Investigation of Fabric Waste Reduction Strategies in Awoven Bottom Manufacturing Industryin Sri Lanka.

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Abstract- Fabric waste reduction strategies formulation, especially maximum utilization and unnecessary waste reduction strategies are certainly valuable for textile industries to acquire the maximum waste reduction and profit. This study formulated the best fabric waste reduction strategies for unnecessary fabric wastes generating places of the woven cloth production while performing the fabric waste audit for a single product of a selected style bottom within a boundary of a woven manufacturing industry. From the total allocated fabric raw materials (7037.2 kg), 20 % of the fabrics were measured as waste (1375.704 kg) and 80 % of the fabrics were used (5661.496 kg) to produce 10045 pieces of garments. Accordingly, 137 g of fabrics were generated to produce a single garment. In these wasted fabrics, 79 % of the wastes were from cuttings (1083.5 kg) and others were from final inspection (139.634 kg) 10%, sewing (65.55 kg) 5%, fabric inspection (39.7 kg) 3%, re cut (27.184 kg) 2%, finishing (20.09 kg) 1%, and zero wastage in washing. Fabric inspection process, marker making, layering process were identified as necessary to formulate reduction strategies to reduce fabric waste generation in cutting process and washing defects were identified as main reason for final rejections.

Index Terms- fabric wastes, cutting, final inspection, sewing, fabric inspection, recut, finishing, washing

I. Introduction

Industrialization is the remarkable turning point to the planet from the history of the human revolution on environment and the natural stability. Usage of machineries and the factories for the mass production and the economy led to the numerous environmental hazards frequently (Singh Ahuti, 2015). Municipal solid wastes (MSW) with increasing rapid urbanization and industrialization, managing and handling of MSW has become a major issue in where the population share is 35% in the urban areas like China and Thailand and less developed countries, currently waste generation per capita ranging from 0.2 to 1.7 kg per day (Gunaruwan *et al*. 2015)and is eight times higher than 1947.

In Sri Lanka, approximately generated per capita 0.62 kg of solid wastes per day (Visvanathan and Trankler 2006)and daily 3,242 Metric tons of municipal solid wastes are collected by the local authorities(Figure 1).Waste collection and disposal is a serious problem in most ofthe urban areas in SriLanka(Karunarathne 2015).

Solid waste disposal possess a greater problem because it leads to land pollution when openly dumped, water pollution when dumped in low land and air pollution when burnt (Alom 2016).Intergraded Solid Waste Management (ISWM) is a comprehensive waste prevention, recycling, composting and disposal program and involves evaluating local condition and requirements, through that selecting and combining the most appropriate waste management activity efficiently(Gunaruwan *et al*. 2015).

In case of fabric solid wastes generation, most garment industries are taking main part and considering the production with environmental sustainability manner factories really rare (Bahareh Zamani 2012).Annually they consume 19,000 to 38,000 tons fabric and it produces 10 - 20%of off cuts fabric wastes per each garment factories(Jayasinghe *et al*. 2010). The amount of waste production will vary within the range and depends on their techniques of the production. Within that, 25 % only reused and recycled but 8,000 to 19,000 tons are incinerated under adverse condition so, generating toxic gases like dioxins, particularly from rayon and nylons (Jayasinghe *et al*. 2010) and others often release directly to the environment or dump without any proper safety measures at municipal landfills (Islam *et al*. 2014) and lead to land, air and water pollutions (Chavan 2001).

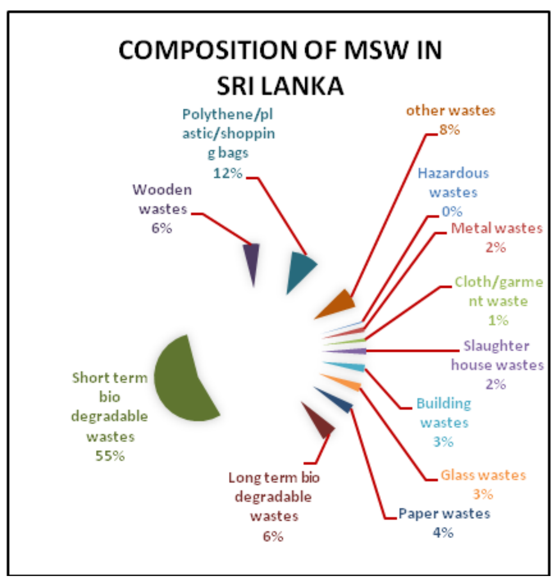

Figure 1.Daily collected MSW by local authorities of Western province of Sri Lanka (Karunarathne 2015).

As a result of demand in customers' consumption pattern changes to environmental friendly production,industries should change their production process pattern to environmental friendly measures (Claudi Vignali *et al.* 2009;Collins and Glendinning 2005). Several process stages in the production flow of garment industries generated wide range of fabric wastage: fabricinspection, layering, cutting, sewing and finishing section (Rahman and Haque 2016: Islam *et al*. 2014) and major waste types which are generated by this process are fiber wastes, offcuts, packaging and pool (Agrawal & Sharan 2015).Figure 2describes the flow chart of the clothing process of industries.

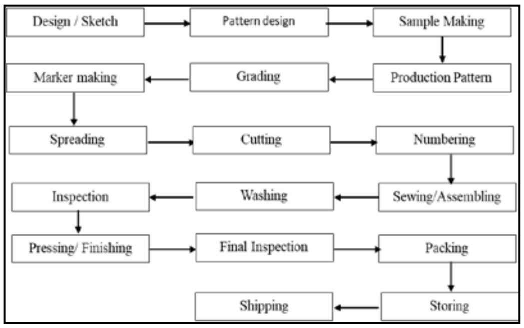

Figure 2. Process flow of garment industries

However, fabric wastages are the most considerable element in this sector because 70 – 80 % of the total cost of the garment production is associated with that fabric cost (Rahman & Haque 2016). Thus, the proper management and accurate measures to the waste generation and reduction strategies must be required (Karunarathne 2015). Waste management is the way best handling method of wastes by considering on reduction, recycling, treating and disposal toward recycling, energy harvesting and improvement of treatment and best suitable healthiest disposal methodswill help to maintain the factory with sustainability. Improving the process efficiency and consequently reducing the cost of the production also push down the environmental impacts. Figure 3shows the waste management Hierarchy (Senthil Velmurugan *et al.* 2014).

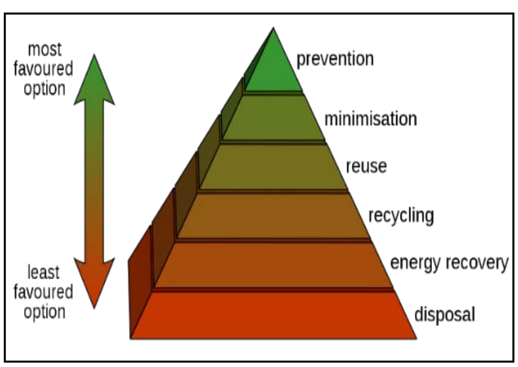

Figure 3.Waste management hierarchy

Fabric wastes generation is unavoidable one but to manage and get maximum utilization of raw material is one of the big challenge that the garment industries are really facing (Tojo *et al.* 2012), mostly fabric wastes includes fiber wastes, yarn spinning wastes, beaming wastes, offcuts, packaging, spools and creels(Ishrat Jahan 2017).

Moreover, this research was conducted in a woven cloth manufacturing industry to (a) identify the unnecessary fabric waste generation sources and (b) to identify reduction strategies possibilities for best utilization of fabric materials.

II. Materials and Methods

Table 1. Product details for the waste audit

Product Details:					
Total purchased order quantity	9567	pcs	5% Additional cutting	10045	pcs
Total roll numbers allocated	127	rolls	Total allocated fabric lengths	13399.45	yds
Total weight of fabrics	7037.2	kg			

The audit was conducted through the chain from the very first of the raw fabric material unloading to the factory to final loading to shipping within the boundary line (Table *1*). Each generated fabric wastes were collected and weighted as kg and noted for the study from July to November of 2017 (Figure 4).

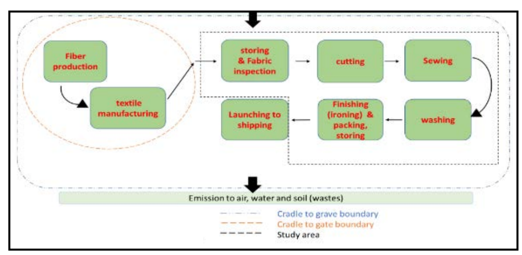

Figure 4.Audit boundary

The most initial fabric waste generation was started in the store as the process followed cut and separation some piece of raw fabric materials for the quality and quantitative checking of the raw fabric materials. Then fabric inspection process was followed next before starting to produce. Randomized selection of 10 % from raw fabric materials from allocated,are cut and separated for testing purposes on color shading and shrinkage.

According to the four point fabric inspection system, maximum defection limit of a fabric roll is 20% (Slayback 2005). But the allocated fabric rolls for this bulk production was12%. Therefore, fabric raw materials got permission to supplyfor further production process. 24 hours of Fabric relaxation was done after fabric inspection process. Then fabric raw materials supplied to layering process and then to cutting process. Small pieces of fabrics were removed for making level and straight to put proper lengthy layers. While the cutting process offcuts, and other fabric waste parts were collected in separate bin and measured the weight of those bins in kg and noted. After that cloth cut pieces were put into sawing process and fabric waste parts were collected and measured. Finished cloths from sawing process, sent to washing process.

Afterwashing process, finishing with quality checking was done by quality control team people and removed excessive parts of the cloths. Removed excessive parts of the cloths were collected and measured in kg and noted for the audit process.

Finally, some garments were removed from shipping loads because of poor quality and defects. Therefore, rejected garments also measured in weight and noted for the waste audit.

2.1. Data Analysis

Used fabrics (kg) = Total weight of Raw Fabrics (kg) − Total weight of wasted fabrics (kg) ------------------ Equation 1

Fabric utilization Per product (kg) = Total Used fabrics (kg) / Total product (kg) ------------------ Equation 2

Fabric wastage Per product (kg) = Total amount of fabric wastages (kg)/ Total product ----- Equation 3

Rejected garments = weight of single garment (kg) X Total rejected garments Fabric weight (kg) ------------------ Equation 4

2.2. Graphical analysis:

Collected fabric wastes in each process of the production were entered in MS – EXCEL sheet and graphical analysis was done by using pie chart and percentage of waste generation in each process obtained from the graph.

2.3. Interviews and discussions with relevant people

Major fabric waste generation places and unnecessary waste generation sources were identified in each processthrough the prepared graphical analysis. Furthermore, the main causes, sub causes and places for waste generation were identified byimmediate questions interviews and through discussions with the top management of the relative processas well as the other workers in the relevant process.

III. Results and Discussions

Fabric waste audit was done by considering the specific system boundary (Figure 4). Before performing the waste audit, a walk-through audit wasdone to identify the production process of the industry and diagram was drawn and describes the detail production flow diagram of the production process.In the waste audit, storing, fabric inspection, layering, cutting, panel checking, sewing and inspection were identified places for fabric waste generation andshows the process and generated fabric waste amounts in kg.

Fabric inspection process is an important procedures for quality products(Tarek Habib *et al*. 2014).But the fabric defects are a constant and continues problem, despite major improvements in fabrics production, yarn manufacturing equipment and weaving machines(Kazım H. *et al*. 2016). Zero defects is still remains a goal and not an accomplished objective of most textile mills (Silvana.Z.*et al*. 2013). In this waste audit, from fabric inspection process, 39.70 kg of fabrics were as waste and it was 3 % of the total fabric wastes.

Main causes for the unnecessary fabric waste generations were identified in the fabric inspection process as: they are following 4 – point international standard and it will allow the fabric raw materials to production if within maximum of20 % of defects(Kazım H. *et al*. 2016).But just below the limit also allow for production therefore, rejections will happen in the final checking with the results of the defects in the raw fabric materials (Alvelos *et al*. 2016).

Fabric relaxing, layering and maker making are preprocess before cutting cloth pieces for sawing. Fabric relaxing process will be act as resistance to deformation during the production process as well as shape saving after finishing (Virginijus Urbelis *et al*. 2007). Therefore, garment rejections and defects because of fabric stress as like: shape out, shrinkage, elasticity and other faults will be under control and fabric wastages will be reduced. Layering process was followed after 24 hours of fabric relaxation and Fabrics were spread for the set length and the number of layers of fabric is dictated by the number of garments needed and the fabric thickness(Li *et al*. 2008). Before spreading, the spreader should configure with layer length, spreading tiers, spreading mode and etc. while the worker doing layering process, will left additional 1- 2 cm both sides to obtain through the layout length (Li *et al*. 2008). From this layering process, 14.3 kg of fabrics were measured as wastes.

Marker making is the process making an efficient layout with pattern pieces for a particular style of fabric and size distribution. The patternmaker makes a pattern (on paper or computer) based on the designer's sketch; the pattern guides the cutter in cutting fabric (Timo Rissasen 1994). In such a way, maximum fabric will be used and minimum fabric will be wasted (Puranik and Jain 2017). Contribution of the marker making process for unnecessary fabric waste generation were identified throughout the study as: dividing the bulk order to purchased order wise and producing different times with different deliveries, needed to draw different marker drawings for a same product because of more than four shrinkage classes of raw fabric materials, raw fabrics materials not in the same booking status of the factory in length and width, time duration to draw the markers in auto TUKO drawing software not enough to achieve maximum efficiency drawing (ziynet ondogan and cetin Erdogan, 2006),Increasing numbers of spreads flies in a layer will caused to more fabric wastages because of marker paper movement or mismatch.

Cutting is the process of cut out the needed shaped, size, pattern pieces form allocated determined fabric layers with the help of marker (Silvana.Z. *et al*. 2013). This is the major process in which fabric wastage high and the recent study tells us 16.36% of fabric raw materials will be wasted from this process (Rahman and Haque 2016). Garment industries mostly focus on reducing the cost of raw materials which often reach up to 75% of total production cost.

This in turn, the technique of orders and planning of cutting layers are of utmost important for effective utilization of fabric raw materials to increase the efficiency of cutting process (Silvana.Z. *et al*. 2013). From the cutting process, 1069.2 kg of fabrics were measured as wastes. In the end of the cutting process, 1083.5kg of fabrics were measured as waste (layering –

14.3kg + cutting – 1069.2kg) and contributed 79% of the total measured fabric wastes.

After cutting process, cut pieces will be transported to the sewing section and all the parts will be attached as sequentially with the help of needle and threads according to the buyer requirement (Golder 2015). From this process 6.37% of the allocated fabrics are wasted normally in the garment textile production (Rahman and Haque 2016) will be the result of as: needle damage, thread breakages, broken stitches, pleated seam, wrong stitch density, uneven stitch density, staggered stitch, improper sewing, and etc(Howard *et al*. 1991). In this study, 65.55kg of fabrics were collected and measured and contributed 5% of the total measured fabric wastes.

Washing process is one of the important process followed by sawing and by through this, dust, dirt and infectious materials will be separated from the cloth and will get a good look to the garment as per buyer requirement and customers' preference (Mondal &Mashiur Rahman 2014). Many treatment processes are followed here such as: enzymatic treatment, bleaching treatment, acid treatment and Silicone treatment. Therefore, finally it will stimulate the customers to buy the garment and increase the continuity of the market potential preference to the garment (Rouf .A. *et al.* 2015). While processing to wash, fabrics will be rejected as wastes because of damages or process failures in the washing factory. But in this particular quantity products, no any fabrics wastage. After washing there is an issue, lots of garment rejections were there, because of Garment size may be change with shrinkage of fabric material, some patches will be created with material partly removed, undesired color changes (Dakuri Arjun*et al.* 2013).

It is very important one after finishing the product before launch to shipping. Low quality with buyer requirement and defection in any ways will be identified and corrective actions will be done in this process (Hameed and Hamzawy 2017). From this finishing process, 20.09kg of fabrics were collected and measured as wastes. Consumers want a best quality product with low price and garment factories will insure and confirm their produced product with certain standard randomly or for full garments (Rehman *et al*. 2009). In mass production garment factories huge numbers of garments will be rejected and wasted from this step because of poor quality and defects. It causes additional costto correct those poor-quality garments. In this re-production process 27.184 kg of fabrics were wasted and rejections in this final checking process will make more reduction in the profit of the factory and take more additional time consumption (Tincher *et al.* 1993). In the end of the final checking process after re production of clothing, 242 pieces were rejected as poor in quality from 10045 pieces of total produced bottoms.

By the way, from 7037.2kg ofallocated fabrics (*Table2*),totally 1236.024 kg of fabrics were measured as wastes for produce 10045 quantity of cloths and 577g of fabrics were consumed for make a single bottom (5801.176 kg / 10045). In case of final 242 bottoms rejection 139.634 kg of fabrics were wasted (242 X 577g). Finally, 1375.704 kg of fabrics were measured as waste (1236.024kg + 139.634kg). Therefore, to produce a single bottom, 137g (1375.704kg /10045) of fabrics were wastes.

Throughout the research study, the amount of fabric waste generated from cutting, final checking, sewing, fabric inspection, recut, finishing and washing were 1083.5 kg (79%), 139.634 kg (10%), 65.55 kg (5%), 39.7 kg (3%), 27.184 kg (2%), 20.09 kg (1%) and 0 kg respectively. Total fabric wastage per single garment was 137g and the percentage of total fabric waste from total production is 19.54% and a used fabric for the whole production is 80.46%.Figure 5, graphically describes the summary of waste audit andthe fabric waste audit.

Table2.Process and generated fabric wastes amount

No	Process	Amount of fabric waste
01	Fabric Inspection	39.70 kg
02	Cutting	1083.50 kg
03	Sewing	65.55 kg
04	Re-cut	27.18 kg
05	Washing	0 kg
06	Finishing	20.09 kg
07	Final checking	139.63 kg
Total		**1375.70 kg**

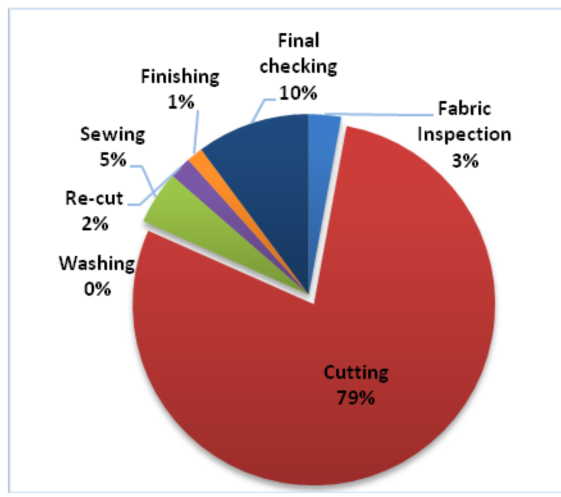

Figure 5.Waste audit results.

IV. CONCLUSION

In this research study, fabric waste audit of a one style bottom was selected in a woven cloths manufacturing industry. According to the waste audit, from the total allocated fabric raw materials (7037.2 kg), 20% of the fabrics were measured as waste (1375.704 kg) and 80% of the fabrics were used (5661.496 kg) to produce 10045 pieces of garments. 137 g of fabrics were generated to produce a single garment. In these wasted fabrics, 79% of the wastes were from cuttings (1083.5 kg) and others were from final inspection (139.634 kg) 10%, sewing (65.55 kg) 5%, fabric inspection (39.7 kg) 3%, re cut (27.184 kg) 2%, finishing (20.09 kg) 1%, and zero wastage in washing. Fabric inspection process, marker making, layering process were identified as necessary to formulate reduction strategies to reduce waste generation in cutting process and washing defects were identified as main reason for final rejections.

V. Suggestions

In the fabric inspection process, through organize Risk analysis meeting, formulate different allowable limits to fabric defects percentage for different fabrics, doing fabric inspection process twice with different randomized selections and shift the inspection from manual to computerized inspection process were suggested to formulate in the factory operation to use as fabric waste reduction strategies. In marker making process, producing all the ordered quantity in a one continues process will help to avoid fabric waste generation as left balanced quantity. If the factory limit and strict on the shrinkage classes to 2-3 will help to no more different drawings, cuttings and other process so out shapes, rejections, left overs so, waste generation will be reduce, factory should instruct and advice the fabric mill to deliver requested width and length as standard for all fabric rolls, as a result of this, may able to use all fabrics with maximum utilization efficiency, auto computerized cad drawings for the instead of manual drawings for all products will help to utilize the fabric materials maximum and limit the number of flies in layering process should limit less than 100 to reduce more rejections and mismatches were suggested as unnecessary fabric wastes reduction strategies.

In cutting process, experienced spreader machine operator should appoint to operate the machine and length of the fly should accuracy much as possible as like drawing's length, implementing straight cutting methods and tries to reduce this uneven width and layering should done after received the drawing and in washing process, If the buyers' requirement make more rejections and damage to fabric then make risk analysis meeting with buyers and convince them to safety process and before sending to the factory from wash garment, factory external checking should be implement there and washing problems should be corrective before sending to the factory for finishing process were suggested to formulate best fabric waste reduction strategies to reduce unnecessary fabric waste generations in the operations.

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