(REFEREED RESEARCH)

FMEA ANALYSIS AND APPLICATIONS IN KNITTING INDUSTRY

ÖRME ENDÜSTRİSİNDE HTEA ANALİZİ VE UYGULAMASI

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ABSTRACT

In this study relevant products errors were determined with error probabilities, severity values, and values of discoverability were calculated at a knitting company by types of Failure Modes and Effects Analysis's (FMEA); process FMEA. Correction steps were determined with RPN (Risk Priority Number) values due to occured errors.According to the obtained results, it was determined that traces of platin, fly, broken needle, lycra eccentric, number of hole, transverse band, and lycra cut are the most critical errors. These errors have been occurred by knitting machines. Furthermore, workers' education and improvment of working conditions critical factors on eliminating errors.

Key Words: FMEA, Knitting errors, RPN, Correction steps, Knitting fabrics.

ÖZET

Bu çalışmada bir örme işletmesinde karşılaşılan hataların, hata olasılıkları, şiddet değerleri ve keşfedilebilirlik değerleri hata tesbit etki analizi yöntemlerinden (HTEA), Proses HTEA çalışması ile hesaplanmıştır. Buna göre belirlenen RÖS (Risk Öncelik Sayısı) değerlerine dayanarak, ortaya çıkan hata türlerine göre düzeltme önlemleri belirtilmiştir. Yapılan çalışmalar ve elde edilen veriler sonucunda işletmede karşılaşılan kritik hatalar, delik sayısı, uçuntu; kırık iğne, lycra kaçığı, platin izi, enine band ve lycra kesiği olarak belirlenmiştir. Bu hataların örme makinası kaynaklı olduğu belirlenmiştir. Ayrıca işçilerin eğitimi ve çalışma koşullarının iyileştirilmesi hataları önlemede kritik faktörler olarak belirlenmiştir.

Anahtar Kelimeler: HTEA, Örme hataları, RÖS, Düzeltme önlemleri, Örme kumaşları.

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1.INTRODUCTION

Failure Modes and Effects Analysis (FMEA) is a powerful analysis technique which can avoid failures by estimating the risks to prevent errors.

FMEA is systematic and analytical study including; identifying and evaulating all possible failures in a design, manufacturing, or assembly process, or in a product or service and activities to eliminate the chance of occurrence of the identified errors (1, 3, 7). Generally, all the possibilities for errors and severity are estimated in FMEA(5). FMEA will provide improvement in the system primarily by addressing the largest contribution of the types of errors on the solution produces instead of making hundreds of errors (6,7).

FMEA was developed for the first time as a discipline by the American army and then have been used by the NASA space technologies (8). Between all industries, it was applied for the first time in automotive industry. Nowadays, several industries carry on formal FMEA standards (2, 4, 5, 12), and also FMEA, QS 9000, ISO / TS 16949, ISO 9001:2000 and other quality management systems have become a necessity today (6).

FMEA is preferred for the purpose of the study because analysis of how a system works is easy, can be characterized with high experience required, and can be applied in all sectors.

Different parts of the system are easy to use and applicable to each sector. Unlike the traditional risk analysis, adding "Detection and Indication" are important factors (5). FMEA not only documents what are the flaws in the system but provides information about the operation of the system as well. Generally, There are four types of FMEA widely used:

System FMEA: After completion of all equipment and design, a method used to make the most favorable analysis and the flow of sub-systems such as manufacturing and quality assurance. FMEA system focuses on the different types of potential errors that cause disturbances in the system. It examines system interaction with other systems and sub-elements (10).

Design FMEA: It is an analytical technique, which all possible types of errors that may arise and also their respective causes are addressed and resolved by it. Design FMEA creates a reference to provide additional information about design requirements, evaluation of alternatives, and types of errors that may occur in processing system and also their results to consider the design/ development process, and planning of the full and effective design and test development programs. Design FMEA is a method of analyzing the design in order to determine the weak points or any critical situation that can do more harm on, especially product reliability and / or safety (10,11).

Process FMEA: It is an analytical technique that provides consideration and resolution of all possible problems that may be taken into account during the creation of the product. The purpose of FMEA process is to take measures for identifying and correcting weaknesses in the production process. Moreover, it can be used to analyze manufacturing and assembly processes.

Service FMEA: It is the method which is applied with coordination of production quality assurance (QA) and marketing in order to improve the customer service. It helps to analyze the defects in the organization. It indicates that determination of priority between the activities of the organization and workflow, and system and process analysis in an efficient way and identifies and control errors on the process of carrying out plans (9,11).

Generally, FMEA process has five phases which are:

- *The pre-work:* In this phase it determines the objectives and the level of FMEA. During this phase criteria on the basic concepts and special procedures for the prevention of unnecessary loss of time and cost are defined.
- *Systems analysis:* Development and analysis of the system, processes, and fault tree diagrams operates according to specified functions, areas of interaction, stages, and their types.
- *Review of results:* potential types of errors are identified, effects of them are evaluated, and control measures to prevent errors are defined according to the analysis and evaluation.
- *Monitoring / Implementation:* During this phase, results and data documentation are obtained.
- *Verification:*

In the following we present some definitions which are popular in FMEA:

Error: It is defined by laching ability to perform functions of a system or abnormal functioning. This error space is determined by type, working effect, and occurrance assumptions of errors. Errors can be classified into five types: (1) exact errors, (2) partial failures, (3) intermittent errors, (4) errors which occur during the time, and (5) during usage (4, 5, 10).

Effects: After determining the types of the errors, effects is determined by the potential consequences which will take place according to the types of these errors. In fact, effects link to the types of the errors. Effect show the change of the system function which caused by each of the errors.

Severity: It meants representing the factor rating system based on the degree of injury caused by an error on customer according to the seriousness from 1 to 10. Severity is only based on the impact of error for a specific effect of the error. All the potential causes of error is sorted as at least by the same weight.

Cause of the error: Distinguishing the elements that are effective in occurence of one type of error. The most common method of determining the cause of the error is *cause and effect* (fishbone/Ishikawa) diagram.

Occurrence: After determining the cause of different types of errors and severity of impact, then the reasons are ranked according to probability of occurrence. Probability of occurrence is estimated and then ranking is done according to the likelihood of potential cause of the error during this process. Thus, the possibility of error is determined by frequency of occurrence (10).

Detectabilty: It is to estimate the probability of error caused by the presence of the identified defect. The controls competence is determined. This determination is based on a statistical basis, which is perfomed using sampling methods.. That aplication prevents access of the error to the customer.

The range of values are between 1 and 10.

Risk Priority Number (RPN): This numerical value can be determined by handling of the three risk factors (severity, occurrence, and detectability) for each type of error. Short and long term measures to be taken to eliminate or avoid error occurence starting from the biggest one acording to RPN values. RPN values enable you to sort the types of errors from top to bottom. This sorting provides admission ranking to the rating of the improvement activities and importance of errors (9).

RPN can be calculated by multiplying these three numbers:

RPN = S (severity) × O(occurrence) × D (detectability)

The results of risk analysis are compared with these measurements and recognized. After all, the critical numbers are revealed, and try to prevent the critical events before they happen. Based on the MIL-STD-1629A (1984), *criticality* is defined as the 'relative measure of the results of the error type and frequency of its occurrence'. RPN values are measures of criticality (8).

In order to begin implementation of measures, it should be started from the largest value of the coefficient of RPN since the largest value is an alarm for the largest loss.

Number of RPN has no value or meaning. Just enable you to sort and compared errors to each other in terms of criticality and show the relative importance. It gives a general idea of the envisaged system. Corrective action will begin according to the RPN depending on the value of the error causes which are analyzed by lining up critical points and with the highest cause of the error. Risk priority value must be between 1 and 1000. The larger the RPN coefficient, the more important it is.

According to the Ford Motor company ranges of values specified for the decision-making:

- RPN <40 is no need to take measures
- 40 ≤ RPN ≤ 100 is worth taking the precaution
- RPN > 100 should take precautions if necessary (12).

If two or more errors have the same value of RPN, firstly with high intensity and then with high deviation ones should be addressed(12).

The corrective actions are taken after errors detection. Corrective actions make changes in several factors to minimize or eliminate possible causes of error in design, manufacturing process, material, and such as the production method. Thus, the value of RPN is derived to be less and less. FMEA analysis is continued until falling down to the desired values.

After defining the corrective actions, the implementation of adequate event is provided for corrective actions, the monitoring and enforcement phase begins to examine obtained results.

Then FMEA is completed by the implementation of corrective actions and confirmation of the persistence of the system.

The goals of FMEA are as follows:

- Defining potential error / fault types, rates, effects and the degree of importance
- Identify the critical and determinant characteristics
- Sorting potential errors of design and process based on severity
- Identifying and testing to eliminate or minimize errors, defects, malfunctions, and changes and to ensure product development
- Avoid potential errors that may occur along to the product or process, by predefining them
- Eliminate potential types of errors to take corrective actions or reduce the posibility of formation.

We will be looking at what are the benefits of FMEA

- Enhances quality, reliability, image, security, and level of competition of the product.
- Helps to increase customer satisfaction.
- Reduces product development time and cost, and provides selecting the most appropriate system and the opportunity to optimize processes.
- Reduce risks by monitoring and documenting methods.
- These documents would be a good guide for the design of system and process that will be developed in the future.

The information obtained from the design FMEA, is used on changes in the production process, material selection, quality control, and quality inspection criteria. Hence, the method can be used as a decision making tool.

Types of errors are reviewed systematic in order to prevent even the smallest damage on product, process, or service.

2. MATERIAL AND METHOD

2.1.Material

Two fleece fabric, single jersey and rib fabrics measured for this study because of their widely usage in knitting industry, which supplied from Ethem Örme Textile company

2.2. Method

Table1. Names and Codes of Errors

ERROR CODE	ERROR NAME
HT 1	Number Of Hole
HT 2	Fly
HT 3	Broken Needle
HT 4	Lycra Eccentric
HT 5	Traces Of Platin
HT 6	Transverse Band
HT 7	Lycra Cut
HT 8	Oil Stain
HT 9	Empty Iro Error
HT 10	Color Difference
HT 11	Longitudinal Lines

Identification of Error Types

Number of hole (HT1): It may cause because of yarn, or the machine elements.

Fly (HT2): Fly-adhesive cotton dusts from machines will cause an error on colorless, knitted fabric during the knitting with colored yarn.

Broken needle (HT3): Errors that may occur on the fabric surface in case of working with broken needle.

Lycra Eccentric (HT4): The error is observed with the needle does not receive during the knitting process because of the rotation of the lycra in the fabric.

Traces of Platin (HT5): The error is formed by the traces seen on the fabric due to the use of worn or deformed platin.

Transverse band (HT6): Yarn and machine are two important factors in the formation of this error.

Lycra cut (HT7): Error caused by wear needles used on the bench or feeding type of lycra.

Oil stain (HT8): Discolorations on the fabric due to the use of oil, haunting with water, in the machine.

Empty iro error (Meninger) (HT9): A type of error caused by can't wind yarns on iro properly.

Color difference (HT10): Using of different yarn lots at the same time cause that error.

Longitudinal lines (HT11): A jump occurs due to motionless of tongue of needle, the loop does not occur on the needle. It occurs an open longitudinal line on fabric.

Identifying the Effects of Error

These errors are not met positive by the customer and included in the second quality class.

Identification of Error Reasons

These errors are occur because of raw materials, machinery, and human.

Applicable Control Measures

- Controlling of yarns that required for knitting
- Setting of machine due to knitting fabric type
- Measuring weight of knitted fabric after beginning of knitting
- Doing raw quality control of fabric
- Controlling of fabrics after dyeing

Application of Scoring

Relevant products error probabilities, severity values, and values of discoverability were calculated by process FMEA

3.RESULTS AND DISCUSSION

3.1.The Possibility Of The Error

In this study unit of meauserd samples that kilograms. The number of working days in the business was 303 days in 2011. Three month's data chose for this study due to business prepared the most order in that months. Table 2 shows the production information and the probability values according to data from the factory. In tables 3 and 4 values of the error severity and detectability of error type are shown.

Table 2. Degrees of Error Probability and Probability Values (August, September, and October of 2011)

ERROR TYPE	NUMBER OF DEFECTIVE (KG)	SHARE IN TOTAL ERROR %	SHARE IN TOTAL PRODUCTION %	DEGREES
Number Of Hole	12,22	9,6	0,005	7
Fly	2,05	1,61	0,0009	6
Broken Needle	40,34	31,78	0,018	9
Lycra Eccentrıc	39,13	30,83	0,018	8
Traces Of Platın	5,73	4,51	0,0026	6
Transverse Band	4,39	4,23	0,0024	6
Lycra Cut	6,47	5,10	0,0029	7
Oıl Staın	4,39	3,46	0,0020	6
Empty Iro Error	3,66	2,88	0,0016	6
Color Dıfference	6,47	1,72	0,0010	6
Longıtudınal Lınes	5,35	4,21	0,0024	6

Table 3. Error Severity Values

ERROR TYPE	SEVERITY
Number Of Hole	7
Fly	8
Broken Needle	8
Lycra Eccentrıc	8
Traces Of Platın	7
Transverse Band	7
Lycra Cut	8
Oıl Staın	6
Empty Iro Error	8
Color Dıfference	7
Longıtudınal Lınes	7

Table 4. Detectability of Error Type Values

ERROR TYPE	DETECTABILITY
Number Of Hole	3
Fly	3
Broken Needle	2
Lycra Eccentrıc	2
Traces Of Platın	3
Transverse Band	3
Lycra Cut	2
Oıl Staın	3
Empty Iro Error	3
Color Dıfference	2
Longıtudınal Lınes	2

3.2. Identifying of Risk Priority Number (RPN)

As we mentioned before, RPN can be calculated by multiplying S (severity), O (occurrence) and D (detectability) for each type of error. Based on the value of PRN, we can decide to start working on which type of error for improvement. Figure 1 depicts the distribution of error values of RPN.

The types of errors are usually caused by a lack of training of personnel were encountered in business. The training should be about planning of work time, place and business plan. Worker should be understand tha aim and do it carefully. Business manager must be make a point of training for that situation. Companies engaged in training activities as required for certification of quality assurance systems and quality assurance. However, after receiving this document, many businesses have failed to continue training activities. continuity of approach of quality production can be achieved with but the continuity of training activities. Failure to precise settings of looms can be defined as the cause of an error. To obtain the required characteristics of the production is possible by made a complete and precision looms settings. The operator, who make loom setting, must be educated and experienced. These improvement activities have to be mind in for zero-defect production, elimination of errors that were encountered and customer satisfaction.

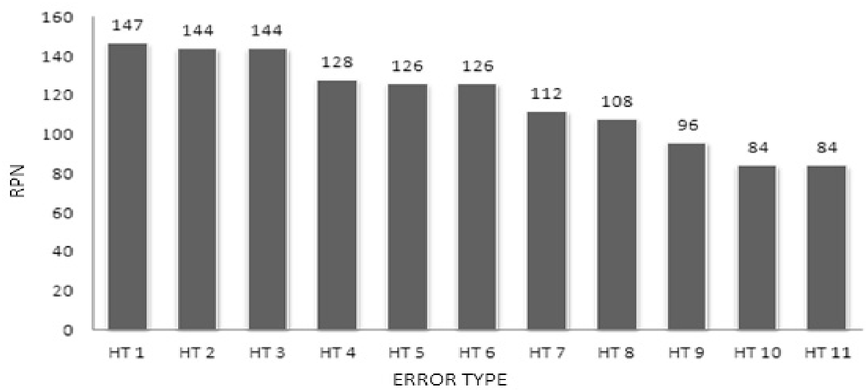

Figure 1. The Distribution of Error Values of Risk Priority Number (RPN)

4. CONCLUSION

Traces of platin, fly, broken needle, lycra eccentric, number of hole**,** transverse band, and lycra cut are determined as the most critical errors. Calculating of RPN has indicated the necessity of applying corrective and preventive actions for each type of error. Most critical errors have been occurred by knitting machines. Although some errors are due to workers, the main reason of errors are depend on making the necessary settings of equipment incompletly and hasty.

Workers' education and improvment of working conditions must be considered, and skilled workers should be introduced to other workers as examples. Different types of training should be given to workers to troubleshoot errors. Moreover, maintenance and settings up of the machines and soft wares should be reviewed. After making discussion for eliminating errors primirally, we should control deformation of needle surface. Especially HT1 and HT3 errors occur because of needle and machine. Clean machine and area are too important factor for decreasing fly amount. Inaddition, working time should be reorganized, and number of break time should be increased, so lack of attention due to fatigue can be eliminated in this way.

RPN should be push down to have zero defect by reducing occurence probability.

Widely usage of that analysis in sector should be increases customer satisfaction due to increasing of quality, reliability and competitiveness. For this reason representatives of the sector should be informed.

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