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Quality Improvement in Manufacturing Processes to Defective Products using Pareto Analysis and FMEA

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Abstract

Quality is a main driver in a customer's choice of products and service. Improvement of quality is a extremely desired objective in the brutally competitive industrial world. There are many methods for quality improvement. Pareto analysis is one of the major technics of statistical process control. It is a broadly applicable method that used for identifying and prioritizing the factors like failure modes, success criteria, downtime reasons etc. in manufacturing or service processes. Failure Mode and Effect Analysis (FMEA) is an evaluation and improvement technique that is applied to identify and eliminate known or potential failures and problems from a system, design, process and service before they actually ocur and reach the customer. Priority ranking of FMEA is determined by Risk Priority Number (RPN) which is computed by multiplication of severity, occurrence and detectability of failures. In this study, it is aimed to determine and classify failure modes and to offer suggestions according to their importance degree by Pareto analysis and FMEA for grinding process. After investigating the reasons of the occurring waste product in grinding process analyzed by Pareto analysis. To apply FMEA, firstly, decision team was established to determine the causes of fault. And then FMEA is performed to prioritize the critical potential failure modes of the process. Finally, some recommended actions were discussed.

Key Words: *Quality Improvement, Pareto Analysis, Failure Mode and Effect Analysis, Process Control.*

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1. Introduction

One of the significant factors of total quality management is to try to improve product and service quality in business enterprises constantly within economic principles. Business processes in which products and services are brought out are dealt with this understanding and such processes are tried to be improved by means of applying several methods (Kumru and Kumru, 2010).

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The ISO (International Organization for Standardization) definition of quality improvement states that it is the actions taken throughout the organization to increase the effectiveness of activities and processes to provide added benefits to both the corporation and its customers (Hoyle, 2000). It is important to use quality improvement techniques in terms of maintaining desired quality level and examining uncertainties in production processes (Adam, 1994). In today's world where a high level of competition is experienced, business enterprises have started to place much more emphasis on improving their current quality level and maintaining it in the same desired level. Such requirement introduced by competition environment has increased the use of quality improvement techniques. As regards present day definition of quality; it is a concept inversely proportional to uncertainty. As per quality improvement, it can be defined as activities to determine and reduce such uncertainties regarding products and processes (Montgomery, 2001). There are several techniques to determine and reduce uncertainty and variability in processes.

Ishikawa argues that a significant part of the problems in a business enterprise can be solved with seven basic techniques of quality control. Basic techniques most widely used to solve the problems likely to be encountered are Pareto Analysis, Cause-Effect Diagram, Histogram, Frequency Distribution, Distribution Diagram, Grouping and Control Graphics (Özcan, 2001; Işığıçok, 2005). It cannot be remarked that all faults likely to occur in a product or process have the same level of significance. The target of Pareto analysis is to ensure the concentration of measures to be taken and activities to be carried out in the most efficient points thereby leading quality control factors regarding the detection of important failure modes. (Kobu, 1987). Whereas, failure modes and effects analysis (FMEA) is a method utilized in order to determine and classify failure types with respect to product development, service, system and improvement of the processes (Eleren, 2007). According to USA Association of Automotive Engineers, FMEA is defined as a structure to analyze potential failure modes of a system, a subsystem or a function, their reasons and effects considering the formation of failure modes of the system in terms of qualitative aspects (Aksay et al., 2012).

The objective of the study is to emphasize that basic quality improvement techniques still continue to play a crucial role regarding the examination of the problems and detection of the solutions about such problems of many business enterprises. A real industrial problem is analyzed in application part and suggestions are made thereby discussing the reasons with regard to occurrence of the problem.

2. Literature Review

Upon reviewing literature, it will be seen that Pareto analysis and FMEA technique can be used in several studies carried out within the scope of different disciplines.

Canbolat (2000) stated that main causes comprising space insufficiency in the storage in a beverage bottling facility in Baku are detected thereby using Pareto analysis. Ahmed and Ahmad (2001) did research in a factory manufacturing glass-bulb of which production five basic materials such as flanged pipe, glass coating, wire with lead content, plug and stopple have an important role. In the firm where the losses regarding basic materials are higher than those anticipated in monthly budgets, factors increasing basic material waste in each step of production process are detected in accordance with their significance levels.

Thereby stating the factory has a great loss of production due to business interruption in a cement factory, Özcan (2001), aimed to detect failure types required to be prioritized since all causes of failures cannot be eliminated at the very time.He detected important causes of business interruptions thereby using Pareto analysis. As to Baysal et al. (2002), they executed FMEA implementation in an automotive supply industry plant. They developed measures against possible failures and made suggestions for follow-up. In their studies executed in textile sector, Bircan and Gedik (2003) detected substantial failure modes thereby analyzing with Pareto method the failure modes and numbers on the product called wind jacket. In their implementation carried out in a business firm manufacturing motor and tractor, Kaya and Ağa (2004) arranged number of failures based on months detected through recordings kept by the business firm, they made histogram for such mistakes. They expressed which failures are more important than others through performing Pareto analysis. As to Karuppusami and Gandhinathan (2006), they classified critical factors of success for total quality management and specified those failures with critical importance among the factors they obtained as a result of literature review they carried out in related areas. Ateş et al. (2006) carried out FMEA implementation study for a product called "a drilling apparatus with adjustable head''. They stated that likely failures can be detected and changes for improvement purposes can be made thereby creating proposals when designs with FMEA are studied.

Arvanitoyannis and Varzakas (2007) carried out in a business firm producing potato chips, executed Failure Mode and Effect Analysis, FMEA method in order to analyze production line. They utilized Pareto diagram for the potential optimization of the model they dealt with. Çöl et al. (2008) used Pareto analysis regarding the issue of stocks classification and they suggested several stock policies for the materials classified according to significance level. Eleren (2007) dealt with the issue regarding the assessment with FMEA of failure modes of production management lesson in management undergraduate program that lead to ineffectiveness in education process. Yücel (2007) dealt with garment industry which he expressed as craft production. He put forward suggestions for improvement thereby analyzing the problem of sewing failures elimination with FMEA.

Cervone (2009) examined substantial factors effective in realization of digital library projects. The author using Pareto analysis to specify significance level of such factors stated that it influences positively the success of such projects to take into consideration the results obtained. Güner (2009) dealt with garment industry and analysed preparation process up to the actual commencement of production. He made use of Pareto analysis to identify the significance level of activities in preparation process before production.

Chin et al. (2009) used FMEA technique together with the new decision-making approach with many criterion. They applied the intended methodology to the design of fishing boat. Özsever et al. (2009) executed productivity analysis for a business firm, utilized Pareto analysis in order to determine which of the business interruptions occurred in the system caused much more loss, in other words, to determine the most important interruption reason. Fedai et al. (2010) dealt with the issue regarding the detection of factors causing variability in the costs and hospitalization duration of patients treated due to brain crisis in GATA Clinic of Neurology Department. They carried out the analysis of factors detected by means of Pareto analysis which is one of the control techniques of statistical process. Temiz et al. (2010)

calculated total equipment effectiveness value of moulding lines of a casting plant within the scope of adequate maintenance concept. They applied to Pareto analysis in order to detect which business interruptions are more privileged. Aksay et al. (2012) laid stress on the contribution of FMEA method to patient security which has a strategic place in health service. In this regard, they introduced an application for laboratory process in a public hospital through literature review about the subject.

2.1. Pareto Analysis

Pareto analysis is a means used to signify and prioritize the reasons leading to problems specified in quality improvement process (Gitlow et al., 2005). The technique developed by Italian economist Vilfredo Pareto has been started to be commonly used in management area especially in consequence of the studies of Joseph M. Juran, the founder of total quality management. Vilfredo Pareto examined how the revenue of Italy is shared by public and stated that about 20% of the population had the 80% of the revenue generated in the country and the remaining 80% of the population only had 20% of such revenue. This detection took place in literature as 80-20 Pareto rule (Bozkurt, 2003). According to Pareto rule, generally 80% of the faults in a system stems from 20% of the reasons constituting the faults (Cravaner et al.,1993). Deming also adopted Pareto analysis following Juran and started to use it intensively. As a result of the transfer of Pareto analysis to Japans in the seminars of Deming conducted in Tokyo, such technique has been started to be commonly used by quality improvement groups. Pareto principle is also called as "80-20", "90-10" rule or "70-30" rule in literature.

Pareto analysis is a technique which is used to separate significant causes from less significant ones. Such technique can also be used in many areas other than economy since it helps to specify priorities thereby stating the problem with the help of graphic and focusing the attention on the most important reason of the subject. It can easily be detected via this technique which faults have a bigger percentage especially when determining the causes of problems in quality control and quality improvement studies (Akın, 1996; Özcan, 2001). Procedure in Pareto analysis is generally as follows:

a) Type of the problems to be examined, information to be gathered and classification type of such are identified.

b) Data are processed on a score table which is classified according to problem types. Totals that belong to each category and their percentages are stated. Problems kept out of selected categories are processed as the last group on ''others'' section.

c) A bar chart, y-axis of which indicates the totals and percentages while the x-axis indicates the groups is produced.

d) Pareto graphic is drawn so as to indicate qualitative totals thereby starting from the upper right-hand corner of the first bar (Figure 1) (Akın and Öztürk, 2005; URL-1).

On Pareto curve; failure modes are indicated on x-axis, whereas the frequency or cost (or both of them) are generally indicated on y-axis. The fault with the highest frequency or cost takes place on the left of the graphic, while the fault with the lowest frequency or cost is on the right. The height of the columns central to curve sketching represents the frequency and/or cost of the failure. Therefore, failure with the highest frequency or the cost is detected to be the first degree problem required to be dealt with or made provision against (Işığıçok, 2005).

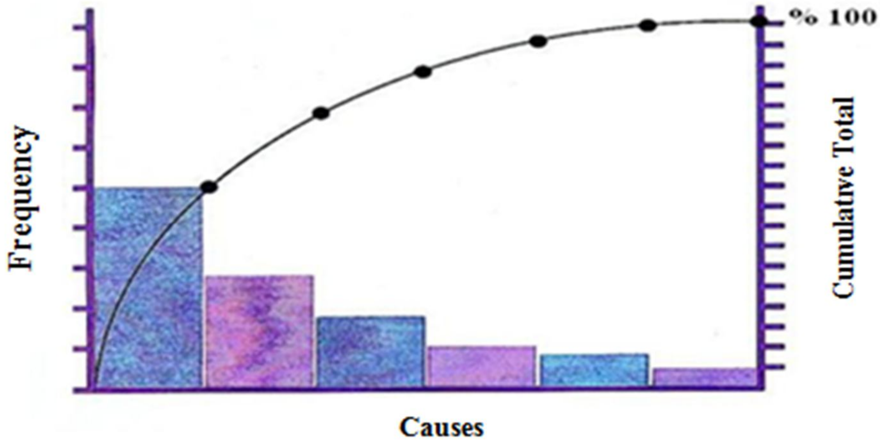


Figure 1: Pareto Curve

The reason why the causes of failures are prioritized from big to small on Pareto curve is that in some cases the cause of one or two failures with substantial quality may comprise an important part of total failure. Such point is important to know which failure or cause should be prioritized. Pareto analysis is mostly considered to be a means to solve problems, however it mostly helps to identify in fact which problems are to be solved earlier rather than how to solve the problem (Bozkurt, 2003).

2.2. Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis (FMEA) is a technique developed to specify, list beforehand the current or potential failure/risk modes and the priorities during improvement phase while developing or improving the system, process, method, model, service or products (Eleren, 2007). Failure Mode and Effect Analysis has a diversity as listed below and its implementation area includes all types of production and service type (Yılmaz, 2000; Besterfield et al., 2012).

> *Design FMEA: Design FMEA is a method defining the potential or known failure modes, ensuring the identification of failures and implementation of regulatory activities before first production is executed.*
>
> *Process FMEA: Process FMEA is a method targeting to produce engineering solutions in order to fulfill quality, reliability, cost and efficiency criteria defined by Design HTEA and the customer. Process FMEA is also used in our study.*
>
> *Service FMEA: Service FMEA, is a modification to the standart process FMEA, because most types of services can be considered processes.*
>
> *System FMEA: System FMEA used to optimize the flow of systems such as production, quality assurance after all units and design are completed.*

In FMEA technique, failure modes are arranged according to risk levels and measures are detected thereby starting from failure modes with the highest priority. Improvement is created step by step. It is at basis of the method to detect the number of risk priority. Such numbers are calculated as follows:

Risk Priority Number (RPN) = Occurrence x Severity x Detection

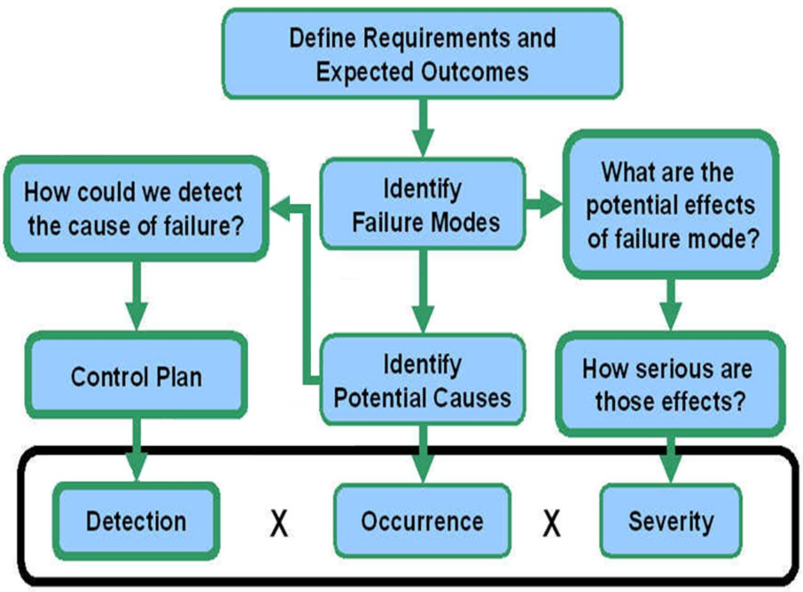


Figure 2: Calculating RPN Value (Wysk, 2010)

"Occurrence" states the frequency level of the failure; "Severity" states the effect/importance level of the failure; and "Detection" states the realization level of such failure before it reaches to the user. The more success can be achieved in implementation depending on how accurately RPN is detected. Numeric and sufficient data in these types of risk analysis techniques are an important factor to increase success. In case that the data are not reliable or that there are no sufficient data, values for occurrence, severity and detection are expressed by asking expert opinion (Kumru ve Kumru, 2010: 172).

Implementation phases of FMEA technique are as follows:

Detecting process or processes to be analyzed

Identifying failure modes

Identifying potential effect or effects of the failure

Identifying causes of failures

Identifying failure severity

Identifying failure likelihood

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

Table 1: Ratings for Severity of a Failure (Chin, 2009; Spackman, 2012)

S (or SEV) Value	Severity	Product/Process Criteria
1	None	No effect
2	Very Minor	Defect would be noticed by most discriminating customers. A portion of the product may have to be reworked on line but out of station
3	Minor	Defect would be noticed by average customers. A portion of the product (<100%) may have to be reworked on line but out of station
4	Very Low	Defect would be noticed by most customers. 100% of the product may have to be sorted and a portion (<100%) reworked
5	Low	Comfort/convenience item(s) would be operable at a reduced level of performance. 100% of the product may have to be reworked
6	Moderate	Comfort/convenience item(s) would be inoperable. A portion (<100%) of the product may have to be scrapped
7	High	Product would be operable with reduced primary function. Product may have to be sorted and a portion (<100%) scrapped.
8	Very High	Product would experience complete loss of primary function. 100% of the product may have to be scrapped
9	Hazardous Warning	Failure would endanger machine or operator with a warning
10	Hazardous Without Warning	Failure would endanger machine or operator without a warning

Table 2: Ratings for Occurrence (Chin, 2009; Spackman, 2012)

O Value	Occurrence	Criteria
1	Remote	1 in 1,500,000 Very unlikely to occur
2	Low	1 in 150,000
3	Low	1 in 15,000 Unlikely to occur
4	Moderate	1 in 2,000
5	Moderate	1 in 400 Moderate chance to occur
6	Moderate	1 in 80
7	High	1 in 20 High probability that the event will occur
8	High	1 in 8
9	Very High	1 in 3 Almost certain to occur
10	Very High	> 1 in 2

Table 3: Ratings for Detection (Chin, 2009; Spackman, 2012)

D Value	Detection	Criteria
1	Almost Certain	Current Controls are almost certain to detect/prevent the failure mode
2	Very High	Very high likelihood that current controls will detect/prevent the failure mode
3	High	High Likelihood that current controls will detect/prevent the failure mode
4	Mod. High	Moderately High likelihood that current controls will detect/prevent the failure mode
5	Moderate	High Likelihood that current controls will detect/prevent the failure mode
6	Low	Low likelihood that current controls will detect/prevent failure mode
7	Very Low	Very Low likelihood that current controls will detect /prevent the failure mode
8	Remote	Remote likelihood that current controls will detect/prevent the failure mode
9	Very Remote	Very remote likelihood that current controls will detect/prevent the failure mode
10	Absolutely impossible	Design control will not and/or cannot detect a potential cause/mechanism and subsequent failure mode

FMEA is a technique used to identify, specify or eliminate problems, potential failures known and/or stemming from system, design, process and/or service before reaching to the customer. It can be utilized to eliminate current/likely failure modes in products and processes, while creating a new product, restructuring a production process or initiating a project (Ateş et al., 2006).

The benefits of FMEA can be summarized as follows (Yılmaz, 2000);

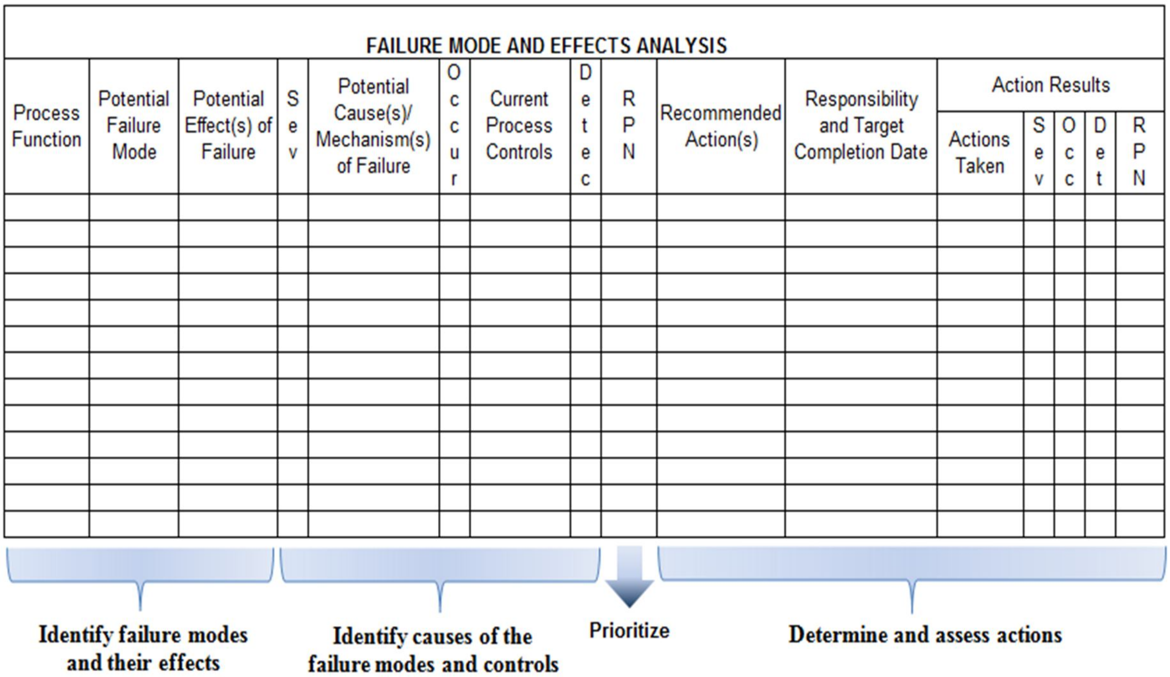
It helps to reduce the failures thereby ensuring the review of such in the processes.

It ensures to enhance customer satisfaction.

It identifies the deficient, poor and insufficient points regarding the areas for security, manufacturing technology reliability and design of the product.

It reduces possible variation costs thanks to calculations made.

It shortens the time for marketization of the product.



FAILURE MODE AND EFFECTS ANALYSIS															
Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential Cause(s)/ Mechanism(s) of Failure	Occur	Current Process Controls	Detec	RPN	Recommended Action(s)	Responsibility and Target Completion Date	Action Results				
											Actions Taken	Sev	Occ	Det	RPN

Figure 3: Process FMEA Form (Kuczek, 2012)

3. An Application

XYZ is a firm operating in forest products industry and it manufactures MDF board with Conti-Roll production technology and Melamine Surfaced MDF (Medium Density Fiber) with Multi-System Melamine Press Line. Work flow in connection with MDF board production is indicated in Figure 4.

Among the boards obtained by means of dry system, it is MDF type that is one of the most important in industrial terms. Tree types with a density between 0.35-0.65 gr/cm^3 are suitable for MDF production. Fiber-chip wood, wood obtained from thinning cutting, lumber industry wastes, rotary-cut veneer waste cylinder, sliced veneer waste timber, rotary-cut slice waste veneer, wood and planning flour, factory wastes of several companies processing wood and vegetal wastes in required fiber length for board production can be used for MDF manufacture. That the diameters of round woods are between 6 cm and 40 cm and their lengths are shorter than 2 m are required specifications. Annual plants such as sugarcane, flax straw, cereal straw and sunflower straws in areas where forest sources are limited are also used as raw material in production. Density of MDF boards range between 0.50 - 0.80 gr/cm^3 (Güller, 2001).

MDF is a smooth-surfaced material which can be coated, printed, dyed and processed as solid wood by woodworking machines. Thanks to its production in appropriate thickness, suitability for procession by machines and its durability, enables MDF to be used as an alternative to solid wood in applications such as drawer sides, mirror frames and edges. That the fibers evenly disperse in each point of MDF and their abundance enable the edges as well as both of the sides of the board to be processed by the machine without any breakage or creating spaces between material particles.This is why MDF can be used on table tops, door panels, edges, or in the production of particles such as expensive or drawer fronts with profile surface. MDF materials with extremely smooth and uniform surface come to fore again as a good base material in decorative folio and timber cover (Güller, 2001).

Grinding process which is one of the last phases of board production in the business firm consists of arrival of MDF boards to rough sander machine via carrier and trading phase, and then arrival to fine sander machine again via carrier and trading phase and finally output phase.

The study executed in the firm considering the improvement of grinding process comprises of the following steps:

1. Creating a study group
2. Method detection studies
3. Detecting failures in the process
4. Identifying important failure modes thereby using Pareto analysis
5. Detection of substantial failure modes, their reasons, the problems they caused and those whoever is responsible
6. Calculation of RPN thereby specifying the values for severity, possibility and detectability
7. Stating improvement studies suggested primarily the failure modes with high RPN value

At the end of FMEA process, RPN calculation is again carried out thereby taking the results of improvement studies into consideration. However, it didn't fall within the article since this phase has not come true in the study yet.

The objective of grinding phase in business firm is to remove thickness failures in the board and obtain a smooth and a little roughsurface before top surface operation. As a result of reports of last three months and observations regarding grinding process, failure assortment of the failures leading second quality or waste product in sandpapering processis as shown in Table 4.

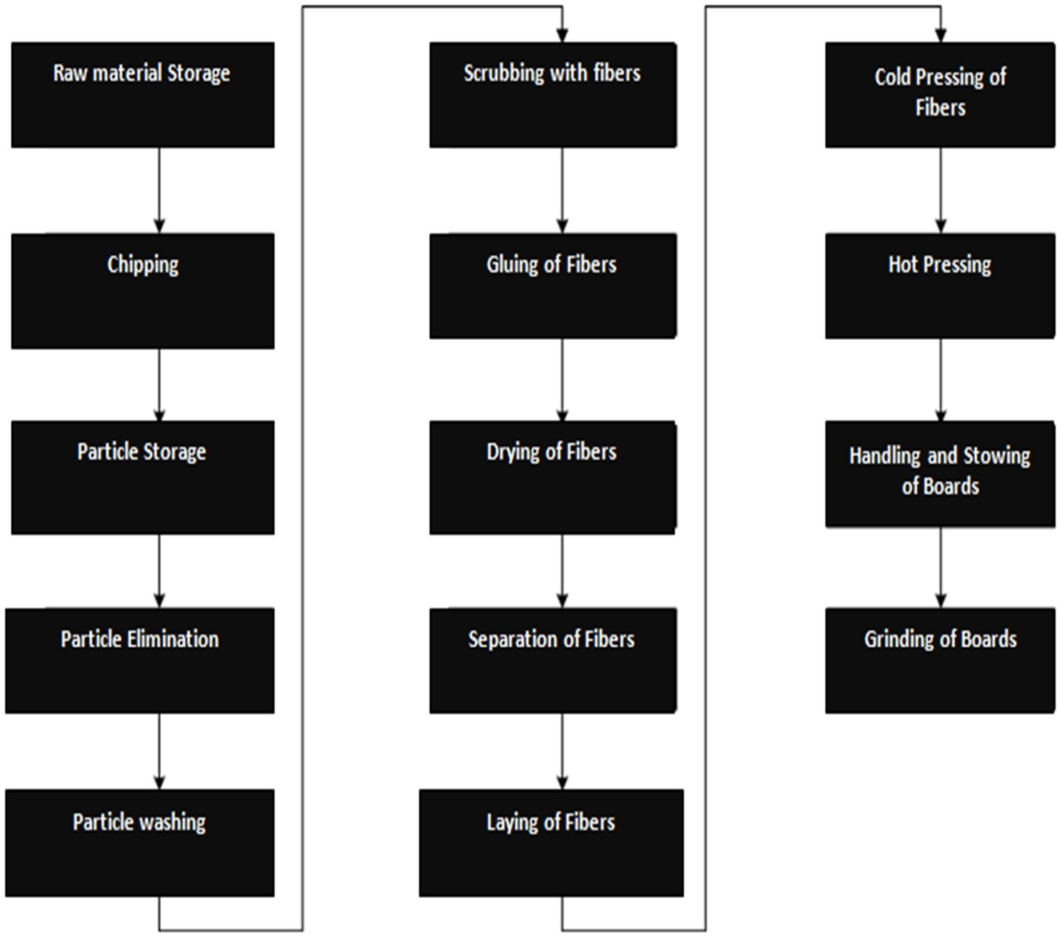


Figure 4: Work Flow with regard to MDF Board Production in XYZ Firm

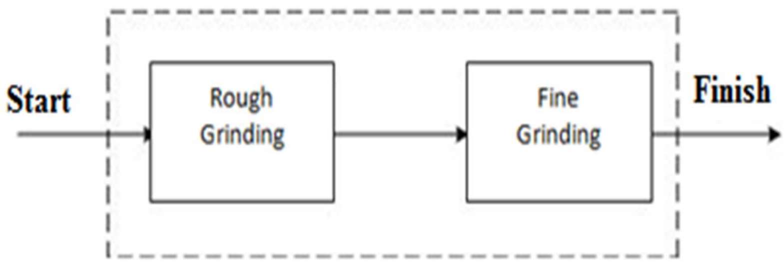


Figure 5: Grinding Process

Total number of failures observed in time slice in grinding process is 473. Presentation of failure modes and frequencies using histogram is indicated in Figure 6.

Table 4: Failure Assortment of Failures Leading Waste Product in the Process

Failure Mode	Number of Failures
Elevator Break	4
Correction	32
Forklift Break	112
Wet Wedge Mark	74
Stain	11
Machine Failure	75
Hole	8
Burst	20
SHS Break	9
Pilling	91
Soft	37
Total	**473**

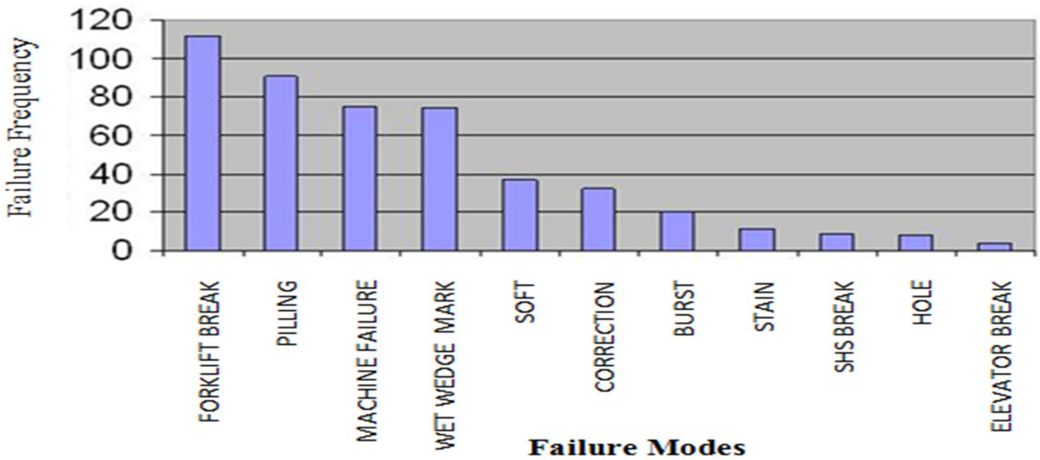


Figure 6: Histogram

Pareto table including cumulative failures created by failure modes and number of failures is presented in Table 5.

Table 5: Creating Pareto Table

Failure No	Failure Mode	Number of Failures	Cumulative Failure	Failure Percentage	Cumulative Percentage
1	Forklift Break	112	112	%23.7	% 23.7
2	Pilling	91	203	%19.2	% 42.9
3	Machine Failure	75	278	%15.9	% 58.8
4	WetWedge Mark	74	352	%15.6	% 74.4
5	Soft	37	389	%7.8	% 82.2
6	Correction	32	421	%6.7	% 88.9
7	Burst	20	441	%4.2	% 93.1
8	Stain	11	452	%2.3	% 95.4
9	SHS Break	9	461	%2.0	% 97.4
10	Hole	8	469	%1.8	% 99.2
11	Elevator Break	4	473	%0.8	% 100
	Total	**473**		**% 100**	

Pareto graphic regarding the data is expressed in Figure7. When y-axis is taken into consideration in Figure 7, the height of columns indicates the number of failures whereas the points passing over curves indicate the number of cumulative failures according to significance level. As to the y-axis on the left on the same figure, it states the percentage of failures and percentage of cumulative failures according to significance level.

According to the results, failures stemming from forklift break, pilling, machine failure and wet wedge which are the first four failures constitute 74.4 % of the total failures. While these causes of four failures are 36.4% of 11 failures, they constitute 74.4 % of total failures. If the source of such four failures is eliminated, it can be ensured a 74.4 % reduction regarding the amount of waste or second quality.

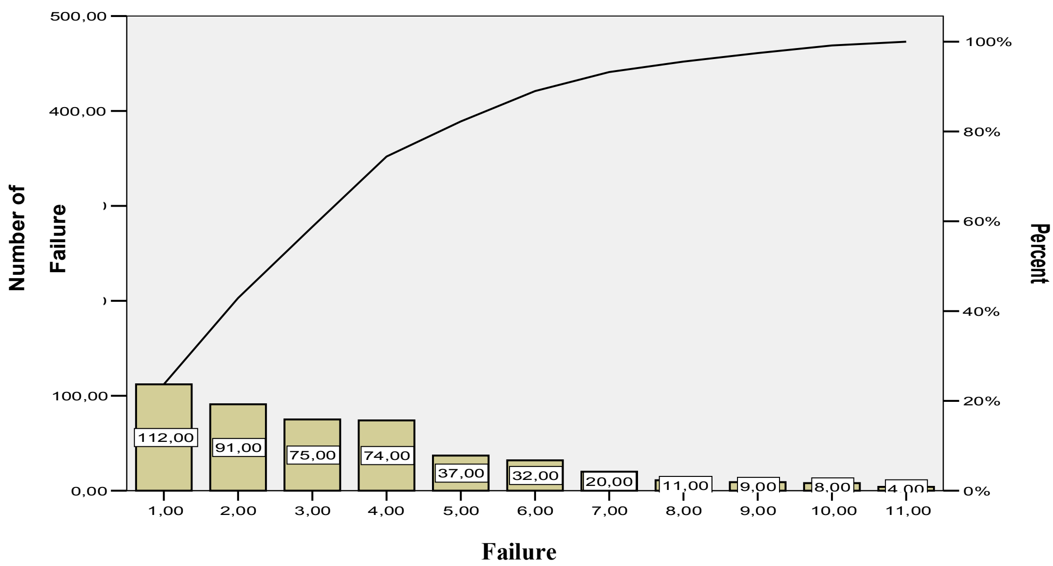


Figure 7: Pareto Curve

Following the detection of significant failure modes, FMEA application is carried out forthe failure modes detected. FMEA table with regard to application of the method explained in detail in part three of this paper to grinding process is stated in Table 6.

4. Results and Discussion

According to the results obtained, it is ‘’Pilling’’ came to fore as the failure mode with the highest RPN value. Such failure mode occurred due to the use of wrong raw materials and the fact that speed is not adjusted properly has 384 RPN value in total. If an improvement study is to be carried out,it should be firstly aimed at removing or reducing this failure mode.

Regarding the production process examined, following types of measures can be taken for the most important failures which are analyzed with Pareto and FMEA:

Pilling on the Board: This failure occurs mostly when oak is used and the capacity is increased. It is proper to use less oak as a measure and the speed should be adjusted in accordance with the requested quality accordingly.

Wet Wedge Mark: It occurs due to moisture. Sufficient drying should be carried out thereby reducing moisture. As a basic measure, it can be said that it is essential to supply kiln-dried wedges. In this regard cost factor should also be taken into consideration.

Forklift Break: Forklifts should be controlled and technical problems arising out of devices or equipment should be removed. In addition, required information and training if necessary must be given to forklift operators.

Machine Failure: Temperature and pressure adjustments of the machines utilized must be followed thereby examining carefully. Further, density problems should be removed thereby adjusting pressing time.

Table 6: FMEA Application for Grinding Processes

FAILURE MODE AND EFFECTS ANALYSIS										
Process Function	**Potential Failure Mode**	**Potential Effects of Failure**	**S**	**Potential Cause**	**O**	**Current Process Control**	**D**	**RPN**	**Recommended Action**	**Responsibility**
Grinding Process	Forklift Break	Damage to Material	7	Use of wrong apparatus	8	By the operator	3	**168**	Operator training and instructions	Production Manager
Grinding Process	Forklift Break	Damage to Material	7	Lack of required information	4	By the Shift Supervisor	3	**84**	Operator training and instructions	Production Manager
Grinding Process	Pilling	Reduction in Surface Quality	8	Use of wrong raw material	5	By the Shift Supervisor	4	**160**	Material based on less oak	Materials Manager
Grinding Process	Pilling	Reduction in Surface Quality	8	Speed increase	7	By the Shift Supervisor	4	**224**	Adjusting time	Production Manager
Grinding Process	Wet Wedge Mark	Bubble and Burr Generation	5	Moisture in storage processes	5	By the Storage Clerk	2	**50**	Eliminating moisture	Materials Manager
Grinding Process	Wet Wedge Mark	Bubble and Burr Generation	8	Insufficient drying	2	By thermal processing representative	4	**64**	Appropriate Drying Process	Production Manager
Grinding Process	Machine Failure	Density problem on layer	6	Shortness of press closure time	3	By the operator	2	**36**	Time Adjustment and control	Production Manager
Grinding Process	Machine Failure	Merging Problem	7	Wrong temperature adjustment	2	By the Operator	2	**28**	Heat Control	Production Manager
Grinding Process	Machine Failure	Separation in Boards	7	Wrong pressure adjustment	2	By the Operator	2	**28**	Pressure Control	Production Manager

S: Severity Rating
O: Occurrence Rating
D: Detection Rating
RPN: Risk Priority Number

5. Conclusions

Pareto analysis which is a technique widely used to identify the sources of significant failure modes regarding production processes in business enterprises is applied in many areas such as quality control, stock management, purchase and control of production processes. It should be ensured to remove or reduce the failures thereby taking measures and carrying out improvements regarding the failures with high significance level which are detected after Pareto analysis and the sources of such failures.

Regarding the analysis executed for XYZ business firm; failures stemming from forklift break, pilling, machine failure and wet wedge mark came to fore as main problems. It is important to take measures promptly for such failures. It is

FMEA technique utilized in order to find out risk priority values considering significant failure modes. Within the frame of such technique, proposed solutions are expressed thereby stating severity, possibility and detectability of such failures.

It is also possible to use cause-effect (fishbone) diagram, another quality improvement technique, if it is requested to investigate the causes of failures in the process. It is required to pay attention to cost factor as well, while taking measures regarding the failures and those main failure sources among the others which can be removed with the most proper expense should be considered firstly.

Measures taken can be varied in accordance with the significance of the failure, preventing cost and the rate of failure prevention. Decrease in the number of failure should be monitored thereby controlling the processes within the measures. The process should be monitored through recalculation of recently obtained data and RPN values. Thus an increase in productivity and regularity is ensured in quality development and improvement.

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