Preventive Maintenance of Utility Equipments at MANMUL, Gejjalagere Mandya

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Abstract-*The need for an adequate maintenance strategy has been perceived as a very important and essential for reducing operational and maintenance costs, especially when the equipment increases in size and complexity. Selection of an appropriate and adequate maintenance and its frequency is considered to be vital for failure free operation of plant equipment maintenance in process industries, particularly in Dairy Industry.In this present work mathematical model is applied to determine the optimal inspection frequency based on stochastic failures under preventive maintenance. Mean time to repair and mean inspection time are fitted to compute optimal inspection frequency of utility equipments such as boilers and compressors based on actual breakdown details and maintenance information obtained from the plant.Implementing the inspection model obtained can reduce the frequency of failures and will extend the useful operating time of the plant equipments*

Keywords:*MTTR, MTTI, OIF, PM*

1. INTRODUCTION

Preventive Maintenance also termed as planned or scheduled or systematic maintenance. It is extremely important function for reduction of maintenance cost and to keep machines in good operating condition, it aims to locate the source of trouble and to remove them before breakdown occurs. Preventive Maintenance (PM) is a time-based procedure where maintenance actions are performed on a pre-determined, periodic basis. PM involves the repair, replacement, and maintenance of equipment in order to avoid unexpected failure. The objective of any PM program is to minimize the total downtime due to inspection and repair. The conventional approach in PM is based on the use of reliability and statistical analysis of equipment failure. Under statistical-reliability (S-R) based PM, the minimum down time objective is pursued by establishing a “optimal” PM interval at which the equipment or system can be replaced or overhauled.

1.1 Methodology of Work

- Study the utility equipment and its accessories working condition.
- Collecting the breakdown details for past years.
- Analysis of the historical data by considering the equipment and the sub equipment.
- Final analysis of the tabulated data: Inspection is an integral part of preventive maintenance program, the optimal inspection frequency is achieved by using “MATHEMATICAL MODELS” based on the analysis of the breakdown details of the equipments.
- Find out the minimization of breakdown by using mathematical models.
- Corrective action according to failure data.

2. OPTIMAL INSPECTION FREQUENCY (OIF) FOR TO MINIMIZE THE DOWNTIME

2.1 Assumptions

Assumption for construction of model

- The machine failure follows a bath tub curve.
- The failure of the equipment follows exponential distribution
- Equipment breakdown according to the -ve exponential distribution and the

- Breakdown rate reduces exponentially with respect to time

2.2 Construction of Model

The objective is to determine ‘n’ so as to minimize the total downtime in operating the equipment.

The total downtime/unit time in operating the equipment is a function of ‘n’ Inspection

Frequency denoted by D (n).

D (n)= Downtime occurred due to repair per unit time+ Downtime incurred due to inspection per unit time.

a. Equipment failure occurs according to the negative exponential distribution Let Mean time to failure = $1/\lambda$
b. The repair time are negative exponential distribution with Mean time to repair = $1/\mu$
c. The inspection time are negative exponential distribution with Mean time to inspection = $1/i$
d. The breakdown rate of the equipment λ is a function of n illustrated in figure

λ_0 → breakdown rate if no inspection is made

λ_1→ breakdown rate if one inspection is made

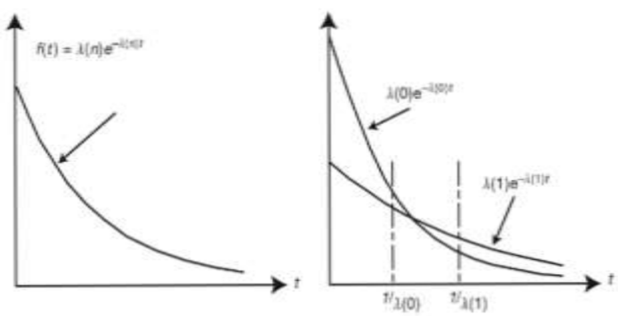

Fig- 1: Breakdown Rate as a Function of Inspection Frequency

I. Downtime due to repair = No. of repair/unit time X Mean time to repair.

= λ (n) x $1/\mu$

II. Downtime due to inspection = No. of inspection/unit time X Mean time to inspection.

= n x 1/i

$D(n) = \frac{\lambda(n)}{\mu} + \frac{n}{i} + \cdots$ (1)

This is the equation of the model, which relates the downtime with the No of inspection n to Total downtime D (n)

To get an appropriate solution to this we assume D (n) to be a continuous function of “n” and differentiate the above equation with respect to ‘n’ and equate to zero.

$$\frac{dD\ (n)}{dn} = \frac{\lambda'(n)}{\mu} - \frac{1}{i} = 0$$

$\lambda'(n) = -\frac{\mu}{i}$ … (2)

The optimal value of 'n' is the value of 'n' which makes the LHS of equation (2) equals to RHS

Assuming the breakdown inversely varies with number of inspections

$$d[\lambda(n)] = \frac{1}{n}$$

$$\lambda(n) = \frac{k}{n}$$

$\lambda'(n) = -\frac{K}{n^2}$ (3)

where,

K: Arrival rate of breakdown when one inspection is made per unit time

Equate (2) and (3), then we get,

$$-\frac{\mu}{i} = -\frac{K}{n^2}$$

$n^2 = \frac{i}{\mu} \text{ x } K$

n = $\sqrt{Kx\frac{i}{\mu}}$……… **For minimizing the downtime….** (4)

3. UTILITY EQUIPMENTS FOR PREVENTIVE MAINTENANCE

In this paper, the utility equipments selected from the Dairy Industry for Preventive Maintenance are:

1. Industrial Boiler
2. Ammonia Compressor
3. Air Compressor

1. Industrial Boiler

Fig - 2: Three pass fire tube Boiler

Boiler in Dairy Industry is used to produce high Quality Steam for a variety of processes to promote chemical reactions and physical changes in raw milk and help to maintain clean sterile conditions.

2. Ammonia Compressor

Fig- 3: Single Stage *Ammonia Compressor*

Ammonia compressor is used for various cooling purposes in Dairy Industry, Ammonia based compressor are low pressure systems with very less sophistication.

3. Air Compressor

Fig -4: Single Stage Screw Type Air Compressor

Air Compressor in Dairy Industry is used for Cleaning the pumps and piping that move milk through the facility Creating the vacuum suction in some types of milking machines Creating an air stream to clear debris and dust from delicate machinery.

4. DATA COLLECTION AND ANALYSIS

In this, an attempt is made to assess how badly the components of utility Equipments is performed for a period of five years of time

Table 1: Breakdown details of the Boiler

Name of the Part	Downtime in hours	Frequency of Failure
Blower Motor	10.5	6
Preheater	32	3
Main steam stop gland	6.5	9
Boiler Nozzle and Filter	1	3
Mobrey	2.9	2
Feed Drop Motor	6.58	5
Steam Line	57	7
Feed Water Pump	1.25	2
Furnace Oil Pump	2.33	2
Flue Chamber & Refractory	76.5	3

Maintenance records were reviewed and the breakdown and maintenance information are obtained for determining optimal inspection frequency. The optimal inspection frequency based on down time computed using the model described by equation (4)

Table 2: Optimal Inspection Frequency for the parts of Boiler

Sl no.	Nature of Breakdown	Arrival rate of Breakdown/year K	Mean Repair time in years $1/\mu$	Mean Inspection time in years 1/i	Optimal number of inspections/year $n = \sqrt{Kx\frac{i}{\mu}}$
1	Blower Motor Breakdown	1.2	1.99×10^{-4}	0.60×10^{-4}	2
2	Preheater Problem	0.67	18.26×10^{-4}	1.71×10^{-4}	3
3	Main steam stop gland filter Problem	1.8	0.93×10^{-4}	0.19×10^{-4}	3
4	Boiler nozzle and filter Problem	0.6	0.57×10^{-4}	0.15×10^{-4}	2
5	Mobry Problem	0.4	1.67×10^{-4}	0.28×10^{-4}	2
6	Feed drop Motor Problem	1	1.5×10^{-4}	0.38×10^{-4}	2
7	Steam line Leakage	1.4	9.3×10^{-4}	2.28×10^{-4}	3
8	Feed water Pump Problem	0.4	0.72×10^{-4}	0.20×10^{-4}	2
9	Furnace oil Pump Problem	0.4	1.33×10^{-4}	0.19×10^{-4}	2
10	Flue Chamber and refractory Problem	0.6	30.25×10^{-4}	4.56×10^{-4}	2

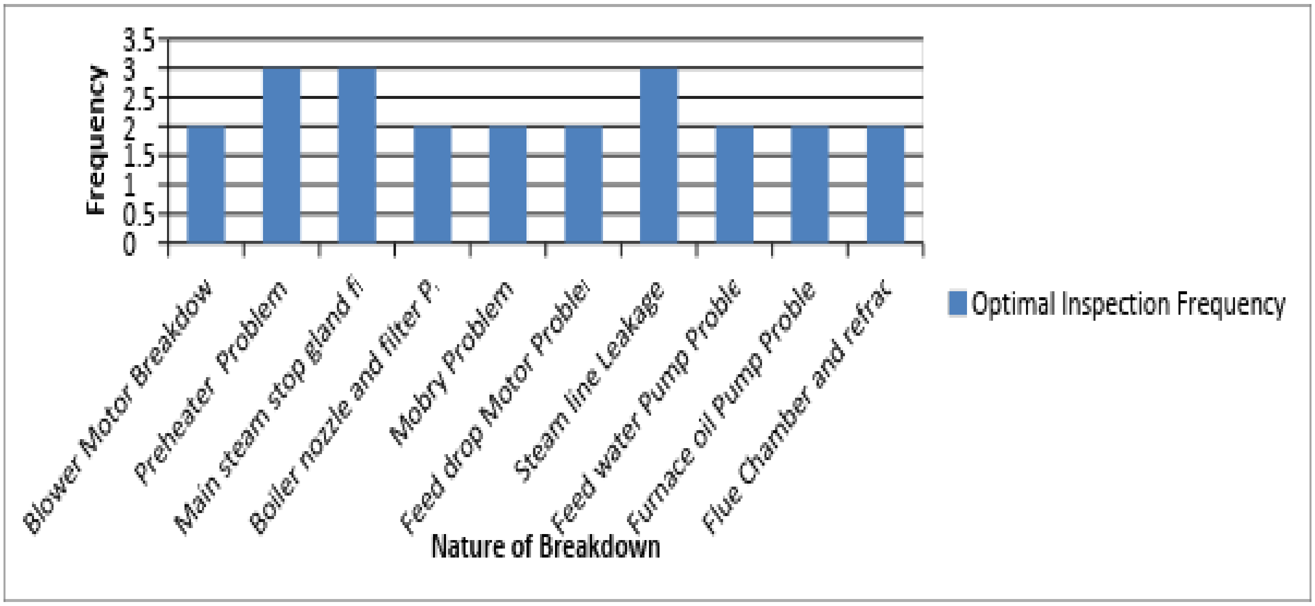

Fig- 5: Graphical representation of Optimal Inspection Frequency of Boiler

Table 3: Breakdown details of the Ammonia Compressor

Name of the Part	Downtime in hours	Frequency of Failure
Compressor Oil	23.5	7
Air Filter	6.5	3
Shaft Seal	120	2
Piston rings, channels & Gaskets	100	2
Unloader Valve	5	2
Coolers	76	2
Non-Return valve	6	3
Suction Valve	7	1

Table 4: Optimal Inspection Frequency for the parts of Ammonia Compressor

Sl no.	Nature of Breakdown	Arrival rate of Breakdown/year K	Mean Repair time in years $1/\mu$	Mean Inspection time in years 1/i	Optimal number of inspections/year $n = \sqrt{Kx\frac{i}{\mu}}$
1	Compressor oil level low	1.4	3.82×10^{-4}	0.38×10^{-4}	4
2	Air Filter Problem	0.6	2.47×10^{-4}	0.38×10^{-4}	2
3	Shaft seal worn out	0.4	68.49×10^{-4}	2.28×10^{-4}	4

4	Worn out piston rings, channel and gasket	0.4	38.05×10^{-4}	2.28×10^{-4}	3
5	Unloader valve Problem	0.4	43.33×10^{-4}	2.85×10^{-4}	2
6	Cooler Problem	0.4	65.06×10^{-4}	21.6×10^{-4}	3
7	Non-return valve Problem	0.6	2.28×10^{-4}	0.41×10^{-4}	2
8	Suction valve Problem	0.2	7.90×10^{-4}	0.57×10^{-4}	2

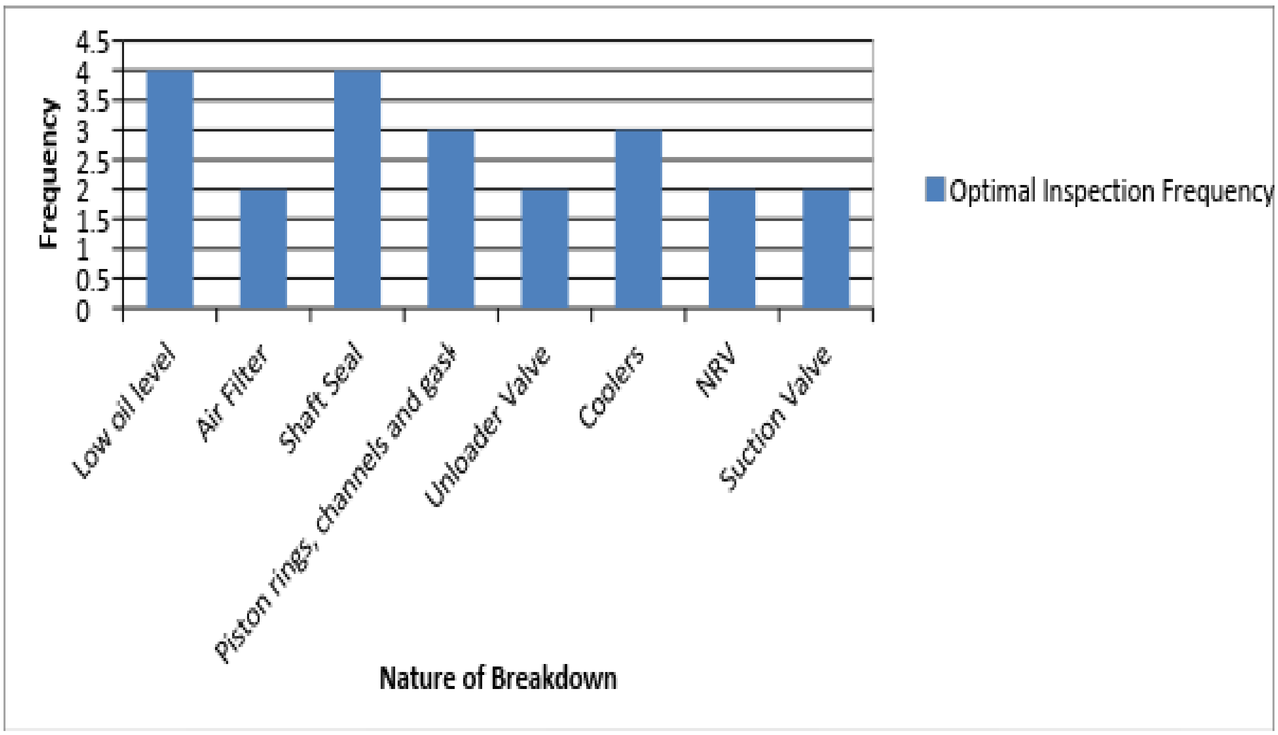

Fig - 6: Graphical representation of Optimal Inspection Frequency of Ammonia Compressor

Table 5: Breakdown details of the Air Compressor

Name of the Part	**Downtime in hours**	**Frequency of Failure**
Suction and Discharge Valve	68	8
Non-Return Valve	7.5	4
Compressor Oil	10.75	4
Spring Set	6	1

Table 6: Optimal Inspection Frequency for the parts of Air Compressor

Sl no.	Nature of Breakdown	Arrival rate of Breakdown n/year K	Mean Repair time in years 1/μ	Mean Inspection time in years 1/i	Optimal number of inspections/years $n = \sqrt{Kx\frac{i}{\mu}}$
1	Suction and discharge valve problem	1.6	9.7×10^{-4}	2.47×10^{-4}	3
2	Non-Return valve Problem	0.8	2.14×10^{-4}	0.47×10^{-4}	2
3	Oil level Low	0.8	3.08×10^{-4}	0.38×10^{-4}	3
4	Spring Set Problem	0.2	6.84×10^{-4}	0.19×10^{-4}	3

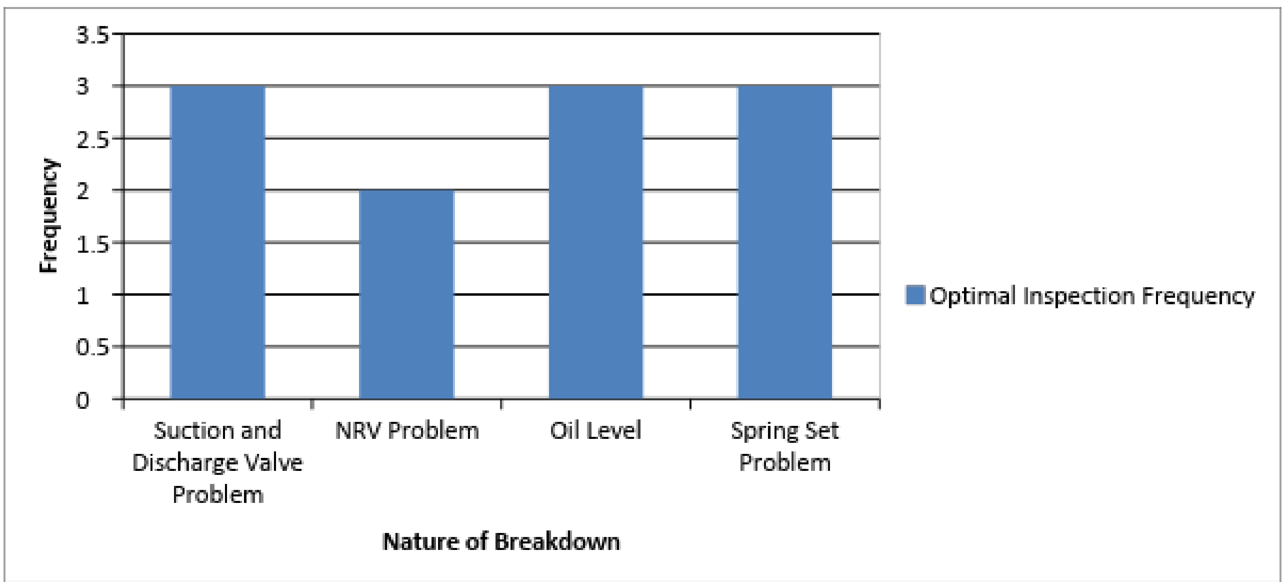

Fig- 7: Graphical representation of Optimal Inspection Frequency of Air Compressor

5. CONCLUSIONS

- A fair estimate of inspection frequency has been derived considering MTTR, MTTI and breakdown details.
- The Optimal Inspection Frequency obtained for Boiler Blower Motor is 2, Boiler Preheater is 3, Boiler Main Steam stop gland is 3 and overall optimal number of inspections to be carried out for Boiler is 23.
- The Optimal Inspection Frequency obtained for Ammonia Compressor Air Filter is 2, Ammonia Compressor shaft seal is 4, Ammonia compressor Piston rings, channels & Gaskets is 3 and overall optimal number of inspections to be carried out for Ammonia Compressor is 22.

- The Optimal Inspection Frequency obtained for Air Compressor Suction and discharge valve is 3, Air Compressor Non-Return valve is 2 and overall optimal number of inspections to be carried out for Air Compressor is 11.

- The scheme has been proposed based on the present work that allows the management of MANMUL to switch over from existing Breakdown Maintenance policy to Preventive Maintenance policy based on Optimal Inspection Frequency and also by implementing this model, helps in increasing the availability and reducing the downtime of the utility equipments

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