



Quality Oriented Process Development in Manufacturing Sector: An Application in Textile Firm

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Abstract

One of the most important problem in the business within the scope of manufacturing and services is the sustainability factor of production quality and quality of obtaining the quality norms in produced products.

This factor directs (impels) a strategy which will create competition(rivalry). Quality-oriented process development provides advantages, outmaneuver in the competition, rivalry scope. Determination of errors and error types are in the scope of the risk analysis. Statistical methods, qualitative and quantitative methods which are based on mathematical and simulation are used and implemented in the Risk analysis process. Prioritization of actions is important towards the improvement of the process. The purpose of this study is to detect errors of negatively affect production in a textile company , to define, decrease the effects of negative factors and it involves which ranked according to their primary factor levels with the calculation of risk priority numbers(RPN) and using RPN(them). According to the ranking the RPNs, FMEA(Failure Mode and Effect Analysis) application in applied and implemented to reduce the risks and finally achieved the results of applications.

Keywords: FMEA(Failure Mode and Effect Analysis), Quality, Process Development, Risk Priority Number(RPN).

Introduction

Failure Modes Effects analysis (FMEA) is a quality control technique which is used during the improvement of new products and processes to identify, define, control and eliminate the causes of failure, while reducing the effects of faults or error conditions that could increase. FMEA is a reliability tool, which requires identifying failure modes of a specific product or system, their frequency and potential causes[1]. This is an engineering technique is prevention tool and an important document between experience concerns and quality performance criteria and factors.

The QS 9000 FMEA defines FMEA as a group of activities aimed at recognizing and improving the potential failure of a product/process and its effects, identifying actions that may remove or reduce the potential failure mode occurring [9].

Slack et al., argued that FMEA is an analytical technique through which all possible “potential failure” modes, the effects that will occur if the failure actually happens and all the causes which can bring about the failure are determined [11,19, 20].

Paparella defines that FMEA is a useful tool for risk assesment, identification and error prevention. RPNs(Risk priority numbers) in FMEA methodology can be used as risk factors for errors because these faults cause vitally factors for risk assessment, such as the probability of errors, probabiliy effects, and the detection of faults. In literature review, Sinha et al. (2004) used FMEA as a means to access the criticality of risk factors within the aeroplane manufacturing supply chain. Kumar et al. (2009) defined FMEA applications to sum up the risk of each steps in reverse logistics activities within the pharmaceutical industry. Van Leeuwen et al. (2009) considered that FMEA to identify the rankings of the risk in analytical screening of drugs, while Chiozza and Pozzenti (2009) focused on the key points from applying FMEA in the medicinal sectors. Chuang (2010) analysed and detected the impact of requiriements to extend his work to quantify the impact of intangible faults effects, such as customer complaints and loss of market share[7];[13-18].

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Value Analysis

Value analysis or total value analysis is defined as value engineering and it is used a tool and identified as systematic approach to acquire the requirement functions, factors for the lowest cost considering with quality, reliability and performance criteria. Value analysis is very significant and focus on scientific method to develop the product or service from the customer's review, ideas depending the product's cost to provide the desired factors or criteria for the cost of resources.

The flow chart for the planned process on the affected systems and sub-components is shown in Fig. 1,2,3. According to the chart, design verifications of all affected systems and sub components will be observed in detail to understand if there were any other design and process changes that may have intended the problems and faults.

On the other hand, as well as communicating with as many customers as much as possible in order to understand the process of the cotton cloth and trying to understand whether the source of the problem is unique to some enviromental factors, employee situations or climates.

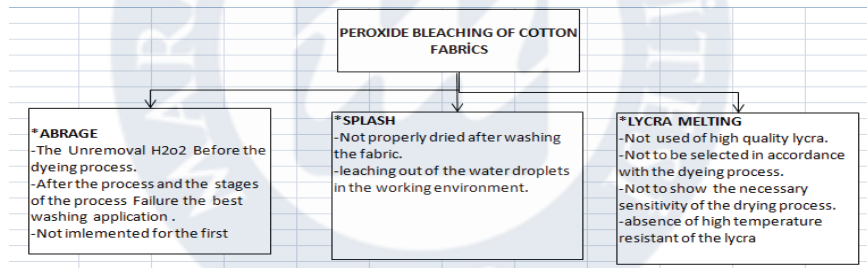


Figure 1. Basic Reasons of Peroxide beleaching of Cotton Fabrics

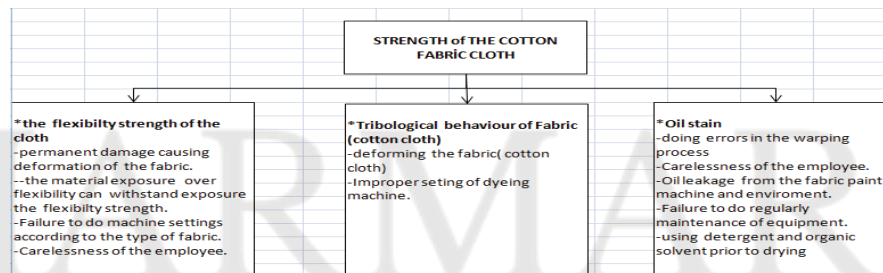


Figure 2. Basic Reasons of Strength of the Cotton Fabric

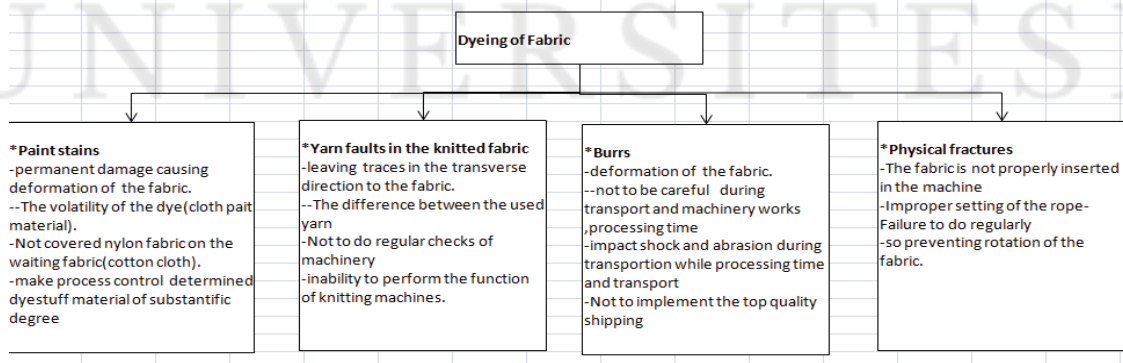


Figure 3. Basic Reasons of Dyeing of Fabric(Cotton Cloth)

All systems and components, as well as the quality of design and production processes, are shown within the fish bone diagram given in Fig. 4. The details of the tests performed on the systems and sub-components are summarized. In the fishbone diagram the most important item is the process component of the cotton cloth and fabric painting system. Therefore, the process was absolutely examined.

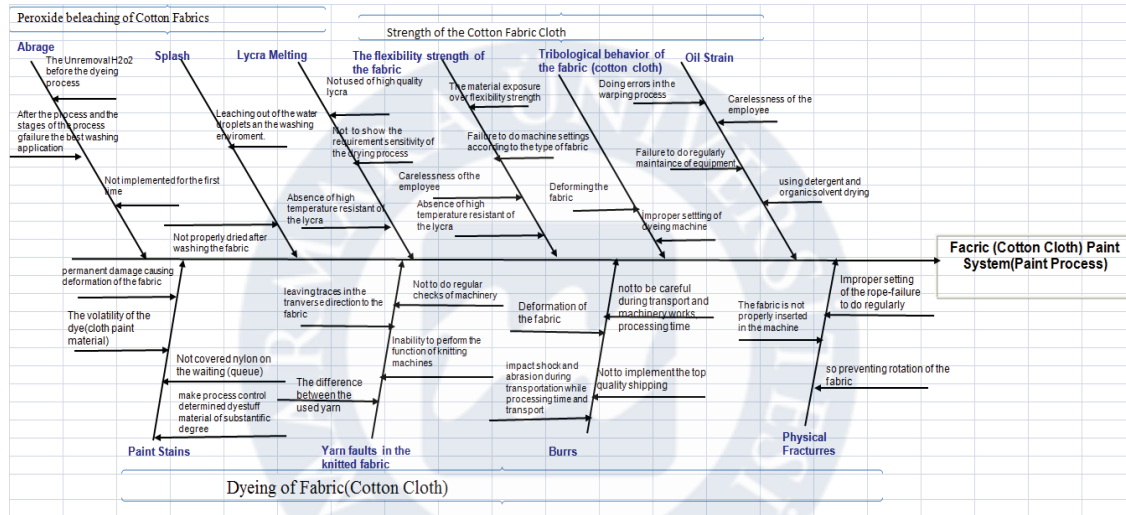


Figure 4. Fishbone Diagram to Detect the Reasons (Errors) for Fabric Cloth Paint

FAILURE MODES AND EFFECTS ANALYSIS

FMEA technique is important to try to improve the above defined compliance at each stage of the Project after completion of these controls and relevant failure mode effect analysis (FMEA), even this may be necessary in this regard for the sake of quick progress of the Project. FMEA risk analysis method is utilized for detecting the failures or defects in the implemented projects before they turn into a hazardous state, and to identify and control the priorities in remedying the failure problems and to eliminate the potential failures and risks before they happen [1, 2, 5, 14].

FMEA enables us to detect and evaluate the hazards and accidents in advance. Despite, Failure Mode Effect Analysis (FMEA) has a wide range of usage field, it is also a strong analysis technique toward preventing the failures by estimating the relevant risks [3, 6, 14, 23].

The advantages of the fmea are given like that it is to improve the quality, reliability, and safety of the product or project, to enhance the customer satisfaction, to reduce the product or project development period and cost, to ascertain the priorities in design or process development activities, to discover the whole potential failures modes, their effects and similarities for all products/processes, to assist in analysis of the design requirements and design alternatives, to assist in definition of potential, critical and important characteristics, to assist in analysis of new production or project stages, to maintain an important media for failure prevention, to enable the definition of corrective & preventive actions and to certify and monitor the risk reducing activities.

This technique can both be utilized during the design review stages of the project and in implementation and installation stage. However it is more suitable to use the technique in design review stages. This technique can both be utilized during the design review stages of the project and in implementation and installation stage. However it is more appropriate to use the technique in design review stages [12].

In the Failure Mode Effect Analysis (FMEA) study, estimations of probability, severity and detectability are used for all defined potential failures and defects. At the end of these estimations, relevant solutions are searched by giving priority to the relatively bigger risks.



Failure Mode Effect Analysis (FMEA) Elements and Calculation Method

In FMEA studies, a suitable work team has to be assigned in accordance with the selected Project. Because, the definition of the problems and risk priority values in the studied project requires qualified personal as well as knowledge and experience. At the same time, the work team has to be consisted of selected personal of having different job profiles and from different departments.

The aim of FMEA is to sort the failure modes in order of importance, three indexes are defined for each failure mode: the occurrence rating (O), the severity rating (S), and the detectability rating (D). A ten-point scale is used to score each category, ten being the number indicating the most severe, most frequent and least detectable failure mode, respectively[8].

The priority of a failure mode is determined through the risk priority number(RPN), which is defined as the product of the occurrence(O), severity(S) and detection(D) of the failure, Those potential causes, with high RPN values, are selected for the corrective action to reduce the risk of failure occurrence. Attention is also given to those parts of a system, where failure would produce adverse customer reaction and loss of company image. Risk priority levels (RPL) for FMEA; is calculated by multiplying the Occurrence (O), Severity (A), and Detectability (S) levels [6, 21, 24].

$$\text{RPN} = \text{O (Occurrence)} * \text{A (Severity)} * \text{S (Detectability)} \quad (1)$$

Severity(S): Importance of the effect on customer requirements Often can't do anything about this without fundamentally changing the system or design.

Occurrence(O): Frequency with which a given cause occurs and creates failure modes (or probability it will occur)

Detection(D): The ability of the current monitoring and control method to detect before or after occurrence of a given cause

The three factors O, S and D are all estimated using the rankings or scores from 1 to 10, as described in Tables 1–3. The failures with higher RPNs are presumed to be more important, vital and must be given higher priorities. FMEA has been proven to be one of the most important early preventative initiatives during the design stage of a system, product, process or service. However, the RPN has been extensively picked apart for various reasons [4,5,7–11]:

When the above mentioned three risk factor elements are assessed altogether, it represents the risk priority level (RPL) for each failure-defect type. And this value defines the numerical level of critical risk [14, 21].

The RPN must be calculated for each cause of failure. RPN shows the relative likelihood of a failure mode, in that the higher the number, the higher the failure mode. From the RPN, a critical summary can be drawn up to highlight the areas where action is mostly needed. Regardless of the resultant RPN, special attention must be given to any cause of failure with a severity rating of “9” or “10” [22].

After calculation of RPN, the company should ensure that the main hazards are removed from the specification by re-engineering. The three remedies in order of desirability, include[16, 17]:

- (1) To eliminate the problem altogether through a design change;
- (2) to reduce the probability that the failure would occur; and
- (3) to improve the chances of detection through improved quality control.

Finally, following the improvement actions, re-evaluation of severity, occurrence and detection must be carried out, and a new RPN should be calculated. The higher the RPN, the higher the chance that the mode will fail, and subsequently, this mode demands higher priority for corrective action [4,10].

Risk priority levels or numbers (RPL), provides the definition of failures to be given priority in failure improvement studies by making priority rating. Risk priority levels (RPL), while enabling the priority rating of failures, on the other hand it provides a useful guidance to the relevant people who take part in the post assessment FMEA analysis, RPL values improvement studies.



Table 1. System FMEA Severity Rating [6,20]

System FMEA Severity Rating		
Effect	SEVERITY of Effect	Ranking
Hazardous without warning	Very high severity ranking when a potential failure mode affects safe system operation without warning	10
Hazardous with warning	Very high severity ranking when a potential failure mode affects safe system operation with warning	9
Very High	System inoperable with destructive failure without compromising safety	8
High	System inoperable with equipment damage	7
Moderate	System inoperable with minor damage	6
Low	System inoperable without damage	5
Very Low	System operable with significant degradation of performance	4
Minor	System operable with some degradation of performance	3
Very Minor	System operable with minimal interference	2
None	No effect	1

Table 2. General Severity Ranking Table [6,20]

General SEVERITY RANKING TABLE		
Rank	Category	External and Internal Effect
10	Liability	Failure will affect safety or compliance to law
9	Reliability / Reputation at risk	Catastrophic customer impact
		Moderate to major reliability failures
		End user recalls
		Premature end-of-life (wear out)
8	Customer quality inconveniences	Increased early life failures
		Intermittent functionality
		Major customer impact
		Minor reliability failures
7	Internal yield or special handling required	Customer line impact / lines down
		Impacts the yield of customer
		Wrong package / part / marking
		Products performing marginally
6	Unnoticed	Involved customer's special handling
		Damaged the customer's equipment
		Product assembly error
		Equipment cross contamination
5	Unnoticed	Damaged to down stream equipment
		Major yield hit
		Significant line yield loss
		Minor yield hit
4	Unnoticed	Low line yield loss
		Special internal handling, effort or annoyance
		Unnoticed either internally or externally
3	Unnoticed	
2	Unnoticed	
1	Unnoticed	

Table 3. Probability of Failure [6,20]

PROBABILITY of Failure	Failure Prob	Ranking
Very High: Failure is almost inevitable	>1 in 2	10
	1 in 3	9
High: Repeated failures	1 in 8	8
	1 in 20	7
Moderate: Occasional failures	1 in 80	6
	1 in 400	5
	1 in 2,000	4
Low: Relatively few failures	1 in 15,000	3
	1 in 150,000	2
Remote: Failure is unlikely	<3.4 in 1,000,000	1

These analysis and controls enables healthy progress of the implemented textile firm for quality oriented process development in this study. In Table 6 the encountered potential risks in the Cotton Cloth (Fabric) definition works is given with the aid of failure mode effect analysis (FMEA) method and risk priority calculation values is ascertained on the basis of previous experience. In this table, there have been considered 15 main aspects to be subjected to the control and may cause risk factor during the route selection definition projects. Among these 10 potential failure and risk modes, 4 of them considered as high risk and remaining 8 of them medium level risk as per the calculated risk priority values.



Table 4. Detection by Design Control

Detection	Likelihood of DETECTION by Design Control	Ranking
Cannot Detect	Design control cannot detect potential cause/mechanism and subsequent failure mode	10
Very Remote	Very remote chance the design control will detect potential cause/mechanism and subsequent failure mode	9
Remote	Remote chance the design control will detect potential cause/mechanism and subsequent failure mode	8
Very Low	Very low chance the design control will detect potential cause/mechanism and subsequent failure mode	7
Low	Low chance the design control will detect potential cause/mechanism and subsequent failure mode	6
Moderate	Moderate chance the design control will detect potential cause/mechanism and subsequent failure mode	5
Moderately High	Moderately High chance the design control will detect potential cause/mechanism and subsequent failure mode	4
High	High chance the design control will detect potential cause/mechanism and subsequent failure mode	3
Very High	Very high chance the design control will detect potential cause/mechanism and subsequent failure mode	2
Almost Certain	Design control will detect potential cause/mechanism and subsequent failure mode	1

Table 5. Detection Criteria –Additional Ranking

Detection	Additional Detection Criteria	Rank
Cannot Detect	Absolute certainty of non-detection of defective product prior to shipment	10
Very Remote	Test/inspection gates probably will not detect defective product	9
Remote	Test/inspection gates will catch all but 25% of defective product	8
Very Low	Test/inspection gates will catch all but 10% of defective product	7
Low	Test/inspection gates will catch all but 1.00% of defective product	6
Moderate	Test/inspection gates will catch all but 0.25% of defective product	5
Moderately High	Test/inspection gates will catch all but 500 DPM of defective product	4
High	Test/inspection gates will catch all but 60 DPM of defective product	3
Very High	Test/inspection gates will catch all but 3.4 DPM of defective product	2
Almost Certain	Test/inspection gates will catch all but 1 DPM of defective product	1

In the implemented failure mode effect analysis work, relevant precautionary measures for reducing the high and medium level risks that have been found as the result of the FMEA studies has been defined by giving reference to relevant actions., By this way it is planned to reduce the risk priority values of the potential risks in the intended construction of Process Fmea in the textile firm, Cotton Cloth (Fabric) Painting workstation. Furthermore, it is aimed that high and medium level risks will be eliminated and the process will progress smoothly.



Table 6. Calculate RPN Before and After Completion of Action Plans to Validate Improvements for Process Fmea in the Paint WorkStation-Textile Firm

Firm Name: X Paint PROSES FMEA													
Product/Item: Cotton Cloth (Fabric)		Model / vehicle: AD-10579		Process Resp.: A		Key Date: _____		FMEA No: 125-1		Security Class: _____		Prepared By: _____	
Core Team: SK/ BK/NU/ NA/KN								FMEA Date: _____		Rev: 0			
Proses / Steps	Potential Failure Mode	Potential Effect(s) of Failure	Potential Cause(s)/ Mechanism(s) of Failure	Current Process Control Prevention	Current Process Control Detection	Severity (S)	Occurrence (O)	Recommended Action(s)	Responsibility & Target Completion Date	Action Results	Severity	Occurrence	R.P.N
Function													
Peroxide bleaching of Cotton Fabrics	Abrage	In the dying stages, leads to color differences in the form of cloud and shadow	The Unremoval H2O2 before the dyeing process	using antiperoksite (sodium thiosulfate)	It is implemented to the fabric wash well after the processes, if the results does not be taken, Paint remover will be used and implemented	6	4	Using the complex-forming in the dye bath	It is implemented in the first production stage.	Control Plan was changed	6	3	54
	Splash	Caused the unwanted traces	not properly dried after washing	To eliminate the water droplets in the workplace	Analysable via the washing process	4	5	To be sensitive for the drying process			4	3	48
	Lyora Melting	leads to strength loss	the Lyora, not to be resistant to high temperature,	using quality lyora and selection the dyeing process according to lyora	It does not have solution.	6	3	using quality lyora		Control Plan was changed	6	3	96
Strength of the Cotton Fabric Cloth	The flexibility strength of the fabric	causing permanent damage to deform the fabric	The material exposure over flexibility strength	Failure to do machine settings according to the type of fabric(cotton cloth)	It does not have solution.	6	3	careful craftsmanship		Control Plan was changed	6	2	64
	Tribological behavior of the fabric (cotton cloth)	It is caused deformation of the fabric	Be tight compared to the normal setting of the paint machine	to circulate freely smooth fabric made of rope adjustment	It does not have solution.	6	3	control plan in certain frequency		Control Plan was changed	6	3	120
	Oil Strain	It is caused that Doing errors in the warping process	The oil flows(leakage) from the environment or from the machine	Doing regularly machinery maintenance	using detergent and organic solvent drying	6	7	Safety working area must be provided for employee and workers		Serious process control	6	5	120
Dyeing of Fabric(Cotton Cloth)	Paint Stains	It is caused failure of template fracture.	Not covered nylon on the waiting (queue) ,By he flight of the dyes, they stick to the pending fabric	covered nylon on the waiting (queue)	However, If you noticed before the painting process., It can be cleared and has solution	6	3	Dye matter which degree of process control substantific identified			6	3	54
	Caustic Stain	It causes that the material in some areas staining darker before	because of not being given Caustic homogeneously	given and implemented caustic progressively and appropriately	It does not have solution.	6	3	Implementing step by step via controlling stages		Process Control	6	3	120
	wing -aerofoil differences	It is caused unrelieved failure	Inhomogeneity of the fabric moisture content	movement of the fabric has sufficient level and fabric temperature difference hydrophillity	It does not have solution.	6	3	Ensuring, providing the circulation of the fabric			6	3	120
Yarn faults in the knitted fabric		leaving traces in the transverse direction to the fabric	Inability to perform the function of knitting machines and The difference between the used yarn	minimized by reducing the difference in machine yarn	If it is noticed during knitting, it has solution and cleared	7	4	Regularly machine controls			7	3	105
	Physical Fractures	It leads self-improve malaise and wrinkles on fabric	The fabric is not properly inserted in the machine	to provide setting of the rope-failure to do regularly, so preventing rotation of the fabric	Moistens the fabric by passing the iron	5	5	Fracture prevention should be used			5	3	60
	Burra	It is caused deformation of the fabric	Improper setting of the rope-failure to do regularly,The fabric is not properly inserted in the machine	Must be careful during transport and machinery works, processing time	If it is not too much, Quality control is performed, cleared	7	3	Implement the top quality shipping, transportation			7	2	70



Conclusion

FMEA analysis in the every sector projects, play an important role especially during the design phase of projects in order to providing the risks to be based on the priority order of importance and for the improvement works for them to be made quickly. However, in the projects of firms(sectors), Risk Priority Level (RPL) values play an important role that are found for post analysis and evaluation of FMEA, will be a good guidance for the people of experts in their field that carry out improvement studies. In this study first 8 important risk items.

The (Risk Priority Number)RPNs is widely used in FMEA for determining the risk prioritization of failure modes. The foregone FMEA cases may be helpful for Design Management to establish the selection principle. Future works will focus on systematic analysis of proper selection for the two indices. Considering the fact that FMEA is a group decision function and cannot be done on an individual basis and different FMEA team members may provide different assessment information. Risk factors are aggregated in a highly nonlinear manner which is neither the simple addition nor the simple product of the risk factors.

More risk factors can be included if necessary. The proposed FMEA is not limited to *O*, *S* and *D*, but applicable to any number of risk factors.

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