RISKS PRIORITIZATION USING AHP METHOD -A CASE STUDY

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Abstract - *In this paper, the system of the power plant has been investigated as a special type of industrial systems, which has a significant role in improving societies since the electrical energy has entered all kinds of industries, and it is considered as the artery of modern life. The electricity power generation plays the important role of every business or industrial, since it must be supplied to cove with the full consumption on demand sites. A survey has been conducted to identify the chances of failures of various machinery/ equipment which may occur in thermal Power Plant at Jaiswal Neco Industries Limited, Raipur. Many factors for failure are come to be known, out of which some major critical factors are identified for which AHP analysis is conducted. Failure Modes and Effects Analysis (FMEA) is methodology for analyzing potential reliability problems early in the development cycle where it is easier to take actions to overcome these issues, thereby enhancing reliability through design. A process or a design should be analyzed first before it is implemented and also before operating a machine the failure modes and effect must be analyzed critically. A comparative analysis of various risks factors reduces the chance of its occurrence. The main motive of this paper is risk Prioritization using AHP method, which are more severe for the Company.*

Key Words: **FMEA, AHP, Risk Prioritization**

1. INTRODUCTION

The analysis of potential failure modes of a system or a machine is an efficient method to evaluate system to increase system efficiency and increase of user safety. An important and practical technique to identify and rank potential and actual factors of failure is FMEA. By identification and ranking of error factors, we can eliminate or mitigate them and increase durability and reliability of system and reduce maintenance costs. The existing models of quality improvement focus on existing condition of elements in institutions and the most important elements are identified finally and this leads to quality improvement but the suitable approach is prevention of failures in system and besides reducing quality, loyalty and commitment of current customers are threatened severely and the application of goods and services can be stopped. Thus, it is required to identify these failures considered as failure to meet suitable quality level and to evaluate scientifically to pass the most sensitive stage for quality improvement. Risk management is a critical component of strategy development and execution, and a driver of firm success.

Maintenance is the crucial issue for the plant with highly complexity and a variety of machines such as thermal power plant, cement plant, oil refining plant and so on. The main of maintenance propose is to suppress the risky of plant suddenly shutdown with uncontrollable system. A thousand of equipments at each plant unit must be take care depending on maintenance policy such time based maintenance, break down maintenance etc. All equipments are mostly importance to be maintained in order to keep them working stability supposed with ill-conditioning operation.

Failure mode, effects and criticality analysis (FMECA) is the also most popular systematic assessment of a process (product) that enables us to determine the location and the mechanism of potential failures, with the aim of preventing process (product) failures. FMECA is characterized by a bottom-up approach by which any complex production system is decomposed into its constituent parts, which are successively analyzed to find all the potential failure causes and their effects.

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FMEA can be apply to recognize probable failure modes, conclude their effect on the process of the product, and categorize actions to diminish the failures. A vital step is anticipating what might go incorrect with a product.

Whereas anticipating each failure mode is not possible, the improvement squad ought to invent as extensive a record of likely failure modes as probable.

Case study

This paper is based on process FMEA which analyses the failure of Turbine auxiliaries and its effect on power generation of Power Plant. In this research the thermal power plant of Jaiswal Neco Industries Limited, Raipur is selected to analye the failure mode. The developed method can help the maintenance team for making decision in spare part management and it is friendly-user to pursuit the maintenance policy focused on critical maintaining equipments in overall systems. Some of the problem arised are:

1. **Problem in Heat Exchanger of Oil System of Turbine.**
   a. Remains high Thrust Pad temperature of Turbine Shaft.
   b. High Axial and differential expansion of turbine.
2. **Found high vibration in Turbine body.**
   a. Problem in Recirculation cooling water pump.
   b. Auxiliary power consumption of plant become high due to running of stand by pump.
   c. Increase in Steam consumption of turbine due to decrease in condenser vacuum.
   d. Exerts high pressure, due to running of standby pump, on oil cooler fins and reduce life of oil cooler.

Major Equipment in which problem has arised are:

OIL COOLERS

Normally two oil coolers of 100% capacity each are provided to cool entire oil supplied to turbine bearings, gearbox, and generator bearings for lubrication. Governing oil is not cooled at oil cooler. This oil is taken out before oil cooler. One cooler is put on line and another one is kept as standby. Online changeover facility is provided to take the standby cooler in to service while turbine is running without interruption of oil supply. Before changeover, it is to be ensured that the standby cooler is filled with oil and air is vented out properly. Otherwise there will be air lock and oil supply to bearings may interrupt.

SHAFT VIBRATION:

Vibration of the turbine indicates condition of turbine in running condition. Rotor rotates at high speed through set of journal bearings. There is little clearance in between rotating and stationary parts. Due to misalignment, disturbance in balancing, rubbing of moving part etc., rotor tends to vibrate. This vibration is supposed to be within permissible limit. Excessive vibration may damage turbine and lead to extensive maintenance.

THRUST PAD/ BEARING TEMPERATURE:

Journal bearings are used to take radial load of the shaft. But it can't axial load. Shaft is permitted to float to both axial float is restricted to certain limit. Excessive axial shift may damage rotating and fixed parts. For this thrust bearing are provided. Particularly in turbine, fluid film tilting pad type thrust bearing is used.

Due to friction heat is generated in journal bearing which is cooled by help of lubricating oil. At higher temperature, babbating material of the bearing can damage. So it is required to keep the bearing temperature within safe limit. For this, temperature of bearing is monitored continuously.

TURBINE BEARING TEMPERATURE:

Journal bearing is a cylinder which surrounds the shaft and is filled with lubricating oil. It consists of a split outer shell of hard metal and a soft metal at the inner cylindrical part. In this bearing a shaft or journal rotates inside the bearing over a layer of lubricating oil, separating the shaft and bearing due to fluid dynamics principle. This lubricating oil layer supports the shaft preventing metal to metal contact. Oil is pumped into the bearing through oil pump. When rotor rotates lubricating oil is drawn up around the journal due to hydro dynamic effect of lubrication. When lubrication is introduced between two surfaces of rolling contact, it creates a large increase in pressure. Some of the failure mechanisms are

1-Overload

2-Overheating

3-Fatigue

4-Erosion

COOLING WATER SYSTEM:

In a condenser cooling water is circulated to condense exhaust steam of turbine. Exhaust steam is having considerable amount of heat energy. This heat energy is required to be transferred to cooling water to condense steam. So the cooling water temperature rises. This cooling water is required to be cool down, again use it in condenser. This cooling is done at cooling tower. From cooling tower, cooling water is circulated through condenser by help of cooling water pumps. This exhaust steam is to be cool down to 41.2^{o}C.There are two types of cooling water circulation system. These are:

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1-Open or once through System

2-Closed system

COOLING TOWER:

Cooling tower is a structure in which hot water is made droplets with the help of nozzle to increase contact surface of water and allowed to come in contact with atmospheric air. Atmospheric air is having certain capacity to absorb water vapors at a given temperature. Water vapors is created due to evaporation of water heat is required. This heat is obtained from remaining water. So this remaining water is cooled as heat is heat is removed from it for evaporation. Rate of evaporation and hence drop in cooling water temperature depends upon following factors.

INDUCED DRAFT COUNTER FLOW COOLING TOWER:

A mechanical fan is located at top of the tower. Water is distributed throughout the area of tower and made droplets with the help of spray nozzles. Mist eliminators are placed above distributed pipe line and nozzle to restrict escape of vapor mist to atmosphere. Hot water is allowed to flow down to the basin by gravity. When fan is started atmospheric air is socked and enters through the louvers. This air moves up and comes in contact with downward droplets. It carries the heat of water and discharge to atmosphere through the fan. Flow of air and water is in counter direction. SO the temperature between the hot water and cool air is almost same throughout the mixing area. So this type of tower is thermodynamically most suitable. Cold water is collected in a basin from where water is drawn out for further use in condenser. This complete arrangement is called as a cell. Cells are connected side by side in parallel to meet the requirement of plant.

2. METHOD AND PROCEDURE

Analytic Hierarchy Process (AHP) is one of Multi Criteria decision making method that was originally developed by Prof. Thomas L. Saaty. In short, it is a method to derive ratio scales from paired comparisons. The input can be obtained from actual measurement such as price, weight etc., or from subjective opinion such as satisfaction feelings and preference. AHP allow some small inconsistency in judgment because human is not always consistent. The ratio scales are derived from the principal Eigen vectors and the normalized principal Eigen vector is also called **priority vector.** Since it is normalized, the sum of all elements in priority vector is 1. The priority vector shows relative weights among the things that we compare.

$$[\mathbf{W}, \lambda] = eig(\mathbf{A})$$

The largest Eigen value is called the Principal Eigen value, which is very close to our approximation (about 1% error). The principal Eigen vector is the Eigen vector that corresponds to the highest Eigen value. Thus the sum of Eigen vector is not one. When you normalized an Eigen vector, then you get a priority vector. The sum of priority vector is one. Prof. Saaty proved that for consistent reciprocal matrix, the largest Eigen value is equal to the number of comparisons, or $\lambda_{max} = n$. Then he gave a measure of consistency, called Consistency Index as deviation or degree of consistency using the following formula

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Again, Prof. Saaty proposed that we use this index by comparing it with the appropriate one. The appropriate Consistency index is called Random Consistency Index (RI).

He randomly generated reciprocal matrix using scale $\frac{1}{9}$, $\frac{1}{8}$, …, 1, …, 8, 9 (similar to the idea of Bootstrap) and get the random consistency index to see if it is about 10% or less. The average random consistency index of sample size 500 matrices is shown in the table below

Table 8: Random Consistency Index (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Then, he proposed what is called Consistency Ratio, which is a comparison between Consistency Index and Random Consistency Index, or in formula

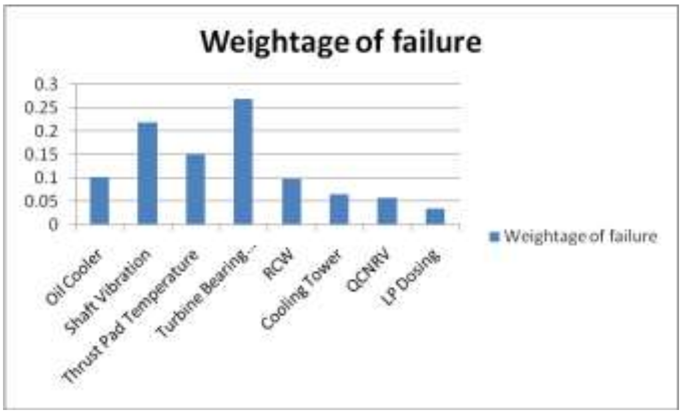
$$CR = \frac{CI}{RI}$$

If the value of Consistency Ratio is smaller or equal to 10%, the inconsistency is acceptable. If the Consistency Ratio is greater than 10%, we need to revise the subjective judgment.

Failures	Oil Cooler	Shaft Vibration	Thrust Pad Temperature	Turbine Bearing Temperature	RCW	Cooling Tower	QCNRV	LP Dosing
Oil Cooler	1	1/3	1/3	1/3	2	3	1	4
Shaft Vibration	3	1	3	1/3	3	3.00	4	4
Thrust Pad Temperature	3	0.333333	1	1/2	2	3	3	4
Turbine Bearing Temperature	3	3	2	1	3	4	4	4
RCW	0.5	0.333333	0.5	0.333333	1	3	3	3
Cooling Tower	0.333333	0.333333	0.333333	0.25	0.333333	1	3	3
QCNRV	1	0.25	0.333333	0.25	0.333333	0.333333	1	3
LP Dosing	0.25	0.25	0.25	0.25	0.333333	0.333333	0.333333	1
SUM	12.08333	5.833333	7.75	3.25	12	17.66667	19.33333	26

Failures	Oil Cooler	Shaft Vibration	Thrust Pad Temperature	Turbine Bearing Temperature	RCW	Cooling Tower	QCNRV	LP Dosing	weight
Oil Cooler	0.082759	0.057143	0.043011	0.102564	0.166667	0.169811	0.051724	0.153846	0.103441
Shaft Vibration	0.248276	0.171429	0.387097	0.102564	0.25	0.169811	0.206897	0.153846	0.21124
Thrust Pad Temperature	0.248276	0.057143	0.129032	0.153846	0.166667	0.169811	0.155172	0.153846	0.154224
Turbine Bearing Temperature	0.248276	0.514286	0.258065	0.307692	0.25	0.226415	0.206897	0.153846	0.270685
RCW	0.041379	0.057143	0.064516	0.102564	0.083333	0.169811	0.155172	0.115385	0.098663
Cooling Tower	0.027586	0.057143	0.043011	0.076923	0.027778	0.056604	0.155172	0.115385	0.06995
QCNRV	0.082759	0.042857	0.043011	0.076923	0.027778	0.018868	0.051724	0.115385	0.057413
LP Dosing	0.02069	0.042857	0.032258	0.076923	0.027778	0.018868	0.017241	0.038462	0.034385
SUM	1	1	1	1	1	1	1	1	

By now you have learned several introductory methods on multi criteria decision making (MCDM) from simple cross tabulation, using rank, and weighted score until AHP. Using Analytic Hierarchy Process (AHP), you can convert ordinal scale to ratio scale and even check its consistency.



3. CONCLUSION

A survey has been conducted to identify the chances of failures of various machinery/ equipment which may occur in thermal Power Plant at Jaiswal Neco Industries Limited, Raipur. Many factors for failure are come to be known, out of which some major critical factors are identified for which AHP analysis is conducted. From the survey conducted is it is found that Turbine Bearing Temperature, shaft vibration, problem in Cooling Tower are major concern which are to be taken in account.

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