VIBRATION ANALYSIS ON FORCED DRAFT FAN

SEMINAR REPORT

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By

VISHAKH C

Reg.No. AJC15ME125

Under the guidance of

Asst.Prof. Rohit Rajeev

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DEPARTMENT OF MECHANICAL ENGINEERING
AMAL JYOTHI COLLEGE OF ENGINEERING
KOOVAPPALLY , KANJIRAPPALLY

CERTIFICATE

This is to certify that **VISHAKH C (AJC15ME125)** has satisfactorily completed his seminar titled, "**VIBRATION ANALYSIS OF FORCED DRAFT FAN** " as a part of partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Mechanical Engineering** from Amal Jyothi College of Engineering, Kanjirapally, affiliated to APJ Abdul Kalam Technological University Kerala.

Asst. Prof. Tony Varghese	Asst.Prof. Rohit Rajeev
Seminar Coordinator	Guide

Mr. Toms Philip
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CONTENTS

ABSTRACT

When a machine fails or break down, the consequences can range from annoyance to the financial disaster or personal injury and possible loose of life. For this reason early detection, identification and correction of machinery problems is paramount to anyone involved in the maintenance of industrial machinery to insure continued, safe and productive operation. In order to run the machines efficiently and to know the onset of impending defects condition and monitoring of machines is important. There are several indicating phenomenon like Vibration, noise, heat, debris in oil, sound beyond human abilities etc., which emanate from these inefficiently running machines. Monitoring of these indicators provide early warnings of impending failures.

This seminar is primarily focused on the implementation of vibration based maintenance on critical rotating machines namely FORCED DRAFT FAN (FD FAN 6B) which is one of the boilers auxiliary. FD fans for boilers force ambient air into the boiler, typically through a preheater to increase overall boiler efficiency. The required vibration readings were taken. The levels of vibration of the fan driving end (hub1) are beyond the safe limits of desired velocity and displacement limit values. These further may cause to failure of the fan. This paper also explains about the Spike energy readings which were calculated and explained. After reading are taken it was noticed that fan driving end bearing was failed due to long life time of bearing, which is one of the cause for the increase of vibrations. This problem was rectified by replacing the new bearing and again vibration readings are noted found to be in safe limits of velocity.

Keywords: *MDE, MNDE, FDE (HUB 1), FNDE (HUB 2), Spectrums, Spike energy, Displacement, Velocity, Condition Monitoring*

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NOMENCLATURE

MNDE	Motor Non Drive End
MDE	Motor Drive End.
Hub1	Fan Drive End
Hub 2	Fan Non Drive End
H	Horizontal
V	Vertical
A	Axial

CHAPTER 1

INTRODUCTION

Forced Draft Fan is a type of a fan supplying pressurized air to a system. In the case of a Steam Boiler Assembly, this fan is of a great importance. When air or flue gases are maintained above atmospheric pressure. Normally it is done with the help of a forced draft fan.

For the proper and the optimized heat transfer from the flue gases to the boiler tubes draft holds a relatively high amount of significance. The combustion rate of the flue gases and the amount of heat transfer to the boiler are both dependent on the movement and motion of the flue gases. A boiler equipped with a combustion chamber which has a strong current of air (draft) through the fuel bed will increase the rate of combustion (which is the efficient utilization of fuel with minimum waste of unused fuel). The stronger movement will also increase the heat transfer rate from the flue gases to the boiler (which improves efficiency and circulation). It is used to regulate amount of air-to-fuel ratios in order to maximize fuel efficiency and to minimize EPA-regulated emissions, such as NOx (Nitrogen Oxides).

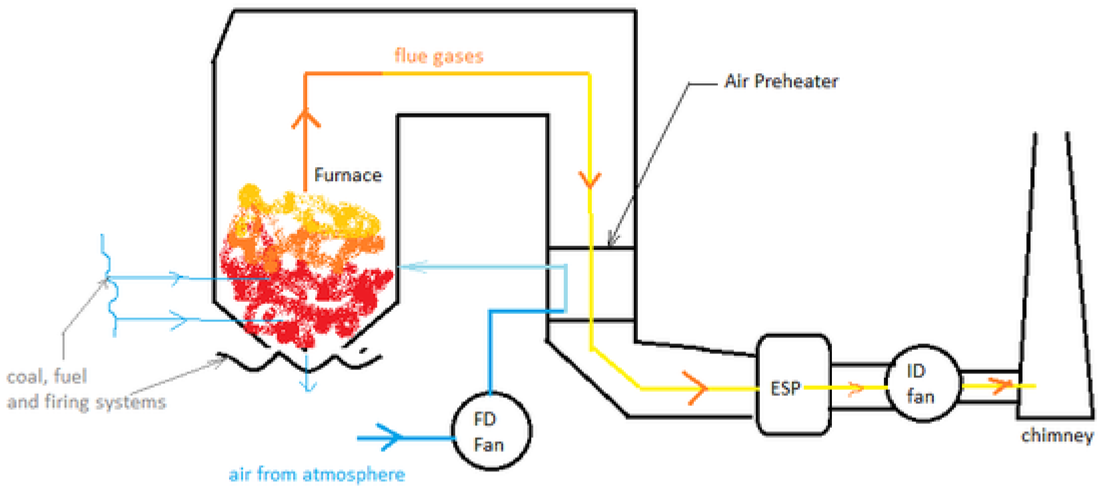

Fig 2.0 Air path in a thermal power plant

Monitoring is the systematic collection ,analysis and information as a project progresses. It is aimed at improving the efficiency and effectiveness of a project or organization. It is based on targets set and activities planned during the planning faces of work. It helps to keep the work on track and can let management know when things are going wrong. If done properly, it is an invaluable tool for good maintenance, and it provides a useful base for evaluation.

It enables you to determine whether the resources you have available are sufficient and are being well used, whether the capacity you have is sufficient and appropriate and whether you are doing what you planned to do.

Maintenance strategies are classified by three developmental stages:

1. Break down maintenance
2. Preventive maintenance
3. Predictive maintenance

1. Break Down Maintenance:

This provides the replacement of defective part or machine after the machine becomes incapable of further operation. Break down maintenance is the easiest method to follow and it avoids the initial costs and training personnel and other related upfront costs.

1.1.Drawbacks of break down maintenance are:

1. Failures are untimely
2. Since machine is allowed to run till to failure repair is more expensive. Sometimes total replacement is required.
3. Failures may be catastrophic. Hence loss will be more.
4. Production loss will be more, as it requires more time to restore normalcy.
5. It reduces the life span of the equipment.

2. Preventive maintenance:

In preventive maintenance, maintenance is scheduled on calendar or hours to run and is performed irrespective of machine condition.

2.1 Advantages:

1. Down time of machine is reduced by 50-80%
2. Lower expenses of over pay may same as much as 30%
3. Increases the equipment life expectancy.
4. Improve the employee’s safety
5. Damage to machine is less

2.2 Disadvantages:

1. Periodically dismantling of each and every critical machine is expensive and time consuming.
2. It may lead to unnecessary inspections even on healthy machine also which may further lead to more complications.
3. It is difficult to predict time interval between inspections which ultimately may lead to break down maintenance.

3. Predictive Maintenance:

Trending and analyzing machinery parameters we can detect the developing problems in early stages. Hence repair works can be carried out before failure of a machine.

3.1 Advantages:

1. Shut down can be done at convenient times.
2. Work schedule can be prepared for mobilizing men , tools and replacement parts before shut down reducing machinery down time.
3. Identifying problem, costly trial and error procedures to solve a problem can be avoided.

3.2 Disadvantages:

1. Require skilled labour.
2. It is costly affair.

1.1 Objectives

Condition monitoring is the process of monitoring a parameter of condition in machinery, such that a significant change is indicative of a developing failure. The most efficient way of doing predictive maintenance is by condition monitoring technique. Predictive maintenance by condition monitoring technique will boost up the availability of the equipment; will increase the efficiency and industrial safety.

The various objectives involved in condition monitoring program are:

1. Plant survey feasibility report.
2. Machine selection strategic and economic importance.
3. Select optimum monitoring techniques there is a large number of parameters that can be collected and analyzed in order to determine machine condition.
4. Establish a predictive maintenance programmed inspection schedule, data handling, administration and training.
5. Set acceptable condition, data and lists based on machine severity charts, manufacturer's specializations and experience.
6. Condition analysis – is in the death analysis of machine condition often involving the joint application of number of techniques. The object of this is to confirm the existing fault, location and the corrective action required.
7. Fault correction – having diagnosed the fault it is required to schedule the corrective action. The details of the identified faults should feedback to the diagnosis and improve the diagnostics capabilities of the program.

CHAPTER 2

LITERATURE REVIEW

2.1 CONDITION MONITORING TECHNIQUES:

1. Vibration monitoring
2. Debris analysis lubes oil analysis
3. Corrosion monitoring
4. Thermography
5. Visual monitoring
6. Contaminant monitoring
7. Performance and behavior monitoring

This seminar report is mainly focused on vibration monitoring which is the most commonly used method for rotating machines.

First select all available critical machines in the plant. Prepare a schedule for all these machines for data collection identify bearing locations of the machine train motor non drive end, MND, FNDE, FDE, PNDE, PDE, etc…identify the directions where vibration data is collected like H, V, A etc. define which vibration parameters are to be collected via displacement, velocity, acceleration etc. after doing all these start collecting vibrating data and related data and record them. Collect the data for every fortnight or monthly or so by trending and interpreting the data, identify source of vibration.

After identifying the source of vibrations analyze to pin point the root cause for vibrations. This can be achieved by eliminating process. Follow confirmative procedures in support of analysis. Open and inspect he machine at a convenient time and make necessary corrections. After corrections put the machine in service and again collect vibration data and look for elimination of source.

2.2 VIBRATION MONITORING:

Vibration monitoring is well established method for determining the physical movement of the machine or structure. Vibration is the best indicator of overall mechanical condition and the earliest indicator of the developing defects. There are other indicators like temperature, pressure and flow and oil analysis. If only one indicator is to be used to monitor machine health then vibration is usually the best choice. All rotating and reciprocating machines vibrate either to a smaller or to a greater extent. Machines vibrate because of defects or in accuracies in the system. When the inaccuracies are more it results in increased vibration.

2.3 VIBRATION ANALYSIS

Vibration analysis is a non-destructive technique which helps early detection of machine problems by measuring vibration. Vibration analysis has been proven to be the most successful predictive tool when used on rotating equipment, both in increasing equipment availability and reliability. In order to maximize the finite life associated with rolling element bearings and optimize equipment production life, excessive wear caused by misalignment, unbalance, and resonance must be minimized. The presence of trained vibration specialists with equipment to conduct analysis will form the basis of a strong vibration program.

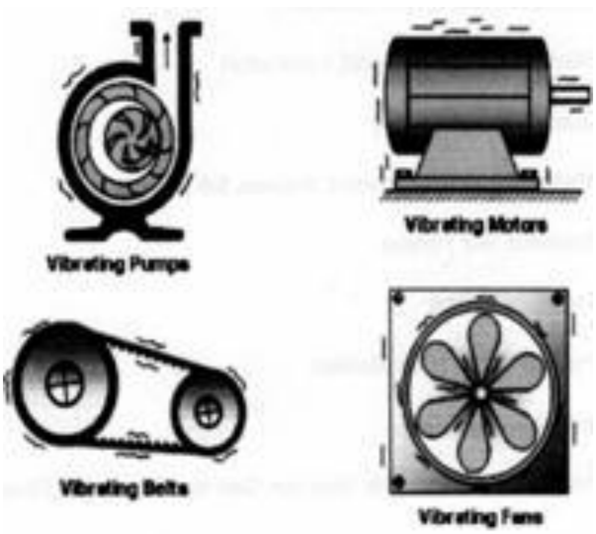

Fig 2.1 Machine vibrations

Causes for vibrations:

1. Change in direction with time, such as a force generated by a rotating unbalance.

2. Change in amplitude with time, such as unbalanced magnetic forces generated in an induction motor due to unequal air gap between the motor armature and stator.

3. Result in friction between rotating and stationary machine components is much.

4. Cause impacts, such as gear tooth contact or the impacts generated by the rolling elements of a bearing passing over a flaw in the bearing raceways.
5. Cause randomly generated forces such as flow turbulence in the fluid handling Devices such as fans, blowers and pumps; or combustion turbulence in gas turbines or boilers.

Machine vibration:

A vibrating object moves to and fro, back and forth motion. We experience many An example in our daily life like vehicles driven on rough terrain vibrates. There are various ways we can tell that something is vibrating. We can touch a vibrating object and feel the vibration. We may also see the back and forth movement of a vibrating objects**.**

Sources of vibration:

1. Misalignment of couplings, bearings and gears.
2. Unbalance of rotating components.
3. Looseness
4. Deterioration of rolling element bearings
5. Gear wear
6. Eccentricity of rotating components such as "v "belt pulleys or gears.

Detection by Vibration Analysis:

1. Unbalance (Static, Couple, Quasi-Static),
2. Misalignment (Angular, Parallel, Combination)
3. Eccentric Rotor, Bent Shaft
4. Mechanical Looseness, Structural Weakness, Soft Foot
5. Resonance, Beat Vibration
6. Mechanical Rubbing
7. Problems Of Belt Driven Machines
8. Journal Bearing Defects
9. Antifriction Bearing Defects (Inner race, Outer race, Cage, Rolling Elements)
10. Problems of Hydrodynamic & Aerodynamic Machines (Blade or Vane, Flow turbulence, Cavitation)
11. Gear Problems (Tooth wear, Tooth load, Gear eccentricity, Backlash, Gear misalignment, Cracked or Broken Tooth)

2.4 Methods to detect causes of vibration:

There are literally hundreds of specific mechanical and operational problems that can result in excessive machinery vibration. However, since each type of problem generates vibration in a unique way, a thorough study of the resultant vibration characteristics can go a long way in reducing the number of possibilities hopefully to a single cause. A simple, logical and systematic approach that has been proven successfully in pinpointing the vast majority of the most common day-to-day machinery problems.

Interpreting the data

1. Identify the machine component (motor, pump, gear box, etc.) of the machine train that has the problem .
2. Reduce the number of possible problems from several hundred to only a limited few.

Identifying the Problem Component Based On Frequency:

Figure2.2 shows a fan operating at 2200 RPM, belt driven by an 1800 RPM motor. The rotating speed of the belts is 500 RPM. Assume that a vibration analysis was performed on this machine and the only significant vibration detected had a frequency of 2200 CPM or 1 x RPM of the fan. Since the vibration frequency is exactly related to fan speed, this clearly indicates that the fan is the component with the problem. This simple fact eliminates the drive motor, belts and possible background sources as possible causes. Most problems generate vibration with frequencies that are exactly related to the rotating speed of trip in trouble. These frequencies may be exactly 1 x RPM or multiples (harmonics) of 1 x RPM such as 2x, 3x, 4x, etc. In addition, some problem's may cause vibration frequencies that are exact sub harmonics of 1 x RPM such as 1/2x, 1/3x or 1/4 x RPM. In any event, the FFT analysis data can identify the machine component with the problem based on the direct relationship between the measured vibration frequency and the rotating speed of the various machine elements.

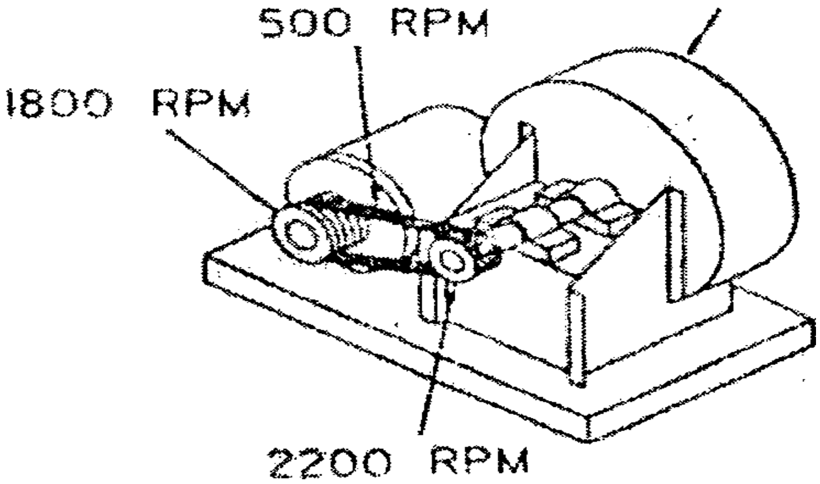

Fig 2.2 Components generate different vibration frequencies

Identifying the Problem Component Based On Amplitude:

Identifying the fan as the source of vibration based on vibration frequency was quite easy in the above example because of the notable differences in the rotating speeds of the various machine components. In this case, the component with the problem is normally identified as the one with the highest amplitude. For example, consider a motor direct coupled to a pump. Examining the analysis data, it is noted that the highest vibration amplitude on the motor is 1.0 in/sec compared to 0.12 in/sec on the pump. In this case, the motor is clearly the problem component since its vibration amplitude is nearly 8 times higher than that measured on the pump. In general, the machine component that has the problem is usually the one with the highest amplitude of vibration. The forces that cause vibration tend to dissipate in strength at increased distances from the source.

2.5 DATA PAC 1500

Instrument: Data Pac 1500

Company: ENTEK IRD

Feature: portable data collector / analyzer in a small lightweight package.

Data PAC 1500 is part of Entek's complete range of monitoring products and services to all industry segments worldwide. The data PAC 1500 is a fully featured portable data collector.

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Fig 2.3 DATA PAC 1500

2.6 SPECIFICATION OF FD FAN

FD-MOTOR:

SPEED: 993 RPM

VOLTS: 3300V

CURRENT: 229amps

TYPE: induction motor.

FREQUENCY: 50HZ

PHASE: 3PHASE.

FANS -500 MW BOILER

FAN	F D FAN	PA FAN	ID FAN
TYPE	AXIAL	AXIAL	RADIAL
NO per boiler	2	2	2
FLOW ,M3/S	251.6	184.0	574.6
PRESS,mmwc	390	1200	467
TEMP,DEG C	45	50	150
DRIVE	MOTOR	MOTOR	MOTOR
SPEED,RPM	980	1480	580
MOTOR ,KW	1225	2725	3950
CONTROL	VARIABLE PITCH CONTROL	VARIABLE PITCH CONTROL	INLET DAMPER+ VFD

Fig 2.4 Parameters of a 500 MW boiler

FD-FAN:

TYPE: axial reaction

MEDIUM HANDLED: fresh air

SPEED: 1480 rpm

NO.OF BLADES: 23

BEARING NO: NU226E

HUB DIA: 1100mm

OUTERDIA: 1800mm

S.No	Position	Velocity (mm/s)			Displacement (µm)		
		H	V	A	H	V	A
1	MNDE	8.71	0.751	1.75	108	363	14.8
2	MDE	9.93	1.35	1.66	111	8.34	14.6
3	HUB1	8.83	1.8	5.14	108	20.5	14.5
4	HUB2	9.24	1.76	5.41	114	20.8	16.2

Table 2.1. Vibration data sheet of FD fan 6B before rectification

Limits as per ISO 10816 part2 (mm/sec peak)

Good : 0 to 6.0 mm/sec

Satisfactory: 6.0to 12.3mm/sec

Alarm : 12.3 to 16.0 mm/sec

Not Permitted : >16.0mm/sec

THE FOLLOWING ARE THE SPECTRUMS TAKEN TO OBSERVE THE CAUSE OF VIBRATIONS

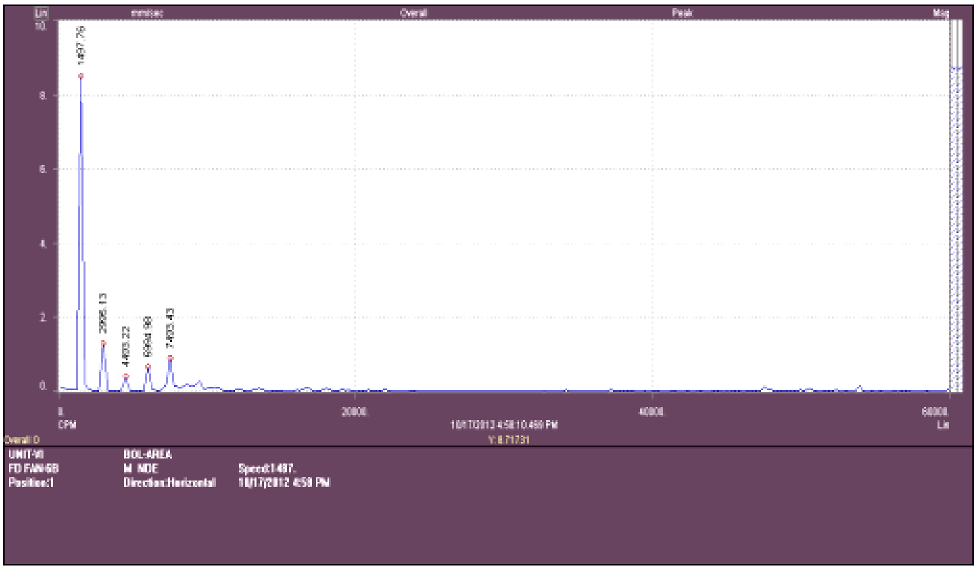


Fig 2.5 Velocity spectrum MNDE horizontal direction

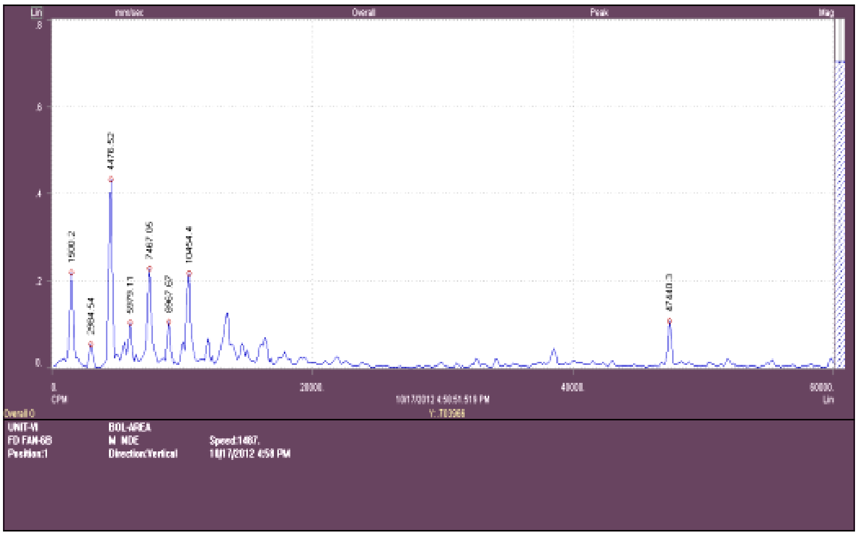


Fig 2.6 Velocity spectrum MNDE vertical direction

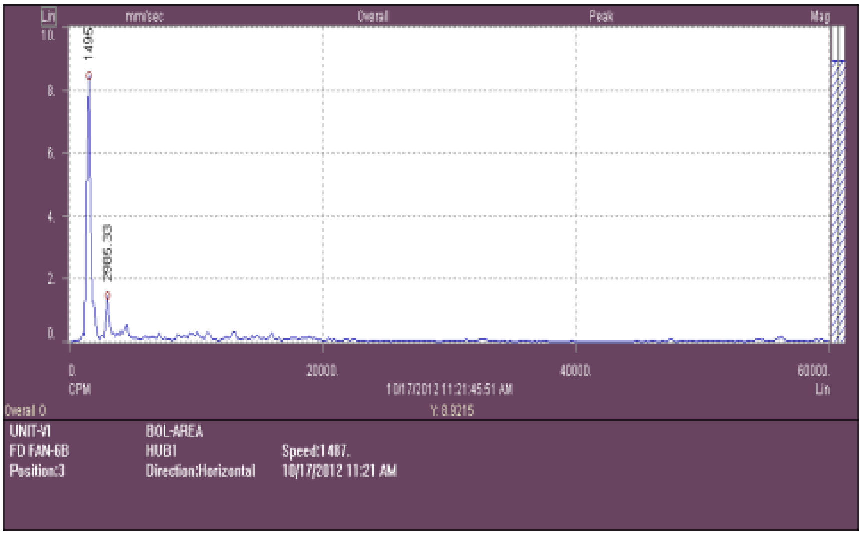


Fig 2.7 Velocity spectrum FDE (HUB 1) horizontal direction

Observations from the spectrums

1. Overall vibrations of all the bearings are in in satisfactory zone as per ISO 10816.

2. Horizontal direction vibration at MNDE, MDE.HUB1, and HUB2 are high side.

3. 1X Frequency is dominant in spectrums in all positions

4. Observed ½ Blade pass frequency and 1XBlade pass frequency and its side harmonics are present in HUB1 and HUB2 in axial direction

5. High vibrations in Horizontal direction at MNDE, MDE, HUB1 and HUB2 due to any flow obstruction in fan blades or may be unbalance in fan rotor.

Actions taken based on report

1. Since each unit runs with 2 FD fans, FD fan-6B is stopped for one day and the failure bearing was removed.

2. Maintenance was taken up and the FD fan was replaced with new bearings.

3. After replacement again the vibrations data was collected.

Position	Velocity (mm/sec)			Displacement(μm)		
	H	V	A	H	V	A
MNDE	*1.1*	*0.404*	*0.421*	*11.5*	*1.8*	*2.29*
MDE	*1.18*	*0.445*	*0.411*	*12.5*	*1.36*	*2.29*
FDE(HUB1)	*1.36*	*0.205*	*0.552*	*17.1*	*2.16*	*2.35*
FNDE(HUB2)	*1.37*	*0.228*	*1.19*	*17.6*	*2.67*	*2.94*

Table 2.2 vibration data sheet of FD fan 6B after rectification

Observations after rectification:

1. Vibration frequencies are in normal ranges.

2. Even after the rectification the peaks are obtained at MNDE, MDE, FDE, and FNDE in axial direction which indicate high axial vibrations are existed.

3. The vibrations caused in axial direction indicate bent shaft or angular misalignment

4. The rectification of bent shaft or angular misalignment can be done only during overall shut down period of the unit.

5. Hence the bearing replacement is carried out which lead to reduction of vibrations and allowing smooth running of FD fan

Data before Rectification:

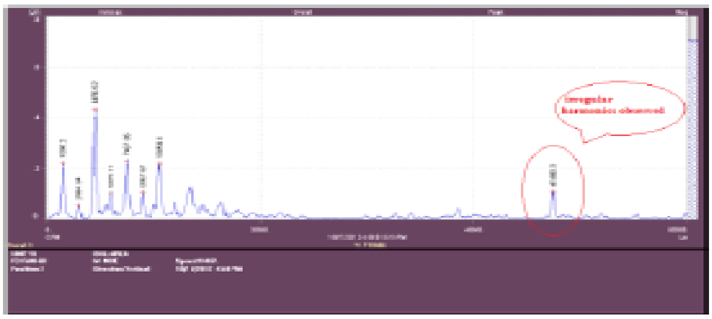
S. No	Date	Position	Velocity (mm/sec)			Displacement(μm)		
			H	V	A	H	V	A
1	17/10/2012	MNDE	*8.71*	*0.751*	*1.75*	*108*	*3.63*	*14.8*
2		MDE	*8.93*	*1.35*	*1.66*	*111*	*8.34*	*14.6*
3		FDE(HUB1)	*8.83*	*1.8*	*5.14*	*108*	*20.5*	*14.5*
4		FNDE(HUB2)	*9.24*	*1.76*	*5.41*	*114*	*20.8*	*16.2*

Data After Rectification

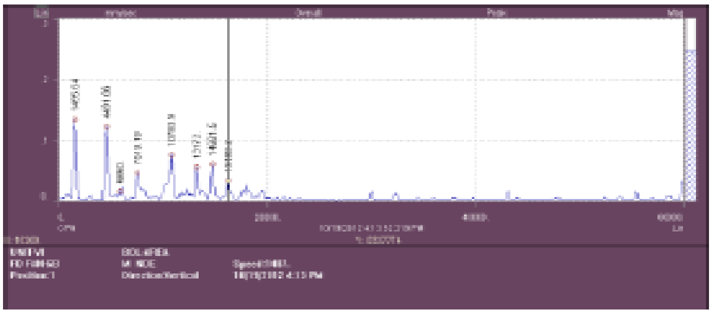
S. No	Date	Position	Velocity (mm/sec)			Displacement(μm)		
			H	V	A	H	V	A
1	19/10/2012	MNDE	*1.1*	*0.404*	*0.421*	*11.5*	*1.8*	*2.29*
2		MDE	*1.18*	*0.445*	*0.411*	*12.5*	*1.36*	*2.29*
3		FDE(HUB1)	*1.36*	*0.205*	*0.552*	*17.1*	*2.16*	*2.35*
4		FNDE(HUB2)	*1.37*	*0.228*	*1.19*	*17.6*	*2.67*	*2.94*

Table 2.3 Showing before and after rectification

In Vertical Direction at MNDE



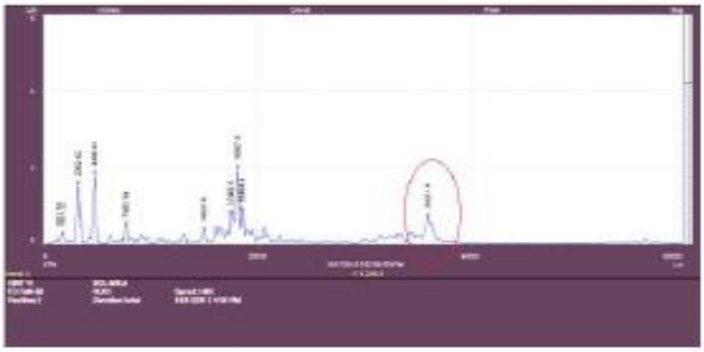
Before Rectification



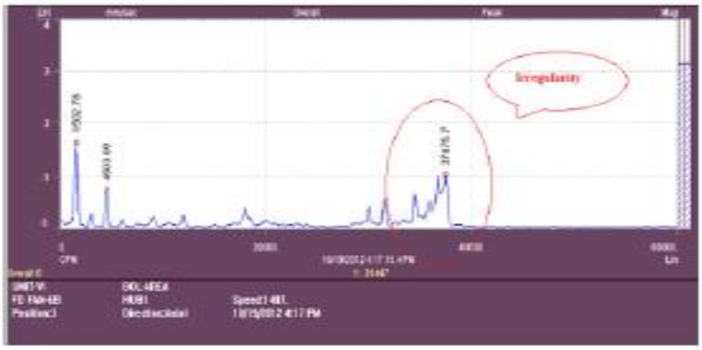
After Rectification

Fig 2.8 Comparison at MNDE

In axial direction at FDE (HUB-1):



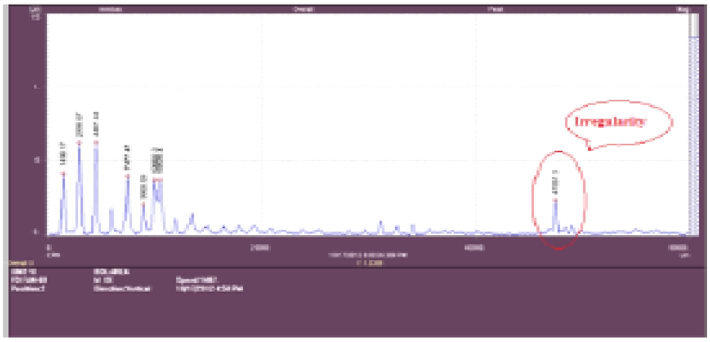
Before Rectification



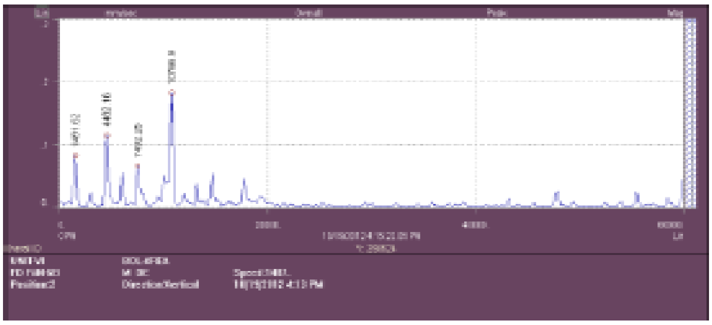
After Rectification

Fig 2.9 Comparison at FDE

In vertical direction at MDE:



Before Rectification

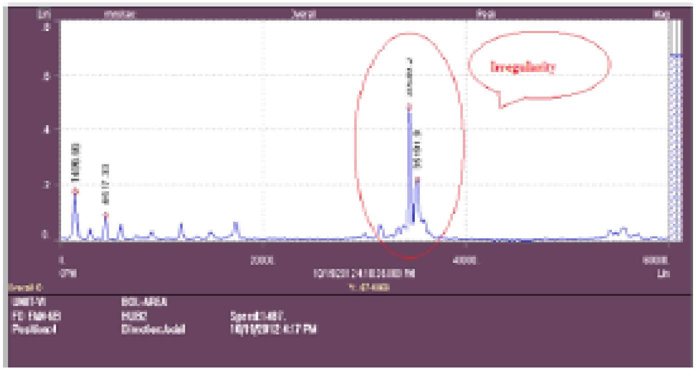


After Rectification

Fig 2.10 Comparison at MDE

In axial direction at FNDE (HUB-2)

Before Rectification



After Rectification

Fig 2.11 Comparison at FNDE

Even after the replacement of the failed bearing with new bearing there are still some irregular harmonics observed in axial direction at MDE, FDE (HUB 1) and FNDE (HUB 2). The irregular harmonics in axial directions are shown in the following spectrums.

The spike energy data is taken into criteria because of frequency obtaining >600000 rpm. The equipment used in V.T.P.S is set only to horizontal direction, where the readings are obtained. From the above data flaw is found out at MNDE, and still the spectrum criteria is taken into considerations in order to find out the existing defects.

CHAPTER – 3

CONCLUSION

. From the above observed graphs the irregular harmonics are observed in the axial direction, which indicates that the bending of the shaft caused due to bearing failure. After replacement of bearing, the previously occurred irregular harmonics were vanished in horizontal and vertical direction

.

The required vibration readings were taken. The levels of vibration of the fan driving end (hub1) are beyond the safe limits of desired velocity and displacement limit values. These further may cause to failure of the fan. This paper also explains about the Spike energy readings which were calculated and explained. After reading are taken it was noticed that fan driving end bearing was failed due to long life time of bearing, which is one of the cause for the increase of vibrations. This problem was rectified by replacing the new bearing and again vibration readings are noted found to be in safe limits of velocity.

In order to run the machines efficiently and to know the onset of impending defects condition and monitoring of machines is important. There are several indicating phenomenon like Vibration, noise, heat, debris in oil, sound beyond human abilities etc., which emanate from these inefficiently running machines. Monitoring of these indicators provide early warnings of impending failures.

The replacement of bearing requires a temporary pause of FD-FAN (about a day). But the replacement of the shaft requires the overall shut down of the unit. So instant replacement of shaft is not possible as of bearing. So due this factor the fan is allowed to run with irregular harmonics in axial direction which doesn't affect majorly for a period of time, and can be rectified during overall maintenance.

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