

Equipment Performance Improvement Using Condition Based Maintenance through Vibration Analysis in Sugar Plant

Mr. M.B. Joshi¹ and Prof. Dr. M.M. Nadakatti²

*¹Research Scholar, Gogte Institute of Technology, Belgaum & Principal,
Nanasaheb Mahadik Polytechnic Institute, Peth (Sangli), Maharashtra.*

*²Professor, Mechanical Engineering Department,
Gogte Institute of Technology, Belgaum
E-mail: ¹maheshbjoshi@gmail.com*

Abstract

Condition based maintenance is a process for determination of the condition of the machine or a device and its change with time in order to determine its condition at any given time. A variety of technologies can and should be used as part of a comprehensive condition based maintenance programme. Since mechanical systems or machines account for the majority of plant equipment, vibration monitoring is generally the key component of most condition based maintenance programmes. However, vibration monitoring cannot provide all of the information that will be required for a successful condition based maintenance programme. Implementing vibration analysis on the machines will improve the reliability of the machines and lead to better machine efficiency and reduced down time eliminating mechanical or electrical failures. Vibration analysis programs are used throughout industry worldwide to identify faults in machinery, plan machinery repairs, and keeps machinery functioning for as long as possible without failure. (Abstract)

Keywords: condition based maintenance, Vibration analysis (Keywords).

1. Introduction

Mechanical industries have gone through the significant changes in last decade. Competition, cost, and equipment complexity have increased while budgets, operating

margins, and maintenance staffs have decreased. So, maintenance department must be able to show a positive effect on the “bottom line”. Customers focus on product quality, product delivery time and cost of product. Because of these, a company has to develop or introduce quality and maintenance system. For medium scale industry annual maintenance cost is 2 to 3 cores. If equipments are not maintained properly then breakdown occurs which results in different losses as production loss, loss due to accidents, parts replacement loss etc. Cost of these losses is more than 3 cores. So inline monitoring and offline tests of equipments are necessary to maintain equipments properly.

A variety of technologies can and should be used apart of a comprehensive condition based maintenance programme. Since mechanical systems or machines account for the majority of plant equipment, vibration monitoring is generally the key component of most condition based maintenance programmes. Comprehensive condition based maintenance programme must include other monitoring and diagnostic techniques. These techniques include: Vibration analysis, Corrosion analysis, Lubricant analysis, Process parameter monitoring, visual inspections.

2. Vibration Analysis

Vibration means to mechanical oscillations about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random such as the movement of a tire on a gravel road. Rotating machines are engines that transform the input energy, such as electrical energy, into useful energy needed for the powering of its motion, and waste energy. Rotating machines typically comprise numerous components such as shafts, bearing, gearbox, coupling, electric motors and belt drives. The conditions of these components contribute to the overall machine performance. The findings show that bearing related faults are the most common machine fault, accounting for about 40% of total machine failure A rotating machine has one or more machine elements that turn with a shaft, such as rolling element bearings, impellers, and other rotors. In a perfectly balanced machine, all rotors turn true on their centerline and all forces are equal. In industrial machinery, however, it is common for an imbalance of these forces to occur. In addition to imbalance generated by a rotating element, vibration may be caused by instability in the media flowing through the rotating machine. The main causes of mechanical vibration are unbalance, misalignment, looseness & distortion, Blower rpm: 1635 defective bearings & gearing & coupling inaccuracies, rotor shaft misalignment, bent rotor shaft & so on. These are some of the most common faults that can be detected using vibration analysis. The main causes of failures bearing defect, Dynamic forces are generated in the machine are directly transmitted to the bearing. So bearing is important element in machine. If any defect is present in bearing it creates vibration in machine. Identification of all above fault in machine is very important to avoid catastrophic failure. Vibration analysis is an important tool for identification of these defects.

3. Bearing Faults

Antifriction bearing failure is a major factor in failure of rotating machinery. As a fatal defect is detected, it is common to shut down the machinery as soon as possible to avoid catastrophic damages. Performing such an action, which usually occurs at inconvenient times, typically results in substantial time and economical losses. It is, therefore, important to monitor the condition of antifriction bearings and to know the details of severity of defects before they cause serious catastrophic consequences. The vibration monitoring technique is suitable to analyze various defects in bearing. This technique can provide early information about progressing malfunctions. Time domain analysis, frequency domain analysis have been employed to identify different defects in bearings. The results have demonstrated that each one of these techniques is useful to detect problems in antifriction bearings.

4. FFT Analyzer Set Up

FFT = Fast Fourier Transform. The FFT is a faster version of the Discrete Fourier Transform (DFT). The FFT utilizes some clever algorithms to do the same thing as the DFT, but in much less time. The DFT is extremely important in the area of frequency (spectrum) analysis because it takes a discrete signaling the time domain and transforms that signal into its discrete frequency domain representation. Without a discrete-time to discrete-frequency transform we would not be able to compute the Fourier transform with a microprocessor or DSP based system Fourier's theorem states that any waveform in the time domain can be represented by the weighted sum of sine's and cosines.



Fig. 1: FFT Analyzer set up.

The FFT spectrum analyzer samples the input signal, computes the magnitude of its sine and cosine components, and displays the spectrum of these measured frequency components. FFTs and the Power Spectrum are useful for measuring the frequency content of stationary or transient signals. FFTs produce the average frequency content of a signal over the entire time that the signal was acquired. For this reason, you should use FFTs for stationary signal analysis or in cases where you need only the average energy at each frequency line.

5. Methodology of FFT Analysis

Procedure for industrial vibration analysis by FFT

- Firstly decide the areas where to take readings and clean that area with the help of clean cloth.
- One end of accelerometer connects to the FFT port.
- FFT analyzer then connected to Laptop having 'Pulse-live' software installed in it.
- After these settings, give power supply to whole system.
- Another end of accelerometer mounts on the bearing housing in radial direction.
- This set up gives the analysis in the form of time and frequency domain curves.
- Wait for 1 minute to achieve accurate graphs.
- Then do the same procedure for induced draft fan and forced draft fans.
- For the above components take two readings each in radial and axial directions.
- After achieving all readings compare these readings with ISO Standard 10816 and also with Severity and acquisition charts.
- With the help of all standard results diagnose that what causes take place into each equipment and conclude their remedies for each equipments.

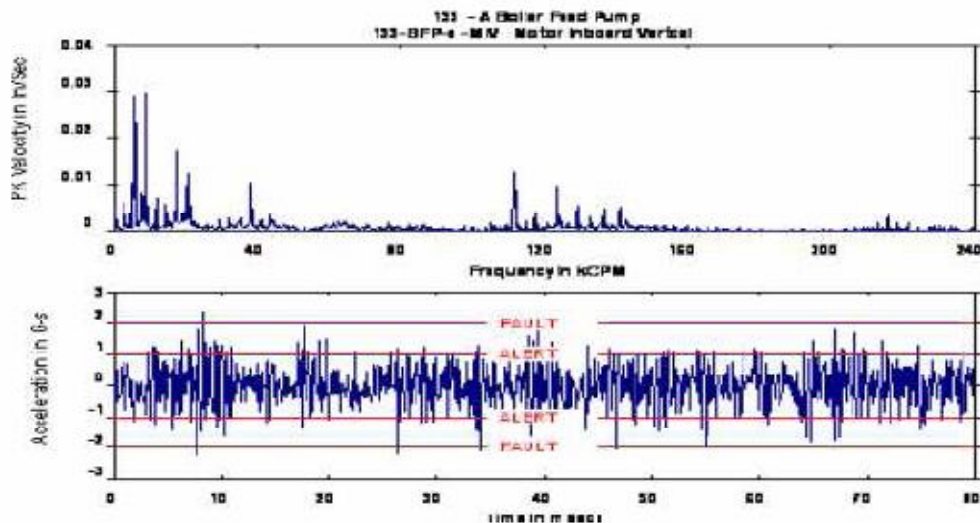


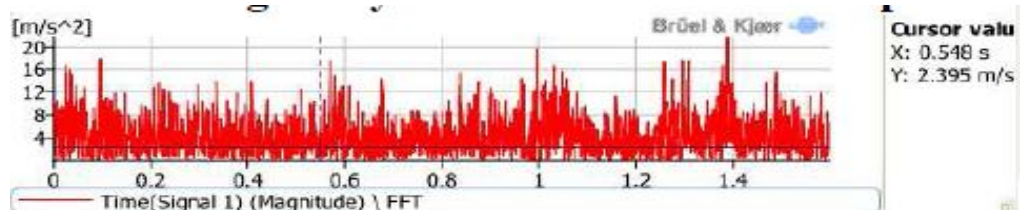
Fig. 4.5: Time Wave Form.

The measurement and analysis of dynamic vibration involves accelerometers to measure the vibration, and a data collector to collect the data. Analysis is usually completed by a technician trained in the field of rotating machinery vibration. The analog voltage output of the accelerometer, 100mV/g, is measured by the data collector and presented as a Time Waveform and FFT (Fast Fourier Transform) for frequency identification. The plots of amplitude vs. time, (Time Waveform) and amplitude vs. frequency (FFT) are required for the trained technician or engineer to analyze and determine the machine fault. Since each rotating element generates an

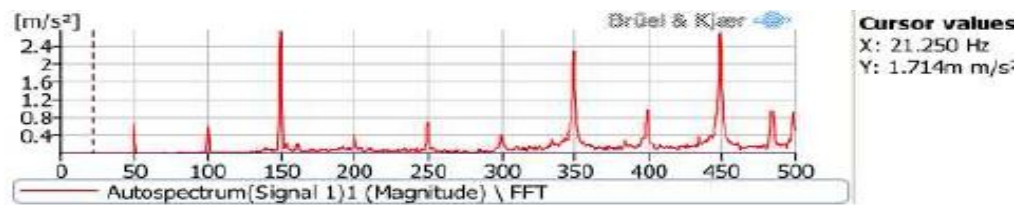
identifying frequency, analyzing the frequency disturbances will identify the faulty element. Once the fault is identified, parts can be ordered and repairs can be scheduled.

6. Vibration Monitoring

6.1 Bearing analysis for Feed Water Pump

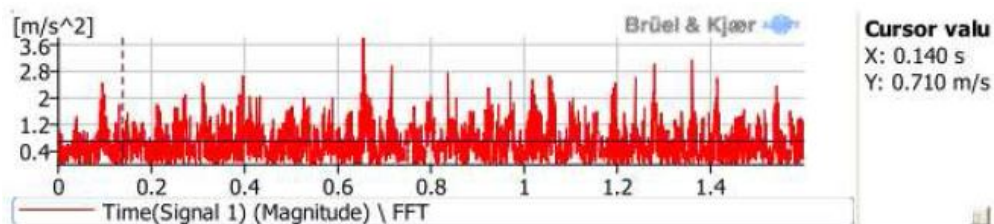


Graph 1: Time domain curve.

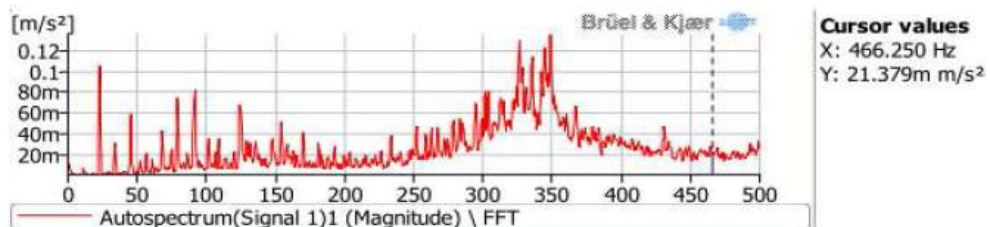


Graph 2: Frequency domain curve.

6.2 Bearing analysis of Induced Draft Fan

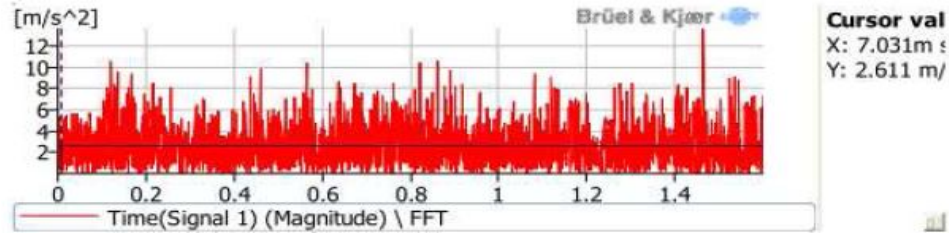


Graph 3: Time domain curve.

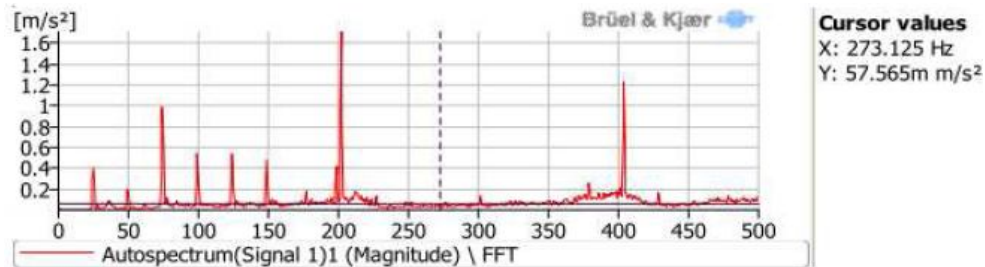


Graph 4: Frequency Domain Curve.

6.3 Bearing analysis of Forced Draft Fan



Graph 5: Time Domain Curve.



Graph 6: Frequency Domain Curve.

7. Analysis

7.1 Vibration Monitoring

7.1.1 Bearing analysis for Feed Water Pump

Rpm = 3000 rpm, Rpm in terms of Hz = $3000/60 = 50$ Hz, from standard results above graphs comes under zone B We got highest peak point at 3^* rpm in frequency domain curve.

7.1.1.1 Causes:

Internal rub in bearing.

7.1.1.2 Comment:

Bearing may get progressively worse, galling between contact surfaces or heat built up may cause seizure & shaft failure.

7.1.2 Bearing analysis of Induced Draft Fan

Rpm = 1000 rpm, In Hz = $1000/60 = 16.667 = 17$ Hz, We got maximum peaks at 21 Hz, 328.95Hz, 348.125Hz.

7.1.2.1 Causes:

Worn journal bearing, cavity critical misalignment, shaft crack, coupling lock up, internal rubs, structural resonances and hydraulic causes.

7.1.2.2 Comment:

- Worn journal bearing.
- Axial values of amplitudes are greater than radial value so, misalignment in shaft take place. So realign at operating conditions, loads causing misalignment, such as nozzle loads may have to be reduced.
- Coupling lock ups – start stop may change vibration pattern.
- Internal rubs- may get progressively worse galling between contact surfaces or heat built up May causes seizure & shaft failure.
- Structural resonance- increase or decrease stiffness of structure or add or remove mass to change natural frequency.

7.1.3 Bearing analysis of Forced Draft Fan

Rpm= 985 rpm, Hz = $985/60 = 16.04$ Hz = $1 * \text{rpm} = 17$ Hz Highest peak = 200Hz, Radial & axial results are same.

7.1.3.1 Cause:

Tensional resonance in bearing

7.1.3.2 Comment:

Additional filters would be introduced into the VFD to reduce the periodic tensional excitation.

7.1.4 Vibration Monitoring Corrective action

From above all observations and analysis it is cleared that bearing of feed pump are in safe zone i.e. zone B. But due to continuous working there may be internal rub in bearing of feed pump. Forced draft fans are also comes in to safe zone i.e. zone B. The main problem analyzed in forced draft fan is tensional resonance. Induced draft fan is come in zone C. i.e. to make repair after few days that means it comes in alarm zone. There may be number of problems arise in the Induced draft fan. The problems analyzed in Induced Draft fans are wearing of journal bearing, Cavities in races, Misalignment of shaft or shaft crack, internal rubs etc. from these results it is clear that the Induced draft fans needs repair Rather than feed pump and forced draft fans. The site Mechanical Engineer was immediately made aware of the change in the vibration levels with a recommendation to replace the Induced draft fan bearing as soon as possible. The machine was subsequently taken off line and the bearing replaced. On examination of the original bearing, a large area of flaking (spilling) was evident on the outer race. Due to the accurate analysis and prompt action a catastrophic failure had been prevented with a mechanical cost saving of several thousand Rupees

8. Conclusion

From above all observations and analysis it is cleared that bearing of feed pump are in safe zone i.e. zone B. But due to continuous working there may be internal rub in bearing of feed pump. Forced draft fans are also comes in to safe zone i.e. zone B. The main problem analyzed in forced draft fan is torsional resonance. Induced draft fan is come in zone C. i.e. to make repair after few days that means it comes in alarm zone. There may be number of problems arise in the Induced draft fan. The problems analyzed in Induced Draft fans are wearing of journal bearing, Cavities in races, Misalignment of shaft or shaft crack, internal rubs etc. from these results it is clear that the Induced draft fans needs repair Rather than feed pump and forced draft fans The understanding of FFT analysis tools for vibration dynamics and mechanical systems will be valuable to many of these students as they go into the work place. The use of the FFT analyzer enables us to meet our goal of providing hands-on experience in FFT analyzer principles and operation. This educational experience provides our engineers with a good foundation for future career.

References

- [1] Connection Technology Center, Inc.: “Industrial Vibration Analysis for Predictive Maintenance and Improved Machine Reliability” 590 Fishers Station Drive Victor, New York 14564
- [2] Chuck Yung: “Vibration analysis: what does it mean?”The Electrical Apparatus Service Association, Inc.(EASA)
- [3] Brian P. Graney: “Pump Vibration Analysis” MISTRAS Products & Systems November 2011 Pumps& Systems
- [4] Michael S. Johnson Jr., P.E.: “Vibration Tests for Bearing Wear” PREDICT/DLI, Bainbridge Island, Wash. ASHRAE Journal October 2000.
- [5] Kumaraswamy. S.Rakesh. J and Amol Kumar Nalavade: “Standardization of Absolute Vibration Level and Damage Factors for Machinery Health Monitoring” Proceedings of VETOMAC-2, 16-18December, 2002 Department of Mechanical Engineering Dr. Ambedkar Institute of Technology, Bangalore –560 056.
- [6] H. Mohamadi Monavar, H. Ahmadi and S.S. Mohtasebi: “Prediction of Defects in Roller Bearings Using Vibration Signal Analysis” World Applied Sciences Journal 4 (1): 150-154, 2008 ISSN 1818-4952© IDOSI Publications, 2008 Department of Agricultural Machinery, College of Biosystem Engineering, University of Tehran, I.R. Iran
- [7] Tatsunobu Momono and Banda Noda: “Sound and Vibration in Rolling Bearings” Basic Technology Research and Development Center. Motion & Control No. 6 — 1999.
- [8] Stanford Research Systems (SRS): “About FFT Spectrum Analyzers”9. Educational Services Committee (ESC): “Vibration Analysis” Volume 5, Issue 2 December 1998 BSA, 800Roosevelt Road, Building C, Suite 20, Glen Ellyn, IL60137-58.