yönetim ve ekonomi araştırmaları dergisi
journal of management and economics research

Cilt/Volume: 16 Sayı/Issue: 2 Haziran/June 2018 ss./pp. 162-178
M.T. Bilişik Doi: http://dx.doi.org/10.11611/yead.398967

FAILURE MODE AND EFFECT ANALYSIS AND IMPLEMENTATION IN A TEXTILE FACTORY

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ABSTRACT

Quality concept has been keeping on its importance by assimilating and developing the customer service orientation. The companies which satisfy customer requests properly and reasonably get more powerful relationship compared with competitors. So, the companies have to provide the best services that customers deserve. With that study which performed in a textile plant, risk priority numbers before and after the improvement is calculated for faults met and for faults which may appear later. To apply Failure Mode and Affect Analysis (FMEA), firstly, a decision team has been established to determine the causes of faults. And then FMEA has been performed to prioritize the critical potential failure modes of the process. Finally, after improvement, some recommended actions regarding the findings were discussed.

Keywords: *Failure Mode and Effect Analysis, Risk Priority Number, Textile*

JEL Codes: *L15, L67, O32*

HATA TÜRÜ VE ETKİLERİ ANALİZİ VE TEKSTİL SEKTÖRÜNDE BİR UYGULAMA

ÖZ

Kalite kavramı müşteri hizmetini özümsemeyi ve odaklanmayı dayalı olarak önemini sürdürmektedir. Müşteri ihtiyaçlarını tutarlı ve makul şekilde karşılayabilen işletmeler, rakiplerine göre müşterileriyle daha güçlü ilişkiler geliştirmektedir. Bu nedenle, işletmeler müşterilerin hak ettiği en iyi hizmeti sunmalıdır. Bir tekstil fabrikasında gerçekleştirilen bu çalışmada, yapılmış olan bir iyileştirme çalışmasından önceki ve iyileştirme çalışmasından sonraki saptanan ve karşılaşabilecek hataları ölçen risk öncelik sayıları hesaplanmıştır. Hata türü ve etkileri analizi uygulamasında, hata nedenlerini araştırmak üzere bir karar takımı oluşturulmuştur. Ardından, hata türü ve etkileri analizi uygulanmış olup süreçte meydana gelen kritik potansiyel hata türleri önceliklendirilmiştir. Son olarak, iyileştirme ardından, bulgulara ilişkin öneriler tartışılmıştır..

Anahtar Kelimeler: *Hata Türü ve Etkileri Analizi, Risk Öncelik Sayısı, Tekstil.*

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JEL Sınıflandırması: *L15, L67, O32*

1. 1. INTRODUCTION

Quality concept imprtance is getting appreciated day by day which become compulsory. As the customers identify the quality issue, the customer satisfaction should be maximized. So, to accomplish the objective, we have to provide service faultlessly and reliably.

FMEA determines the risks which cause failure, also array the reason and effects of these failures by proper improvement techniques. Moreover, in order to minimize failures and prevent faulty items on the further processes, related optimization techniques may be used.

The goal of any FMEA study is to identify what might go wrong before an error is actually made, whether that is an error in design or in realization of the design. Thus, a systematic approach is used to assess these potential errors in order to quantitatively prioritize risk (Anleitner,2010). FMEA, requirements on quality assurance, techniques for solving problems, chairmanship of meetings, and auditor training(Müller, 1995). Whereas, failure modes and effects analysis (FMEA) is amethod utilized in order to determine and classify failure types with respect to product development, service, system and improvement of the processes (Eleren, 2007).

Failure mode and effect analysis (FMEA) is an important method for designing and prioritising preventive maintenance activities and is often used as the basis for preventive maintenance planning. (Braaksma et al. 1055–1071)

Preventing process and product problems before they occur is the purpose of Failure Mode and Effect Analysis (FMEA). Used in both the design and manufacturing processes, they substantially reduce costs by identifying product and process improvements early in the develop process when changes are relatively easy and inexpensive to make. The result is a more robust process because the need for after-the-fact corrective action and late change crises are reduced or eliminated (Raymond 2008).

There are many studies to be found in the literature regarding FMEA. FMEA flight control system came into use flight control system development in USA at teh beginning of 1950 which kept using on aerospace industry regularly after 1960. In case of civillian use, Ford developed for automative industry firstly and after 1972, FMEA worked out for Ford. (Akın, 1998:12).

In 1993, Automative Industry Action Group (AIAG) and American Society for Quality Control (ASQC) created FMEA standardization for industry. That standart FMEA were accepted by Chrysler, Ford ve General Motors which made a corparation for developing of QS 9000. Recently, many industries carry on formal FMEA standards and also FMEA, QS 9000, ISO / TS 16949, ISO 9001:2000 and other quality management systems have become a necessity today. Upon reviewing

literature, FMEA technique can be used in several studies carried out within the scope of different disciplines until today. Today it is also used in different industries widely.

The goals of FMEA are as follows: (Ozyazgan, 2014)

• 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

The benefits of FMEA are as follows: (Yılmaz, 2000);

- Assisting to error reduce and investigating faults in this way,
- Increasing of customer satisfaction
- It is describe to missing points of production safety, production technology safety
- Cost reduced by preventing mistakes.
- Decreasing of marketing time.

FMEA needs detailed information for each phase/component of the system, thus making possible to analyze the modalities in which each phase/component can fail. The required information is not always readily available.

Types of Failure Mode and Effect Analysis;

FMEA method is basically handled in four ways; (Raymond, 2008)

Product FMEA: Product FMEAs can be conducted at each phase in the design process (preliminary design, prototype, or final design), or they can be used on products that are already in production.

Design FMEA: The objective for a design FMEA is to uncover problems with the product that will result in safety hazards, product malfunctions, or a shortened product life. The key question asked in design FMEAs is: How can the product fail?

Process FMEA: Process FMEAs uncover process problems related to the manufacture of the product. It is helpful when conducting a process FMEA to think in terms of the five elements of a process: people, materials, equipment, methods, and environment.

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

2. APPLICATION STEPS OF FAILURE MODE AND EFFECT ANALYSIS

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.

Implementation phases of FMEA technique are as follows:

- Setting of FMEA team and detecting process or processes to be analyzed as below list;
- Identifying failure modes
- Identifying potential effect or effects of the failure
- Identifying causes of failures
- Identifying failure severity
- Identifying failure cccurrence
- Identifying detectability condition of failures
- Calculating Risk Priority Numbers (RPN)
- Making proposals thereby paying attention to values calculated
- Carrying out regulatory or preventive applications
- Comparing RPN numbers with priorities after improvement

The risk of possible failures is assessed using the risk priority number (RPN), which is calculated on the basis of assessment of failure severity, probability of occurrence and probability of detection. (Vykydal, 2015)

RPN = Occurrence × Severity × Detection

This is the way the product of these three values RPN (Risk Priority Number) is obtained (Roszak et al. 449-451).

Severity is the value of item by customer side after error occured (Yakıt, 2011). The second criterion involves potential technical causes used to estimate the probability of impact risk occurrence (O). Finally, one can estimate the possibility of influence of the causes and the related risk. For the criteria used to evaluate the importance of environmental impact (S), the probability of cause occurrence (O) and for the causes of influence (D), like in the quality area, values in the range of 1 (small risk) to 10 (high risk) are assigned.

In case of occurrence, 1 is remote probability of occurrence. If the prosess under control seen as low probability of occurrence as statistically, it is numbered between 2-5. If the problem is moderate,

but process is under control, this is 6. If the problem frequency is high, this is numbered as 7-8. In case of very high probability of occurrence, it is 9-10.(Sabır and Bebekli,2015)

According to the Ford Motor company ranges of values specified for the decision-making: (Bertsche, 2008)

• RPN <40 is no need to take measures

• 40 ≤ RPN ≤ 100 is worth taking the precaution

• RPN > 100 should take precautions if necessary

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

After theresults have been recorded, it is time to confirm, evaluate, and measure the success or failure.

This evaluation takes the form of three basic questions (Stamatis, 2003)

• Is the situation better than before?

• Is the situation worse than before?

• Is the situation the same as before?

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. (Ozyazgan, 2014)

Success of FMEA belongs to make right availeble and potential error determination, and action plan to this errors. So FMEA have to accepted by all company workers.

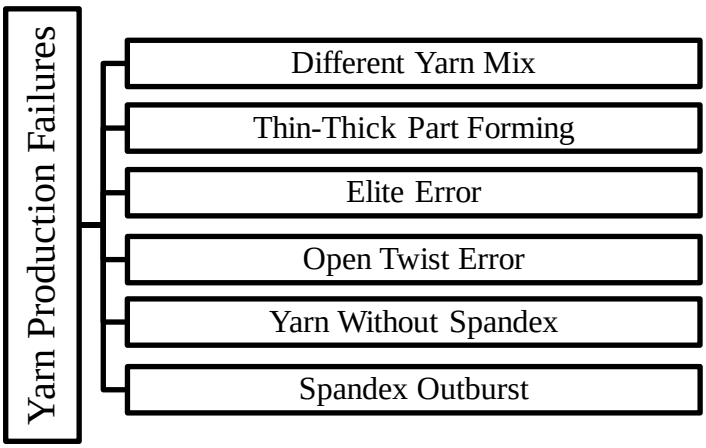
3. IMPLEMENTATION

Implementation technique phases of FMEA indicated are performed in a textile company for each part of factor which are yarn production, weaving and dyehouse in a row during 10 month. First of all, FMEA team was formed from production managers, production engineers, maintenence chiefs. This team has determined the potential failures, effects, and causes of the failures trough brainstorming and using cause-and effect diagrams. When we score the rating of severity, occurrence, detection to reach RPN value, we consulted to customer feedbacks, quality control sheets, our observations and experience of FMEA team. Determined all datas were recorded and created RPN table. The causes with higher RPNs were considered as the more important causes, which would be selected and solved further.

3.1. Yarn Production Part

In this study, we described 6 available and potential error with FMEA team in yarn production part.

Figure 1. Error Types For Yarn Production Failures



Regarding described error in yarn production part, as firts step,we determined the effects of the failures and causes of failures with FMEA Team. Hereby, we reached First RPN Value.

After our actions with FMEA team to errors, we got Final RPV Value for each fault which showed below Table1.

Table 1. Yarn Production Part Fmea Application

	Function Mode	**Failure Modes**	**Effects of the failure**	**Causes of Failures**	**First RPN Value**	**Recommended Activity**	**Undertaken Activity**	**Final RPN Value**
1	Yarn Production	Different yarn mix	faulty fabric production by using different yarn bobbin	Stocking of same color-different bobbin together in same place	160	Stocking of different yarn bobbin on different places	Different yarn bobbins are stocked different places and all lines are marked	120

2	Yarn Production	Thin-Thick Yarn Forming	Not able to produce homogen thickness yarn on production which will effect quality of fabric	Dirtness of some aparatus related with yarn machine or defect of machine aparatus	120	Increasing of peer-reviewed control of related aparatus and bobbin	No of peer-reviewed control of related machine aparatus and bobbin control is increased	72
3	Yarn Production	Elite Error	Occuring of Neps unevenness on the yarn	Mechanical instability of twisting machine aparatus cause this	84	İncreasing of twisting aparatus changing peirod	twisting aparatus changing peirod have been increased	63
4	Yarn Production	Open Twist Error	Not to reach required twist and getting loose yarn which effect quality of fabric	Abnormal working condions of belt system on ring machine cause this problem	128	Controlling period of belt system on ring machine which provide movement makes as weekly	Belt system control has been done as weekly	96
5	Yarn Production	Yarn Without Spandex	Not to get target yarn by breaking of spandex on connecting of spandex and rigid yarn	Damaging of spandex shift other carriers on machine which connnect spandex and rigid yarn break the spandex	90	Controling of spandex shift by operators periodically	Controling of spandex shift by operators has been done as daily	72
6	Yarn Production	Spandex Outburst	visibility of spandex after fabric production because of uncentering spandex on yarn production	Imperfection work of aparatus which makes the spandex centered in ridig item on yarn machine	72	İncreasing of control of aparatus which makes the spandex centered by operators	Controling of related aparatus is provided regularly by visual control	60

As we mentioned before, RPN can be calculated by multiplying S (severity), O (occurrence) and D (detectability) for each type of error.

At below table, fault possibilities, density values and detectability values of FMEA study for the relevant product were calculated.

Table 2. Yarn Production First And Final Rpn Comparison

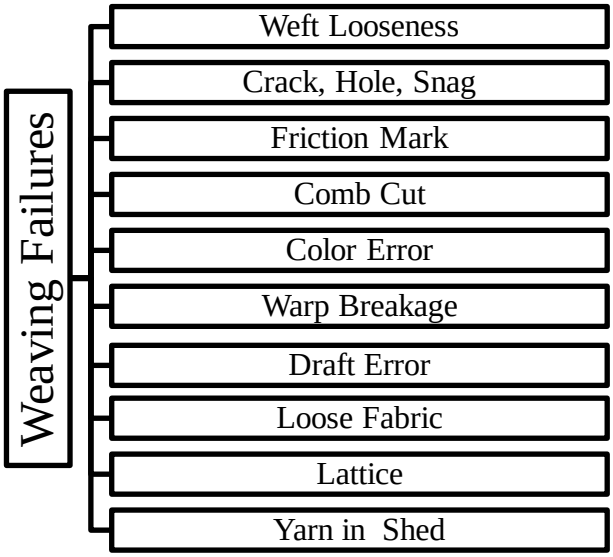
Function Mode Line	Severity	Occurrence	Detection	First RPN Value	Severity	Occurrence	Detection	Final RPN Value	RPN % Change
1	8	4	5	160	8	3	5	120	25
2	6	5	4	120	6	3	4	72	40
3	7	4	3	84	7	3	3	63	25
4	8	4	4	128	8	3	4	96	25
5	6	5	3	90	6	4	3	72	20
6	6	6	2	72	6	5	2	60	16

As we investigate causes of faults and undertaken activities, abnormal machine aparatus condition or insufficient control by operators are observed as source of main reason of errors in yarn production part. Periodic control of relevant aparatus and operators education was increased. With this study we get 25% quality progress in yarn production part.

3.2. Weaving Part

In weaving part, there are some preparation process before weaving which increased possibility of creating error. We have got 10 available and potential errors with FMEA team by using brainstorming.

Figure 2. Error Types For Weaving Failures



Based on described error in yarn production part, as firts step we determined effects of the failures and causes of failures with FMEA Team. Hereby, we reached First RPN Value.

After our actions with FMEA team to errors, we got Final RPV Value for each fault which showed at below table 3;

Table 3. Weaving Part Fmea Application

	Function Mode	**Failure Modes**	**Effects of the failure**	**Causes of Failures**	**First RPN Value**	**Recommended Activity**	**Undertaken Activity**	**Final RPN Value**
1	Weaving Part	Weft Loosenes s	Hole during weft wise because of lacking of weft yarn in shed	Machine instability, abnormal shed closure degree or low weft yarn strength	180	Increase the controling of related machine aparatus and weft yarn strength	weft yarn strength and the controling of related machine aparatus are provided	120
2	Weaving Part	Crack, Hole, Snag	Damaged part formation on surface of fabric	Some mechanical breakdowns, Bad transfering of fabric roll, or foreign body	108	To educate the operators regarding fabric roll transfering and not use sharp	Operators are educated regarding fabric roll transfering snd using of	72

				damage the fabric		and small items by the machine	sharp and small items are banned by the machine	
3	Weaving Part	Friction mark	Some continuous lines like shining or tone through the warp wise on fabric	Unbalanced operation of weft yarn carrier, inadequate shed or some burrs on moving parts	100	Making of mechanical control of moving parts and checking of surface of aparatus regularly	Controls of moving parts and surface of item are provided	75
4	Weaving Part	Comb Cut	Cutting of weft yarn within shed	Damaged comb, high warp tension or high weft density	112	Increase the controling of related machine aparatus and warp tension control for evey yarn on beam	Aparatus control and warp tension control for evey yarn on beam are done and	56
5	Weaving Part	Color Error	Deviation on fabric due to wrong pattern repeat of warp yarn	When the breakage happen on the machine, operators tie the wrong warp yarn or draft fault	216	To provide the pattern control after yarn cut and loading the machine new yarn on beam	Operators are educated regarding pattern control.	108
6	Weaving Part	warp breakage	Weaving disorder becasue of non fall of drop wire and making hole on fabric surface	Non fall of drop wire or non drop wire on draft process	147	To educate the operators regarding optimum fabric surface	Operators are educated to check fabric structure ever so often	105
7	Weaving Part	Draft Error	Error on fabric surface through the	Drafting error on draft machine when the loading	144	Beginning of weaving after loading full yarn	Checking of original fabric and fabric on	108

			warp wise because of draft fault	time of yarn on beam		on beam, to compare original fabric and fabric on the machine	the machine are provided	
8	Weaving Part	Loose fabric	Variation of weft density because of İrregular working condition of Warp let-off motion	Disproportion of Warp let-off motion	80	To make periodic control to Warp let-off motion	Warp let-off motion peridic control is done	60
9	Weaving Part	Lattice	Because of low slashing level , broken warp yarn directly goes to weaving part instead of going insde of drop wire	Low slashing level cause higher friction which cause yarn breakages.	72	To check every slashing level before loading th weaving machine	Slashing level control are provided for evey yarn on beam.	54
10	Weaving Part	Yarn in Shed	Small weft yarn in shed	Weft yarn knife dull or abnormal shed closere degree.	96	To make more periodical for Weft yarn knife and shed closere degree.	Periodical control of Weft yarn knife and shed closere degree are provided	48

At below table, fault possibilities, density values and detectability values of FMEA study for the relevant product were calculated .

Table 4. Weaving Part First and Final RPN Comparison

Function Mode Line	Severity	Occurrence	Detection	First RPN Value	Severity	Occurrence	Detection	Final RPN Value	RPN % Change
1	6	6	5	180	6	4	5	120	33
2	9	3	4	108	9	2	4	72	33
3	5	4	5	100	5	3	5	75	25
4	7	4	4	112	7	2	4	56	50
5	6	6	6	216	6	3	6	108	50
6	7	7	3	147	7	5	3	105	29
7	6	4	6	144	6	3	6	108	25
8	4	4	5	80	4	3	5	60	25
9	3	4	6	72	3	3	6	54	25
10	4	4	6	96	4	2	6	48	50

As we investigate causes of faults and undertaken activities, undesirable machine aparatus works were seen because of insufficient maintenance. We focused on increasing mechanical control of machines and educations of maintenance team. So we reached the 34,5% success with undertaken activities that we have done.

3.3. Dyeing and Finishing Part

Dyehouse is the last department of production. In that plant, they apply both bobbin dying and fabric dying. Fabrics are dyed and colored based on customer request and send out after quality control. So, to get high quality goods as customers wish, we need the best finishing process. We found 8 available and potential error with FMEA team.

Figure 3. Error Types For Dyeing And Finishing Part

Based on described error in dyehouse, as firts step,we determined effects of the failures and causes of failures with FMEA Team. Hereby, we reached First RPN Value.

After our actions with FMEA team to errors, we got Final RPV Value for each fault which showed at below table;

Table 5. Dyeing And Finishing Part Fmea Application

	Function Mode	**Failure Modes**	**Effects of the failure**	**Causes of Failures**	**First RPN Value**	**Recommended Activity**	**Undertaken Activity**	**Final RPN Value**
1	Dyeing Process	Abrage	Stained or abnormal appearance on surface of fabric	Abnormal dyestuff dissolution or machine speed or undasirable temperature increase	175	Operator education regarding optimum dyeing conditions	Operators have been educated about optimum dyeing conditions	140
2	Dyeing Process	Upper bottom twistin g error	Uneven dyeing on bobbin dying process because of bobbin winding	Getting not to desired density bobbin winding because of machine adjustment	100	Checking bobbin regularly density of bobbin before bobbin dyeing and giving information to yarn production part	They checked the bobbin density more frequent and gave info to production	60

							side	
3	Dyeing Process	Upper bottom equipment error	On bobbin dyeing process, inhomogeneous bobbin dyeing by dyestuff	Changing dyestuff quantity which is passing through the bobbin because of dyestuff leakage on dyeing machine	120	To make periodical check some points which provide movement of dyestuff in machine	periodical check is provided	60
4	Dyeing Process	Fastness	Low fastness affect of dyetuff after dyeing process	insufficient dyeing temperature, not done right PH condition and suitable chemicals	210	To educate the operators regarding optimum dyeing conditions during dyeing operation	Operators are educated about dying prosess standats.	126
5	Dyeing Process	Dye trace	This is a unevenness effect such as stripre on surface of fabric after dyeing	Low-speed machine than optimum conditon or non- return of fabric in machine	147	To make more periodical check fpr some machine part which provide movemet to fabric	More periodical check is provided	105
6	Dyeing Process	felting	Undesirable furry surface on fabric after dyeing process	Higher dyeing period, overheating of fabric or Poorness of some chemicals	144	To educate the operators regarding optimum dyeing conditions during dyeing operation	Operators are educated about dying prosess standats.	96
7	Dyeing Process	dye stain	Stains on fabric because of low dissolution effect of some dyestuff	Poor cleaning of dyeing machine , Low dyestuff affinity to the fabric	125	To educate the operators regarding optimum machine cleaning and chosing suitable	optimum machine cleaning and chosing suitable	75

						dyestuff	dyestuff are provided	
8	Dyeing Process	uncolo ured yarn	Stripe issue on fabric because of undyed warp yarn	circulating pumps are on the blink	100	To make more periodical check to circulating pumps	Run properly of circulating pumps are provided	40

At below table, fault possibilities, density values and detectability values of FMEA study for the relevant product were calculated.

Table 6. Dyeing and Finishing Part First and Final RPN Comparison

Function Mode Line	**Severity**	**Occurrence**	**Detection**	**First RPN Value**	**Severity**	**Occurrence**	**Detection**	**Final RPN Value**	**RPN % Change**
1	7	5	5	175	7	4	5	140	20
2	5	5	4	100	5	3	4	60	40
3	5	6	4	120	5	3	4	60	50
4	7	5	6	210	7	3	6	126	40
5	7	7	3	147	7	5	3	105	29
6	6	6	4	144	6	4	4	96	33
7	5	5	5	125	5	3	5	75	40
8	5	4	4	100	5	2	4	40	60

4. FINDINGS AND CONCLUSION

When we investigate causes of faults and undertaken activities, lack of knowledge of workers and non standardisation proses are seen as main problem. We made a standard prosess especially for on dyeing diagram. So we have got 39% success in dyehouse.

As we check the source of problem of all departmant, we reach the insufficient working of some aparatus, careless working of operators as main cause. So, we determined periodic control to relevant machine and aparatus as 1 month and 3 month. Thereby, problems are be almost zeroized before taking place. In case of workers education, they organize meeting to self-improvement of them to get systematic approach for problem issue.

Objective for production 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 production, determining and application of control for preventing activities shall provide a range of benefits.

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