is very much prone to dimensional change due to structure especially for hydrophilic fibers such as cotton. The limitation of cotton fiber for dimensional change is due to natural origin (Thomas, 1994). Nevertheless, there are various reasons for that kind of properties which are associated with yarn, knitting, finishing and assembling the garments (Anand *et al*., 2002). The moisture content of the fiber largely influences the dimensional change of the hydrophilic fibers. To control the dimensional changes both chemical and mechanical finishing is applied in industries. Chemical finishing is associated with various toxic and harmful ingredients and the strength of the fabric decreased drastically. Mechanical finishing is one of the prominent areas to control the dimensional stability of knit fabric (Hasani, 2010). Several comprehensive finishing machines are employed for knit fabric finishing. These include slitting and dewatering, stenter, tensionless dryer and open or tube compactor. Slitting and dewatering is used to

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remove the excess amount of water after dyeing, tensionless dryer is used to dry the fabric and stenter is applied both for drying and various finishing purposes in case of open fabric. Residual shrinkage of fabric is minimized by the action of compactor. Mechanical finishing is applied along with thermal action to stabilize the knit fabric. This involved stretching in length or width direction and over feeding or under feeding technique. The fabric speed is controlled critically in various machines for synergistic effect with both mechanical and thermal action.

Very few workers demonstrated on the knitted fabric and as well as on the effect of finishing processing on the quality of knit fabric (Matsudaira and Matsui, 1992; Kawabata and Niwa, 1989). The objectives of this study is to know the effect of finishing processes on fabric quality especially shrinkage and GSM. These properties are very much important for weft knitted cotton fabric. As for buyer requirement is concerned to get the target GSM within acceptable shrinkage limit, these finishing stages are very much important in different structure. The investigation was conducted at Epylion Fabrics Ltd. Twenty seven batches were examined from dewatering to compaction.

Materials and Methods

In this study three commercially popular fabrics such as single jersey, (1x1) rib and pique were investigated. The GSM taken for study were 140, 160 and 180 for single jersey, 200, 220 and 240 for plain 1x1 rib and 140, 160 and 180 for pique fabric. Each GSM is studied for three colors such as light, medium and dark. The fabric composition is 100% cotton and stitch length of different GSM against different colors and count is tabulated below in table 1.

Table 1. Stitch length of different structure fabric

Single Jersey					Plain Rib					Pique				
GSM	Count	Stitch length in mm			GSM	Count	Stitch length in mm			GSM	Count	Stitch length in mm		
		W	M	D			W	M	D			W	M	D
140	32	2.70	2.75	2.80	200	30	2.50	2.60	2.55	140	40	2.35	2.35	2.40
160	28	2.85	2.74	2.65	220	28	2.60	2.65	2.70	160	30	2.50	2.55	2.60
180	24	2.74	2.78	2.80	240	26	2.75	2.80	2.55	180	28	2.55	2.60	2.65

Note: W= White, M= Medium, D= Dark

The fabric was processed in dewatering, stenter and compactor sequentially. Each batch of particular color and GSM was observed from dewatering to compactor. The following paragraph describes the sequential contribution of aforementioned machines.

Slitting and Dewatering Machine: Slitting is a process that is applied for cutting the tubular fabric to open out it through the intended break wales line on lengthwise direction prior to facilitate the next subsequent process. The removal of excess water after dyeing

is done by the dewatering machine. Present investigation is carried out by slitting and dewatering machine by Bianco originated in Italy.

Stenter Machine: Stenter is a versatile machine used in textile processing plant. It can be used for fabric drying, heat setting and various chemical processes including coloration of fabric. In this investigation the stenter was applied for drying and control the gsm of the fabric. It was by LK & LH Co- LTD originated in Taiwan.

Open Compactor Machine: Actual residual shrinkage of the knit fabric is controlled by compactor. The compressive blanket action and thermal energy are synergistically applied onto the fabric. The mechanism of compaction is described elsewhere (Marsh, 1957). The experiments were conducted on compactor by Tube-Tex originated in the USA.

The set parameters of these three machines for different structure of fabrics, colors and GSM are described in table 2, 3 and 4. In case of dyeing for white Brightener (Syno white 4bk) was used as self shade and for medium and dark combination shade of reactive dyes were used. Here 2% shade was used as medium and 3% shade was used as dark shade.

Table 2. Set parameters of the machines for single jersey fabric

Colour	GSM	De-Water m/c Parameter	Stenter m/c Parameter			Compactor m/c Parameter		
		Padder Pressure (Bar)	Temp ^{0}C	Over Feed %,	Speed m/min	Temp ^{0}C	Over Feed %,	Speed m/min
White		1.5	140	200	22	100	45	25
Medium	140	1.5	140	200	18	110	40	25
Dark		2.0	150	180	18	110	40	30
White		2.0	150	200	18	100	45	25
Medium	160	2.0	160	180	17	110	40	25
Dark		2.0	160	180	17	110	40	25
White		2.0	150	180	18	110	45	30
Medium	180	2.0	160	180	18	110	45	30
Dark		2.0	160	170	20	120	30	30

Table 3. Set parameters of the machines for rib fabric

Colour	GSM	De-Water m/c parameter	Stenter m/c parameter			Compactor m/c parameter		
		Padder pressure (Bar)	Temp ^{0}C	Over Feed %	Speed m/min	Temp ^{0}C	Over Feed %,	Speed m/min
White		2.5	150	160	20	110	45	30
Medium	200	2.5	150	150	18	110	45	30
Dark		2.5	160	150	18	120	40	35
White		2.5	150	140	18	110	35	35
Medium	220	2.6	160	140	19	120	25	30
Dark		2.7	160	135	20	120	25	30
White		2.0	160	140	18	120	30	30
Medium	240	2.5	160	140	18	120	30	35
Dark		2.5	160	140	18	120	30	35

Table 4. Set parameters of the machines for pique fabric

Colour	GSM	De-Water m/c parameter	Stenter m/c parameter			Compactor m/c parameter		
		Padder pressure (Bar)	Temp ^{0}C	Over Feed %,	Speed m/min	Temp ^{0}C	Over Feed %,	Speed m/min
White		2.25	140	200	22	110	45	30
Medium	140	2.50	150	190	20	120	45	30
Dark		2.55	160	180	20	120	30	35
White		2.0	150	200	22	110	40	35
Medium	160	2.25	160	180	20	120	40	35
Dark		2.35	160	180	20	120	35	35
White		2.15	160	200	20	110	45	25
Medium	180	2.0	160	190	19	110	45	25
Dark		2.0	160	180	18	120	40	30

Determination of Grams per Square Metre (GSM): The GSM of the fabric was measured according to ISO 3801 (ISO, 1977).

Determination of Dimensional Stability: The dimensional stability and spirality of the fabric was measured according to ISO 5077 (ISO, 1984) and ISO 16322-2 (ISO, 2005).

Results and Discussion

The dimensional change of fabric is termed as shrinkage and expressed in percentage. Decrease (shrinkage) is denoted by minus (-) sign and increase (stretch) is denoted by plus (+) sign and both phenomena are revealed as shrinkage differentiating with minus(-) and plus (+) sign. Shrinkage is measured in two directions lengthwise and width wise. Table 5 shows the shrinkage of single jersey fabric of 140 GSM of three shades after dewatering, drying and compacting. From the results it is shown that lengthwise shrinkage is significant after dewatering that the fabric tends to decrease in length. This finding supports that, during exhaust dyeing the fabric undergoes length wise stretch.

Table 5. Changes in dimension in different stages of finishing for Single Jersey 140 GSM fabric

	Dewatering			**Stentering**			**Compacting**		
	Shrinkage (%)			Shrinkage (%)			Shrinkage (%)		
Shade	L	W	Spirality (%)	L	W	Spirality (%)	L	W	Spirality (%)
White	-11	2	6	-4	-6	4	-4	-5	3
Medium	-12	1	7	-6	-7	3	-5	-6	3
Dark	-12	-2	5	-5	-6	5	-4	-5	3

Note: L=Lengthwise W= Widthwise

After drying in stenter the fabric stabilizes too much extent as a result of shrinkage comes to 5 to 6% in both length wise and width wise direction. In the compactor the shrinkage of the fabric stabilized to a great extent and the amount stands 4 to 5% without some fluctuations.

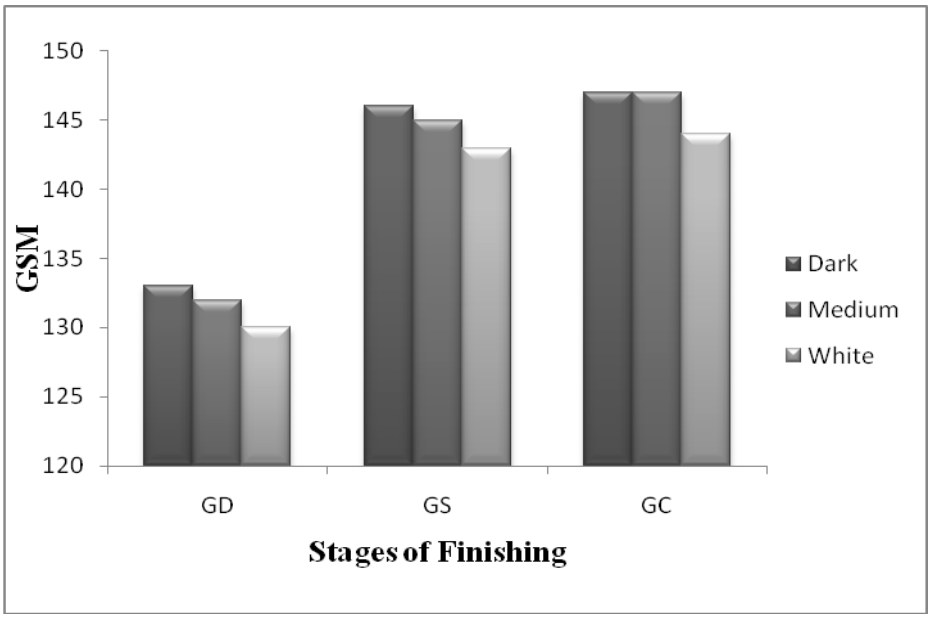

Fig. 1. Change of GSM in different stages of finishing for S/J of 140 GSM.

Here, GD = GSM after Dewatering, GS = GSM after Stentering, GC = GSM after Compacting

The changes of GSM in different processes of finishing for S/J 140 GSM fabric for different shades are shown in Fig. 1. Moreover, in comparison with required GSM after dewatering it decreases 8 to 10 but after stentering and compacting it increases 14 to 15 from dewatering for each shade. The effect of stentering and compacting in dark color is approximately same but in white and medium color compacting shows a little bit good results than stentering.

Table 6. Change in dimension in different stages of finishing for Single Jersey 160 gsm fabric

	Dewatering			**Stentering**			**Compacting**		
	Shrinkage (%)			Shrinkage (%)			Shrinkage (%)		
Shade	L	W wise	Spirality (%)	L	W wise	Spirality (%)	L	W wise	Spirality (%)
White	-10	1	5	-4	-6	4	-4	-6	3
Medium	-11	2	4	-6	-7	3	-5	-5	3
Dark	-11	2	4	-5	-6	5	-4	-6	3

The shrinkage of single jersey fabric of 160 and 180 GSM of three shades after dewatering, drying and compacting are given in table 6 and 7. The result revealed that the fabric tends to decrease in length due to lengthwise shrinkage (Table 6). After drying in stenter and compacting the fabric stabilize too much extent as same as 140 GSM single jersey fabric. But in case of table 7, both lengthwise and widthwise shrinkage is not

significant for white and medium shade. For dark shade it is same to 140 and 160 GSM fabrics.

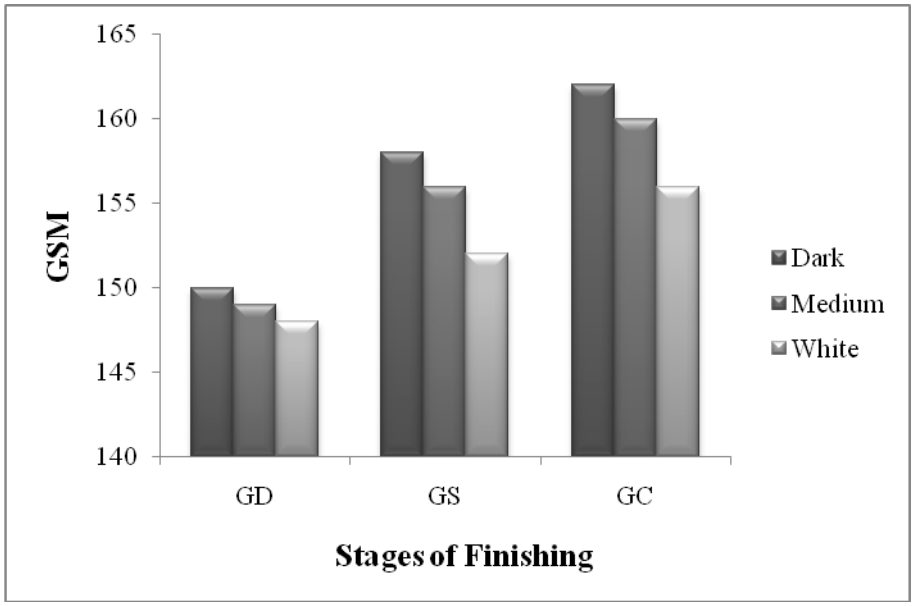

Fig. 2. Change of GSM in different stages of finishing for S/J of 60 GSM.

The changes of GSM in different stages of finishing for S/J 160 and 180 GSM fabrics for different shades are shown in Fig. 2 and 3. The Fig. 2 shows that in comparison with required GSM, we observed that after dewatering it decreases10 to 12 in trends of shades dark to white. After stentering and compacting, GSM increases for each shade. This effect of increasing is significant for dark and medium color but 4 scales lower for white.

In case of Fig. 3 after dewatering fabric GSM are more than 20 scales lower than the target for all shades. After stentering the difference comes to 10 scales. After compacting we reach to the target for all shades.

Table 7. Change in dimension in different stages of finishing for Single Jersey 180 GSM fabric

	Dewatering			**Stentering**			**Compacting**		
	Shrinkage (%)			Shrinkage (%)			Shrinkage (%)		
Shade	L	W	Spirality (%)	L	W	Spirality (%)	L	W	Spirality (%)
White	-7	3	3	-5	3	3	-6	-2	2
Medium	-8	5	4	-4	-6	3	-5	3	1
Dark	-10	6	2	-7	-3	3	-3	4	2

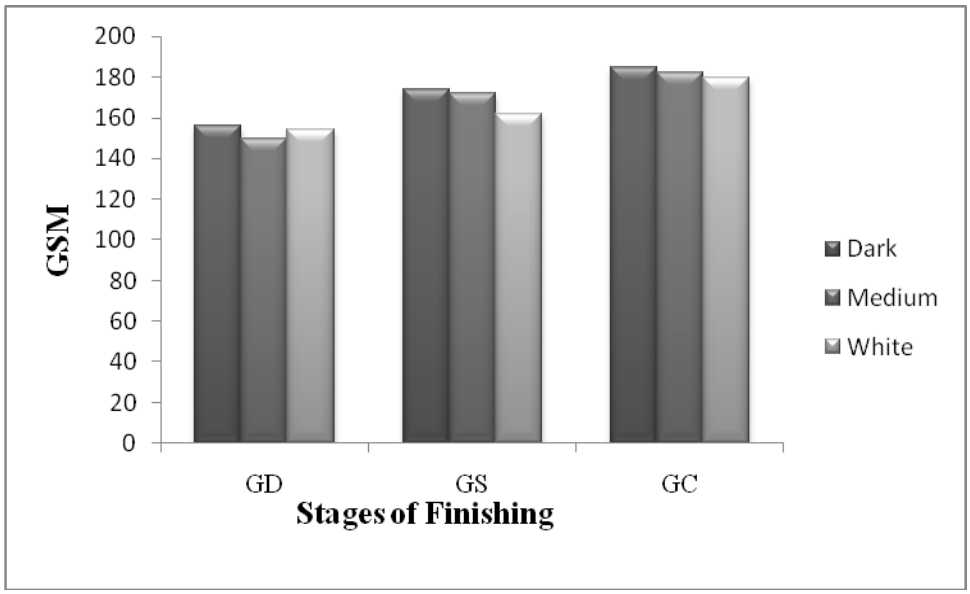

Fig. 3. Change of GSM in different stages of finishing for S/J of 180 GSM.

The shrinkage of (1x1) Rib fabric of 200 GSM of three shades after dewatering, stentering and compacting are shown in Table 8. From the results it is shown that lengthwise shrinkage is more after dewatering that the fabric tends to decrease in length and widthwise shrinkage is more after stentering that the fabric tends to decrease in width. But after compacting the shrinkage comes 3% in lengthwise and 4 to 5% in widthwise which is within limit.

Table 8. Change in dimension in different stages of finishing for (1x1) Rib 200 GSM fabric

	Dewatering			**Stentering**			**Compacting**		
	Shrinkage (%)			Shrinkage (%)			Shrinkage (%)		
Shade	L	W	Spirality (%)	L	W	Spirality (%)	L	W	Spirality (%)
White	-12	1	0	-5	-7	0	-3	-5	0
Medium	-13	2	0	-4	-8	0	-3	-5	0
Dark	-12	2	0	-4	-7	0	-3	-4	0

So, it is said that compacting is very useful for 200 GSM (1x1) Rib fabric for getting required dimension. Fig. 4 shows the change of GSM for (1x1) Rib 200 GSM fabric for different shades and different stages of finishing. We observed in the result after dewatering and stentering GSM decreases 8 to 10 for three shades. After compacting in case of white and dark shades it increases which is near to required but for medium shade it is 5 scales lower than target.

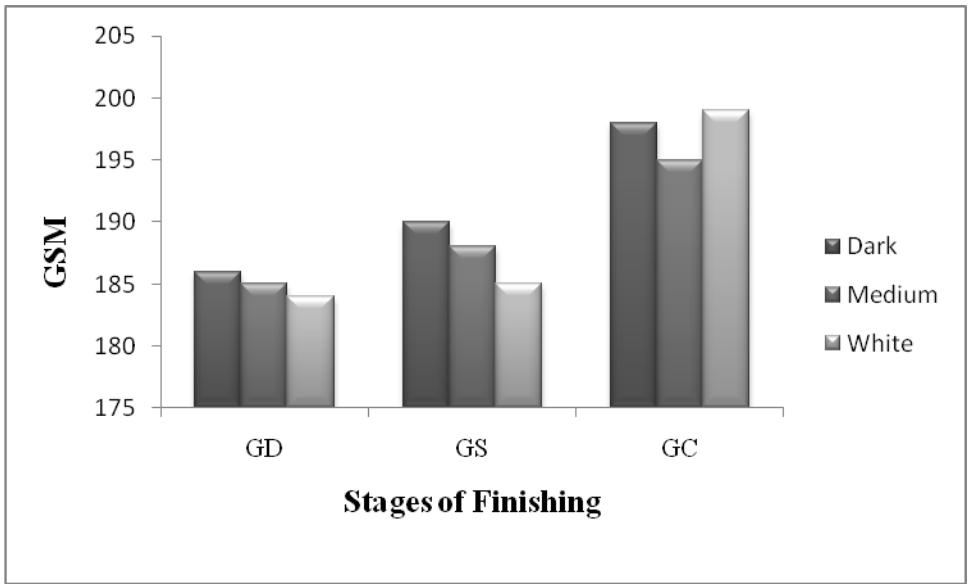

Fig. 4. Change of GSM in different stages of finishing for (1x1) Rib of 200 GSM.

Table 9. Change in dimension in different stages of finishing for (1x1) Rib 220 GSM fabric

	Dewatering			**Stentering**			**Compacting**		
	Shrinkage (%)			Shrinkage (%)			Shrinkage (%)		
Shade	L	W	Spirality (%)	L	W	Spirality (%)	L	W	Spirality (%)
White	-14	4	2	-4	-8	3	-4	-4	3
Medium	-14	4	1	-5	-9	1	-4	-5	1
Dark	-15	5	2	-5	-8	1	-4	-5	1

Table 9 and Table 10 show the shrinkage of (1x1) Rib fabric of 220 and 240 GSM of three shades after finishing. From the results it is shown that for both fabrics lengthwise shrinkage is significant after dewatering and widthwise shrinkage is more after stentering that the fabric tends to decrease in length and width. But after compacting the shrinkage comes 4% in lengthwise and 4 to 5% in widthwise for 220 GSM and 3 to 4% in lengthwise and 5 to 6% in widthwise for 240 GSM which is in acceptance level.

Table 10. Change in dimension in different stages of finishing for (1x1) Rib 240 GSM fabric

	Dewatering			**Stentering**			**Compacting**		
	Shrinkage (%)			Shrinkage (%)			Shrinkage (%)		
Shade	L	W	Spirality (%)	L	W	Spirality (%)	L	W	Spirality (%)
White	-14	2	3	-6	-2	2	-4	-5	1
Medium	-13	1	1	-5	-8	1	-3	-6	1
Dark	-14	2	1	-4	-8	1	-3	-5	1

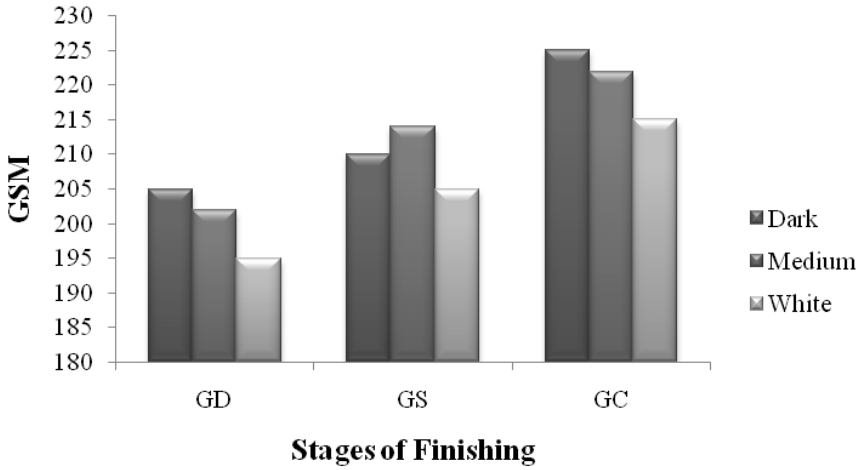

Fig. 5. Change of GSM in different stages of finishing for (1x1) Rib of 220 GSM.

The changes of GSM in different processes of finishing for 220 and 240 GSM of (1x1) Rib fabric for different shades are found in Fig. 5 and 6. From the charts it is shown that in case of 220 GSM fabrics, GSM gradually increased after dewatering, stentering and compacting and reached into 5 scales higher than required except white shade. For white shade it is 5 scales lower than required value. But in case of 240 GSM fabrics stentering has negative effects on it for every shade. The GSM found after dewatering, stentering and compacting are almost lower than required value but good results are obtained after compacting which is very near to required value.

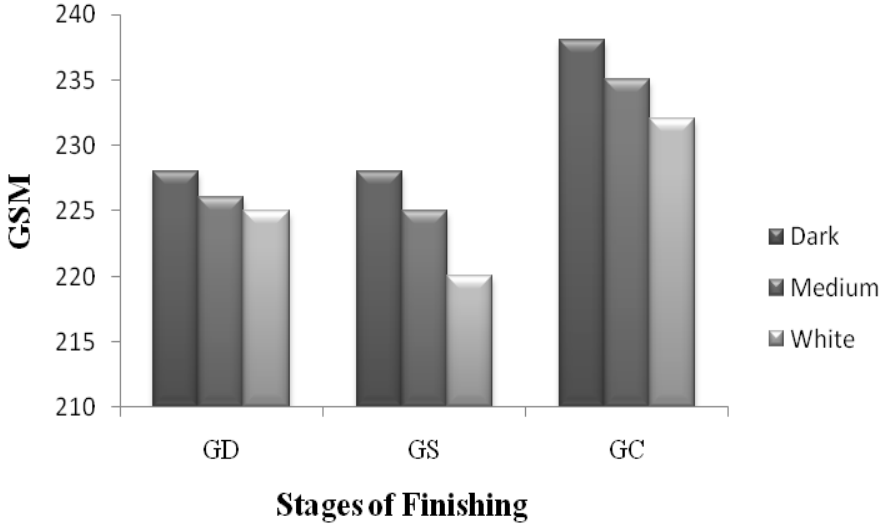

Fig. 6. Changes of GSM in different stages of finishing for (1x1) Rib of 240 GSM.

The table 11 shows the shrinkage of Pique fabric of 140 GSM of three shades after dewatering, stentering and compacting. From the results we observed that lengthwise

shrinkage is more after dewatering and widthwise shrinkage is more after stentering. But after compacting the shrinkage comes 4 to 5% in lengthwise and 6 to 7% in widthwise.

Table 11. Change in dimension in different stages of finishing for Pique 140 GSM fabric

	Dewatering			**Stentering**			**Compacting**		
	Shrinkage (%)			Shrinkage (%)			Shrinkage (%)		
Shade	L	W	Spirality (%)	L	W	Spirality (%)	L	W	Spirality (%)
White	-14	5	0	-6	-8	0	-5	-7	0
Medium	-14	4	0	-5	-8	0	-4	-6	0
Dark	-14	3	0	-6	-7	0	-5	-6	0

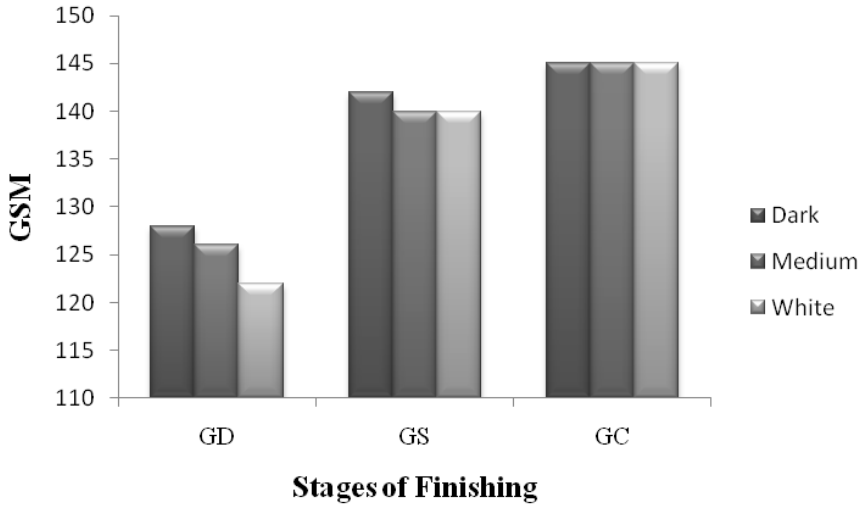

Fig. 7. Change of GSM in different stages of finishing for Pique 140 of GSM.

The GSM changes in different processes of finishing for Pique 140 GSM fabric for different shades are shown in Fig. 7. In comparison with required value after dewatering GSM decreases 18 to 12 in trends of white to dark shades but after stentering each shade has reached at target and after compacting it increases approximately 5 from target GSM for each shades. The effect of stentering and compacting in every color is same.

Table 12. Change in dimension in different stages of finishing for Pique 160 GSM fabric

	Dewatering			**Stentering**			**Compacting**		
	Shrinkage (%)			Shrinkage (%)			Shrinkage (%)		
Shade	L	W	Spirality (%)	L	W	Spirality (%)	L	W	Spirality (%)
White	-14	4	0	-6	-8	0	-5	-6	0
Medium	-14	4	0	-4	-8	0	-4	-6	0
Dark	-13	4	0	-6	-8	0	-5	-6	0

The lengthwise shrinkage is significant after dewatering and widthwise shrinkage is more after stentering (Table 12 and 13). The results are for Pique fabric of 160 and 180 GSM of three shades after finishing. But after compacting the shrinkage comes 4 to 5% in lengthwise for both fabrics and in widthwise 6% for 160 GSM and 4 to 6% for 180 GSM fabrics.

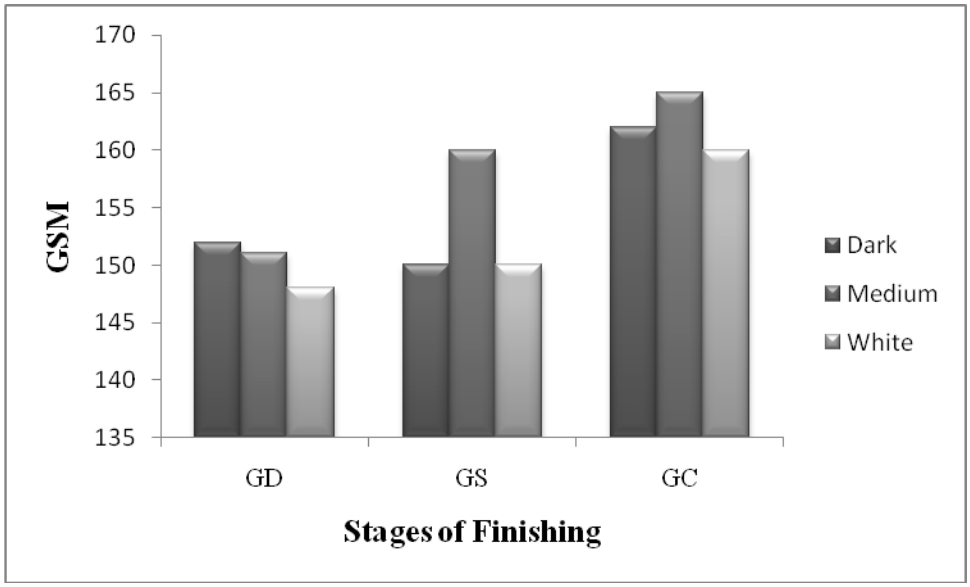

Fig. 8. Change of GSM in different stages of finishing for Pique of 160 GSM.

Table 13. Change in dimension in different stages of finishing for Pique 180 GSM fabric

	Dewatering			**Stentering**			**Compacting**		
	Shrinkage (%)			Shrinkage (%)			Shrinkage (%)		
Shade	L	W	Spirality (%)	L	W	Spirality (%)	L	W	Spirality (%)
White	-13	4	0	-5	-8	0	-4	-6	0
Medium	-13	4	0	-5	-8	0	-4	-6	0
Dark	-14	3	0	-4	-7	0	-5	-4	0

The GSM changes in different processes of finishing for Pique 160 and 180 GSM fabrics for different shades are given in Fig 8 and 9. The Fig. 8 stated that stentering has negative effects on GSM for white and dark shades but good for medium shade. GSM after dewatering is 12 to 8 in trends of white to dark lower than required value but good results are obtained after compacting which is reached at target. But Fig. 9 shows that in comparison with required GSM after dewatering it decreases 11 to 8 in trends of white to dark shades. Stentering has no effect on white and medium color but a little good for dark color. Good results are obtained after compacting for every shade.

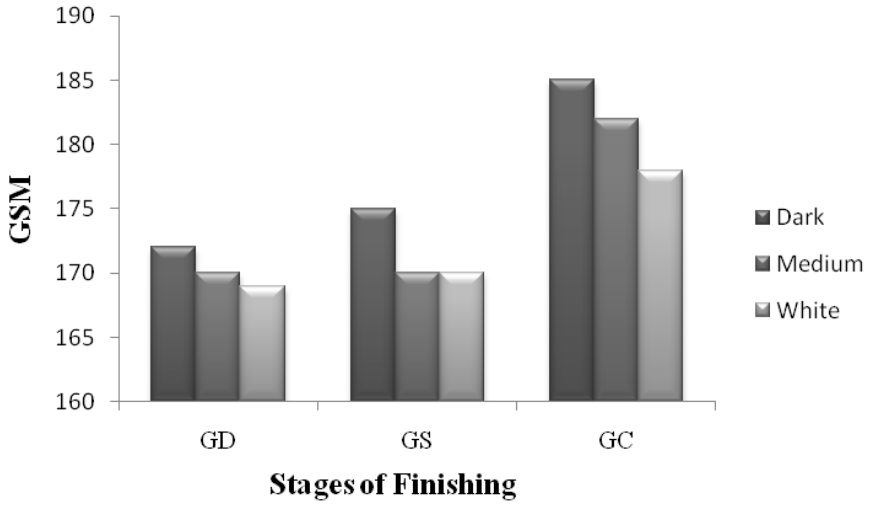

Fig. 9. Change of GSM in different stages of finishing for Pique of 180 GSM.

Conclusion

In case of textile processing cotton knitted fabrics mechanical finishing is required. The effect of the mechanical finishing on dimensional stability and GSM of different structured knit fabrics for different shades was investigated in this study. For all structure fabrics lengthwise shrinkage is more than widthwise but after finishing it becomes under acceptable level. After dewatering GSM is much lower than target level and it is more significant in white shade which is overcome by the process stentering and compacting. So mechanical finishing is very much important and the machines that are used such as stenter, compactor is useful for textile processing.

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