Investigating the Critical Stages of Leather Wastage in Shoe Manufacturing Process: A Case Study of the Sri Lankan Shoe Manufacturing Industry

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ABSTRACT

The Sri Lankan leather product industry is a rising industry which gradually increases its contribution to the country's economy over the years. This research is carried out as a case study in the Sri Lankan shoe manufacturing industry with the objective of identifying the critical stage of leather wastage in shoe manufacturing process. The main raw material considered throughout this research is leather, as it is considered the largest cost factor of a shoe, highest composition material of a shoe as well as the most wasted raw material during the manufacturing process. Selection of leather as the main raw material and selection of cutting, sewing and lasting stages as the leather wasting stages in the shoe manufacturing process were justified by providing evidence from the previous literature and work floor experience of the selected company. For this research, secondary data were used and the sample size was 80 daily records. The descriptive analysis and One-Way ANOVA tests were used for analysis. From the descriptive analysis, the lasting stage was identified as the critical stage of leather wastage in the shoe manufacturing process. In addition, results of the One-Way ANOVA test revealed that the mean difference of leather wastage between sewing and lasting stages is approximately equal. Beside those results, leather wastage occurs in the sewing stage due to vamping damages and in the lasting stage due to upper damages. In the cutting stage, quarters are identified as the most wasting cut component type. Hence, the shoe manufacturing industry should pay more attention in these stages to minimize the leather wastage.

KEYWORDS: Leather Wastage, Cutting Stage, Sewing Stage, Lasting Stage, Sri Lankan Shoe Manufacturing Industry

1 INTRODUCTION

The Sri Lankan footwear and leather industry is growing steadily and has developed into a sector, catering to international markets. The industry involves in manufacturing various products. Among them, shoe manufacturing is the major product and other than that, the leather products industry manufactures processed leather, bags, slippers, wallets, gloves, purses, etc. (Footwear & Leather Products).

There is more than 40000 strong workforce engaged in this sector and has already created a large amount of occupations in the country while positively contributing to the Sri Lankan economy (Asian Tribune, 2015).

According to Maroquinerie (2000), approximately 40 different materials can be used in the manufacturing of a shoe and among them, leather is known to be the single largest factor which represents 25% of material composition of a shoe. Beside this, cost of leather for a shoe is significant compared to other raw materials such as insole, foam rubber sheets, buckles, laces, etc. Also the price of leather is continuously increasing. Thus, it can be justified that, leather is the most significant factor of a shoe.

Cutting, sewing, lasting, moulding and finishing are the main stages of manufacturing a shoe. This research considered only the first three stages, since these stages are the only stages which directly process leather in the shoe manufacturing process. Other stages, namely moulding and finishing do not process leather. Therefore, in those two stages the probability of occurring leather damage is very less.

The main objective of this research is to identify the critical stage(s) of leather wastage in shoe manufacturing process and the factors affecting each stage in the selected company.

Once the critical stage(s) and significant factors affecting leather wastage are identified, secondary objectives to be addressed from this research are,

- to identify possible opportunities to minimize the leather wastage in each stage
- to make recommendations in order to minimize the leather wastage

Section 1 discusses about the leather and footwear industry and the nature of the business sector briefly. Further it provides information on rationale for the research and its objectives. Section 2 discusses the literature reviewed regarding leather wastage. Section 3 includes the research design, data collection and the analysis strategy. Further it discusses the statistical tests used for the research. Section 4 discusses details of responses and details of data analysis. Section 5 includes analysis and interpretations of the results. Finally, section 6 concludes the research.

2 LITERATURE REVIEW

A study done by Staikos and Rahimifard (2007) has revealed that the footwear industry employs a wide variety of materials to make products. For example, leather, synthetic materials, rubber and textile materials are the basic and most commonly used materials. Moreover, the study has mentioned that approximately 40 different materials can be used in the manufacturing of a shoe. According to the material composition of a typical shoe, leather consists of 25%. Therefore, it is clear that leather is the single largest cost factor among other raw materials (Staikos and Rahimifard, 2007).

Maroquinerie (2000), revealed that footwear is the sector which consumes the major part of leather (60 %). Logically, this industry is producing the largest quantity of leather wastes.

Fernando, Jayathilaka, Mahindaratne and Punchihewa (2013) stated that pattern cutting is one of the important functions in footwear manufacturing. According to manufacturers, about 30% of the raw material gets wasted as off cut. This involves in an additional overhead cost and a disposal cost.

A study done by the Battelle Columbus Laboratories (1978) has revealed that, shoe manufacturers only utilize about 70% of the leather material that they buy from the tanner. Of the remaining 30% (1/3) is discarded due to initial material imperfections and the other 2/3 results from the waste incurred during the pattern cutting process.

As per the literature reviewed there are numerous research studies done on apparel and other industries, but very few have addressed the leather products industry. At the same time, although there is much researches done on minimizing wastage, a small number of researches has focused on leather wastage and the critical stage of leather wastage in shoe manufacturing industry and no sufficient empirical literature provided evidence within the accessible limits in the local context. Therefore, this study was done to fill this existing empirical gap.

3 METHODOLOGY

3.1 Research Design

As the initial step of the research, the research problem was identified. Then the importance and potential benefits by solving the problem was considered. Literature was then reviewed and parallel to that, processes with a potential to leather wastage were observed in the selected company.

Then the variables and factors were identified through literature and author observations. Subsequently, the secondary data were collected according to the variables identified. Hypotheses were derived based on the literature reviewed and author observations.

In the analysis, hypothesis testing was conducted for checking the below mentioned conditions.

- To test the normality of the data set
- To test the equal variance
- To test the difference between the population means
- To perform multiple comparison technique [Post Hoc comparisons were pursued after rejection of the null hypothesis (ANOVA H_0) to delineate differences]

3.2 Data Collection and Analysis Strategy

The research was developed by using secondary data which were collected by the Quality Assurance Department of the selected company.

To identify the critical stage of leather wastage, daily reject percentage in each stage was used and it was considered as the dependent variable whereas cutting, sewing and lasting stages were considered as the independent variables.

When analyzing each stage, the quantity of damages was considered as the dependent variable and rejection reasons were used as the independent variables.

One-Way ANOVA and multiple comparison (Post Hoc comparisons) technique were used for analyzing the effect of categorical factors on a response variable. Simply, these techniques were used to determine whether there is a significant difference between groups and if so, which groups are significantly different from which others. All the data were analyzed with 95% confidence level. Beside these methods, descriptive analysis methods such as bar charts, pie charts, etc. were also used in order to gain an overall idea about the collected data and its behavior.

4 DATA COLLECTION AND ANALYSIS

4.1 Details of Responses

Secondary data were collected for 80 days from the three sections, cutting, sewing and lasting which were considered for the sample. Data of inline quality control record sheets of each section were used to analyze the leather wastage.

The data of all three stages were used to identify the critical stage of leather wastage in the shoe manufacturing process while rejection reasons in record sheet of each stage were used to identify the significant factors which affect leather wastage.

4.2 Details of Data Analysis

Once the data were collected, descriptive analysis was carried out in order to obtain an overall idea about the collected data and its behavior. Then normality, independence and equal variance of the dependent variable were checked and justified in order to conduct analysis of variance test.

Further, Post Hoc comparisons were carried out in order to compare population means. This comparison technique allows to rank and compare a pairwise collection of means. Moreover it can be used to identify which specific pair (or pairs) of means are different from each other and to estimate the magnitude and direction of such a difference or differences. The model was justified by testing relevant hypotheses and assumptions as well.

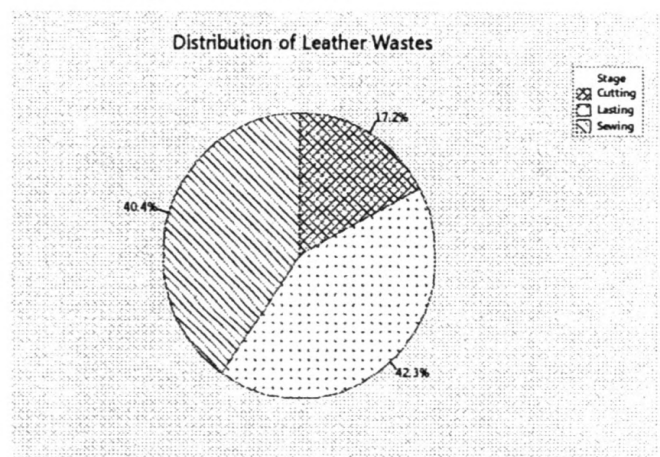## 5 RESULTS AND DISCUSSION

5.1 Descriptive Statistics

Figure 1: Distribution of Leather Wastage

Distribution of leather wastes in the shoe manufacturing process was analyzed by using descriptive statistics and according to the Figure 1, lasting stage was identified

as the highest leather waste generating stage which is responsible for 42.3%. Sewing and cutting stages come next and their contribution to the generation of leather wastes is 40.4% and 17.2% respectively.
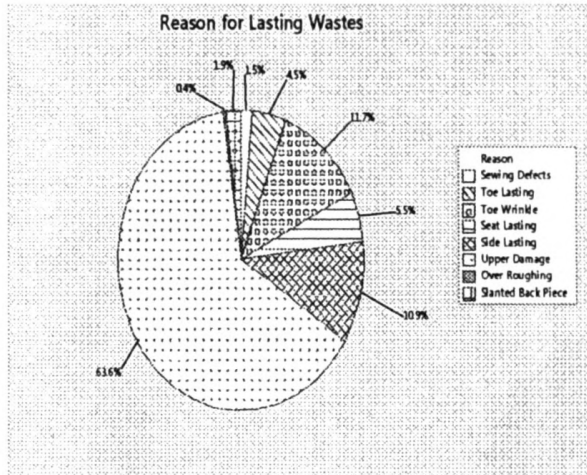

Figure 2: Reasons for Lasting Wastes

Selected stages of the shoe manufacturing process were also separately analyzed using descriptive statistics. According to the Figure 2, in the lasting stage, the most significant reason for the leather wastage was upper damage which represents 63.6%.
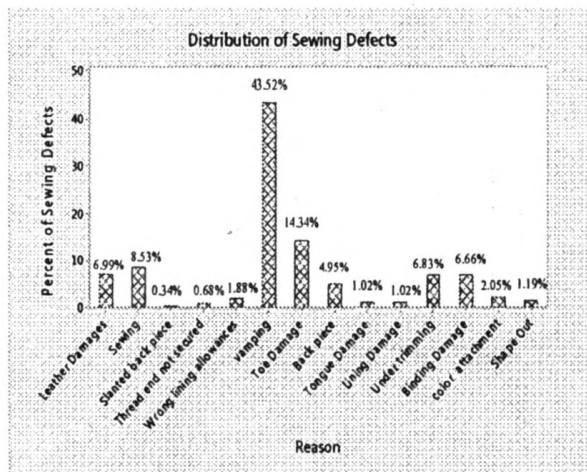

Figure 3: Distribution of Sewing Defects

Figure 3 shows that, in the sewing stage, the most significant reason for leather wastage was the vamping damage and it represents 43.52%. Considering the distribution of cutting wastes, the quarter was identified as the most wasting cut component type that is 36.2%.

5.2 Analysis of Variance Test (One-Way ANOVA)

Before conducting the One-Way ANOVA test, the relevant distributional assumptions were tested. The results showed that the data were normally distributed and all population variances were equal at 5% level of significance.

The normality of the data was tested using histogram and Shapiro-Wilk test. Equal variance was tested by using box plot diagrams and Levene's test. The following hypotheses were used for testing the above mentioned assumptions.

- Normality:

  H_0: Data set is normally distributed

  H_1: Data set is not normally distributed

- Equal variance:

  H_0: All population variances are equal

  H_1: At least one population variance differs from the other

Since the assumptions were satisfied, then the analysis of variance test was conducted for the selected three stages and for each stage separately. Here the testing hypothesis for each case was,

H_0: All population means are equal

H_1: At least one population mean differs from the other

Table 1: P values of One-Way ANOVA Test

Factor	P value	Result
Reject Percentage	0.000	<0.05; Reject H_0
Last Damage	0.000	<0.05; Reject H_0
Sewing Damage	0.000	<0.05; Reject H_0
Cut Damage	0.000	<0.05; Reject H_0

Since for each case, P values were less than 0.05, it could be concluded that at least

one population mean differs from the other at 5% level of significance.

Then, Post Hoc comparisons were used to delineate the differences. Here, the testing hypothesis was,

H_0: The two population means are equal

H_1: At least two population means are significantly different from each other

Table 2: Comparison of the Three Stages

(I) Stage	(J) Stage	P value	Result
Cutting	Sewing	.000	<0.05; Reject H_0
Cutting	Lasting	.000	<0.05; Reject H_0
Sewing	Lasting	.506	>0.05;Do not reject H_0

According to the results of the comparison of the three stages, the mean of reject percentage between sewing and lasting stage has no significant statistical difference at 5% level of significance.

But for the other cases; comparison of rejection reasons in each stage, it was impossible to identify one single significant population (rejection reason) using this test.

The final result of the research could be summarized in the table 3. It describes the leather wastage with respect to the stage and reason. The three columns represent each stage separately.

Table 3: Leather Wastage as a Percentage

Cutting 17.2%	Sewing 40.4%	Lasting 42.3%
Quarter damage 36.2%	Vamping damage 43.52%	Upper damage 11.7%
Vamp damage 26.5%	Toe damage 14.34%	Toe wrinkle 11.7%
Back stat damage 19.0%	Sewing damage 8.53%	Side lasting damage 10.9%

6 CONCLUSIONS

This research is about identifying the critical stage of leather wastage in shoe

manufacturing process. When conducting this research, several previous studies were considered in order to identify the variables. Other than that, the selected company defined variables also considered. Main three stages; cutting, sewing and lasting stages were considered for identifying the critical stage.

The results concluded that lasting and sewing stages are the critical stages which are responsible for the leather wastage in the shoe manufacturing process. Besides that, the top most significant reason for the leather wastage is upper damage and it is responsible for 26.90% whereas the second most significant reason is vamping damage that is 17.58%. The other significant reasons for leather wastage are toe damage, toe wrinkle and side lasting damage which are responsible for leather wastage of 5.79%, 4.95% and 4.61% respectively.

Thus, it can be concluded that the Sri Lankan shoe manufacturing industry needs to be more focused on the above mentioned stages and reasons in order to minimize leather wastage.

Finally, the study suggests adopting lean manufacturing as a leather waste minimizing technique to the Sri Lankan shoe manufacturing industry. There are numerous researches that have proved that lean manufacturing system can reduce waste. Further research can be conducted on identifying not only factors affecting to leather wastage but also for other raw materials wastage as well.

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