

Study on Material Wastes in Air-jet Weaving Mills

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ABSTRACT

The work reported in this article is an account of wastes generated in two air jet weaving mills producing 100% cotton fabrics for the export market. Mainly two types of wastes were categorized, (i) wastes related only to warp e.g., gara cones, knotting waste, gaiting/tying-in, loom setting, beam residue after sizing and weaving, warping, in the sizing zone and the polyester yarns in the auxiliary selvedge etc. and (ii) wastes related only weft, e.g., cut fringe, faulty cones, waste due to loom setting, etc. The study involved collection of data about various wastes (both warp and weft) of 8 different qualities (construction wise) from the two air jet weaving mills. The amounts of respective wastes were then expressed as percentages of the total quantity of warp and weft. The wastes related to warp and weft were found to be in the range of 2.59% to 3.96% and 2.43% to 3.51% respectively. It was also observed that the warp wastes in knotting, gaiting/tying-in, loom setting and as beam residue after weaving, were insignificant whereas warp wastes in the warping and sizing zone were significant. Additionally, weft wastes due to cut fringe and faulty cones were found to be significant, but weft waste due to loom setting was found to be insignificant. The polyester filament (ply) yarns are used as warp in the auxiliary selvedge of fabric, however, due to their high strength; these yarns are being reused again and again for a long period of time.

Keywords: Waste, Cotton weaving, Air-jet, Warp wastes, Weft wastes, Auxiliary Selvedge, Material waste

1. Introduction

Bangladesh is one of the largest Readymade Garments (RMG) exporters in the world. Mainly two types of RMG products are being exported from Bangladesh, woven and knitted. Almost 100% of the knitted fabric required for making knit RMG products is

being made locally. But almost 40 – 50% of the total fabrics required in export-oriented woven RMG are being imported from countries like China, India, Pakistan, and Turkey, etc. As a result, the value added to the woven garments is very low as compared to knit garments, and increment of production of woven fabrics locally is a challenging task

for the textiles and RMG sector of Bangladesh. The Dept. of Textile Engineering of Daffodil International University has undertaken a research project to study the problems of the export-oriented weaving sector of Bangladesh. As part of the project, the present study has been conducted to see the waste percentage generated in the export-oriented weaving factories. Unfortunately, up to now; very little work has been conducted on the matter. Some indirectly related issues came across, e.g., a study (Platt, B., 1997) on weaving textile reuse and waste reduction indicated that tons of weaving wastes could be reused which can ensure the best utilization of resources to get maximum profitability, and benefit the communities ecologically. Another study found that one of the common causes of generation of waste in the weaving industry occurs during the handling of materials throughout the weaving process (Gosh, S.K et al., 2014). Two final year students did their B.Sc. in TE project on “Study on Selvedge Waste in Rapier Loom” under the supervision of the first author. They found that if the width of the fabric increases the waste (weft) percentage will decrease (Roy, A. & Rahman, H., 2014). According to a project funded by the European Commission, European societies are generating more waste, includes wastes often made up of resources, which could be recycled and used. The society has to develop a strategy to conserve the natural resources. It is very important to dissociate economic growth from waste generation. It relates to the concept of sustainable development to avoid

the overexploitation of non-renewable resources as it would endanger the ability to create wealth and to sustain future generations (RESITEX, 2008-2009).

The present study was conducted in two air-jet cotton weaving mills located in the greater Dhaka. During the study, the information of wastes related to warp and weft in each stage of the material handling was collected and studied. The quantities of warp and weft wastes were then expressed as a percentage of the total amount of the warp and weft. The study will provide an idea about wastes generated at each stage of the weaving process. Once the extent of the waste is understood well, then it may be possible to have better control on material waste and effective utilization of materials and resources in any cotton air-jet weaving industry.

2. Methodology

At first, two export-oriented air jet weaving mills were chosen for collecting information. In collecting the data, attempts were made to collect waste data of fabric qualities common to both the mills. Accordingly, eight different qualities (*regarding construction and other weaving details*) were identified, and information about wastes generated in different stages of weaving was recorded. Table 1 shows the details of the above mentioned eight qualities. Each of the fabrics qualities were then denoted by eight letters from A to H, shown in the last column of the table.

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Table 1: Details of various fabric samples which were considered for the study.

Finish Fabric Specification										
Sl. No.	Warp	Wef	Warp Density, EPI	Pick Density, PPI	Weave	FABRIC TYPE	T.END S	Creel	Warp length	ID
	Ne	Ne							yds	
1	20	16	128	60	3/1	TWILL	7,452	621	6250	A
2	16	12	112	60	3/1	TWILL	6,400	640	6000	B
3	40	40	133	96	1/1	Poplin	7,600	634	12450	C
4	30	30	152	84	3/1	TWILL	8,500	709	9300	D
5	10	7	76	40	3/1	TWILL	4,450	557	6300	E
6	30	30	148	80	3/1	TWILL	8,650	721	9300	F
7	30	20	146	76	2/1	TWILL	8,300	692	9300	G
8	20	20	108	58	3/1	TWILL	6,250	625	6250	H

3.1 Waste Related to Warp

3.1.1 Residual yarn left in the cones after warping (Locally known as Gara)

This waste is generated in the warping creel section. In warping it is not possible to empty a cone/cheese completely and there is always some small amount of yarn left in the package. The speed of warping is somewhat fixed in each machine. Initially, when the cones are full-sized, unwinding of only a few coils can satisfy the warping speed, but towards the end of a cone/cheese, the overall diameter of the package decreases. As a result, a greater number coils are required to support warping speed. Because of this, at some stage, the unwinding of so many coils in unit time becomes difficult, this causes the unwinding pattern to look like a balloon and is widely known as ballooning. At some stage of ballooning, the number of unwinding coils becomes high and can no longer support warping speed, this causes warp breaks, and it becomes difficult to stop repeating

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breakage. Because of these breakages, some cones that still contain yarn have to be thrown away. Figure 1 shows pictures of some of these cones in the creel which are locally known as "Gara." The yarns left in the Gara cones are transformed into large cones using a cone winding process. These cones are then used for producing low graded woven fabrics, apart from this, the gara waste is also sold in local factories in Bangladesh at a very low price.

Calculation of Residual yarn left in the cones after warping "Gara" Wastes (%):

The gara waste of a particular warp set is calculated by weighing the gara cones by removing them from the creels. Then the amount of waste yarn is calculated by deducting the weight of empty packages/paper cones. After that, the extent of warping waste is measured in percentage of the total yarn weight.



Figure 1: Residual yarn left in the creels after warping as wastage/gara

The calculation of a particular quality (Sl. No. 1 in Table 2) is described below:

Total no. of ends = 7252

No. of creels used = 621 for making 12 warp beams.

Therefore, there will be 621 cones having residual yarn, i.e., gara.

Weight of each cones having residual yarns = 0.17 lbs

Weight of each empty package, i.e., the paper shell = 0.04 lbs.

Total Weight of yarns wound on to warp beams were = $621 \times (4.593 - 0.04)$ lbs.
= 2827.41 lbs

It may be mentioned that a full cone of 20's CTN weighs 4.593 lbs. In fact, the Bangladeshi spinning mills sell their yarn in bags of 50 kgs where 24 full cones (18 cones

for 10's yarn) are packed. Therefore, the weight of each cone becomes 2.08 kgs (2.78 kgs for 10's). Table-4 shows the details of yarns, counts, cones, and weights, etc.

Total weight of residual yarn (i.e. gara waste) = $621 \times (0.17 - 0.04)$ lbs.
= 80.70 lbs;(i)

Therefore, the warping wastage (in %) = $\frac{80.70 \text{ lbs}}{2827.41 \text{ lbs}} \times 100$
= 2.85 %(ii)

The values mentioned above are shown in equation (i) and (ii) represent the amount and percentage respectively of warping waste, or gara waste of 1st quality, i.e., A. These two data are shown in the 2nd and 3rd columns of the 1st row of table 2. The quantity and percentages of warping or gara waste of the

other qualities were calculated using the above procedure and are shown in the 2nd and 3rd columns of table 3. The warping or gara waste were also calculated using the same procedure, and the results are shown in the 2nd and 3rd columns of table 3.

Table -2: Warp related wastes in various stages of processing (for factory 1):

WARP WASTE of Factory 1																		
I D	Gara waste		Sizing waste			Knotting waste			Gaiting/Tying in waste			Beam Residue			Due to Loom Setting			Total
	Lbs	%	Y d	lbs	%	y d	Lbs	%	y d	lbs	%	Y d	Lbs	%	y d	Lbs	%	%
A	80.70	2.85	22	9.76	0.35	3	1.33	0.05	3	1.33	0.05	3	1.33	0.05	2	0.98	0.03	3.37
B	83.17	2.85	20	9.52	0.33	3	1.43	0.05	3	1.43	0.05	3	1.43	0.05	2	1.07	0.04	3.36
C	95.06	3.29	22	4.98	0.17	4	0.93	0.03	3	0.68	0.02	4	0.93	0.03	3	0.83	0.03	3.58
D	113.40	3.51	25	8.43	0.26	5	1.69	0.05	3	1.01	0.03	3	1.01	0.03	3	1.24	0.04	3.93
E	72.38	2.14	20	10.60	0.31	2	1.06	0.03	3	1.59	0.05	2	1.06	0.03	2	1.25	0.04	2.59
F	115.30	3.51	21	7.21	0.22	5	1.72	0.05	3	1.03	0.03	4	1.37	0.04	3	1.21	0.04	3.89
G	110.66	3.51	22	7.25	0.23	4	1.32	0.04	3	0.99	0.03	4	1.32	0.04	2	0.79	0.03	3.88
H	81.22	2.85	18	6.70	0.24	2	0.74	0.03	3	1.12	0.04	2	0.74	0.03	2	0.81	0.03	3.21

Table -3: Warp related wastes in various stages of processing (for factory 2):

WARP WASTE of Factory 2																		
I D	Gara waste		Sizing waste			Knotting waste			Gaiting/Tying in waste			Beam Residue			Due to Loom Setting			Total
	Lbs	%	Y d	lbs	%	y d	Lbs	%	y d	lbs	%	Y d	Lbs	%	y d	Lbs	%	%
A	90.00	3.18	30	13.30	0.47	3	1.33	0.05	2	0.89	0.03	3	1.33	0.05	2	0.98	0.03	3.81
B	88.00	3.02	30	14.29	0.49	3	1.43	0.05	2	0.95	0.03	3	1.43	0.05	2	1.07	0.04	3.68
C	89.00	3.08	35	7.92	0.27	6	1.36	0.05	2	0.45	0.02	3	0.68	0.02	3	0.83	0.03	3.47
D	102.50	3.18	32	10.79	0.33	5	1.69	0.05	2	0.67	0.02	3	1.01	0.03	3	1.24	0.04	3.65
E	70.00	2.45	30	13.39	0.47	2	0.89	0.03	2	0.89	0.03	3	1.34	0.05	1	0.53	0.02	3.05
F	112.50	3.43	32	10.98	0.33	4	1.37	0.04	2	0.69	0.02	3	1.03	0.03	2	0.82	0.02	3.88
G	110.00	3.49	33	10.87	0.34	4	1.32	0.04	2	0.66	0.02	3	0.99	0.03	2	0.79	0.03	3.96
H	86.00	3.02	30	11.16	0.39	3	1.12	0.04	2	0.74	0.03	3	1.12	0.04	3	1.21	0.04	3.56

Table 4: Details of the yarn packages and yarn bags marketed by Bangladeshi spinners.

Yarn Count	Bag Wt.	Cones per bag	Cone Wt.	Cone Wt.	empty cone	Yarn Wt.
Ne	Kgs.		Kgs.	Lbs.	Lbs.	Lbs.
40	50	24	2.08	4.593	0.04	4.553
40/2	50	24	2.08	4.593	0.04	4.553
30	50	24	2.08	4.593	0.04	4.553
20	50	24	2.08	4.593	0.04	4.553
16	50	24	2.08	4.593	0.04	4.553
10	50	18	2.78	6.124	0.04	6.084

3.1.2 Sizing Wastage

Usually, at the start of a new set, it is necessary to eliminate a portion of warp yarn to ensure that properly sized warp yarn is wound on the weaver's beam. Apart from this, at the end of a sizing set, a relatively a large length of warp sheet (*equal to the yarn path length in the sizing machine*) is required to be left in the sizing machines as waste.

These warp yarns are used to tie-in the warps of the next set of sizing. When the next set is started, the sized yarn of the previous set is pulled out and thrown away as waste. Figure 2 (left) shows some pulled out sized yarn. Apart from this, a substantial amount of warp sheet is also wasted at the end of sizing as residual or left over yarn on the warp beams situated in the creel section of the sizing machine.



Figure 2: Warp sheet wasted during sizing (left); warp sheet wound on the weaver's beam (right)

Calculation of sizing wastes %:

Sizing wastage is measured as the percentage of the calculated weight of wasted warp sheet to the weight of yarn occupied for that

particular set. Consider the reference data table, which is *Table 03*. Similarly, the sizing wastes of other qualities of the two mills were calculated and shown in the 5th & 6th column of *Table 2* and *Table 3*.

From *Table 03* the 1st row represents the construction $\frac{20 \times 16}{128 \times 60} 58'' - 3/1$ Twill having

Total no. of ends = 7452

Warp Length = 6250 yds

Total Weight of occupied cones = 2827.41 lbs [see section 3.1.1]

Total length of warp sheet wasted = 22 yds (*shown in the 1st row of Table 2*)

$$\begin{aligned} \text{Total weight of sizing wastage} &= \frac{22 \text{ yds} \times 7452}{840 \times 20 \text{ Ne}} (\text{lbs}) \\ &= 9.76 \text{ lbs} \text{ (shown in the 1st row and 5th column of Table 2)} \end{aligned}$$

$$\begin{aligned} \text{But the sizing wastes with respect to the occupied yarn for the particular set} &= \frac{9.76 \text{ lbs}}{2827.41 \text{ lbs}} \times 100 \\ &= 0.35 \% \text{. (shown in the 1st row and 6th column of Table 2)} \end{aligned}$$

3.1.3 Knotting Wastage

Knotting is the attachment of warp ends of an existing set of warps to the warps of a newly installed weavers beam. Knotting can only be carried out in cases when the number of total ends and construction of previous and new beams are exactly same. Knotting is done on a 'one to one basis' by tying a knot between the warp ends that exists in a loom and warp

ends of the new beam. Such knotting eliminates the extra time and effort of beam gaiting and tying in. To perform knotting efficiently, small lengths of warp sheet from both the newly installed weaver's beam and existing warp ends (in the loom) are eliminated. This is done to ensure that all the warp ends of the two beams are available for attaching together.



Figure 3: Warp yarn is wasted at the time of knotting operation

Calculation of knotting wastes %:

Knotting wastage is measured as the percentage of the calculated weight of the warp sheet wasted in knotting to the weight

of the yarn occupied for that particular set. Consider the reference data table which is *Table 01*. Similarly, the knotting wastes of other qualities of the two mills are shown in the 8th and 9th rows of Table 2 and 3.

From *Table 03* the 1st row represents the construction $\frac{20 \times 16}{128 \times 60}$ 58" – 3/1 Twill having

Total no. of ends = 7452

Total Weight of occupied cones = 2827.41 lbs [see section 3.1.1]

Total length of warp sheet wasted = 3yds (*shown in Table 03*)

$$\text{Total weight of knotting wastage} = \frac{3 \text{ yds} \times 7452}{840 \times 20 \text{ Ne}} \text{ lbs}$$

$$= 1.33 \text{ lbs (shown in the 1}^{st} \text{ row and 8}^{th} \text{ column of Table 2)}$$

Therefore, the knotting wastage in percentage = $\frac{1.33 \text{ lbs}}{2827.41 \text{ lbs}} \times 100$

$$= 0.05 \% \text{ (shown in the 1}^{st} \text{ row and 9}^{th} \text{ column of Table 2)}$$

3.1.4 Gaiting/Tying-in Wastage

While installing a new weaver's beam, if the total number of ends and the fabric design of the new weaver's beam is different from those of the existing weaver's beam, knotting in will not work, and the new beam must be installed by gaiting or tying in. After the gaiting/tying process is complete, the next process is the Drawing and denting process. Drawing and denting is a process that is carried out by threading the warp yarns through the required number of drop wire sets, heald wire sets, and finally through the

reed. After completion, the whole arrangement, i.e., weaver's beam, drop wire, heald wire set and the reed is shifted into the loom. After shifting is completed, the drop wire set, heald wire set, and the reed is secured in the loom frame. After that, the ends coming out from the reed are drawn forward and wound on to the cloth roller so that weaving can begin. Gaiting or tying in is also necessary in case of installation of a new loom, i.e., when beginning to weaving on a completely new loom. Figure 4 shows the drawing and denting process.



Figure 4: Warp sheet wasted while tying in and setting up the warp yarn for production

Calculation of gaiting/tying-in wastes %:

Gaiting/Tying-in wastage is measured as the percentage of the calculated weight of warp sheet wasted in gaiting/tying-in to the weight

of yarn occupied for that particular set. Consider *Table 01*. Similarly, the gaiting/tying-in wastes of other qualities of the two mills are shown in the 10th, 11th and 12th columns of *Table 2* and *Table 3*.

From *Table 03* the 1st row represents the construction $\frac{20 \times 16}{128 \times 60}$ 58" – 3/1 Twill having

Total no. of ends = 7452

Total Weight of occupied cones = 2827.41 lbs [see section 3.1.1]

Total length of warp sheet wasted = 3 yds (shown in row 1 and column 10, *Table 2*)

$$\text{Total weight of tying-in wastage} = \frac{3 \text{ yds} \times 7452}{840 \times 20 \text{ Ne}} \text{ lbs}$$

$$= 1.33\text{lbs (shown in row 1 column 11, Table 2)}$$

Therefore, the tying-in wastage in percentage = $\frac{1.33 \text{ lbs}}{2827.41 \text{ lbs}} \times 100$

$$= 0.05 \% \text{ (shown in the 1}^{\text{st}} \text{ row and column 12 of Table 2)}$$

3.1.5 Beam Residual Wastage

At the end or finishing of each weaver's beam, a little portion of the warp sheet is wasted. In fact, it is not possible to weave the warp sheet completely. This proportion of

warp sheet is considered beam residual wastage. The residual warp yarn remaining in the beam at the end of weaving is known as residual warp waste and is shown in *Figure 5*.



Figure 5: Residual warp yarn as residual warp waste remaining in the beam after weaving

Calculation of beam residual wastes %:

Consider the reference data shown in table 2.

From *Table 02* the 1st row represents the construction $\frac{20 \times 16}{128 \times 60}$ 58" – 3/1 Twill having

Total no. of ends = 7452

Total Weight of occupied cones = 2827.41 lbs [see section 3.1.1]

Total length of warp sheet wasted = 3 yds (*shown in Table 2*)

$$\text{Total weight of residual wastage} = \frac{3 \text{ yds} \times 7452}{840 \times 20 \text{ Ne}} \text{ lbs}$$

$$= 1.33\text{lbs (shown in row 1 column 14 in Table 2)}$$

Therefore, beam residual wastage in percentage = $\frac{1.33 \text{ lbs}}{2827.41 \text{ lbs}} \times 100$

$$= 0.05 \% \text{ (shown in row 1 column 15 in Table 2)}$$

Similarly, the beam residual wastes of other qualities of the two mills are shown in the 13, 14 and 15 columns of *Table 2* and *Table 3*.

3.1.6 Warp Wastage Due to Loom Setting

When starting to weave a new weaver's beam on a loom some warp (also weft) yarns are wasted due to trial and error practice before the loom is set to weave the intended fabric perfectly. Apart from this, a little portion of

warp is also wasted in forms of sample grey (6"- 10") fabric to test or check and assure that the right quality is being woven on the loom. Loom setting may also involve checking and adjusting the air pressure on the loom.

Calculation of warp wastes due to loom setting:

Consider the reference data table which is *Table 03*.

From *Table 03* the 1st row represents the construction $\frac{20 \times 16}{128 \times 60}$ 58" – 3/1 Twill having

Total no. of ends = 7452

Total Weight of occupied cones = 2827.41 lbs [see section 3.1.1]

Total length of warp sheet wasted = 2 yds (*shown in row 1 column 16 in Table 2*)

Total weight of sampling wastage = $\frac{2 \text{ yds} \times 7452 \times 1.10}{840 \times 20 \text{ Ne}}$ lbs [*warp crimp is 10% for this construction*]
 = 0.98lbs (*shown in 1st row and column 17 in Table 2*)

Therefore, on-loom or sampling wastage in percentage = $\frac{0.98 \text{ lbs}}{2827.41 \text{ lbs}} \times 100$
 = 0.03 % (*shown in 1st row and column 18 of Table 2*)

Similarly, the wastes related to the loom settings of other qualities of the two mills are shown in the columns 16, 17 and 18 Table 2 and Table 03.

3.2 Auxiliary Selvedge Wastage

Auxiliary selvedge is a dummy or false selvedge used to hold the weft yarn during the beat up period. The auxiliary selvedge is usually composed of 5 to 9 warp yarns (*polyester ply yarn – usually 40/2's polyester*) kept at a certain distance from the last warp ends of the main fabric. The polyester warp yarns are provided from individual packages from a particular creel arrangement mounted on the loom. The auxiliary selvedge is separated from the main

fabric as shown in figure 6 by the cutting action of a pair of scissors. The auxiliary selvedge is used in the left or finishing (*of weft insertion*) side of all shuttle-less looms. The purpose of auxiliary selvedge is to hold the weft yarn during beat up. After beat up, some fabric is woven, and the auxiliary selvedge, which includes both polyester ply yarn and weft fringe, is separated from the main fabric by being cut with a pair scissors and accumulated in the appropriate waste box (*see figure 7 also*).

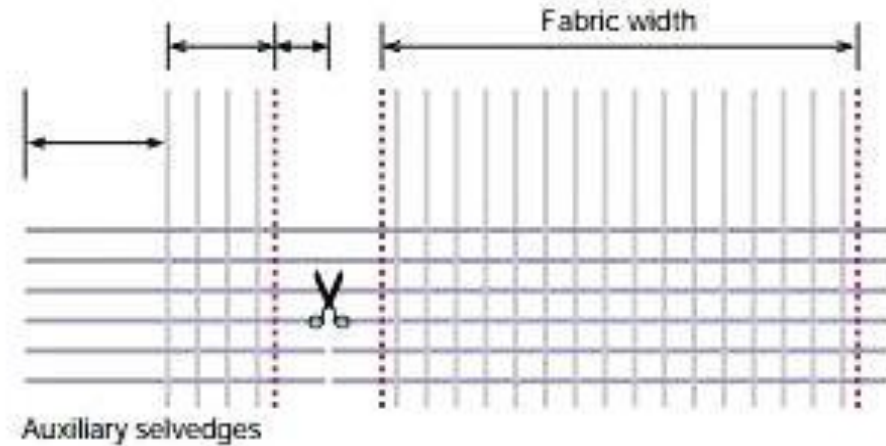


Figure 6: Polyester ply yarns are separated after cutting each pick



Figure 7: Weft cut fringe waste is guided to the basket

Calculation of Auxiliary Selvedge Wastage:

Consider the reference data table which is *Table 5*.

From *Table 07* the 1st row represents the construction $\frac{20 \times 16}{128 \times 60} 58'' - 3/1$ Twill having

Length of each polyester ply yarn in auxiliary selvedge = Total beam length or Sizing length
= 6240 yds

No. of polyester ply yarn used in auxiliary selvedge = 5

Total weight of polyester ply in auxiliary selvedge = $\frac{5 \times 6240 \text{ yds}}{840 \times \text{polyester ply Count (Ne)}} \text{ (lbs)}$

$$= \frac{5 \times 6240 \text{ yds}}{840 \times 40/2 \text{ Ne}} \text{ lbs}$$

$$= 1.86 \text{ lbs (shown in 1}^{\text{st}} \text{ row last column of Table 5)}$$

Similarly, the wastes of this category for other qualities are shown in the subsequent rows of table 5. It may be mentioned that it was not possible to get the data of factory 2.

Table 5: Waste due to Auxiliary selvage as warp (Factory 1)*

Finish Fabric Specification								Total grey Prod	Auxiliary Selvage Waste (5 ends)	
SL NO	Warp	Weft	EPI	PPI	Weave	FABRICS TYPE	T/ENDS		yds	Yds
	Ne	Ne								
1	20	16	128	60	3/1	TWILL	7,450	5670	6240	1.86
2	16	12	112	60	3/1	TWILL	6,400	5330	5985	1.78
3	40	40	133	96	1/1	Poplin	7,600	10198	12435	3.70
4	30	30	152	84	3/1	TWILL	8,500	7856	9286	2.76
5	10	7	76	38	3/1	TWILL	4,450	5316	6290	1.87
6	30	30	148	80	3/1	TWILL	8,650	7916	9290	2.76
7	30	20	146	76	2/1	TWILL	8,300	7672	9285	2.76
8	20	20	108	58	3/1	TWILL	6,250	5750	9286	2.76

* It was not possible to get information about selvage waste of factory 2

3.3 Weft Wastage

3.3.1 Weft wastage in Auxiliary selvage (as cut fringe)

In an air jet loom, after successful insertion of each pick, it is necessary to cut each pick at both ends of the fabric width. This is done to maintain a uniform selvage fringe at the two sides of the fabric. At the main nozzle end, i.e., at the starting end, there is no cut fringe, so there is no wastage. But at the finishing end, the extent of each pick is different and needs to be cut so that the extreme fringe of the fabric looks uniform. On average 1½" – 2" excess of each pick is maintained in the finishing end of the loom (see figure 6). The excess weft portion of

each pick is off course woven along with the main fabric and maintained in a continuous auxiliary selvage discussed in section 3.2. The polyester ply yarns are collected for reuse by throwing the weft fringes by simple mechanical action.

Calculation of Weft wastage in Auxiliary selvage (as cut fringe):

Weft wastage in auxiliary selvage (as cut fringe) can be measured as the percentage of the calculated total weight of wasted weft cut fringe to the total weight of weft yarn occupied for making the grey for that particular set length. Consider the reference data table which is Table 6.

From Table 05 the 1st row represents the construction $\frac{20 \times 16}{128 \times 60} 58" - 3/1$ Twill having

Total Length of grey produced = 5670 yds (From the particular warping length as mentioned in Table 6)

Total weight of weft yarn occupied in fabric

$$= 5670 \text{ yds} \times \frac{\text{Reed Width in inch} \times \text{PPI}}{840 \times \text{Weft Count (Ne)}} \text{ lbs} \times 1.01$$

$$= 5670 \text{ yds} \times \frac{62'' \times 60}{840 \times 16} \text{ lbs}$$

$$= 1569 \text{ lbs (Shown in 1st row of Table 6)}$$

Total weight of wasted cut fringe was found to be 38 lbs (shown in the 1st row of Table 6)

Therefore, the percentage of weft wastage in auxiliary selvage (as cut fringe)

$$= \frac{38 \text{ lbs}}{\text{Total Wt. of Weft (lbs)}} \times 100$$

$$= \frac{38 \text{ lbs}}{1621 \text{ lbs}} \times 100$$

$$= 2.34 \%$$

This is shown in the 1st row of Table 6, and similarly, the wastes of this category for other qualities of the two mills are shown in table 6 and table 7.

3.3.2 Weft wastage due to faulty cone

Due to the defective cones, the grey fabric quality is affected and results in rejection. To

avoid rejection, these faulty cones are carefully detected and considered as wastes. Wasted weft yarn cones are rejected and kept aside in separate bags as shown in Figure 8.



Figure 8: Wasted weft yarn cones are rejected and kept aside in separate bags

Calculation of Weft wastage due to faulty cone:

Weft wastage due to faulty cone can be measured as the percentage of the calculated

From Table 6 the 1st row represents the construction $\frac{20 \times 16}{128 \times 60} 58'' - 3/1$ Twill having

Total weight of faulty yarn found = 13.5 lbs [weighted on balance reducing the wt. of empty paper cones]

Therefore, the percentage of weft wastage due to faulty cone = $\frac{13.5 \text{ lbs}}{\text{Total Wt. of Weft (lbs)}} \times 100$

$$= \frac{13.5 \text{ lbs}}{1621 \text{ lbs}} \times 100$$

$$= 0.83 \% \text{ (shown in 1st row of Table 6)}$$

Similarly, the wastes of this category for other qualities of the two mills are shown in the subsequent rows of table 6 and table 7.

3.3.3 Weft Wastage Due to Loom Setting

As was mentioned in section 3.1.5, at the start of the weaving process, on each beam some warp, as well as weft yarns, are wasted due to the trial and error practice. Apart from this, a little portion of weft is also wasted in forms

of sample grey fabric which is 6'' – 10'' that is woven for the quality department to test and check the fabric in case of any change in picks or other parameters. Loom setting is also done to check and adjust the air pressure on the loom.

Calculation of Weft wastage due to loom setting:

Consider the 1st row of *Table 6* that represents the construction $\frac{20 \times 16}{128 \times 60}$ 58" – 3/1 Twill having Grey wasted in looming/sampling = 2 yds (*shown in Table 6*)

$$\begin{aligned} \text{Weight of wasted weft yarn in looming/sampling} &= 2 \text{ yds} \times \frac{\text{Reed Space in inch} \times \text{PPI}}{840 \times \text{Weft Count (Ne)}} \text{ (lbs)} \\ &= 2 \text{ yds} \times \frac{62.5'' \times 60}{840 \times 16 \text{ Ne}} \text{ lbs} \\ &= 0.56 \text{ lbs (shown in 1}^{\text{st}} \text{ row of Table 6)} \end{aligned}$$

$$\begin{aligned} \text{Therefore, the percentage of weft waste due to looming} &= \frac{0.56 \text{ lbs}}{\text{Total Wt. of Weft (lbs)}} \times 100 \\ &= \frac{0.56 \text{ lbs}}{1621} \times 100 \\ &= 0.03 \% \text{ (shown in 1}^{\text{st}} \text{ row of Table 6)} \end{aligned}$$

Similarly, the wastes of this category for other qualities of the two mills are shown in the subsequent rows of table 6 and table 7.

Table 6: Weft related wastes in various stages of processing (for factory 1):

Identity as in Table 2	Total Fabric Production			WEFT WASTE of Factory 1								
				Due to cut fringe		Due to faulty cone		Due to loom settings			Total wt. of Weft	Total Waste
	yds	lbs	%	lbs	%	Lbs	%	yds	Lbs	%	lbs	%
A	5670	1569	96.79	38.00	2.34	13.5	0.83	2	0.56	0.03	1621	3.21
B	5330	1967	96.86	48.00	2.36	15	0.74	2	0.74	0.04	2031	3.14
C	10198	1807	97.02	44.00	2.36	11	0.59	3	0.54	0.03	1862	2.98
D	7856	1624	96.95	39.50	2.36	11	0.66	3	0.63	0.04	1675	3.05
E	5316	2130	97.09	52.00	2.37	11	0.50	2	0.81	0.04	2194	2.91
F	7916	1558	97.19	37.50	2.34	7	0.44	3	0.60	0.04	1603	2.81
G	7672	2152	96.93	52.00	2.34	15.5	0.70	2	0.57	0.03	2220	3.07
H	5750	1231	96.58	30.00	2.35	13	1.02	3	0.65	0.05	1274	3.42

Table 7: Weft related wastes in various stages of processing (for factory 2):

Identity as in Table 2	Total Fabric Production			WEFT WASTE of Factory 2								
				Due to cut fringe		Due to faulty cone		Due to loom settings			Total wt. of Weft	
	yds	lbs	%	lbs	%	Lbs	%	yds	Lbs	%	lbs	%
A	5620	1556	97.00	37.50	2.34	10	0.62	2	0.56	0.03	1604	3.00
B	5350	1974	97.30	46.00	2.27	8	0.39	2	0.74	0.04	2029	2.70
C	9936	1760	96.68	45.00	2.47	15	0.82	3	0.54	0.03	1821	3.32
D	7806	1613	96.49	42.00	2.51	16	0.96	3	0.63	0.04	1672	3.51
E	5320	2244	97.57	50.00	2.17	5	0.22	2	0.85	0.04	2300	2.43
F	7916	1558	96.79	38.00	2.36	13	0.81	3	0.60	0.04	1610	3.21
G	7326	2055	96.95	52.00	2.45	12	0.57	2	0.57	0.03	2119	3.05
H	5796	1241	96.60	30.00	2.34	9	0.69	3	0.65	0.05	1284	3.08

4. Discussion

4.1 Warp Wastage

As seen in the last column of table 2 and 3, the average waste related to warp lies in the range 2.56 to 3.95. There are various types of warp related waste; this waste is created in warping (gara cones), in the sizing zone, knotting, gaiting/tying-in, loom setting, as beam residue at the end of weaving, in and the polyester ply yarns in the auxiliary selvedge, etc. It was observed that the gara waste accounts for about 85% of total warp waste and all other warp wastes account for only 15%. The “Gara” occurs because the speed of warping is somewhat fixed on each machine. Initially when the cones are full, unwinding only a few coils can satisfy the warping speed, but towards the end of a cone/cheese, the overall diameter of the package decreases. As a result, a greater number coils are required to support warping speed. Because of this, the unwinding of so many coils in unit time becomes difficult, at this time the unwinding pattern looks like a balloon and this effect is widely known as ballooning. Towards the end of the cone, due to the unwinding of an excessive number of coils, the ballooning effect becomes severe and under this circumstance, the unwinding speed can no longer support warping speed and the warp breaks. It becomes difficult to stop repeating breakage, and it becomes necessary to throw away cones which still

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contain some yarn. Normally, using cone winding machines, the gara wastes are converted to larger cones and are either used as weft where possible or sold to local markets for producing low-grade fabrics. It seems that there are two ways by which the “Gara” waste can be avoided, e.g. (i) by increasing the diameter of the empty cone shell, in that case the maximum amount of yarn in each cone will be lower than before; and (ii) by decreasing the speed of warping towards the end of the cones. These two aspects will be studied later.

Apart from “Gara,” all other wastes related to warp account for approximately 15%, this somewhat fixed for any set length of warp and there is very little or no scope for further reduction. However, if a larger set length is used, the waste percentages of various warp waste, except gara, will be lower than 15% of total waste. Therefore, it seems that any attempt to reduce gara waste will have a direct impact on warp waste reduction.

4.2 Auxiliary Selvedge Wastage

Table 5 shows that the selvedge waste (polyester ply yarns) account for 1.86 to 3.70 lbs which is not significant. The yarns are 40/2 Ne which means two yarns of 40 Ne were plied together to give a resultant count 20 Ne. In Bangladesh, the factories make the best utilization of this polyester selvedge waste by reusing again and again. The

auxiliary selvedge is collected from the waste box and cut fringes of weft are separated by just throwing away, and the polyester ply yarns are taken to the re-coning section to make reusable cone packages.

4.3 Weft Wastage

Table 6 and Table 7 show the information about weft related wastes in various stages of processing. It can be seen in the tables that the weft waste lies in the range of 2.70% to 3.51%. The tables show that the cut fringe, accounts for approximately 80% of total weft waste and it is somewhat fixed. The waste due to faulty cones is not very significant but varies between the two factories. The spinning factory is mainly responsible for faulty cones and can be controlled to a great extent by taking proper measures in the spinning mill. Another source of weft waste is generated due to loom setting which is very negligible but fixed.

5. Conclusion

The results reported in this study imply that waste generated from warp and weft is not very significant. In case of warp, gara is the main waste which could possibly be controlled by increasing the diameter of empty cones and reducing warping speed towards the end of the cone; further research will be necessary to confirm this. The waste due to faulty cones can be reduced by taking care during the winding process. All other wastes, e.g., knotting waste, gaiting/tying-in,

loom setting, as beam residue after sizing and weaving and cut fringe, etc. are somewhat fixed. The polyester ply yarns used in the auxiliary selvedge are also negligible even these yarns are reused again and again for long period of time.

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