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Application of Generalized Linear Model to the Minimization of Defectives in Sewing Process of Apparel Industry

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Abstract- The Apparel industry in Sri Lanka represent as one of the largest contributors for the export revenue of the country. The quality of garments is vital to its survival in an increasingly competitive apparel industry in order to maintain the production of high quality garments and improved productivity in the apparel industry.

The objective of this study is to improve efficiency of the sewing process in apparel industry through the reduction of defectives. This study is focused in three major defect types; run off stitches, unbalanced shape and wavy seams. I have developed generalized linear models for each defect type to find the significant factors affecting on the proportion of occurrence of defects. Under these models, I have recommended few remedial actions to be implemented. On implementation of recommended remedial actions, the percentage of defectives was up to an acceptable level. The outcome of this study reflected that an industry may gain higher productivity and profitability with improved quality product by minimising reworks activities.

Index Terms- Defects, Defects in sewing, Generalized Linear Model, Quality

I. INTRODUCTION

Despite its modest beginnings in 1970s, the apparel industry in Sri Lanka has grown to become one of the largest contributors to the export revenue of the country representing over 43% of its total exports. Moreover the apparel industry also contributes around 39% to the industrial production of Sri Lanka. Being the single largest employer in the manufacturing sector, the apparel industry provides at least 75% of Sri Lanka's employment directly as well as indirectly.

The quality of garments is vital to its survival in an increasingly competitive apparel industry in order to maintain the production of high quality garments and improved productivity in the apparel industry.

Presently statistical methods are widely used by industries for improving the production process and reducing its defects. Most of the industries in Sri Lanka collect data pertaining to its day to day production process. Only few industries make use of such data for the improvement of their industry. If one can analyze such data by using the proper statistical methods, it would be possible to come across valuable findings, which could be used for the improvement of that industry.

One of the major problems in the apparel industry is the high defect rate. As a result, the rate of production is not as high as expected and also the industry cannot achieve its targets. The biggest disadvantage is the buyer dissatisfaction since the quality of the products is considerably at very lower level. Further cost of the labour used for the reworking of defective products and cost for materials used for defective products are significantly high. Therefore the loss generated due to defects is also significantly high.

In this paper, only the subjects of sewing quality are analyzed. As sewing defects are minimised it is possible for firms to decrease their costs, while they increase the production speed. Hence, they can be more powerful at a competitive atmosphere.

Primary objective of this research is to figure out explanations for any discrepancies of this considerably high percentage of defects. Second one is finding out possible ways to overcome the factors that increase defect rate. There are lots of women's brassiere styles manufactured in 'Sintesi Private Limited'. Brassiere style DN672 is inspected for defects since this was one of the major products of the company due to the high demand and the profit margin of this particular style. Main buyer of the style is Marks and Spencer. The

style consists with four colours which are Black, Cream, Chocolate and Pink mix. Information and data of the garments was required for this study and were collected during the period from December 2011 to February 2012.

Table 1.1: Details of the DN672 style

Item	Type of the fabric/foam	Supplier
Inner cup fabric	Garry fabric	South Asia textiles
Foam	KBRB	Hocheung
Outer cup fabric	IPE012	Hayleys

Manufacturing Process

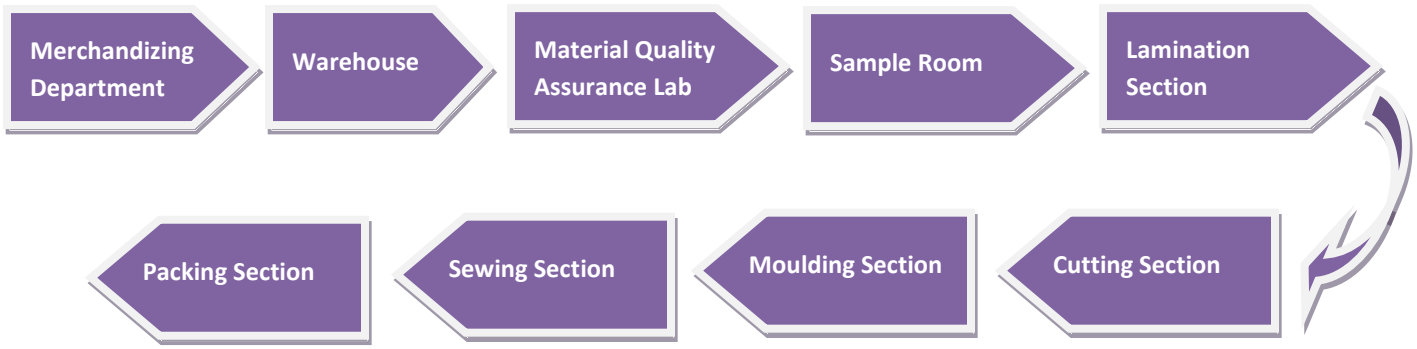

Figure 1.1: Chart of Manufacturing Process of brassieres

II. ANALYSIS AND DISCUSSION

Major types of defects were identified through Pareto Chart shown in Figure 1.2 below;

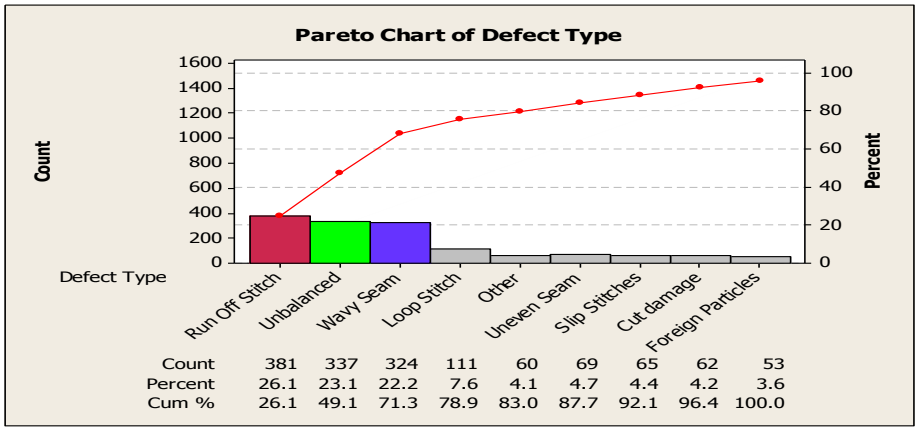

Figure 1.2: Pareto Chart of Defect Type

Major defects from Pareto Chart are considered for analysis and the defects are listed in Table 1.2 below;

Table 1.2: Major defects identified from Pareto Chart

Defect Type	Percentage

Run Off Stitch	26.1
Unbalanced	23.1
Wavy Seam	22.2

Four factors identified as a result of the preliminary study and are listed in Table 1.3 which are expected to have an effect on the percentage of defectives;

Table 1.3: Potential Factors

Factors	Levels
Colour of the garment	Chocolate Cream Black Pink mix
Size of the garment	Small Large
Line Number	2 3 7 8
Target per Day in each line	200-300 301-400 401-500 501-600 601-700

In order to analyze and identify which factors have the most significant impact on the percentage of defects, the 'Generalized Linear Modelling' technique was used with the aid of 'GLIM 3.76' statistical package, which was developed by the 'Working Party' on Statistical Computing of the Royal Statistical Society. GLIM programs were tried to write for major defect types, considering the presence or absence of a defect in a garment as a Bernoulli trial.. Since the number of parameters is higher than the number of observations, full model could not be fitted. Then I tried to fit the model with main factors and certain two-way interaction terms. However, adequate model was not found under the binomial distribution.

Then the 'General Linear Model' was utilized to find the adequate model for proportion of defects. It was assumed the defect proportion has the normal distribution. Since the assumptions were not satisfied by this method, it failed to identify the factors which affect the defect proportion.

Then the Generalized Linear Model was used by considering the gamma distribution. Initially full model was fitted for each defect type. The goodness-of-fit for generalized linear models can be characterized by the deviance value, which is formed as the logarithm of a ratio of likelihoods. The deviance for the full model was approximately zero and the deviance for all other models was positive. Hence the smaller the deviance, the better the model fit. The deviance was often used as a goodness-of-fit statistic for testing the adequacy of a fitted model.

After fitting a particular model, the importance of each factor in the model can be evaluated by the resultant increase in deviance when we remove that factor from the model. This increase can be compared with the appropriate F statistic to compute the p-value for this factor. If the p-value is less than 0.05, then the factor is significant at the 95% level.

GLIM models which are fitted for 'Run Off Stitches', Unbalanced and Wavy Seams are presented in Table 1.4, Table 1.5 and Table 1.6 respectively. 'Anscombe' residual analysis was satisfied for all the models.

Table 1.4: Generalized Linear Model for proportion of Run Off Stitch

Parameter	Estimated value	Standard error	T-statistic
Constant	2.514	0.4351	5.778
Colour (chocolate)	2.342	1.082	2.164
Line (7)	3.174	1.355	2.342
Line (8)	1.806	0.8714	2.072
Deviance = 7.0293		DF = 23	

According to the Table 1.4, it is clear that the colour and line are factors that affect on occurrence of 'Run Off Stitches'. The garments which are coloured Black, Cream and Pink mix had the same effect on occurrence of 'Run Off Stitches', while Chocolate colour garments had a different effect. The lines 2 and 3 had similar effect, while lines 7 and 8 had a different effect.

Table 1.5: Generalized Linear Model for proportion of Unbalanced Shape

Parameter	Estimated value	Standard error	T-statistic
Constant	13.34	2.478	5.383
Line (8)	-20.6	7.485	-2.752
Target	-0.00654	0.00186	-3.516
Line (8).Target	0.03674	0.0453	2.401
Deviance = 8.5225		DF = 23	

According to the Table 1.5, it is clear that the Line and Target are factors that affect in occurrence of unbalanced shape. The lines 2, 3 and 7 have similar effect while Line 8 has different effect.

Table 1.6: Generalized Linear Model for proportion of Wavy Seams

Parameter	Estimated value	Standard error	T-statistic
Constant	3.354	2.325	1.442
Colour(chocolate)	-3.403	0.9709	-3.505
Size(large)	2.626	1.233	2.129
Target	0.007461	0.002911	2.563
Size(large).Target	-0.007467	0.002919	-2.558

According to the Table 1.6, it is clear that the size, colour and target are factors that affect on occurrence of Wavy seams.

Solutions Provided

Through discussions with the managers and supervisors, following remedial actions were implemented for the each defect which is indicated in the Table 1.7.

Table 1.7: Defects and Remedial Actions

Defects	Action
Run Off Stitches	The stitches are extended than required and the operators are trained to control the speed of the machine
Unbalanced	The operators are trained to check for unevenness by using a sample garment

Wavy Seam	Operators are trained to handle large size garments in proper way

After the remedial actions were taken, the garments were checked for defects. The results are indicated in Figure 1.3.

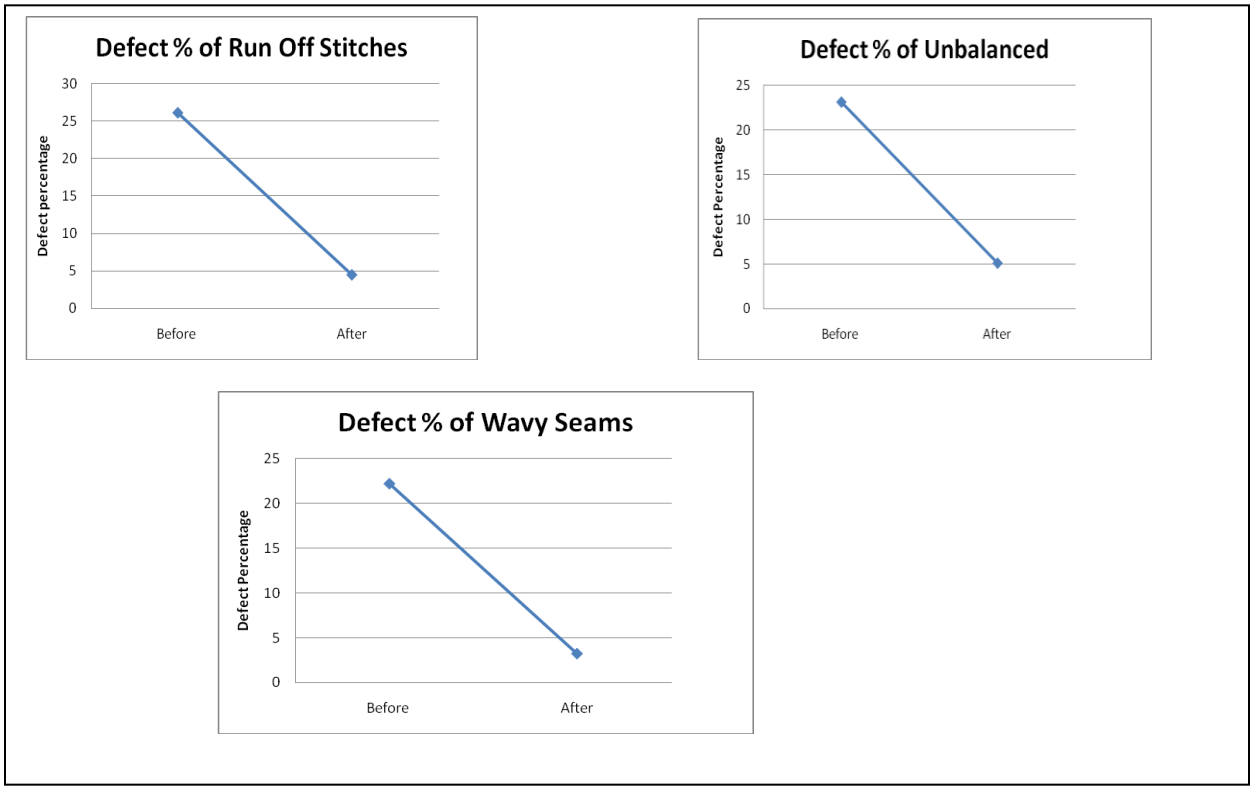

Figure 1.3: Defect Percentage each defect type Before & After Implementation

III. CONCLUSION

Good quality increases the value of a product or service, establishes the brand name and builds up good reputation for the garment exporter, which in return results in customer satisfaction, high sales and foreign exchange for the country. In this study there were three major defect types occurred in a garment. All the defect types had a very high percentage of occurring and that was more than the acceptable level of 5%. Using Generalized Linear Models, significant factors affected on the defect percentage had been found. Remedial actions had been discussed with the management to overcome these significant factors. After implementing the remedial actions, the defect percentage of each defect was decreased to an acceptable level.

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