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DEVELOPMENT OF AN EXPERT SYSTEM FOR DIAGNOSIS OF BEARING FAULTS OF ROTATING COMPONENTS IN A POWER PLANT

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ABSTRACT

Today era of machines influenced the maintenance engineer to upkeep equipment in good condition apart from this he needs to consider quality, reliability, safety and most essential productivity. This puts the Maintenance department to pick "Condition Monitoring" which is predictive kind of maintenance method for upkeep of a machine, which includes in identifying the initial issues present in machine ahead of time and gives time to fix them. The Vibration based monitoring of machine is highly effective due to its wide application and effective way to detect faults. It is used to evaluate condition of rotating like Boiler Feed Pump Trains, Turbines and Windmills. The present work highlights monitoring of Boiler Feed Pump and Turbine assembly health by analysing Tri-axial data. Considering the velocity as important parameter, the Tri-axial velocity in different directions are compared to limiting velocity for a particular speed approved from Indian Standard Organisation which are based on ISO 2372.Then based on conditions the possible faults can be predicted. Mode shapes for different shafts are generated from ANSYS. In order to reflect the above work an Expert system is developed in Java Jframe using Netbeans IDE. The Expert system which is named as EXSYSTEM is meant to take input as velocities in different directions and predict the possible faults along with remedial measures.

Keywords: vibration, condition monitoring, boiler feed pump train, turbine assembly, tri-axial measurements, displacement, velocity, acceleration, mode shapes and expert system.

1. INTRODUCTION

Condition monitoring and fault diagnosis is one of the possibly advantageous in terms of being multidiscipline, Problem solving so it is powerful as it aims with anticipating change and planning for it by linking strategies and procedures from various disciplines keeping in mind the end goal to change obsolete mentalities and practices effectively. Condition Monitoring and fault diagnosis is a novel idea which empowers us to distinguish ahead of time any partial failures of machinery effortlessly and trust in any part of a dynamic system before such partial failures turn to complete failures.

2. DESCRIPTION AND EXPERIMENTATION OF ROTATING COMPONENTS

2.1 Boiler feed pump train

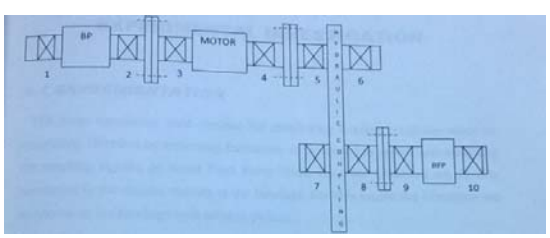

Figure-1. Boiler Feed Pump Train (BFPT).

The booster pump (BP), motor, coupling and boiler feed pump (BFP) are connected by flexible coupling and are supported by 10 journal bearings, shown in fig.

a) Booster pump non-driving end (BPNDE)

b) Booster pump driving end (BPDE)

c) Motor booster pump end (MBPE)

d) Motor boiler feed pump end (MBFPE)

e) Input shaft driving end (IPSDE)

f) Input shaft non-driving end (IPSNDE)

g) Output shaft motor end (OPSME)

h) Output shaft pump end (OPSPE)

i) Boiler feed pump shaft drive end (BFPDE)

j) 10. Boiler feed pump shaft non-drive end (BFPNDE).

The BFP train selected for the present investigation is a part of thermal power plant of large utility, Boiler feed pump is a multistage pump provided for pumping feed water to economizer. The high pressure BFP is a very expensive machine, the safety in operation and efficiency of the feed pump doesn't not only depend on the correct design and careful manufacturing in the works, but also reliable operation and maintenance.

2.2 Turbine assembly

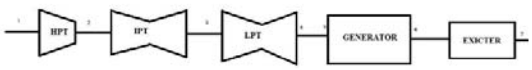

Figure-2. Turbine assembly (TA).

HPT - High Pressure Turbine
IPT - Intermediate Pressure Turbine
LPT - Low Pressure Turbine

The turbine is a tandem compound machine with HP, IP and LP parts. The HP part is a single-flow cylinder and the IP and LP parts are double-flow cylinders. The individual turbine rotors and the generator rotor are connected by rigid couplings. The HP cylinder has a throttle control. The initial steam is admitted before the blading by two combined main stream stop and control valves. The lines leading from the two HP exhaust branches to the reheater are provided with swing check valves which prevent hot steam from the reheater flowing back into the HP turbine. The steam corning from the reheater is passed to the IP part via two combined reheat stop and control valves. Cross around pipes connects the IP and LP cylinders. Bleeds are arranged at several points of the turbine.

Table-1. Experimentation for BFPT.

Month	Velocity direction(mm/sec)		
	Horizontal	Vertical	Axial
OCT	7.52	2.71	1.96
NOV	4.82	6.91	2.16
DEC	3.49	2.33	1.72
JAN	7.63	3.52	1.55
FEB	4.25	2.49	1.57
MAR	3.81	7.82	2.06

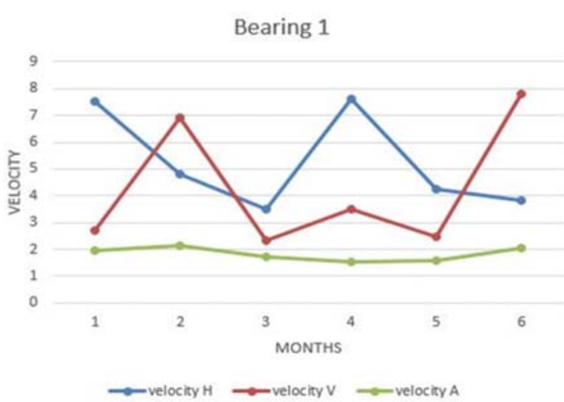

Figure-3. Velocity trend at bearing1 of BFPT over six months.

Table-2. Experimentation for turbine assembly.

Month	Velocity direction(mm/sec)		
	Horizontal	Vertical	Axial
APR	4.52	4.77	1.91
MAY	6.4	9.1	5.2
JUN	4.42	4.44	2.09
JULY	4.68	3.64	2.36
AUG	4.34	4.37	2.2
SEP	3.86	3.77	2.74
OCT	4.02	4.98	2.32
NOV	3.72	3.5	2.45
DEC	3.81	3.67	2.19
JAN	5.5	8.1	5.4
FEB	4.53	3.63	1.75
MAR	4	3.74	1.95

Figure-4. Velocity trend at bearing1 of TA over twelve months.

3. RESULTS AND DISCUSSIONS

3.1 Boiler feed pumptrain

The trends of Tri-axial measurements at bearing 1 which are present in table 1 and represented as a graph in Figure 3 where Months on X-axis and Velocity on Y-axis which is known as Time domain in Signature Analysis. It is observed in the month of January the velocity in horizontal direction is exceeding the permissible limits, where as in vertical direction and axial direction the velocity is well within the limits. The Reason behind excess vibrations is magnetic unbalance, cracked shaft and Improper Bearing Clearances, Where as in month of March the velocity in vertical direction is more than permissible limits where as in under limits in other directions the reasons for excess vibrations are loose pedestal and wiped Bearing. These faults can be nullified by checking shaft condition, balancing the booster pump shaft magnetically about its centre of rotation and checking proper Bearing clearances in January and check

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for bearing condition and bolts for the bearing housing are tight, by doing the above actions the velocity limits will be in acceptable in coming Months.

3.2 Turbine assembly

The Tri-axial measurements for bearing 1 are presented in table 2and represented as a graph in Figure 4. It is observed in May and January the velocity in the vertical direction is more than permissible limits whereas the velocity in axial direction and horizontal direction are well within the permissible limits. From this we can predict the faults might be loose pedestal or wiped bearing. So in order to get the velocity values under control it is necessary to check the bearing condition along with its fixtures.

4. MODE SHAPES

4.1 Boiler feed pump train

The modal analysis of boiler feed pump train is performed using ANSYS software. The mode shapes of boiler feed pump train are shown in Figures 5 and 6.

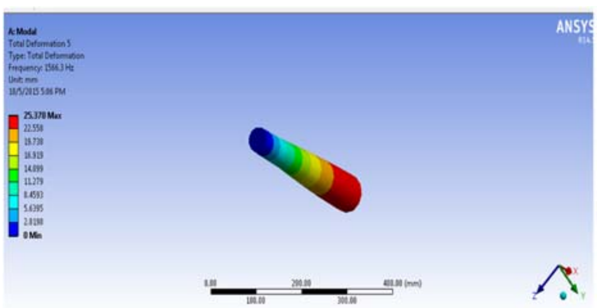

Figure-5. Mode Shape 5.

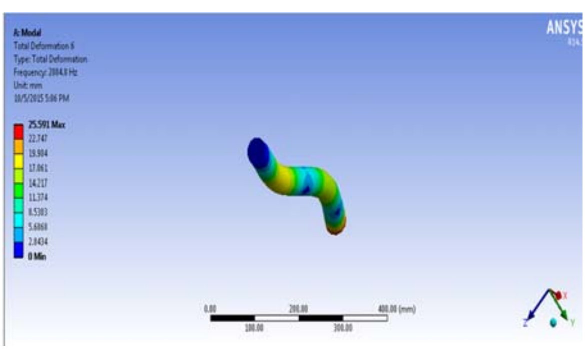

Figure-6. Mode Shape 6.

4.2 Turbine assembly

4.2.1 High pressure turbine shaft

The modal analysis of high pressure turbine shaft is performed using ANSYS software. The mode shapes of boiler feed pump train are shown in Figures 7 and 8.

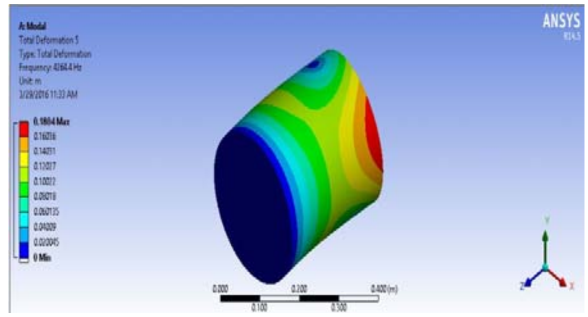

Figure-7. Mode Shape 5.

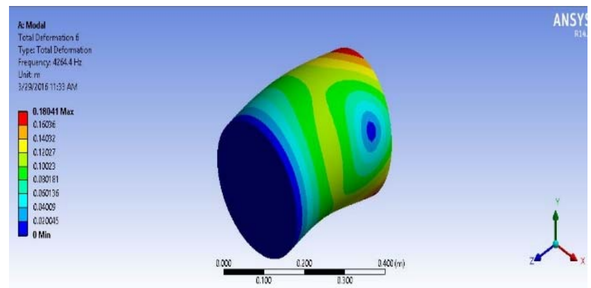

Figure-8. Mode Shape 6.

4.2.2 Intermediate pressure turbine shaft

The modal analysis of intermediate pressure turbine shaft is performed using ANSYS software. The mode shapes of boiler feed pump train are shown in Figures 9 and 10.

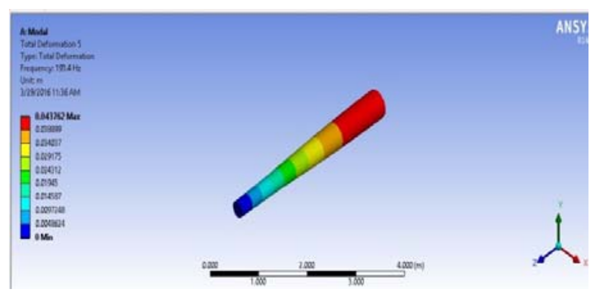

Figure-9. Mode Shape 5.

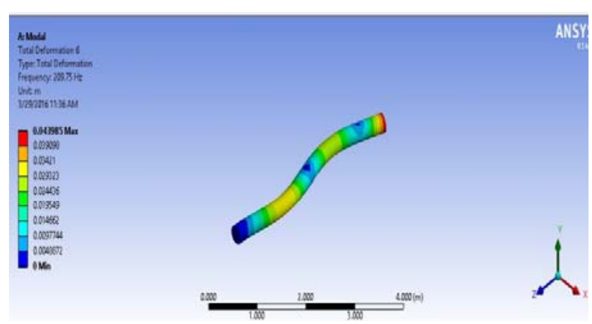

Figure-10. Mode Shape 6.

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4.2.3 Low pressure turbine shaft

The modal analysis of low pressure turbine shaft is performed using ANSYS software. The mode shapes of boiler feed pump train are shown in Figures 11 and 12.

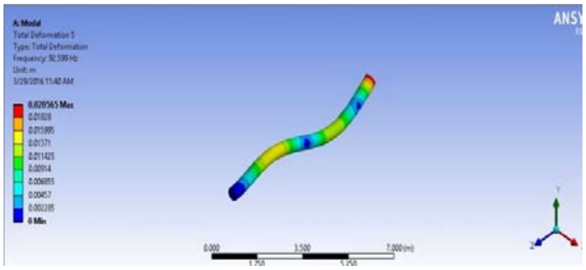

Figure-11. Mode Shape 5.

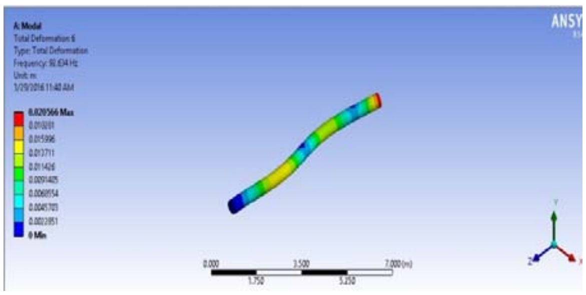

Figure-12. Mode Shape 6.

5. EXPERT SYSTEM

The Figure-13 is Expert System named as EXSYSTEM this is displayed, when we run the Source programme in source tab in NetBeans IDE 8.1. It consists of fields such as Enter the Equipment Name, Enter the Sub Assembly Name, Enter the Bearing Key point, Enter Speed in RPM, Enters Velocities and Buttons such Reset, Result, Recommendation and Save each having Specific Function. In this Expert system the main inputs are Selection of Speed and Entering Tri-axial Velocities. When the necessary input is given to this EXSYSTEM the result is displayed by clicking Result button. It Displays faults when the Tri-axial readings are well beyond limits as displayed in Figure-14. For the Precautions for the faults we need to click at Recommendation button as displayed in Figure 15. Thus with this EXSYSTEM we can predict the faults well in advance and fix them with ease.

Figure-13. Expert system initialization.

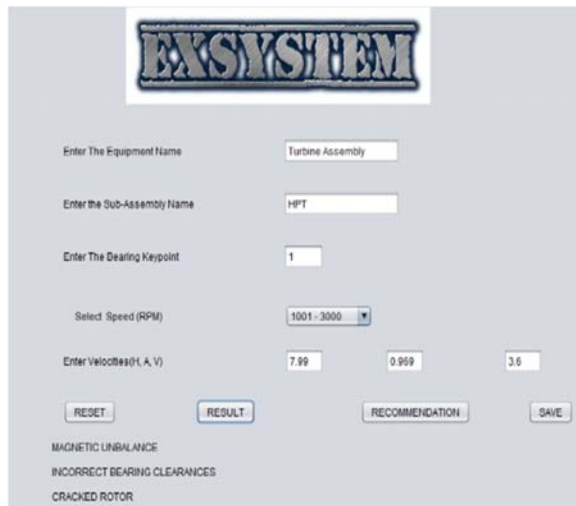

Figure-14. Expert system result.

Figure-15. Expert system result.

6. CONCLUSIONS

The present work has been taken up to monitor condition of the rotating parts like Boiler Feed Pump Train and Turbine Assembly of a Thermal Power Station using Expert System. The investigation has been done over a period of 6 Months for Boiler feed pump train for 10 Bearings and for Turbine Assembly a period of 12months for 7 Bearings the Tri-axial Data is obtained.

Amongst condition Monitoring Techniques Vibration based monitoring has been adopted. From data of Tri-axial Measurements has been analysed with a systematic and scientific approach for fault diagnosis along with the remedial measures. In order to replicate the work in a live system an Expert System has been made to monitor the condition along with fault fixing measures are shown just by giving Tri-axial velocities inhorizontal, vertical and axial Directions. By this we can predict the problem well in advance and Fix it to keep System safer.

REFERENCES

K.L. Narayana and K. V. Ramana. 2014. Condition Monitoring and Diagnostic Analysis of Induced Draught Fan Rotor System.

Shanmukha Priya, M.R. Ramesh and VPS Naidu. 2014. Bearing Health.

Condition Monitoring Frequency Domain Analysis' International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering.

N. Jamaludin, D. Mba and R.H. Bannister. Condition Monitoring of Slow-Speed Rolling Element Bearings Using Stress Waves. Journal on Process Mechanical Engineering.

Sudhanshu Goel, Ripul Ghosh, Satish Kumar and Aparna Akula. A Methodical Review of Condition Monitoring Techniques for Electrical Equipment.

John T. Roth and Sudhakar M. Pandit. Condition Monitoring and Failure Prediction for Various Rotating Equipment Components.

Kevin C. Lancon and Keith D. ataoka Schindler. 2006. System of Monitoring Operating Conditions of Rotating Equipment.

Syed Tafazzul Mahmood. Use of Vibrations Analysis Technique in Condition Based Maintenance.

K.V.Ramana, B.Raghu Kumar and K.L.Narayana. 2014. An Expert System for Diagnosis of Bearing Faults of Rotating Machinery.

Ralph, A. Callacot. 1988. Condition Monitoring and Fault Diagnosis. Theme Paper.

Carter D.L. 1996. A new method of processing rolling element bearing signals. Proc 20th Annual Meeting of the Vibration Institute.

Stipho N.A. 1984. Reliability Management Programmes for developing countries. International Journal of quality and reliability Management.

Ralph, A. Callacot. 1975. 'Mechanical Fault Diagnosis, Chapman and Hall, London.

Hersey J and Nair M N K. 1990. Condition Monitoring Based COMADEM Maintenance in practice in a heavy chemical plant. proceedings of COMADEM.

Victor Wowk. 1991. 'Machinery Vibration. Measurement and Analysis. Mc Graw - Hill INC.

Mc Mahon R J. 1990. Condition Monitoring at a continuous coal handling facility. Proceedings of COMADEM.

Miller D S. 1988. Condition Monitoring from raw materials to the grave. Journal of Measurements and control. 21(4).