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Analysis of failure modes with Pareto Chart for various equipment in Alfanar Factory for Ceramics & Porcelain, KSA.

Abstract:

This study discusses the failure mode and impact analysis of various industry equipment used in Alfanar Ceramics and identifies the risks related to all that essential equipment that may result in human loss, property loss, or environmental harm. There are a total of three different pieces of equipment taken into account, allowing for the creation of a Pareto chart based on the risk priority number and the subsequent suggestion of an action plan. The management can review the issues based on RPN and, if they are serious, refer to an action plan to address them as needed. The required suggestions are given for each failure mode that has been discovered so that preventive measures can be done before that failure mode causes an accident.

1. Introduction:

Today's globe is experiencing an increase in industrialization, which has resulted in the development of vital machinery that not only improves output but also carries a number of risks that could result in accidents. Several steps must be made to stop these kinds of occurrences from happening in order to avert accidents. Therefore, hazard identification is the initial phase and demands a lot of expertise and professional knowledge to implement the best hazard identification technique. Failure mode effect analysis is one of the finest ways to achieve this, especially if we take equipment safety into account. For this purpose Pareto chart will be a good analysis tool which help the company to prioritise their action plan form vital few to trivial few.

In this research study, we analyze the failure modes of different equipment used in Alfanar Ceramics and make a priority plan according to the risk priority number. In order to calculate the Risk priority number we calculate chance of occurrence, severity and detection system with the help of process engineer at Alfanar Ceramics.

About the company:

The main business activities of Alfanar group include the production of a variety of Low, Medium, and High Voltage Electrical Construction Products, as well as EPC solutions for both

traditional and renewable power plants, related engineering services, and design engineering. This group owns Alfanar factory for Ceramics and Porcelain which is a Saudi Arabian manufacturer of design high quality Porcelain and Ceramic Tiles for internal & external walls & floors tiles. The process sheet of Alfanar Ceramics is given below:

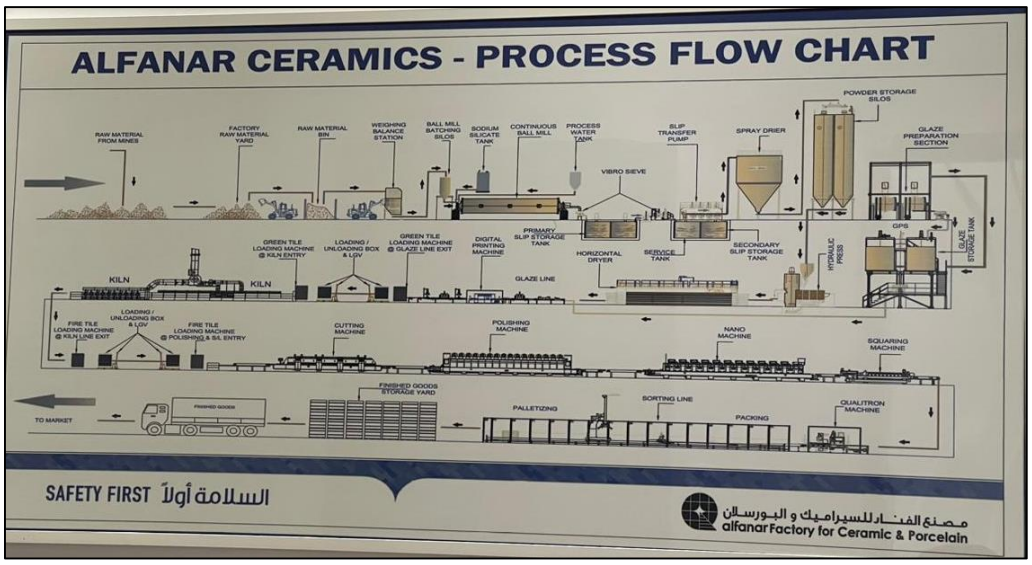

Figure 1: Alfanar Ceramics Process flow chart

Workflow diagram for manufacturing of ceramics:

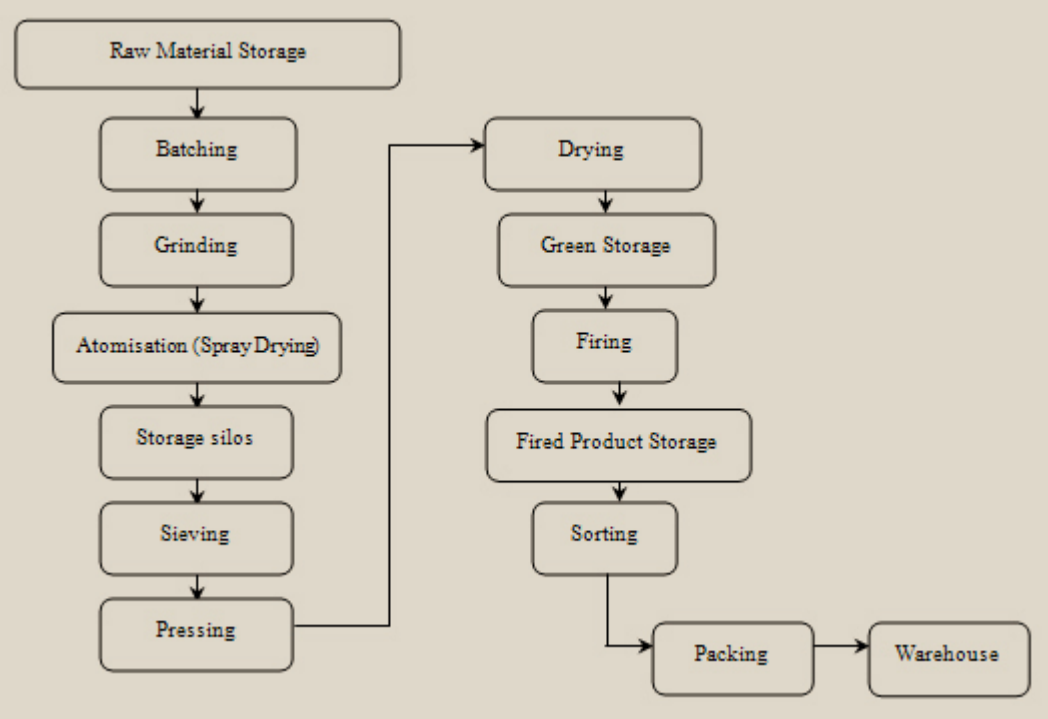

Figure 2: Workflow diagram

2. Methodology:

First of all, we collect the data by taking interview of process engineer he gave us the data of three equipment. Data includes the detail of failure mode, their impact and preventive measure. After getting data we make the rank list according to RPN and make the tables of all the data. At the last step, we categorize our data according to RPN number and make Pareto chart. From the Pareto chart, we can make the priority for action plan from vital few to trivial few.

3. Data presentation and calculation:

In this section, first of all we make a table of all the parameters involved in compilation of data for Pareto chart.

3.1. Risk Priority Number (RPN):

The Risk Priority Number, or RPN, is a numerical assessment of risk given to a process in which a team gives each failure mode a numerical value that measure the chance of its occurrence, detection, and severity of its impact.

$$RPN = Occurrence\ x\ severity\ x\ detection$$

3.1.1. Chance of occurrence rank list (O):

It covers the chance of occurring of any failure mode, which should be taken into account when calculating RPN. The scale is shown in the table below in accordance with the likelihood of occurring of each given event.

Table 1: Rank of chance of occurrence

Rank of chance of occurrence	Detail
1	Never
2	Once in 05 years
3	Once in a year
4	Once in a month
5	Once in a week

3.1.2. Severity rank list (S):

The intensity of the event that will follow failure is discussed in this table since failure modes can occasionally result in extremely hazardous events. Therefore, while calculating the RPN, severity must also be taken into account.

Table 2: Rank of Severity

Rank of Severity	Detail
1	No loss
2	Minor performance loss only
3	Partial breakdown of system and can be repaired
4	Complete breakdown of system / minor injury
5	Major losses or fatal/ multiple injury

3.1.3 Detection rank list (D):

The below particular table talks about the detection method so that it may be understood how quickly a failure can be seen and action can be made since it might create some undesirable events if it goes beyond a certain point in time.

Table 3: Rank of detection

Rank of detection	Detail
1	Online detection and automatic response
2	Online detection and manual response
3	Manual detection and manual response
4	Random manual detection and manual response
5	No system installed for detection

3.2 RPN Calculation:

Following are the equipment that are being used in Alfanar Ceramics.

3.2.1 Air operated diaphragm pump:

Alfanar Ceramics uses Air operated diaphragm, pump to transfer slip, glaze and water via air medium. On interview with process Engineer we were able to get the following data and we calculated the RPN on the basis of given data.

Figure 3: Air operated diaphragm pump

Table 4 : Calculation of RPN of Air operated diaphragm pump

Failure mode	Impact	Corrective/preventive Action	O	S	D	RPN
Wear and tear of balls and sheets	Pump will cease to function.	Shield must be replaced on a regular basis.	3	3	3	27
Along with air, there is water coming.	O-ring and air seal were damaged.	Use an air filter or a hair dryer element.	1	2	2	4

3.2.2. Heat Treatment Dryer:

Alfanar Ceramics uses Heat Treatment Dryer to dry the finished product (ceramics). On interview with process Engineer we were able to get the following data and we calculated the RPN on the basis of given data.

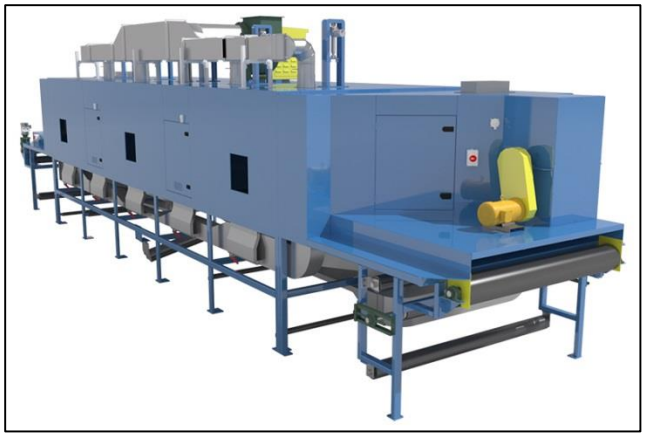

Figure 4: Heat Treatment Dryer

Table 5 : Calculation of RPN of Heat Treatment Dryer

Failure mode	Impact	Corrective/preventive Action	O	S	D	RPN
The dryer's motor may be damaged by overheating.	Bearing damage/Motor burn	It is necessary to create a damper system to stop overheating.	3	4	3	36
Due to a software issue, the panel or automation system may be failed.	Dryer will cease working	It is necessary to observe properly.	2	2	3	12

3.2.3. Kiln Blower:

Alfanar Ceramics uses Kiln blower to Suck and discharge the air to maintain temperature of the kiln. Following data were collected and tabulated below in the table:

Figure 5: Kiln Blower

Table 6: Calculation of RPN of Kiln Blower

Failure mode	Impact	Corrective/preventive Action	O	S	D	RPN
Due to heat or wear and strain, a bearing may be failed.	Blower will cease to perform its function.	In order to prevent overheating, routine maintenance and lubrication are required.	3	4	2	24
Blower out of balance as a result of a failing belt after experiencing a jerk	Blower will cease to perform its function.	The vendor must perform the rebalancing.	3	3	2	18

3.3 Cause and effect Analysis:

On the basis of above data we develop cause and effect analysis. Below figure shows the cause and effect analysis:

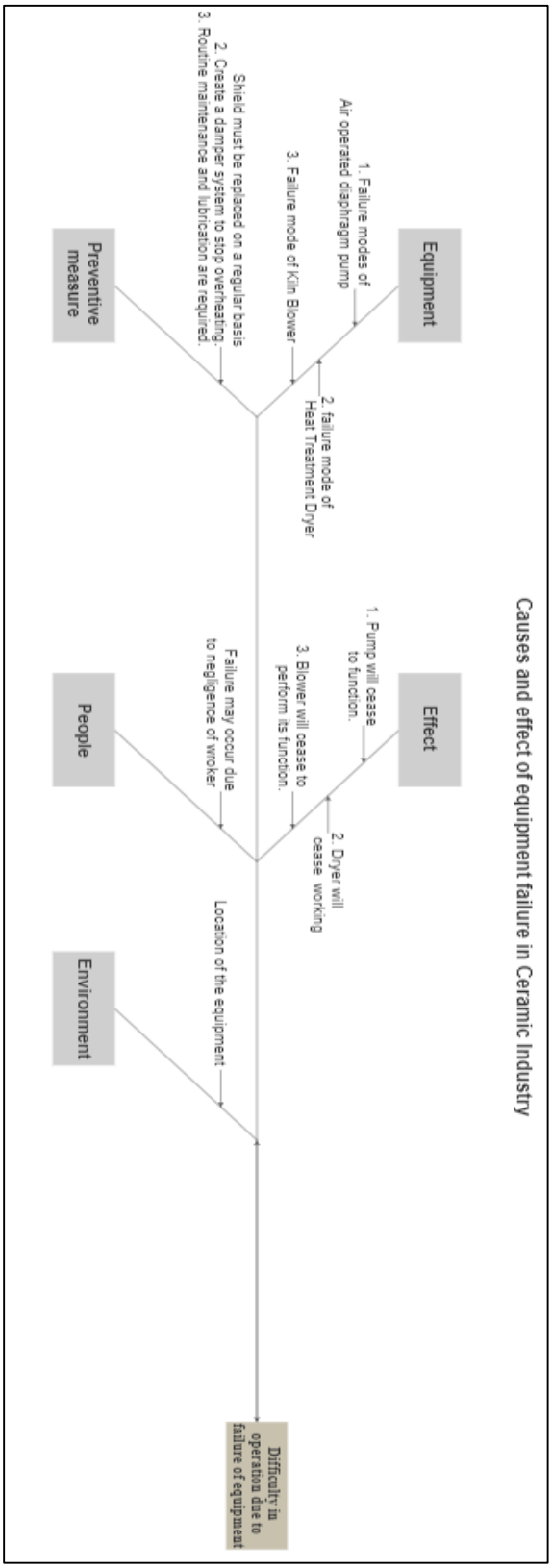

Figure 6: Cause and Analysis of our project

4. Pareto Chart formation:

Following table categories the RPN on the basis of RPN number. Adding all the data in excel and we plot Pareto chart of give data at marker of 80%.

Table 7: Input data for Pareto Chart

Category	RPN	Cumulative RPN	Cumulative %age
Category 1	36	36	35%
Category 2	27	63	61%
Category 3	24	87	84%
Category 4	12	99	96%
Category 5	4	103	100%

Data representation in pie chart:

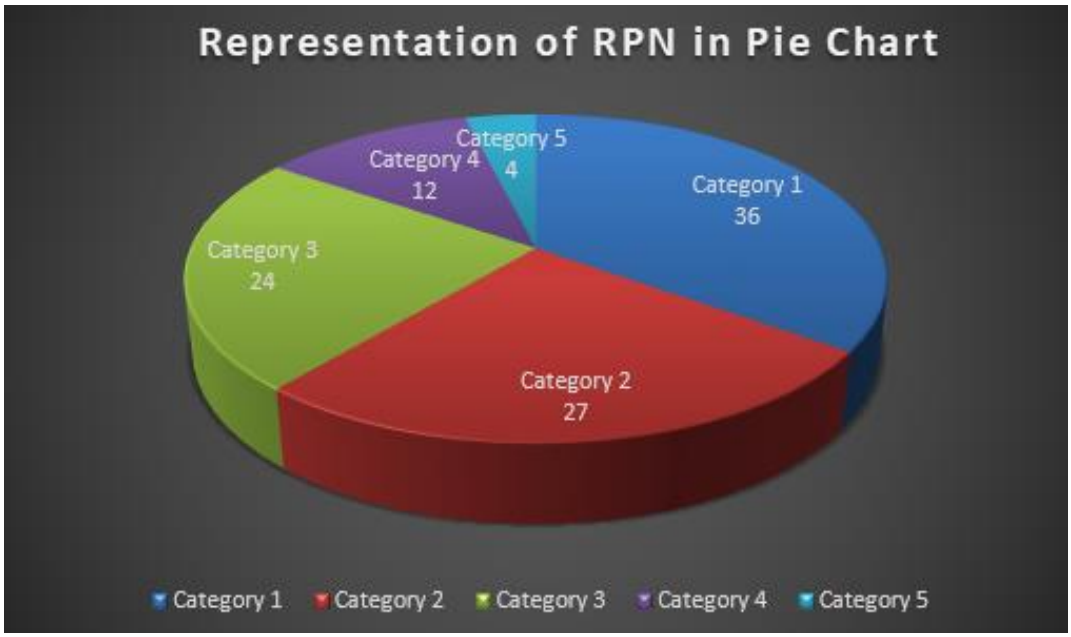

Figure 7: Pie Chart Representation

Pareto chart:

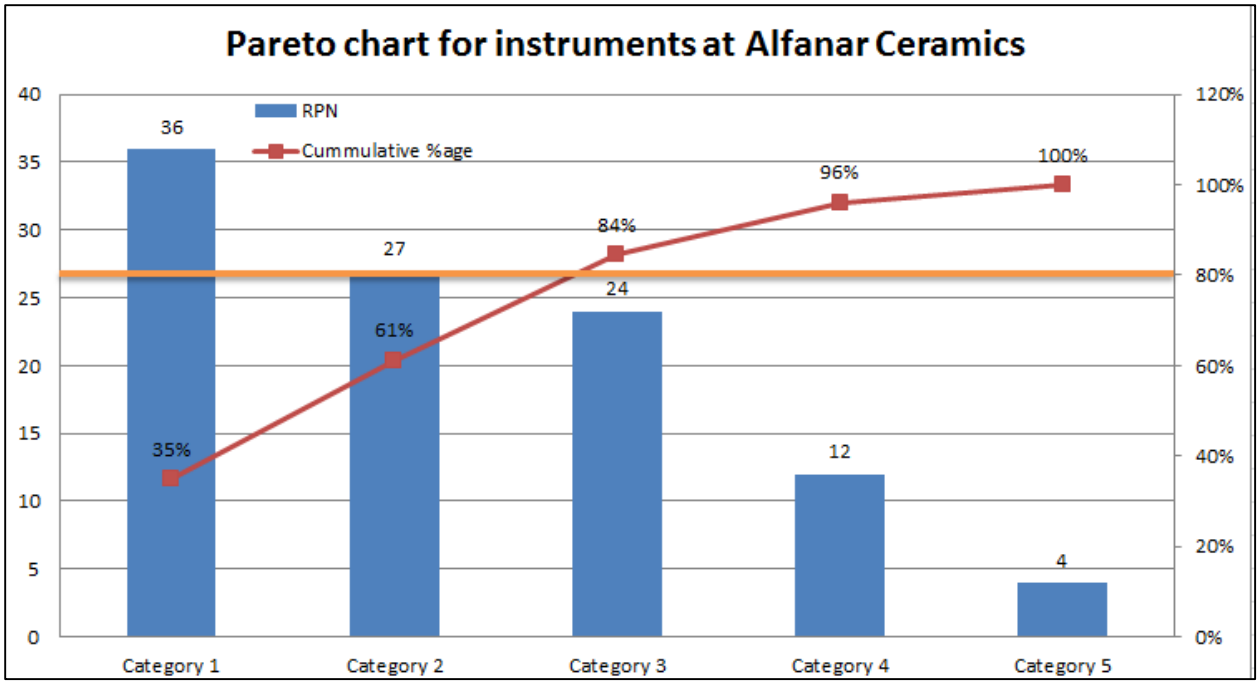

Figure 8: Pareto Chart

5. Results and conclusion:

The maximum RPN would be 5*5*5=125, and based on this information, we came up with five different categories of RPN, ranging from 4 to 36. When the same Pareto analysis is performed, it can be seen with an 80% marker which categories require immediate action and which require ongoing monitoring to ensure they do not exceed the safe RPN. Below is a detailed discussion of all the equipment.

Air operated diaphragm pump: The air operated diaphragm pump's maximum RPN of 27 represents a failure mode that needs a high priority (Vital Few). Preventive action for this is advised, which must be followed to prevent such failure modes, particularly the provision of mesh and the replacement of shield.

Heat Treatment Dryer: The Heat Treatment Dryer's maximum RPN of 36 represents a failure mode that needs a high priority (Vital Few). An adequate damper system must be installed to prevent overheating.

Kiln Blower: The maximum RPN associated with kiln blower is 24 according to Pareto Chart it needs intermediate priority for taking preventive action (Trivial Many). As a result of frequent failures of the belt and bearing, it is necessary to undertake routine maintenance and monitoring.

6. References:

[1]. Risk Priority Number (from Failure Modes and Effects Analysis) | IHI - Institute for Healthcare Improvement. (n.d.). Www.ihi.org. Retrieved December 9, 2022, from https://www.ihi.org/resources/Pages/Measures/RiskPriorityNumberfromFailureModesandEffectsAnalysis.aspx#:~:text=Formula%3A%20The%20Risk%20Priority%20Number

[2]. Wilkinson, L. (2006). Revising the Pareto chart. The American Statistician, 60(4), 332-334.

[3]. ASQ. (2019). What is a Pareto Chart? Analysis & Diagram | ASQ. Asq.org. https://asq.org/quality-resources/pareto