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Effect of Woven Fabric Structure on Dimensional Stability- A Lead Time Saving Approach for the Sustainability of Bangladeshi Woven Industries

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Abstract

In this study a common problem regarding the sustainability of Bangladeshi woven industries in respect to lead time management has been identified as a result of random estimation of raw materials while sourcing and an empirical solution has been approached for two basic woven structures. Different constructions of plain and twill weaves of cotton dyed yarns were manufactured using rapier loom. We found that shrinkage % for plain fabric is comparatively higher than twill fabric. For both structures, shrinkage % follows certain range. But for small order quantity usually less than 1000 meter shrinkage % goes higher than upper limit of the range. And the shrinkage % of different structures has a positive correlation with cover factor of these fabrics. For the experimented fabric structures a certain shrinkages % has been also suggested on the basis of fabric construction, type of weaves and dye shade percentage to meet the order quantity.

Key words: woven fabric, lead time, shrinkage %, plain weave, twill weave.

Introduction

Woven fabric is mostly used among all other fabrics because of its versatile application for clothing, industrial, commercial and other technical purposes [1]. Though Bangladesh is an auspicious land of textile production, the demand of woven cloth is comparatively less than the knitted one [2]. Among many other reasons of placing small volume of order, improper lead time management is a very crucial fact [3]. Lead time is the time span from the order confirmation to ship the material [4]. Inability to ship the material as per schedule (failing to meet lead time) brings customer boredom and

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subsequently order cancellation and more threading is that buyers become reluctant to order for further material sourcing. Factors affecting lead time procurement includes some internal factors for instance time and cost overruns; poor communication; lack of experience by the procurement manager; procurement delays; lack of planning; poor infrastructure; inadequate resources; lack of motivation; tendering methods; variations; project environment, poor project definition. In addition, inflation, project complexity, inaccurate estimates; change orders; design changes; late submission of drawings; poor specifications; incorrect site information; poor project management are also some internal factors considered for lead time procurement [5]. On the other hand external factors include different environmental issues viz. market, legal, political environment, and other environmental factors [6]. Lead time management is necessary for the sustainability of industry [7]. In case of woven fabric production, manufacturing lead time consumes most of total lead time (as the productivity of loom is comparatively low) which is highly influenced by estimating required raw materials to execute the order given by buyer [8]. Woven fabric is produced by the interlacement of two sets of yarns named warp yarn (lengthwise) and weft yarns (widthwise) and the ultimate length of fabric is highly influenced by shrinkage %. Different weave structures have different shrinkage % due to variation of fabric geometry and yarn interlacement [9, 10]. Large numbers of weave structures are applied in weaving industries like plain, twill, satin etc. with a great variety of derivatives to serve different purposes [11]. But in Bangladesh, woven fabric manufacturers don’t follow any strict rules in calculating shrinkage %. They just work on their estimation and experience which doesn’t have any mentionable basis and also unscientific. As a result, it causes manufacturer’s enigma from over production (which consumes more time and extra production is worthless in some cases) as well as under production (which requires reproduction and takes much time, in-time delivery becomes difficult to maintain). This paper focuses to meet this apparent difficulty; to minimize manufacturing lead time by the fulfillment of an order in due time and also to reduce excess production than required by sourcing right amount of material through calculating the required material needed for production considering fabric structure, yarn counts, yarn density and shrinkage %. This study gives an overall idea of benchmark of shrinkage % of yarn to be considered for different weave structures during production. Thus actual calculation means saving time to create more order which results more profit and more employment opportunities on which the sustainability of woven industries of Bangladesh depends. In addition, it is very important to delivery product in time to manage the lead time properly. Otherwise it will hamper buyers’ satisfaction and create disinclination in their future order. Therefore, it is very important to look after the delivery of product within scheduled time which can also be achieved by actual calculation of raw material required for fabric production. Interestingly it is also the reason of buyers’ satisfaction. In this way, this manuscript approaches sustainability of both buyers’ satisfaction and woven industries of Bangladesh.

Materials and Method

In conducting this research we applied our concept for different woven structures especially for yarn dyed plain and twill woven fabric. We did our research in Noman Composite Textile Limited, Valuka, Mymensing, Bangladesh. The structures and constructions of weaves have been enlisted in the Table 1.

Table 1: Different constructions of fabrics

Sl. No.	Type of Weave	Constructions	Frequency of Orders
1	Plain	20x20/64x54	4
2		26x26/90x72	15
3		40x40/100x70	6
4		40x40/110x90	12
5		40x40/120x80	10
6	Twill	20x20/64x54(S-twill)	7
7		20x20/72x62(S-twill)	5
8		40/2x40/2/68x48(S-twill)	5
9		20x20/100x58(S-twill)	3
10		20x20/72x62(Z-twill)	3
11		30x30/88x76(Z-twill)	9

These above structured fabrics were woven by using rapier loom of following specification:

Brand	:	Picanol Optimax
Origin	:	Belgium
Rapier type	:	Flexible (Double)
RPM	:	600-800
Reed Width	:	190 cm
Reed type	:	Plain/Flat
Cam	:	Tappet
Heald Frame	:	06
Selvedge type	:	Leno

During production the machine parameter were set up as follows**:**

Back rest height	:	+6…+10
Shed angle	:	24^0 -26^0
Crossing angle	:	312^0
Warp Tension	:	2-3 Kilo Newton

Calculation and Result

We applied the ideas for 47 plain and 30 twill fabrics

Determination of shrinkage %: Different parameters to facilitate our research have been tabulated in the Table 2. Moreover, explanation of calculation system has also been mentioned here.

Shrinkage = (length of yarn to be required – the length of fabric manufactured)*100%/ length of yarn required [12].

Table 2: Calculations for 1/1 Plain & Twill Weaves (2/2)

Sl No	Construction	Total Order quantity	Frequency of orders	Estimated average shrinkage %	CV% of Estimated average shrinkage %	Total Fabric Manufactured at estimated shrinkage %	Fabric manufactured extra	Actual average/suggested shrinkage%	CV% of Actual average shrinkage %	Cover Factor
1/1 plain weaves										
1	20x20/64x54	10755	4	10.16	27.48	10932	177	8.6	10.472	26.4
2	26x26/90x72	29824	15	16.7	14.93	31002	1178	12.7	11.819	31.82
3	40x40/100x70	28149	6	11.9	12.753	29181	1032	8.9	8.557	26.89
4	40x40/110x90	109310	12	16.0	26.544	111551	2232	12.2	19.262	31.64
5	40x40/120x80	51006	10	16.0	27.643	51900	894	14.7	38.521	31.64
Twill weaves (2/2)										
1	20x20/64x54(S-twill)	33055	7	11.8	25.691	34852	1797	7.6	59.369	19.69
2	20x20/72x62(S-twill)	78931	4	9.7	62.225	94428	2061	8.8	45.662	22.45
3	40/2x40/2/68x48(S-twill)	32266	5	18.2	82.919	33202	936	7.7	37.547	19.35
4	20x20/100x58(S-twill)	8412	3	16.8	50.792	8748	336	10.5	33.381	25.03
5	20x20/72x62(Z-twill)	50169	3	8.9	25.754	50096	-24	8.8	22.818	22.45
6	30x30/88x76(Z-twill)	205249	8	11	14.185	211172	5923	8.2	17.031	22.36

Column 2: Construction: 20x20/64x54 which indicates-

EPI (Ends per Inch) X PPI (Picks per Inch) / Warp count X Weft count

Column 3: Total order quantity: The sum of all individual order quantities of this structure

Say, for 1st Construction the sum of total order = (4698+1187+387+4483) Meter

=10755 Meter

Column 4: Frequency: The number of order of this structure during research. For 1st Construction total number of order is 4. That's why frequency is 4.

Column 5: Estimated average shrinkage % of yarn which means the estimated percentage of yarn to produce the required ordered fabric. For 1st Construction 1st order, order quantity is 4698 meter, estimated % of shrinkage is 9.65, total yarn=5200 meter. From here it shows that we need 5200 meter yarn to produce 4698 meter fabric. And the average of estimated shrinkage% shows in column 5. For four order of 1st Construction the Estimated average shrinkage % of yarn =9.65+7.3+14+9.7/4 =10.16

Column 6: CV% of estimated average shrinkage %: The Coefficient of Variation (CV) represents the ratio of the standard deviation to the mean expressed into percentage, and it is a useful statistical tool for comparing the degree of variation from one data series to another, even if the means are drastically different from each other. For 1ST construction, the calculation system for the determination of CV% has been shown in Table 3.

Table 3: Calculation of coefficient of variation (CV %)

Shrinkage %, X	Arithmetic mean , $\bar{x}$	(X- $\bar{x}$)	(X- $\bar{x}$)^2	$SD=\sqrt{\frac{\sum(x-\bar{x})^2}{N-1}}$	$CV = \frac{s}{\bar{x}} \times 100$
9.65		-.51	.26		
7.3	10.16	-2.86	8.18	2.7	27.48
14		3.84	14.75		
9.7		-.46	.2116		
			$\sum$(X - $\bar{x}$)^2=23.4		

Column 7: Total Fabric Manufactured.

The total fabric produced against estimated yarn shrinkage%. By using 10.16 estimated shrinkage % of yarn we get total fabric 10932 meter.

Column 8: Fabric manufactures extra which means the amount of excess fabric production than actual order quantity. For 1st construction total order quantity is 10755 meter. But by using 10.16% estimated shrinkage% 10932 meter fabric is produced. So extra fabric production =10932-10755=177 meter.

Column 9: Actual average shrinkage% means the shrinkage% by using which shrinkage% we met the actual order quantity without any excess production. For 1st construction if we use 8.6% yarn shrinkage, the total fabric production will be 10755meter.

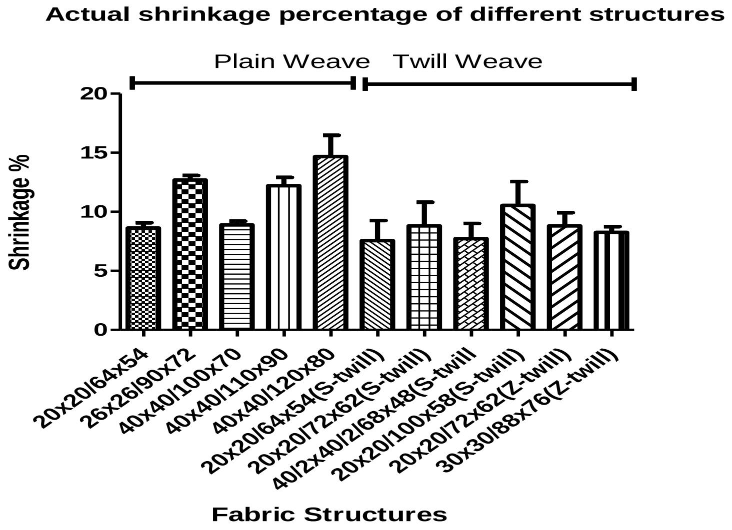

Figure 1: The average of shrinkage % of same structure during different order

Column 10 : CV% of Actual average shrinkage % which is calculated same as column 6.

Column 11 : Recommended shrinkage% means the shrinkage% by using this we met the actual order quantity without any less production. Although 8.6% yarn shrinkage met the order without any extra production but if 5% extra yarn shrinkage is added, it will give better security.

Column 12 : The cover factor indicates the degree of density of the fabric. The higher the figure is, the denser the fabric will be and the more beat-up will be obtained.

Cover factor = (EPI/√Warp count + PPI/√Weft count) x correction factor

Correction factor for plain weave =1

Correction factor for 2/2 Twill weave =0.7469

For 1st construction cover factor = (20/√64+20/√54) x 1 =26.4

Discussion

Table 2 shows approximately how the right amount of yarn is determined by determining the shrinkage % of fabric. The estimated shrinkage % was estimateded randomly (Mentioned in Appendix) without using any scientific base or model or reference which is a common practice of most of the Bangladeshi weaving Industries. Column-5 of the tables 2 describes the variation in shrinkage percentage in terms of Coefficient of Variation (CV %) of same construction of two weaves at different order quantity as there is no strong basis or benchmark used for the estimation of shrinkage %. The shrinkage percentage of the above structures of plain weave is comparatively greater than that of twill weaves. This is because of more numbers interlacement in plain weave than twill weave and geometry of construction. In case of our experimented construction of plain weave warp-way shrinkage % ranges from 7.1% to 15.8% and for twill weave it becomes 4.5% to 14.7%. It is shown that from the tables that for most of the cases the variation in estimated shrinkage % is higher than that of actual one. For instance, if we consider the construction no. 2 of plain weave, it shows for 15 individual orders of same construction different shrinkage % were set up during different order execution. As a result there is found more CV% value counted as 14.93 (estimated) than the actual one, 11.819 which indicates that shrinkage % surrounds a some certain values. Here actual values are found different that may be due to different shade % during dyeing, incorrect machine settings or process control etc. Some researchers have found that shrinkage increases with the increment of dye shade percentage [13]. Another noticeable thing is that some red marked CV% values show that the estimated CV% is lower than the actual one. Theoretically it is not supposed to be happened. But practically for some small order quantities (red marked in the appendix) there are some fixed wastages and processes. That’s why it counts some extra amount of material and become responsible for the increment of wastage%. So it appeared that it became difficult to meet the order quantity less than 1000 meter if the fabric is manufactured at the referred values. Due to inappropriate and random estimation of shrinkage %, sometimes it failed ship to right volume material(asked by buyer) as a result of shortage and consequently fail to meet lead time(given by buyer). Or sometimes manufacturing excess but unnecessary amount generates wastage which is worthless in some cases. So for above constructions to meet future order quantity more than 1000 meter the average of actual shrinkage % can be followed with a little allowance depending on the machine parameters and machine condition.

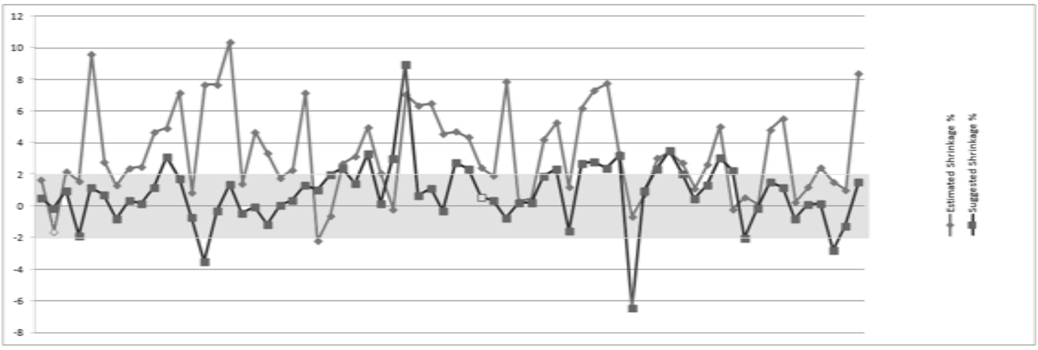

Figure 2: Order fulfillment within +/-2% of order quantity at estimated and suggested shrinkage %.

The Figure 1 & 2 shows that for most of the constructions according to the suggested shrinkage percentage, the order can be fulfilled with more approximation than estimated one. In our experiment we conducted total 77 experiments among which 11 orders' quantity are less than 1000 meters. For rest 66 orders, as per estimated shrinkage % 23 orders which is 35% of total orders comes successful and as per suggested value 40 orders (more than 74%) comes successful within the allowable range(+/-2%) if the respective fabric under goes their own actual shrinkage percentage. The graph shows that within +/- 2% range of order quantity most of orders come successful enabling to meet lead time as well as discarding excess. So it can be applied for further same orders to minimize wastage and meet lead time.

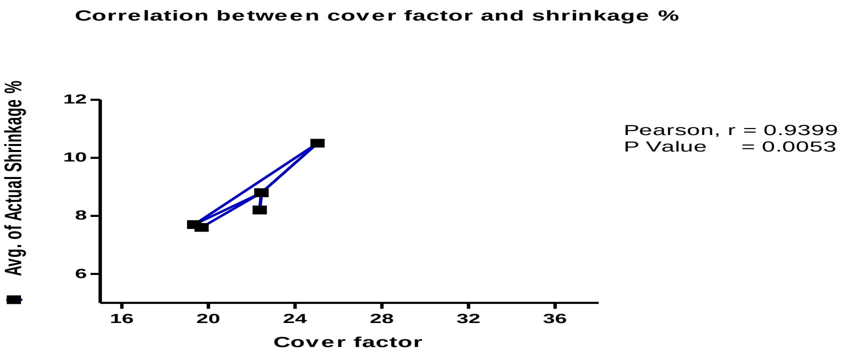

Figure 3: Co-relation between cover factor and actual shrinkage % for plain weave

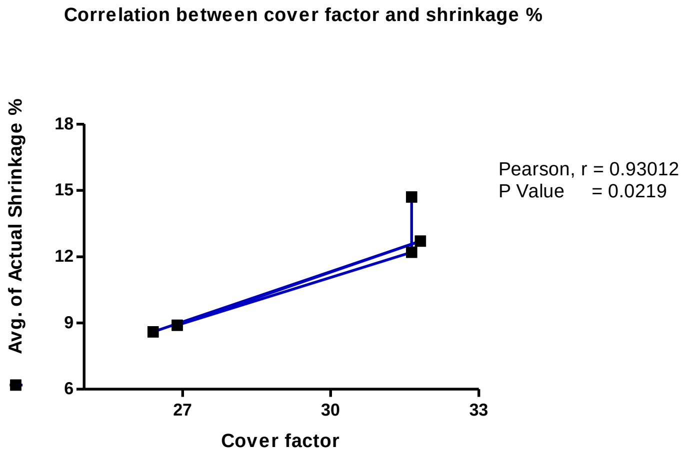

Figure 4: Co-relation between cover factor and actual shrinkage % for twill weave

Table 4: Ratio of cover factor and shrinkage %

Shrinkage %	Cover factor	Cover factor/ Shrinkage %
8.6	26.4	3.069767
12.7	31.82	2.505512
8.9	26.89	3.021348
12.2	31.64	2.593443
14.7	31.64	2.152381
7.6	19.69	2.590789
8.8	22.45	2.551136
7.7	19.35	2.512987
10.5	25.03	2.38381
8.8	22.45	2.551136
8.2	22.36	2.726829

At this juncture, it is also mentionable that for different constructions there is different shrinkage %. It shows that there is a positive correlation between shrinkage % and fabric construction which has been expressed in term of cover factor. The P value is also significant for both plain and twill fabric which can be illustrated from the Figure 3 and Figure 4. On the other hand, table 4 shows that if cover factor (which can be calculated easily from the fabric construction) is divided by 2.5-3 we get an approximate shrinkage % of those structures before placing any order. Therefore, our study provides at least a range of shrinkage % to be estimated during placing an order for sourcing material. It would be defined a more specific value here if it would have been possible to consider some more information for instance type of weave, no of interlacements , dye shade percentage, surface characteristics of materials etc.

Conclusion

The consumption of yarn for different fabric structures and to what amount of yarn to be sourced to execute buyer’s order can defined using the suggested shrinkage % shown in the paper. Cover factors of fabric has a very influential effect on shrinkage % which has also been proved in this research. This paper basically was prepared to meet lead time given by buyers by determining the amount of required raw material (yarn). The effect of lead time to the sustainability of woven industries of Bangladesh and buyers’ satisfaction has also been suggested in the manuscript. We applied our concept for very limited structures and further research can be suggested for variety of structures and to get more lucid and logical approaches.

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