Failure mode and effect analysis: An application in jeans production process

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Apparel production quality is influenced depending upon machine, operator, material and process. Therefore, production is not possible with zero defect. The purpose is to prevent the possible defects by taking measures or to minimize them. In order to determine and remove the these possible defects during production stages, various engineering applications are used for this purpose. One of them is "Failure Mode and Effects Analysis (FMEA)" technique. In this study, defects encountered at the quality control department of jeans production in apparel firm were observed and analyzed according to FMEA method.
Key words: *apparel sector, jeans production process, quality control, Failure Mode and Effects Analysis (FMEA)*

1. Introduction

Quality as one of the prior conditions to participate in local and global markets is an important subject for companies to provide a competitive advantage. Expectations of the customers from the products they buy has increased in time and changed to a structure so that there is no chance for any defect. The consumer has no tolerance to a fault even it is very small or negligible. As this approach is valid in other sectors, it is valid in apparel sector, too. Actors taking place in this sector are in cutthroat competition with each other. Since apparel business in market is active in countries with cheap labor power, it has to present the best quality to the customer by considering the materials in agenda and developments in fashion with minimum cost. Especially since our country has important exporter position and makes production in huge quantities to the big international companies; the quality subject inevitably takes position among our first priorities. When the sector is examined with respect to production process; different from other sectors, it continues its labor intensive structure in spite of the increasing automation. In such case, it continues to be a potential for evolution of man-made defects.

Since FMEA provides systematic analysis of technical defects and removal of the defects, it helps to minimize the risks caused by defects, to decrease defect costs, to increase the reliability, and to develop quality systematically. It provides determination of potential defect belongs to system, process or product in planning and development stage before the existence, specification of importance degrees of them, evaluation and taking necessary actions for preventing the them [1].

FMEA technique was used widely in manufacturing sectors, especially in automotive industry formerly, but now it is used in all companies active in production and service sectors according to their areas of need. Precautions has developed against possible defects that might happen in automotive subsidiary industry plant with the applicatin of this method [2]. A result oriented method is obtained assessing defect, dimension of the defect effect and cost of precaution together [3]. Ready-made clothing company used failure mode and effects analysis in terms of worker's health and work safety for the risk evaluation of company [4]. A new FMEA model based on fuzzy digraph

and matrix approach is developed to solve the problems and improve the effectiveness of the traditional FMEA [5]. Another study proposes an FMEA which uses Data Envelopment Analysis (DEA), a well-known performance measurement tool, to determine the risk priorities of failure modes [6]. In order to achieve a better protection of the environment FMEA is utilized as a convenient technique for determining, classifying and analyzing common failures in the municipal solid waste lifecycle [7].

As understood from literature study, besides the use of traditional FMEA technique in different sectors, it is observed that it can be used together with different methods by considering some deficiencies of the method. In this study quality control department of an apparel firm active in jean production was investigated by FMEA method. Defect types, effects and causes, preventive actions to reduce or elminate them are identified.

2. Material and method

2.1. Material

This study was realized on a plant having business on producing outerwear like especially pants, skirts, jacket from woven fabrics located in İzmir.

Possible defects during jean production, impact of these defects and causes that may occur according to the workflow and measures to be taken were studied. Later all of this issues and control measures to be taken were determined with FMEA team with the help of brainstorming.

2.2. FMEA methodology

At first FMEA technique was developed by US Army and this method is a reliable technique for evaluation of system and equipment defects. Primarily it was used by Ford Automobile plant [8]. Today it is also used in different industries widely. Instead of defining FMEA method to be used as planning for making improvement for hundreds of defect types, this method is defined as a method prioritizing the types of defects that will provide the greatest contribution to the whole system [9].

Basic objectives of this technique are listed as predetermining the potential defects that may occur in the product or process, taking measures to prevent these defects, determining the degree of impact and criticality of the defect type.

Applicability of the method depends on the need for continuous development and improvement which is the main objective of the total quality management.

2.2.1. Types of Failure Mode and Effect Analysis

FMEA method is handled in four ways basically [8].

***System FMEA*:** It analyzes the systems as main and subsystems and it is a method for finding potential defect types among the elements that make up the system.

***Design FMEA*:** It is a method for evaluating past defect or complaints during product design / development stage occurred before production and for determining and aiming to prevent types of defects that may occur during new product / technology design or development.

***Process FMEA*:** It serves the objective of removal of defects arising from production and assembly processes and analyzing them.

Service FMEA: It is a method to analyze the service before it reaches to the customer.

2.2.2.Application steps of Failure Mode and Effect Analysis

FMEA application process basically consists of three stages:

- Preparation,
- System Analysis,
- Evaluation of Results.

A basic FMEA application contains calculation of defect types, reasons, probabilities, severity and discoverability and risk priority number of the functions respectively and listing them from higher to smaller and taking some measures to decrease risk. Risk Priority Number (RPN); is the value obtained multipliying by defect occurrence, severity and detection [10]. Here "Occurence" is the defect frequency, "Severity" is the seriousness of the defect effect and "Detection" is opportunity to notice the defect before it reaches to the end user. In order to determine these values, scale of ten is used.

$$RPN = Occurrence \times Severity \times \times Detection \quad (1)$$

At the last stage, it is decided to bring improvement suggestion and to start corrective actions at which stage of the production process and for which types of defects by looking at the calculated RPN values and degree of severity for each defect.

RPN values are listed from the highest to the lowest by considering the criteria selected, at this point it is natural that highest RPN values rank in prority with respect to others for the improvement [11].

3. Implementation and results

Before starting the study, necessary feedback has been provided to the company executive about the analysis and the benefits that it shall bring was mentioned. FMEA team was organized; responsible people were selected with ability to take part at every stage of the process, to define the defect reasons and to review properly. Then it was defined that process which FMEA would be applied was selected as production process of jeans.

The study carried out between the dates of 05.11.2014 to 18.12.2014 and after determining the defects during this period, five basic classifications were realized.

Explanations encountered during jean production process and defect types directly or indirectly have effect on the company were given at Tab.1 [12].

During the observation period, 5600 products were controlled in total. 1726 products nearly 30% of them

Tab.1 Types of defects observed during jeans production process

Defect code	Type of defect	
D1	Label defects	• Missing label • Torn washing label • Incorrect seam together of label • Differential feed of label
D2	Rivet defects	• Missing or an extra rivet • Breaking rivet
D3	Seam defects	• Broken thread • Skip seam • Burst of the seams • Gathering • Curved seam • Uncomplete seam • Sewing process in the wrong direction • Seam opening • Inconvenient stitch length • Erros of bartacking
D4	Belt loop defects	• Broken belt loop • Unseamed belt loop
D5	Other defects	• Defectof measurement • Meto label stain • Grease stain • Dust welded stain • Glue mark visible at surface • Embroidery defects

Tab.2 Amount of defect determined in jeans production process

No	Defect type	Amount of Defect
1	Seam defects	1114
2	Label defects	153
3	Belt loop defects	78
4	Rivet defects	58
5	Other defects	323
Total		1726

were processed again due to their defects. Numerical distribution of the defect types encountered was given in Tab.2.

According to Pareto chart in Fig.1, 65.54% of the defects has originated from sewing defect. "Other Defects" following label defects have important percentage as 18.71%. Bridge and the rivet defect is calculated as 4.51% and 3.36% respectively with values close to each other.

Defective products, as they require extra processing often leads to loss of time, in many cases they are not accepted by the customer and are released to the market as a second quality product. Specifying the reason by FMEA team for the defect that occurred, reasons in the formation process of the defect types are detailed with fishbone analysis. Causes of the defects determined are shown clearly in Tab.3.

Defect type reason was graded by using ten scale regarding occurrence, severity and detection and later, priority list was obtained by calculating a RPN value by multiplying each three values.

While values were being determined it was tried to benefit from past data as far as possible, the resulting weight values and detection values are determined by the experiences of team members. RPN values have given in Tab.4.

It was found that defect types to be improved primarily according to their RPN values are sewing and the rivet defects. It was observed that these defects arise basically from machine, operator and raw material. In this sense it should be provided that personnel should be trained, that he should do his work carefully and that his work should be controlled. Firm should spend more time for training and provide its continuity.

It should be provided that quality control during production process must be conducted in a more disciplined way since long repair work for product defect and repeated controls cause time loss. The next operation should start after the evaluation of quality control process by the person doing that work. For this reason operator training is essential. Thus intermediate and final controls can be decreased seriously.

If it is desired to work with zero defect, RPN values are needed to be lowered down. This can be done by lowering the occurrence probabili-

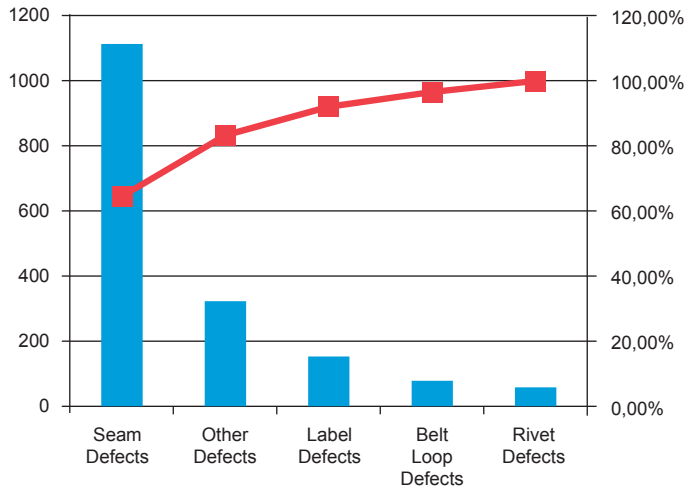

Fig.1 Pareto analysis relating to defects

Tab.3 Determining cause of defect

Defect type	Cause of defect
Seam defects	• Machine set up defects • Using inconvenient needle thread, presser foot for fabric • Unstable material • Carelessness of workers
Label defects	• Carelessness of workers • Using wrong label • Using inconvinient needle and threah for label • Disusing of label apparatus
Belt loop defects	• Carelessness of workers • Lack of motivation • Using incorrect scissors
Rivet defects	• Carelessness of workers • Improper rivet to the model • Inappropriate machine set up and apparatus for related process
Other defects	• Poor machine maintenance • Selecting wrong material • File defect • Selecting wrong method for the process

Tab.4 Defects ranking according to RPN values

No	Defect type	Occurrence	Severity	Detection	RPN values
1	Label defects	7	6	2	84
2	Rivet defects	6	5	5	150
3	Seam defects	10	4	5	200
4	Belt loop defects	5	4	3	60
5	Other defects	7	3	6	126

ties. For this reason continuity of preventive and corrective activities are important.

4. Discussion and conclusion

Objective for apparel companies is to reach the desired quality level by continuous improvement. Determining defect types of the process related with product to be produced, evaluating the future effects of the defects on the customers, decreasing even removing of the defects that may arise in assembly process and production, determining and application of control for preventing activities shall provide a range of benefits.

Failure Mode and Effects Analysis technique is a powerful numerical analysis tool oriented to prevention of defects before appearing. As a result of FMEA application on a jean production company having activity in apparel industry; measures have been developed for identification and removal of possible defects during process and for maintaining a high level of customer satisfaction.

Today jean products are subjected to high number of chemical and mechanical processes until it reaches to the end consumer. Thus, in these process steps, deterioration of the fabric forming the garment, the sewing thread and accessories are inevitable. Unlike other apparel productions, jean clothing production needs to know processes of the product after the sewing and it is needed that sewing thread, stitch type and accessories to be used in production have to be selected as resistant to these processes. Thus, it would be possible to prevent majority of stitch defects that may happen later.

As a result of controls performed in the firm, majority of the defects consists of stitch defects. Stitch defects can originate from material, machine, operator and method. In order to remove defects originating from material, it should be taken care of following processes and material choice should be done accordingly.

In order to remove defects originating from machine, machine settings should be followed and importance should be given to machine maintenance. Technological innovations in this field should be followed and correct machine should be selected in the beginning. Necessary apparatus should be provided for the standard quality. Apparatus costs are not so high, thus it improves the quality seriously. The most important thing is to select the most suitable ones for the operation.

In order to remove defects originating from employee, each member taken to the plant should be passed from training, primarily. Even training expenses make up a cost at the beginning; this cost loses its importance by quality and efficiency increase afterwards. If the employee knows his works very well, it serves to provide possibility to control them well and thus, interlude controls are not needed. Besides these, mechanic should be trained in such a way so that he can handle and judge the operations more than one. Thus business disruption shall not occur when there is one person leaving the job. Since this sector with labor circulation is very intense, depending one person puts plants in a difficult positon. To prevent this to be happen, it may be provided that operators work rotationally. Trainings should not be limited to staff recruitment. In necessary places, intermediate trainings can be organized.

Since the company doing application works as subcontracting, importance should be given to selection of outsource business, if it is necessary, common quality awareness should be developed. Mutual exchange of information with outsourced companies provides a healthier working condition. Business by directing the quality control team to outsources,

should give importance to pre-control and intermediate controls.

In order to remove defects originating from method, it is important that planning and organization departments work systematically. Explanation of all details related with production and packaging such as the process steps of each model, auxiliary materials needed for that product, accessories to be used shall be disclosed in a clear and unambiguous manner. Production should not be started before controlling the accuracy of the information in the files that contain explanations.

Although apparel production has many automation, it still continues labor intensive structure. Therefore it is not possible to make production with zero defect. However, with the adoption of certain measures, possible defects can be minimized.

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