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IMPROVING ROTATING EQUIPMENT PERFORMANCE FOR ENHANCEMENT OF RELIABILITY OF REFINERY UNITS – AN EMPIRICAL STUDY

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Abstract

Crores of money is being spent annually towards premature failure or untimely maintenance and repair of rotary equipments, thereby reducing the operating profit of the company. Rotating equipment and their components, seals, bearings, and couplings etc represent a major opportunity for improving their performance thereby contributing maximum towards plant reliability. Even though the unit are built with the latest API rotating equipments, additional plans for the improvement of reliability are a must. The paper aims to study and review the rotating equipments performance in terms of premature failure and development of plans for maximising the reliability of the unit. The focus of the study is to improve the Mean Time Between Failure (MTBF) of the rotating equipments to maximise the reliability of the refinery units. This paper attempts in a small way to document the promising results in increasing the MTBF of the rotary equipments thereby enhancing the reliability of the refinery units.

Keywords: - *Maintenance, Rotating equipments, Mechanical seals, Performance, Reliability, Refinery*

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1. INTRODUCTION

Considering today's slim operating margins and increased global competition, improvement in the equipment performance is of utmost importance. Unplanned shutdowns due to equipment failures and higher maintenance costs can seriously affect the bottom line of the company.

Crude Oil refinery contains thousands of rotary equipments that are subject to wear and tear over a period of time resulting in increased breakdowns and unit outages. Making equipment more reliable is all about extending the time between failures. Maintenance today plays a critical role in reducing equipment outages and improving reliability of the equipments. The reliability and availability of rotating equipments of a unit are crucial to refinery units for continuous operation thereby achieving the 100% capacity utilisation. Performance measurement of the rotating equipments plays an important and critical role in maintenance and is must to ensure the maintenance activities planned and executed have given the expected results. It supports the building of actions needed to attain equipments performance thereby contributing maximum towards plant reliability.

Thorough literature review reveals that the most of researchers have discussed about a particular maintenance approach such as Preventive Maintenance, Predictive Maintenance, linking performance with the maintenance strategy, application of specific maintenance techniques like Preventive Maintenance, Predictive Maintenance, RCM, CBM etc. However few researchers have discussed about the equipment performance and the proactive maintenance strategies leading to increased reliability of the equipments.

Reliability Analysis is a necessity when we want to maximise the operational plant availability and uptime. "Mean Time Between Failure" (MTBF) is a reliability term used to provide the amount of failures per million hours of an equipment.

As per Pintelon et al (2000) unplanned downtime is a function of the number of breakdowns within a specified time period and related measures such as mean time between failures (MTBF) and mean time to repair (MTTR). Wilson (1999) claims that MTBF and MTTR are the measures of equipment achievement and are related to objectives such as functional performance and process capability.

Rosqvist et al (2009) in their study has mentioned that equipment performance can be analyzed proactively by maintenance task of equipment (Preventive tasks and actions/Maintenance tasks), equipment reliability (Number of functional failures/Operational cycles of equipment) and equipment availability (Downtime/Operational period of equipment).

As per Swanson (2001) there is a strong positive relationship exists between proactive & aggressive maintenance strategies and also reliability of the unit can be improved by studying such relationship.

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As per Knezevic et al (1994) equipment history is one of the most required records having equipment details & its history of maintenance carried out on the equipment.

The paper provides comprehensive study on rotary equipment performance leading to the improvement in the reliability of the refinery unit.

2. ROTATING EQUIPMENT PERFORMANCE STUDY

The selection of maintenance strategy mainly depends on the cost of implementation versus expected reliability. The reactive maintenance techniques is the most costliest and least reliable. Preventive maintenance techniques being schedule based maintenance consume valuable times and resources that may not be required by the equipments. Predictive maintenance techniques are designed to assess the conditions of the equipment periodically to carry out maintenance. This approach will help in reduction of maintenance cost because maintenance will be carried out only when warranted

Rotating equipments like pumps motors, compressors, fans etc are critical to plant operations and failures of the rotating equipments can significantly affect plant production capacity. Deteriorating rotating machinery performance is mainly associated with bearing failures, seal failures, lubrication problems, misalignment issues etc. Early detection of these underlying problems and rectification can reduce maintenance costs, while increasing availability.

In order to study the rotary equipment performance and to enhance the reliability of the refinery unit, study of rotary equipments of one of the main refinery units has been carried out. Out of 228 pumps, the performance measurement, in terms of MTBF, of 103 pumps, which are critical in nature to the refinery unit and which impacts the production of the unit were carried out. Each pump failure history was studied in detail. The failure data considered for the study is from the year 2000 till 2017 i.e. 17 years. The results of only 19 pumps were tabulated for the purpose of this study.

The chart depicting the MTBF of such failures is as shown in fig-1.

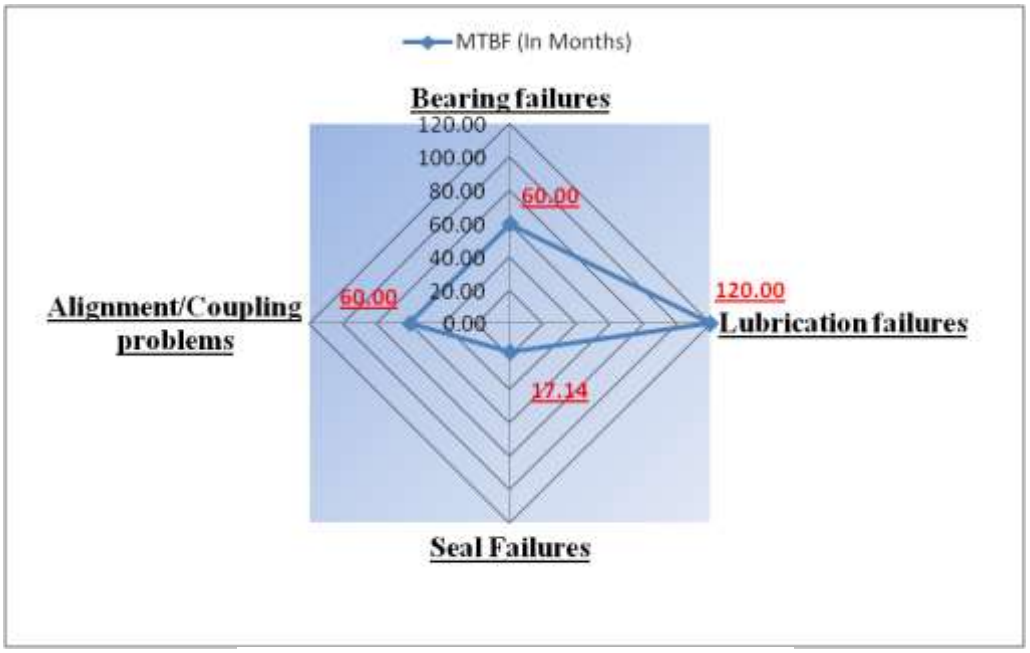

Fig-1: Chart depicting the MTBF of the equipments

As can be seen from the above chart, the MTBF for the seal is the lowest.

The pump mechanical seal is very susceptible to failure in the adverse operating conditions. The seal failures not only result in high maintenance costs and downtime, but also create safety and environmental hazards. It is impossible to define an exhaustive list of factors causing failure of mechanical seals. Based on the repetitive pattern of failures, it is possible to arrive at few factors that may help to address the issues thereby enhancing the reliability of the rotary equipments.

Considering the lowest MTBF with respect to the seal failures, an extensive study of the failures and the Root Cause Failure Analysis (RCFA) of each of the seals failed was carried out to analyse the causes for the failures. Based on the study of failures of each equipment, the preventive maintenance plans along with the schedule for the implementation for the individual rotary equipment were formulated. It may be noted here that, the PM plans along

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with schedule were specific to the individual equipments and was not generic in nature.

For the study, data with respect to seal failures from the year 2000 till 2017 were considered.

The typical PM plan with schedule for the a rotary equipment is as per the Table – 1

Table-1: Typical PM plans with schedule of rotary equipment of the refinery unit.

SL NO	PM PLAN NO	TAG NO	JOB DESCRIPTION
1	1007922	A	CLEAN SEAL FLUSHING LINES AND ORIFICES
2	1007923	B	CLEAN SEAL FLUSHING LINES AND ORIFICES
3	1007931	G	CLEAN SEAL FLUSHING LINES AND COOLING WATER LINES
4	1007932	H	CLEAN SEAL FLUSHING LINES AND COOLING WATER LINES

SL NO	PM PLAN NO	TAG NO	CYCLE (IN MONTHS)	SCHEDULING PERIOD (IN YEARS)
1	1007922	A	12	10
2	1007923	B	12	10
3	1007924	C	12	10
4	1007925	D	9	10
5	1007926	E	9	10

The notifications with respect to PM plans were generated in the SAP (enterprise application software) as per the scheduled cycle against the concerned equipments. Extensive reviews were conducted periodically to ensure that the PM plans scheduled be executed as per the schedule.

After the study, the comparison of the data from year 2000 to 2010 i.e. prior to the implementation of the PM plans as well as the data from the year 2011 to 2017 i.e. after the implementation of the PM plans with respect to the seal failures of the equipment tags is tabulated below as Table – 2

Table-2: Comparison of the data before and after implementation of PM plans

SI NO.	EQUIPMENT TAG NO	NO OF SEAL FAILURES YEAR 2000 TO 2010	MTBF (In Months) YEAR 2000-10	NO OF SEAL FAILURES YEAR 2011 TO 2017	MTBF (In Months) YEAR 2011-17	Overall MTBF (In Months) YEAR 2000-2017	% AGE INCREASE IN MTBF
1	A	4	30	1	72	41	36
2	B	2	60	1	72	68	13
3	C	1	120	1	72	102	-15
4	D	7	17	2	36	23	32
5	E	9	13	3	24	17	28
6	F	5	24	6	12	19	-23
7	G	2	60	0	72	102	70
8	H	1	120	0	72	204	70
9	I	9	13	2	36	19	39
10	J	2	60	2	36	51	-15
11	K	4	30	7	10	19	-38
12	L	2	60	0	72	102	70
13	M	4	30	1	72	41	36
14	N	4	30	0	72	51	70
15	O	7	17	0	72	29	70
16	P	7	17	2	36	23	32
17	Q	3	40	0	72	68	70
18	R	11	11	1	72	17	56
19	S	9	13	0	72	23	70

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The fig – 2 indicates the number of failures before and after the implementation of the PM plans. It is observed that the seal failures of the rotary equipment reduced drastically, thereby improving the performance of the equipment.

Fig-2: Chart depicting the number of seal failures before and after the implementation of the PM plans

The Fig- 3 indicates the MTBF of the equipments under study, before & after the implementation of PM plans.

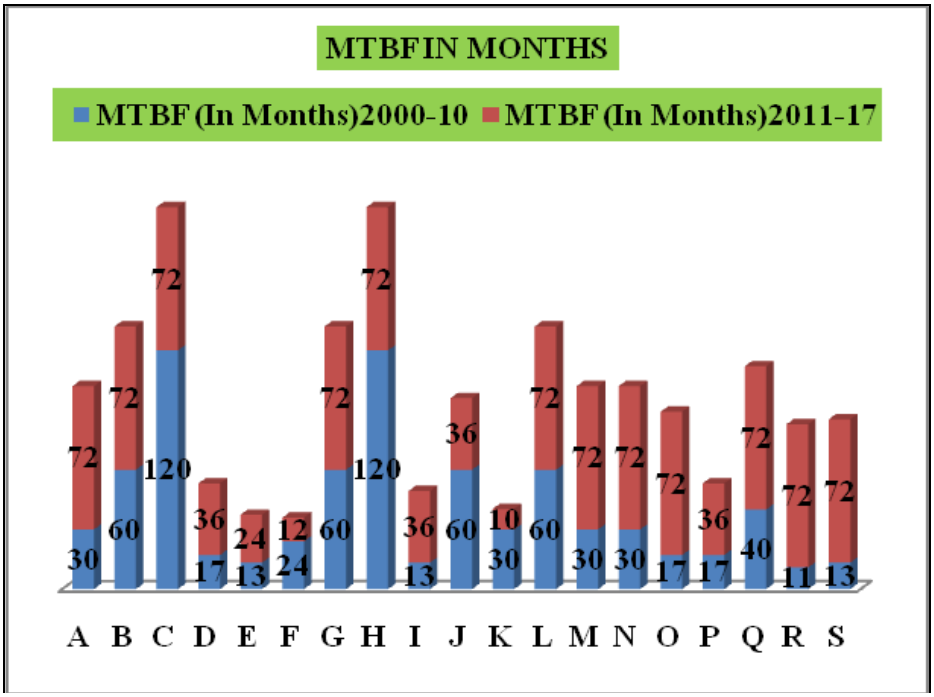

Fig-3: Chart depicting the MTBF of the equipments under study, before & after the implementation of PM plans

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The Fig- 4 indicates the percentage increase in the MTBF of the rotary equipments, It is observed that most of the equipments are having positive increase in MTBF

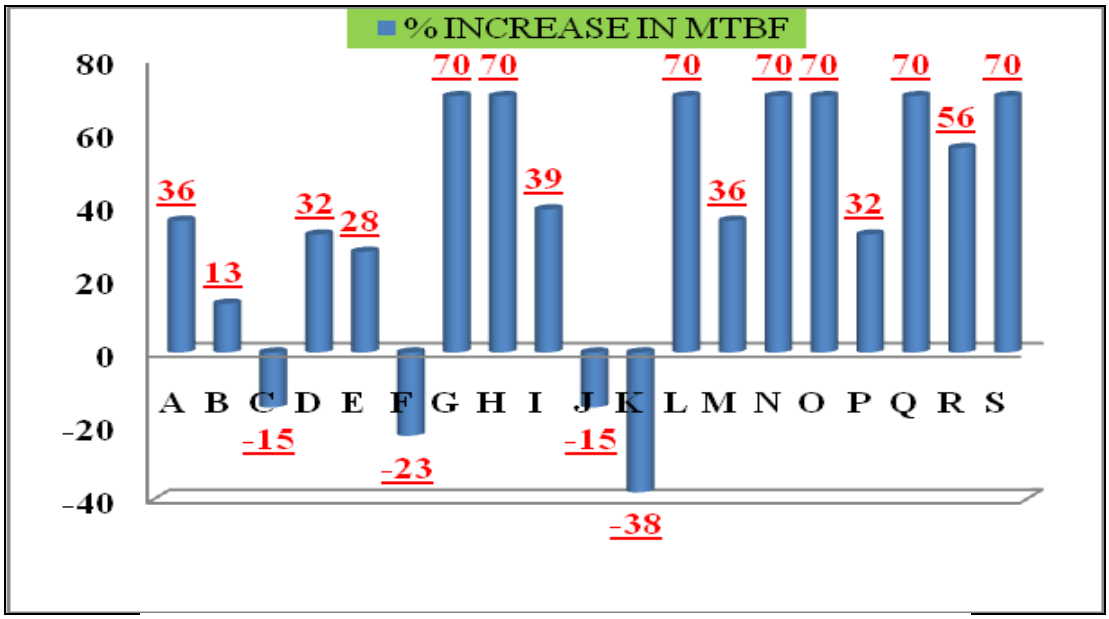

Fig-4: Chart depicting percentage increase in MTBF of the rotary equipments

As can be seen from the results, the actions initiated in terms of PM plans have yielded positive results in terms of increase in MTBF of the 80% of the pumps under study. Few pumps where MTBF has decreased have been assessed and corrective actions have been initiated after the study.

3. CONCLUSION

Knowledge is only effective if it is put into action. Enhancing the reliability of the seal requires focussing on improving the existing systems and conditions. It requires consistent efforts to implement the improvement concepts into reality thereby achieving the required results. Although initial efforts may seem high and lot of initial hiccups, but will result in improvement in the reliability of the seals. The study has shown that detailed study of seal failures of individual rotary equipments and actions implemented in terms of PM plans has yielded positive results in terms of increase in MTBF. This paper attempts in a small way to document the promising results in increasing the MTBF of the rotary equipments thereby enhancing the reliability of the refinery units.

LIMITATIONS OF THE STUDY

While analysing the results, the results of this study are promising. However further study of the rotary equipments of the other units of the refinery are still needed. Also, the design of the future study could be developed by considering the other failures, related to the bearings, couplings etc of the rotary equipments and can be carried out with a larger sample across the various refinery units.

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