Failure Mode Effect Analysis in a Frying Pan Manufacturing Industry

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Abstract – Nowadays nonstick frying pans find a large demand in the market due to its non-stick property. Customers prefers the non-stick frying pan because it is very easy to cook the food with less use of oil, easy cleaning of the utensils, supports uniform distribution of heat. Thus the quality of the frying pans has importance. This paper deals with application of Failure mode effect analysis in the machine used in the manufacturing of the frying pan. In FMEA, Risk priority number is found for each failure modes. Thus each Failure modes are ranked according to the RPN number. The failure modes with high risk are found out.

***Key Words*: Failure Mode Effect Analysis (FMEA), Non-Stick Frying Pan, Machine maintenance, Risk Priority Number (RPN), Roller machine, Presser, Riveting machine, Heat treatment apparatus**

1. INTRODUCTION

After the 20th century, a big industrial revolution took place. The industries became competitive. In order to thrive in the competitive global market, the industries were forced to innovate better methodologies and models and equipment. Many strategies were tested and applied to make success in the market. Some of the strategies were replaced by other strategies. The maintenance is a strong stratergy used to compete in the market. The proper maintenance will improve the productivity of the industry, reduce the idle time of the machines in the industry. Maintenace done in a planned manner will increase the life of the machine. Failure mode effect analysis (FMEA) is a powerfull tool to estimate the maintenence level required in each machine. In the nonstick manufacturing industry, it uses mainly four machines for the production of the frying pan. The purpose of the FMEA analysis is to analyse the different failure modes of the machines in the industry and to categorise the different failure modes according to the risk associated with each failure mode. The improved maintenance will produce defect free and quality product. No specific published record considering FMEA in a Non stick manufacturing industry have been found till now. FMEA method helps in redusing the risk associated with failure modes by taking essential corrective actions.

In this paper FMEA is applied to the machines used for the production of the frying pan. Common failure modes are identified and corrective actions are recommended to reduce the probability of occurring of failure modes.

2. NON STICK FRYING PAN

Frying pan is a flat bottomed cooking utensil which is used for frying and browning foods. There are many varieties of frying pans. Some does not have coating. Some pans have nonstick coating. Some use hard anodized layer of non-stick coating. Customers prefers the non-stick frying pan because it is very easy to cook the food with less use of oil, easy cleaning of the utensils, supports uniform distribution of heat. Frying pans are made in variety of materials. Aluminum is the most common material used for the manufacturing of frying pans. Nowadays non-stick frying pans find a large demand in the market due to its non-stick property. The machines used for the production of the frying pan is roller machine, Heat treatment apparatus, presser machine and riveting machine. The machines experience some failures, which may cause down time and time wastage.

3. Failure Mode Effect Analysis (FMEA)

FMEA is a powerful preventive method for risk management, which aims in eliminating potential failures associated with each component of a machine. FMEA is used to identify potential failure modes, determine their effect on the product manufacturing, and suggest actions to avoid the failures. Since FMEA method is based on finding, prioritizing, and minimizing the failures, it has been widely used in many industries. FMEA was first used in the 1960‟s in the APOLLO missions. Later the automobile industry used FMEA widely to reduce risks related to the poor quality.FMEA is broadly used as a reliability tool which is used to recognize failures that are likely to happen. Thus it aims in reducing the risk in the manufacturing. Failure mode and effect analysis is a"bottoms up approach"that essentially divides the manufacturing process into steps, and then detects the potential failures at each step. Compared with other analysis method, the main advantage of the FMEA analysis is that it is a quantitative analysis. Levent Kurt and Sibel ozilgen et al[2] conducted a Failure mode and effect analysis for dairy product manufacturing and Implementation of the recommended actions appeared to have reduced the RPN values below the acceptable limit. It has been widely used by manufacturing companies for quality and safety assurance. FMEA is based on finding, prioritizing and minimizing different types of failures. In the FMEA methodology, potential risks of the processes are detected and assessed in every step by assigning values for frequency of each failure (O), seriousness of the failure (S) and possibility to detect the failure (D) before consumption. A Risk Priority Number (RPN) is calculated for each failure mode by multiplying the three determined values (O S D). The calculation of the RPN is studied from the study conducted by Hamid Reza Feili et al [1].

Table -1: Severity rating scale

Rank of severity	Description
1-2	Failure is of such a minor one that has negligible effect on the system performance
3-5	Failure will result in slight deterioration of the system function
6-7	Failure will result in operator dissatisfaction or may cause deterioration of the system performance
8-9	Failure may result high degree of operator dissatisfaction and cause malfunction of the system
10	The failure will result major damage or safety problem

Table -2: Occurrence rating scale

Rank of occurrence	**Description**
1	A negligible probability of occurrence
2-3	A small probability of occurrence ranging between 0.001 and 0.01
4-6	An occasional probability of occurrence between 0.01 and 0.10
7-9	An occasional probability of occurrence between 0.10 and 0.20
10	A high probability of occurrence of above 0.2

Table -3: Detection rating scale

Rank of detection	**Description**
1-2	Very high chance of detecting the failure
3-4	High probability of detecting the failure
5-7	Moderate chance of detecting the failure
8-9	Low probability of detecting the failure
10	Very low or zero chance of detecting the failure

Severity refers to the intensity of the failure in the production process i.e. severity rating of 10 refers to a major damage or safety problem. The details of the severity rating are shown in the table.1. Occurrence refers to the probability of a failure to occur during the production process. The occurrence rating is described in the table.2. Detection stands for the likelihood to detect the failure. A detection rating of 1-2 refers a condition of open condition, or a failure which will indicate its initial failure through noise or color etc. The detailed rating criteria for detection are described in the table.3. The severity, occurrence and detection factors are ranging from 1 to 10. All external and internal factors, parts of the machines are identified from the literature survey and field study. The literature survey including books and online links has been considered. In order to collect data and to get expert opinion, questionnaires and discussion with the operators and production manager is considered. The FMEA tables for the four machines are made and corrective actions are recomended (Table.4-7).

4. RESULTS

FMEA analysis was made on the machines in the industry. The RPN number was found for each failure in the four machines namely Roller machine, Heat treatment machine, Presser machine and Riveting machine. The failure modes with high RPN number should be maintained and monitored.

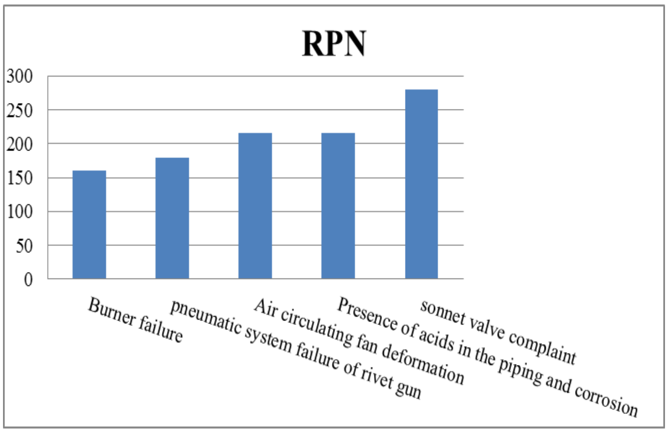

Fig -1: Top 5 RPNs

These failures should be given more importance. In the case of roller machine, the highest RPN number obtained is for “worn out of bushes” with RPN number of 150. The second important failure in the roller is “brush failure of the motor” with RPN number of 144. In the case of heat treatment machine, the highest RPN number is for “Sonnet valve complaint” with a RPN number of 280. The second important failure in the heat treatment machine is “Burner coil complaint” with RPN number of 160. In the case of the presser machine, the highest RPN number is for “worn out bushes in arms of the presser” with RPN number of 150. In the case of riveting machine the highest RPN is for “Accumulation of water in the compressor storage tank” with RPN of 216. The second priority is for “washer blockage in the rivet gun cylinder” with RPN of 180. Actions were recommended for each failure for better performance of the industry. Fig.1 shows the top failure modes with high RPN.

Table -4: FMEA table for roller machine.

Compo nent	Failure	Effect	Cause	O	S	D	Recommended action	RP N
Clutch	Breakage of clutch	Stoppage of the rollers, Downtime.	Wrong thickness of the sheet.	2	4	2	Replace the clutch	16
Gear box	Rough meshing of gears.	Increase in friction and decrease the smoothness of working	Improper oiling of the components	3	5	4	Proper lubrication of the gears.	60
Roller cylinde r	Dull and rough surface of the roller and change in diameter	Reduces the finishing of the aluminum plates.	Due to the presence of impurities in the sheet.	4	7	3	Skillful polishing with emery papers.	84
Bush	Worn out bushes	Vibration and unsteady rotation of the rollers	Lack of lubrication and entrapment of dust.	6	5	5	Replace the bushes.	15 0
Motor failure	Damage of carbon brushes	It will produce spark and damage the armature.	Wear and tear produced by the daily usage	4	6	6	Replace the brushes	14 4
V-Belt	Belt slipping	Squealing sound. Low efficiency.	Wear	5	4	3	Replace the belt	60

Table -5: FMEA table for Heat treatment apparatus

Component	**Failure**	**Effect**	**Cause**	**O**	**S**	**D**	**Recommended action**	**RPN**
Burner	Damage of firing coil	No firing of gases is made. Thus no heating of air.	The increase in hardness of the wire due to the hot temperature.	5	8	4	Replace the firing coil	160
Belt of the motor	Belt slipping	Sound and noise. Low efficiency and low power transmission	Heat and contamination	4	5	3	Replace the belt.	60
Non return valve	Fails to close in one direction	Fire and explosion	Breakage of diaphragm and Improper seating- due to the foreign material contamination and corrosion	2	10	4	Employ more number of non-return valve in the pipeline. Replace the damaged valve immediately.	80
Air passage gaps	Blockages in air passage gaps	Heat air is not circulated efficiently to every part	Contamination	6	6	3	A planned cleaning of the passage gaps.	108
Air circulating fan	Deformation of the fan blade	Sound and noise. Rough working of the fan.	High temperature of the surrounding.	9	5	3	Replace the fan blade.	135
Motor	Damage of the carbon brushes	Low current supply and sparks are produced which may damage the armature	Carbon brushes worn out	6	5	5	Replace the carbon brushes.	150
Automatic firing relay	Electrical failure	No firing or ignition is produced	Due to the voltage fluctuation	8	5	3	Replacement of the relay	120
Sonnet valve	Mechanical failure	The air and gas mixture is altered. This may cause overheating.	Due to the presence of contaminants in the valve seats.	5	7	8	Replace the sonnet valve	280

Table -6: FMEA table for Presser machine

Component	Failure	Effect	Cause	O	S	D	Recommended action	RPN
Oil circulating system	Contaminated oil	Less supply of oil in to the bushes. Increases the friction in the bushes.	Due to the presence of dust particles in the oil	4	6	6	Change the engine oil.	144
	Loss of oil	Vibration of moving parts resulting in wear and tear.	Leakage of oil through moving cylinders through small clearance.	2	6	4	Change the oil.	48
	Pumping motor fails	Lubrication of the moving parts resulting in the deterioration of the moving parts.	Electrical failure and damage of carbon brushes.	4	5	2	Replace the carbon brush. Design a robust electrical wiring.	40
Clutch plate	Fails in power transmission	Decreases the efficiency. Low power to the punch arm.	Wear and tear	3	5	4	Replacement of the clutch plate.	60
Bushes in arms	Worn out bushes.	Non uniform pressure distribution resulting in damage to the utensils and die.	Lack of oiling	6	5	5	Replacement of bushes.	150
Belt of the motor	Belt slipping	Power loss and low efficiency. Noise.	Excessive heat and contamination	5	5	2	Replace the belt.	50
Motor drive	Damage of the carbon brushes	Burnt smell and sparks that lead to damage of armature.	Wear and tear	4	6	6	Replace the carbon brush	144
Electrical supply	Relay becomes open all the time.	The machine becomes idle.	Contamination and mechanical wear.	2	3	2	Protect the relay from dust	12

Table -7: FMEA table for Riveting machine

Component	**Failure**	**Effect**	**Cause**	**O**	**S**	**D**	**Recommended action**	**RPN**
Spring in the rivet gun	The loss of stiffness of the spring	The rivet gun could not be uplifted to the open position automatically.	Wear and tear.	2	4	6	Replace the spring	48
Punch	Breakage of the punch	Downtime- replacement of the punch	Due to the absence of the rivet between the punch.	2	6	2	Replace with a new punch	24
Pneumatic system	The washer in the cylinder gets locked	The riveting movement is stopped.	Accumulation of water droplets from the compressor.	6	5	6	Drain the water from the compressor before the use.	180
Compressor	Accumulation of water in the storage tank	Produces acids in the piping and thus initiates corrosion	Improper draining	6	6	6	Design such a way that the water trap is at the lowest position and drain the water before the use daily.	216
	Electrical failure	Damages the motor, Down time	Power surge	2	6	4	Redesign the electrical system with surge protectors.	48
	Belt slipping	Loss of efficiency, noise	Excessive heat and contamination.	5	5	4	Replace the belt	100

The failure mode with highest severity was the complaint of the non-return valve. The failure of non-return valve may lead to explosion, which is a dangerous failure, which results in loss of life and property. The failure modes with high severity are shown in the fig.2. The failure mode with high chance of occurring was the deformation of the Air circulating fan in the heat treatment machine. The blades of air circulating fan was made of aluminum and was likely to deform. It was seen that the blades were replaced in every 4 weeks in average. The failure modes with top frequency are shown in the fig.3

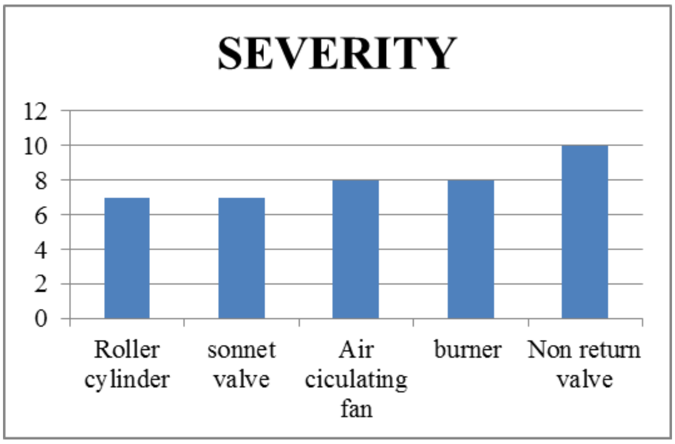

Fig -2: Top failure modes depending on severity

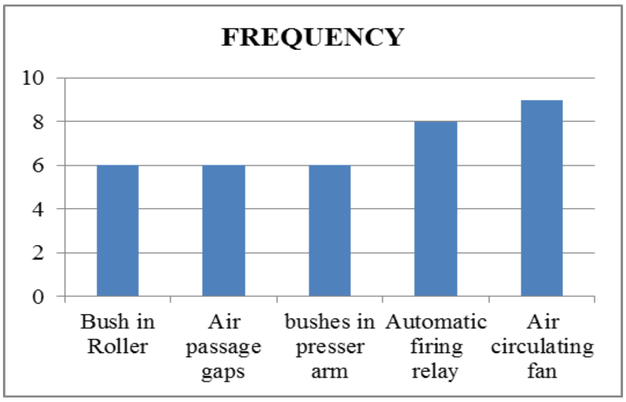

Fig -3: Top failure modes depending on frequencies

5. CONCLUSIONS

It is very important to prevent the failures before the failure happens. Risk analysis was carried out in the machines of the frying pan manufacturing industry using FMEA. The main purpose of the FMEA analysis is to quantify the risk associated with each failure mode by determining the RPN. The RPN values should be minimum always. The RPN value below 100 is always acceptable. FMEA is used to focus on the prediction of possible failure modes and avoid the potential failures during the production process involved in the manufacturing of the frying pan. Thus FMEA analysis was implemented for the machines in the industry. The RPN number was found for each failure in the four machines namely Roller machine, Heat treatment machine, Presser machine and Riveting machine. The critical failure mode was determined for each of the machine. The failure mode with high RPN value should be considered as important. The highest RPN number is for "Sonnet valve complaint" in the heat treatment machine with a RPN number of 280. Similarly the failure mode with least RPN value was relay failure in the presser machine, which has a RPN value of 12. Consequently recommended actions for all failure modes have been shown in the FMEA table.

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