FMEA ANALYSIS AND IMPLEMENTATION IN A TEXTILE FACTORY PRODUCING WOVEN FABRIC

DOKUMA KUMAŞ ÜRETİMİ YAPAN BİR TEKSTİL FABRİKASINDA HTEA ANALİZİ VE UYGULAMASI

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ABSTRACT

Within the scope of this study, the failure possibilities, weight values and detectability values of failures occurring in a factory producing woven fabric were calculated by using Process FMEA. The fixing proposals were offered according to existing failure types. As a result of conducted searches, it was determined that the critical failures in company are weft runs, warp runs, basket, oil stain, slay, taras, leg failures, double weft and weft pile. Among these errors, those with high probability of error are warp breaks and double weft errors. Also it was determined that those failures are caused by weaving machine and personnel. Also it was determined that trained personnel and improved work conditions are critical factors in eliminating the failures.

Key Words: FMEA, Weaving failures, RPN, Problem fixing measures, Woven fabrics.

ÖZET

Bu çalışmada bir dokuma kumaş üretimi yapan tekstil işletmesinde karşılaşılan hataların Proses HTEA çalışması ile hata olasılıkları, şiddet değerleri ve keşfedilebilirdik değerleri hesaplanmıştır. Ortaya çıkan hata türlerine göre düzeltme önlemleri belirtilmiştir. Yapılan çalışmalar sonucunda işletmede karşılaşılan kritik hatalar, atkı kaçığı, çözgü kaçığı, sepet, yağ lekesi, tefe, taras, ayak kaçığı, çift atkı ve havlı atkı olduğu tespit edilmiştir. Bu hatalar arasında hata olasılıkları yüksek olanlar, çözgü kopuşları ve çift atkı hatalarıdır. Ayrıca bu hataların dokuma makinası ve personel kaynaklı olduğu belirlenmiştir. Ayrıca işçilerin eğitimi ve çalışma koşullarının iyileştirilmesi hataları önlemede kritik faktörler olarak belirlenmiştir.

Anahtar Kelimeler: HTEA, Dokuma hataları, RÖS, Düzeltme önlemleri, Dokuma kumaşlar.

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1. INTRODUCTION

As technologic improvements change day by day, the competition between production companies leads to necessity to conduct error-free production. Customers pay attention to obtaining the performance they expected from the product they bought. The seeking of qualified product became a priority of customers. Under such conditions, the efforts of producers to produce qualified products have increased. The high quality of product is not enough for clients. One of the characteristics being sought is the price of the product. In this point, there is a challenge standing in front of producers. It is to produce a qualified product with cheap price. It may be possible to solve this problem with using more than one solution method. One of those methods is Failure Mode and Effects Analysis (FMEA).

The aim of FMEA is to keep the customer satisfaction at highest point and to enhance the image of company at that point, to provide competitive superiority by minimizing the

costs from production failures and improving the production efficiency. The Failure Mode and Effects Analysis is a technique used for eliminating the release of unsuccessful products which may harm to company (1).

Failure mode and effects analysis is the most efficient method which can be used during system and product design, production process and maintenance activities, and it comes to the fore as the quality method which can provide maximum profit to companies if implemented appropriately. The main aim of implementation of method is to minimize the effect of failure, and consequently that of reason of failure (2). It reaches that goal by determining those elements (3):

- System or its components,
- Potential failure modes,
- The effects of potential failures,
- Severity values,

- The causes of potential failures,
- Frequency of failures,
- Design of corrective actions,
- Risk Priority Coefficient.

The terminology of FMEA in brief;

Client: They are the final person or interim departments where or whom the good or service reaches. As well as the client may be the final point where the final product reached, also it can be the middle points for semi-products. The point where the product exiting from company reaches in market is foreign customer. As that product moves from one to other department within that company, each of departments is the client of previous department. The client in this point is named internal client. Within FMEA study, the client is considered as people or departments being affected from any possible failure.

Function: They are the characteristics demanded from any product or process. As well as any possible failure may prevent the appropriate function of some properties of the product or process, it may lead to complete malfunction. The needs of customers cannot be satisfied at this point, and some problems occur in this point such as decrease in competitive power and profit losses.

Failure and Failure Mode: Failure is the inability of any problem or process to perform the expected function (4). Considering those functions, the failure modes can be determined by classifying the each of failures.

Failure cause: It is the factor causing the occurrence of failure. Multiple factors can lead to a failure. Basic (deepest) reasons should be investigated while evaluating the failure causes within the scope of FMEA study.

Effects of Failure: It is the stage where it was investigated that what will be the effects/results of failure on final product when failure modes are not prevented or eliminated. It is the determination of what the client will recognizes or which happens to client. The results of products with similar characteristics and previous failure modes must be taken into account while determining the effects (5).

Existing Controls: They are the procedures which are conducted in order to determine whether the functions of final or semi-product work appropriately or not. Those controls must be the efforts to detect or eliminate the failure occurrence formerly, not to detect the failure in final product.

FMEA Components: They are the elements, steps and data which will be investigated, implemented and evaluated within the scope of FMEA.

Severity: It is the value of effects of product on client after failure occurred (6). The severity can only be decreased through change in design. If the change can be provided, the elimination of failure can be possible (7).

Determination: It is the possibility to detect before failure occurs (8).

Occurrence: It is the frequency of occurrence of failure. It is the determination of failure occurrence interval as duration (7).

Risk Priority Coefficient: It is a measurement representing the risk value of the failure. It is used for ordering the corrective actions to be implemented (9). It is calculated by multiplying the severity, determination and occurrence values. The failures are queued from highest to lowest RPC values. The corrective-preventive action with highest RPC value is implemented first. RPC = Severity (S) × Determination (S) × Occurrence (O)

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 (10). 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 (11).

If two or more errors have the same value of RPN, firstly with high intensity and then with high deviation ones should be addressed (11).

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

Poly / cotton (50-50) tablecloths and poly / viscose (50-50) dress fabrics are used in this study.

Table 1. The technical data of the fabrics

The Type of Fabric	Yarn Number	Weft Density	Warp Density	Weight	Woven Type
Poly/Cotton (50-50) tablecloths fabric	30/1 Ne	18	28	195	Plain satin
Poly/Viscose(50-50) dress fabric	30/2 Ne	28	38	350	Dimity

2.2. Method

Identification of Fault Types

Faults Resulting from the Weaving Machine:

Temple Mark (DM1): Needles are found on the temples and these needles perforate the fabric and stretch it by shrinking it towards outer direction. If the needles of the temple do not rotate properly, they leave mark on the fabric. This is called as temple mark. In order to prevent such faults, needles on the temple should be adjusted appropriately so that they will shrink the fabric outward properly.

Foot Ladder (DM2): Feet connected to the frames need to form the knitting by moving upward and downward for the formation of the textile fabric. The feet may not move upward either due to the malfunctioning of magnets if the weaving machine is a dobby or the abrasion of the eccentrics if it is an eccentric machine. The fault resulting from this situation is called foot ladder or weft break. To prevent such faults, the maintenance of the eccentric or dobby should be performed frequently.

Stop Marks (DM3): When a loom stops and restarts due to any reason, beat-up or carding faults can occur as the loom gives the wrong apron. If the loom gives apron more than needed when it stops, carding fault can occur. However, if it gives apron less than needed, beat-up fault can occur. In order to prevent such faults, let-off settings should be made properly.

Shrunk Selvedge (DM4): It is the inward shrinkage occurring in one selvedge due to overextension of one weft or several wefts.

Baggy Selvedge (DM5): It refers to the bagginess occurring in the selvedges due to bagginess of selvedge warp threads or misfit between selvedge knitting and floor knitting.

Bowed Selvedge (DM7): It refers to bowing or folding of a selvedge on its outer surface due to faulty selvedge structure or faulty machine settings.

Thick Selvedge (DM8): It refers to the presence of a thicker thread bundle on the selvedge in comparison to the normal thickness.

Weft Pattern Fault (DM9): It is the fault resulting from making picks (weft insertion) at different colors and numbers from the weft color report.

Weaving Preparation Faults:

Interlacing Point (DH1): These are the points formed as warp and weft threads interlace through one another in various ways. These are the points where warp threads pass below or above the weft thread or weft threads move in the same way. If one or some of these interlacing points are skipped, a fault occurs.

Drawing-in, Pattern, Repeat Fault (DH2): According to the fabric to be woven, a drawing-in draft plan or color report is prepared. Accordingly, the machine is drawn in, pattern is entered in the machine according to the color report and draft report is entered in the loom. If the person or machine to perform drawing-in skips anything or makes a fault, the necessity of repeating the drawing-in may occur. Otherwise, the fabric will be faulty.

Sliver Marks (DH3): Longitudinal sliver marks are formed through the use of different lot threads at the phase of warp preparation. Besides, longitudinal sliver marks may occur due to deformity in the tension settings or maladjustment of the distance between the cables. Latitudinal sliver marks result from the difference of the weft thread lots that are used. Original threads should be used to prevent faults.

Reed Marks (DH4): These are the faults resulting from the maladjustment of the distance between two dents due to any harm given to the reed in use or any impurity in the reed.

Effect thread (DH5): It is the take-off fault occurring in the thread formation. Irregularity on the surface of the thread leads to a rough appearance after it is woven in the fabric.

Size Excess (DH6): It is the different appearance caused by the excessive amount of size found in the warp on the fabric surface.

Faults Related to the Warp

Warp Breaks (YYÇ1): They refer to the fault of forming a basket-like shape due to the break of one the threads entering into the knitting from the warp.

Mottled Warp Thread (YYÇ2): It refers to the dyeing difference seen in the warp due to the fault occurring during the dyeing of the warp thread or due to the difference of its ability to combine with the dyestuff in the fiber.

Loose Warp Thread (YYÇ3): One or several ends which are not adequately tight.

Tight Warp Thread (YYÇ4): One or several ends which are tighter than needed.

Dirty, Oiled Warp (YYÇ5): It refers to the dirt and oil stains on the warp thread.

Thin or Thick Warp (YYÇ6): Presence of a warp thread at a different thickness than normal in the fabric forms a pile on the fabric and especially after the finishing processes, this pile offends the eye.

Thread Irregularity in the Warp (YYÇ7): This is the fault resulting from the regularity difference in a warp thread or between warp threads (including twist)

Mixed Warp (YYÇ8): It refers to a situation where warp threads of different structure or color in terms of twist and thread number etc. are mixed with the wrap.

Foreign Fiber (Thread) in Warp (YYÇ9): It refers to the foreign fiber (thread) mixing with the warp thread during the thread formation or weaving.

Pile (YYÇ10): It refers to different color faults seen as slivers or routes along the warp due to the warp threads having difference in terms of receptivity for dyes or a highness of tightness in one part or frequency differences in the warp.

Hollow Wrap (YYÇ11): It is the fault caused by hollow ends during one or several weft threads due to the fall of one or several frames.

Double Wrap (YÇ12): It is the fault occurring when the end of a broken warp winds round the adjacent end and starts making the same movement with it before the loom could be stopped.

Selvedge Mark (YYÇ13): It refers to the mark caused by the bowing or folding in a selvedge on the other fabric layers at the end of winding.

Mesh (YYÇ14): It is the surface fault stemming from the lack of connection between one or several wrap threads and one or several weft threads.

Loose Frame (YYÇ15) : Frame cannot lift off and causes a fault in the form of knitting irregularity on the fabric.

Semi-Loose Frame (YYÇ16): Frame lifts off but immediately falls down while the shedding remains open.

Faults Related to Weft (YYA1):

Breaking of Weft Thread (YYA1): Bobbins coming from the spinnery as wound on a bobbin are put behind the weft motor in the loom and after it is principally wound on the weft motor, the thread is passed through the necessary parts and the machine is started. If there is anything to result in burr or snagging in the parts through which the thread passes, weft is broken and the machine stops.

Weft Deformity (Defect) (YYA2): It refers to the fault resulting from short and elliptical deformations seen in close wefts due to the tightness in the weft thread or the diffence in size take-up.

Weft Loop (Shantung, Bouclé) (YYA3): It refers to small loops that weft thread forms on its own surface due to excessive twist on the thread or the failure of the braking function.

Weft Skip (YYA4): It is the fault occurring when one or several weft threads skip over the warp thread without short or long connections across a space.

Weft Column (Weft Band) (YYA5): This is the fault which results from the differences related to twisting, number, blending, color within the weft thread or mild frequency difference at the weft and appears in the form of bands alongside the fabric width.

Thick – Thin Weft (YYA6): Presence of unusually thick and thin picks in the fabric.

Dirty – Oiled Weft (YYA7): Dirt and oil stains on the weft thread.

Stopped-up Weft (YYA8): This is the fault caused by a weft thread stopped up by a knot in the warp thread for a short interval.

Floating Weft Thread (YYA9) : It is the fault occurring when a clew enters into the shedding in the direction of the weft and is woven in the normal fabric texture.

Loose Weft Thread (YYA10): One or several weft threads which are not tight enough.

Tight Weft Thread (YYA11): One or several weft threads that are tighter than needed.

Weft Thread Irregularity (YYA12): It refers to the faults stemming from the irregularities in the weft thread.

Mixed Weft (YYA13): It refers to a fault where weft threads of different structure or color in terms of twist, thread number, layer and source etc. are mixed with the weft.

Shuttle Slap (YYA14): It refers to the fault occurring when shuttle breaks several wraps or wefts in the shuttle looms.

Semi-Broken Pick (YYA15): It occurs when weft thread becomes missing in some part of the fabric width as the weft thread breaks in the shedding.

Double Weft (YYA16): It occurs when double weft threads pass through the shedding.

Weft Interval (YYA17): As the weft thread cannot be inserted into the shedding properly, an interval occurred along the fabric width or in one part of the fabric.

Tight, Loose Weft (YYA18): It is the fault stemming from the weft frequency difference in the fabric. It appears as bands (slivers).

Unraveled Weft Mark (YYA19): It is the mark left by several weft threads that are unraveled and woven once more.

Crushed Weft Thread (YYA20): It refers to the marks of the weft threads crushed in the recess by the shuttle.

Foreign Fiber in Weft (YYA21): It refers to the foreign fiber mixing with the weft thread during the thread formation and weaving.

Double Wefts on the Selvedge (YYA22): It is the fault that occurs alongside a part of the fabric width when the additional weft thread found on the fabric selvedge is not cut and enters into the shedding together with the normal weft thread and thus,

Weft Aggregation (YYA23): It occurs when a thread bundle enters into the shedding in the direction of the weft and is woven within the normal fabric texture.

Weft Ladder (YYA24): It occurs when weft thread is shorter than the selvedge since the shuttle keeping the weft thread releases the weft early or selvedge device shuts down late.

Control Measures that are Applied

Fabric quality control is performed manually by the operators in this method. Operator carries out the quality control of the fabric on an illuminated board moving at a speed range between 8-20 meters in a minute; marks the location of the fault on the fabric by stopping the motor moving the fabric once a fault is detected and runs the motor once more. When the control of the whole fabric is completed, the fabric is classified by the number of faults per meter along the fabric. If the operator encounters with excessive faults of different types or numerous faults of the same type, the production department is warned to ensure that probable mistakes in the production are eliminated. Control results are found reliable in the large and obvious faults. However, while some small faults could not be noticed, occasionally large ones could also be overlooked during the control. The width of the fabric ranges between 1.60 and 2.00 in general. Therefore, it is rather difficult for a person to detect the faults on a fabric that has the above-mentioned width and moves at a speed of 10 m per minute. It is observed that enterprises pay importance to the control methods and processes are kept under control. Besides, it

is apparent that a higher level of sensitivity is shown to such issues when it is understood that loosening control methods will give harm to the enterprise.

3. RESULTS AND DISCUSSION

3.1. Implementation of the Scoring System

In the subsequent steps, fault possibilities, density values and detectability values of Proses HTEA study for the relevant product were calculated.

Table 2. Degrees of fault probability and probability values

FAULT TYPE	NUMBER OF DEFECTİVE (METRE)	SHARE IN TOTAL FAULT %	SHARE IN TOTAL PRODUCTION %	DEGREES
FOREIGN FİBER IN WEFT	312,9	0,1	0,00005	6
WEFT LADDER	68,84	0,022	0,00001	6
WARP BREAKS	1032,6	0,33	0,00017	9
MESH	1001	0,32	0,00017	6
OIL STAINS	147,1	0,047	0,00002	6
REED MARKS	137,7	0,044	0,00002	7
FOOT LADDER	165,84	0,053	0,00003	6
WEFT LADDER	112,6	0,036	0,00002	7
DOUBLE WEFT	93,87	0,03	0,00002	9

Table 3. Fault severity values

FAULT TYPE	SEVERITY
Weft Ladder	6
Warp Breaks	9
Mesh	6
Oil Stains	6
Weft Ladder	7
Foreign Fiber in Weft	6
Foot Ladder	6
Reeds Marks	7
Double Weft	9

3.2. The Possibility of Detecting the Fault

Production information and possibility values are shown in the following table according to the factory data.

Table 4. Detectability of Fault Type Values

FAULT TYPE	DETECTABILITY
Weft Ladder	3
Warp Breaks	2
Mesh	2
Oil Stains	3
Foreign Fiber in Weft	2
Foot Ladder	2
Double Weft	3
Reeds Marks	2

3.3. Identifying of Risk Priority Number (RPN)

Table 5. RPN Values

FAULT TYPE	OCCURRENCE (O)	SEVERITY (S)	DETECTABILITY (D)	RPN VALUES
Foreign Fiber in Weft	6	6	2	72
Weft Ladder	6	6	3	108
Warp Breaks	9	9	2	162
Mesh	6	6	2	72
Oil Stains	6	6	3	108
Reed Marks	7	7	2	98
Foot Ladder	6	6	2	72
Double Weft	9	9	3	243

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.

This types of errors are usually caused by the lack of training of personnel. The training should be about the planning of work time, place and business plan. Worker should understand the aim and follow it carefully. Business manager must make a point of training for that situation.

Companies engaged in training activities are required to get 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 the continuity of training activities. Failure to precise settings of looms can be defined as the cause of an error. Obtaining the required characteristics of the production is possible by making a complete and precise looms settings. The operator, who make loom setting, must

be educated and experienced. These improvement activities have to be mined in for zero-defect production, elimination of errors that were encountered and customer satisfaction.

4. CONCLUSION

Optimizing costs by maximizing the customer satisfaction constitutes the basic principle of creating quality. It is sufficient to produce faultless and complete product and offering it to the clients, the expectations of customers should also be met. The most important point for HTEA study is to ensure that the executives to lead the implementation process provide full support for the project to be implemented. Besides, systematic conduct of the project constitutes another important point. Pre-determination of the steps and setting a specific time for each step are advantageous both in terms of the follow-up of the project and finishing the study at the specified period. While the implementation team is selected, the individuals interested in the issue should be selected. If these individuals are selected out of employees working in different steps of this process, development of new views with different perspectives will be possible in the team. A successful HTEA study will only be possible when all the people included in the process support the study in addition to the HTEA team.

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