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Condition Monitoring and Vibration Analysis of Boiler Feed Pump

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Abstract- Condition Monitoring is an advanced and very useful tool of predictive maintenance techniques. It has made good progress in recent years in identifying many types of deterioration in plant machinery, so that pro-active maintenance can be performed, improving overall plant productivity. There is a wide variety of condition monitoring techniques currently in use for the diagnosis and prediction of machinery faults, but little attention has been paid to the occurrence and detection of vibration analysis of rotating equipments The application of computers and electronic measuring and detecting system has provided a new improvement for condition monitoring and has a particular relevance for plant engineers in utilities and service departments. It eliminates unnecessary opening of equipment with considerable savings in personnel resources.

This paper aims at the implementation of condition based maintenance on BOILER FEED pump critical Machine used in the thermal plant, by adopting Vibration spectrum analysis which is a predictive maintenance technology.

For the BOILER FEED pump the vibration readings show that values are more than normal readings. Spectrum analysis was done on readings and found that mass unbalance in vanes. It was corrected based on phase analysis and vibration readings were observed after modification which gives the values with in normal range. It eliminates unnecessary opening of equipment with considerable savings in personnel resources.

Nomenclature

BFP : Boiler Feed Pump
MNDE : Motor Non Driving End
MDE : Motor Driving End
FDE : Fan Driving End
FNDE : Fan Non Driving End
PDE : Pump Driving End
PNDE : Pump Non Driving End
BPNDE : Booster Pump Non Driving End
BPDE : Booster Pump Driving End
MMDE : Main Motor Driving End

I. Introduction

Condition monitoring pre-supposes knowledge of machines condition and its rate of change, which can be ascertained by selecting a suitable parameter for measuring deterioration and recording its value at intervals either on a routine or continuous basis. This is done while the machine is running. The data obtained may then be analyzed to give a warning on failure. This activity is called as condition monitoring.

Condition monitoring essentially involves regular inspection of equipment using human sensory facilities and a mixture of simple aids and sophisticated instruments. The central emphasis is however on the fact that most inspections should be preferably done while the machine is running.

In recent years as observed by R.K BISWAS, [1] states that Condition Monitoring is defined as the collection, comparison and storage of measurements defining machine condition. Almost everyone will recognize the existence of a machine problem sooner or later. One of the objectives of Condition Monitoring is to recognize damage that has occurred so that ample time is available to schedule repairs with minimum disruption to operation and production.

Broch [2] there has been considerable interest in the maintenance techniques based on condition monitoring, with the analysis of vibration characteristics generated by machines, which makes it possible to determine whether the machinery is in good or bad condition.

Simmons [3] opened that vibration from their sources origin may be small but excite the resonant frequencies of the rotating parts such as the rotor shaft and set-up considerable extra dynamic load on bearings. The cause and effect reinforce each other and the machine progresses towards ultimate break down. As per Gyarmathy [4] there are generally two situations in which vibration measurements are taken. One is surveillance mode to check the health of machinery on routine basis. The second situation is during an analysis process where the ultimate goal is to tag the problem. In the later case, vibration measurements are taken to understand the cause, so that an appropriate fix can be undertaken.

Lingaraju [5] Vibration monitoring which is most frequently used method in condition monitoring provides information about machinery health as it can reveal the cause of potential problem and provide an early indication of mechanical failure. This gives the possibility for diagnosing and converting malfunctions leading to an optimum management of engine operation.

1.1 Background:

In the early days, equipment maintenance was conducted only when equipment actually failed. The work was more “fix it” than maintenance. Shortly thereafter, came the recognition that performing regular maintenance and refurbishment tasks on equipment could keep equipment operating longer between failures. This became known, variously, as Periodic Maintenance, Calendar Based Maintenance or Preventive Maintenance (PM). The goal was to have most of the equipment be able to operate most of the time until the next scheduled maintenance outage. This approach is also outdated. Now Condition monitoring has made good progress in recent years maintenance is being carried out based on condition of machine which reduces the cost of unnecessarily opening of equipment. Most of the defects encountered in the rotating machinery give rise to a distinct vibration pattern (vibration signature analysis techniques)Vibration Monitoring is the ability to record and identify vibration "Signatures" which makes the technique so powerful for monitoring rotating machinery. Vibration analysis is normally applied by using transducers to measure acceleration, velocity or displacement. The choice largely depends on the frequencies being analyzed

1.2 Condition Monitoring

Condition monitoring pre-supposes knowledge of machines condition and its rate of change, which can be ascertained by selecting a suitable parameter for measuring deterioration and recording its value at intervals either on a routine or continuous basis. This is done while the machine is running. The data obtained may then be analyzed to give a warning on failure. This activity is called as condition monitoring.

Condition monitoring essentially involves regular inspection of equipment using human sensory facilities and a mixture of simple aids and sophisticated instruments
The central emphasis is however on the fact that most inspections should be preferably done while the machine is running.

Condition monitoring is concerned with the analysis and interpretation of signals from sensors and transducers installed on operational machinery, employing sensors positioned outside the machine, often remove from the machine components being monitored, normally does the monitoring of a machine condition and health, using established techniques, the analysis of information provided by the sensor output and interpretation of the evaluated out put is the needed to establish what actions to be taken.

Condition monitoring can also be a test and quality assurance, system for continuous processes as well as discrete component manufacture. It maximizes the performance of the company's assets by monitoring their condition and ensuring that they are installed and maintained correctly, it aims of detecting condition leading to catastrophic breakdowns and loss of service, reducing maintenance overhauls, fine turning of operating equipment increasing production and operating efficiency and minimizing the replacement parts inventory. This is because a readily monitor able parameter of deterioration can be found in every plant, Machinery and probabilistic element in future prediction is highly reduced or almost eliminated thus maximizing the items life by minimizing the effect of failure

Condition monitoring techniques

There are only seven main techniques of condition monitoring. They are:

a) Visual monitoring
b) Contaminant or debris monitoring
c) Performance and behavior monitoring
d) Corrosion monitoring thermograph
e) Sound monitoring.
f) Shock pulse monitoring.
g) Vibration monitoring.

Vibration monitoring:

Vibration monitoring measures the frequency and amplitude of vibrations. It is Known that readings will change as machinery wear sets in. such readings can be interpreted as indicators of the equipments condition, and timely maintenance actions can be scheduled accordingly. Electrical machines and mechanical reciprocating or rotating machines generate their own vibration signatures (patterns) during operation. However such raw signals contain a lot of background noise, which makes it difficult or even impossible to extract useful, precise information by simply measuring the over all signal. It is thus necessary to develop an appropriate filter to remove the operationally and environmentally contaminated components of signals (the background noise) so as to reveal the clear signals generated by the events under study. To capture useful condition monitoring data, vibration should be measured at carefully chosen points and directions.

Vibration monitoring is a well established method for determining the physical Movements of the machine or structure due to imbalance mounting an alignment this method can be obtained as simple. Easy to use and understand or sophisticated real time analysis, vibration monitoring usually involves the attachment of a transducer to a machine to record its vibration level special equipments is also available for using the out put from sensor to indicate nature vibration problem and even its precise cause.

Transducers for the measurement of vibrations employ electromagnetic electrodynamics, capacitive, piezoelectric, or strain gauge principles out of these piezoelectric accelerometers is most widely used since the recent past, Among the monitoring techniques vibration monitoring as gained considerable importance because of following fundamental factors

1) All rotation and reciprocating machines vibrate either to a smaller or greater extent machines vibrate because of defects or incurrence in system
2) When inaccuracies or more it results in increased vibration each kind of defect provides a vibration characterized in the unique way.

Therefore vibration characteristics reveal the health condition of machine.

1.0 Vibration Analysis

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 successful in pinpointing the vast majority of the most common day-to-day machinery problems.

Define the problem

The following lists some of the reasons for performing a vibration analysis:

1. **Establish "baseline data" for future analysis needs**.
2. **Identify the cause of excessive vibration.**
3. **Identify the cause of a significant vibration increase**.
4. **Identify the cause of frequent component failures**
5. **Identify the cause of structural failures**
6. **Identify the source of a noise problem.**

II. Description of the Equipment

BOILER FEED PUMP 4B

Boiler Feed Pump (BFP) is used to pump the feed water (chemically treated water) in to the boiler. The FK6D30 type BFP consists of FAiB56 Booster Pump (BP) directly driven from one end of the shaft of an electric motor. BFP is driven from the opposite end of Motor shaft through a spacer type flexible coupling.

The BP is a single stage, horizontal, axial split casing type, having the suction and discharge branches on the casing bottom half, thus allowing the pump internals to be removed without disturbing the suction and discharge pipe work or the alignment between the pump and the driving motor.

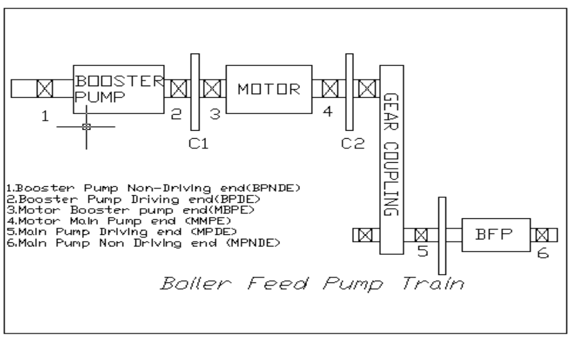

Fig: 1 Boiler feed pump train

The rotating assembly consists of the shaft, Impeller, nuts, keys, seal sleeves, thrust collar, the rotating parts of the mechanical seals, pump coupling. The rotating assembly is supported at each end of the shaft by a white metal lined journal bearing. The residual axial thrust is taken up by a tilting double thrust bearing mounted at the non drive end of the pump. The present work deals with the BP which is connected to the motor directly. The pump motor unit is supported by four Bearings. The line diagram of the entire unit is shown in fig

III. 4.0 Experimentation

The measurements are recorded using “Data PAC 1500”, dual channel seismic pick-up, with a frequency range of 10cpm to 4518000cpm(0.18hz to 75.3 Hz), with A/D converter, VGA resolution screen data collector of Entek IRD,USA make, over a period of 12 months at regular monthly intervals. The instrument is mounted on the 4 bearing supports along horizontal (H), vertical (V), and axial (A) directions, the axial direction being in line with the axis of the shaft. The measurements are made in displacement and velocity modes. Accelerations have been computed. Regular logging of the data has provided on the basis for performance trend monitoring of the rotating structure and prediction of faults to apply reasoning to trace the root cause.

4.1 Experimental data

Measurements are taken on regular basis at all bearing supports along horizontal vertical and axial directions

ISO standards iso-10816

Good: 0 to 5.4mm / sec
Satisfactory: 5.4 to 10.6mm / sec
Alarm: 10.6 to 16.mm / sec
Not permitted: >16. mm / sec

Table 1.0 Vibration readings before rectification

DATE	**SUPPORT POINT**	**DISPLACEMENT (um) H / A**	**V**	**VELOCITY (mm/sec) H / A**	**V**
17th FEBRUARY 2009	1	24.0	12.0	4.70	3.90
	2	13.8		3.10	
	3	19.0	7.00	4.30	2.50
	4	16.0		3.70	
	5	13.0	9.00	2.70	2.10
	6	13.0		3.10	
		10.0	7.00	1.90	1.20
		6.00		1.40	
		24.0	170	9.10	9.40
		4.00		7.80	
		38.0	28.0	9.80	9.70
		12.0		16.2	
30th MARCH 2009	1	17.0	6.42	2.95	2.34
	2	8.88		1.49	
	3	12.9	3.56	1.85	1.21
	4	9.56		1.60	
	5	10.3	7.35	1.47	1.13
	6	8.55		1.18	
		8.95	5.51	1.48	1.04
		3.63		1.15	
		11.3	11.0	4.97	5.74
		9.05		5.40	
		31.8	18.1	11.3	4.40
		9.19		20.7	
14th APRIL 2009	1	26.8	8.60	5.10	3.90
	2	10.0		3.00	
	3	16.6	5.20	3.70	2.10
	4	10.5		3.20	
	5	12.4	8.20	2.30	2.20
	6	11.4		3.00	
		12.6	6.40	2.50	1.80
		5.70		2.30	
		68.6	29.6	15.2	17.1
		26.4		18.1	
		68.4	98.0	23.6	27.7
		27.2		18.1	

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17th	1	26.8	8.60	5.10	3.90
APRIL	2	10.0		3.00	
2009	3	16.6	5.20	3.70	2.10
	4	10.5		3.20	
	5	12.4	8.20	2.30	2.20
	6	11.4		3.00	
		12.6	6.40	2.50	1.80
		5.70		2.30	
		35.8	21.1	9.50	6.60
		20.2		11.7	
		62.89	87.9	16.6	21.5
		20.7		10.0	

4.2 Spectrum Analysis

The following are spectrums taken at the bearings in three directions.

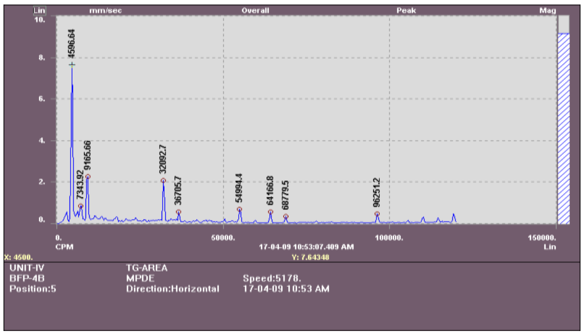

Fig: 1 Velocity spectrum of MPDE bearing in horizontal direction

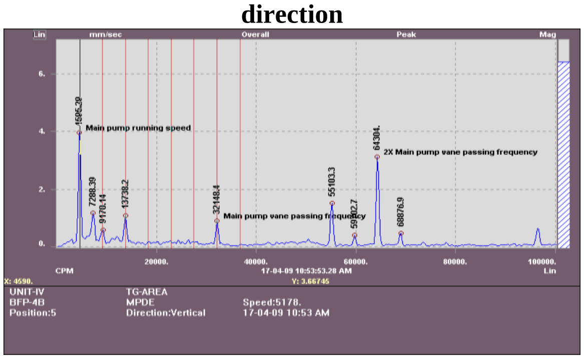

Fig: 2 Velocity spectrum of MPDE bearing in vertical direction

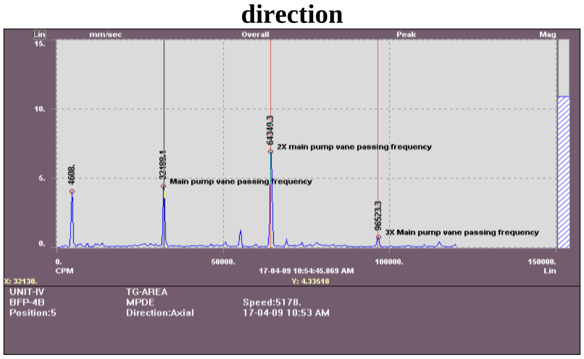

Fig: 3 Velocity spectrum of MPDE bearing in axial direction

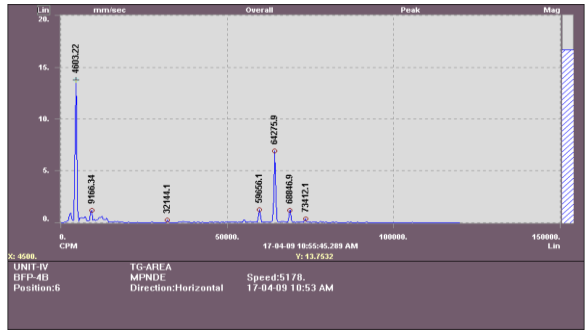

Fig: 4 Velocity spectrum of MPNDE bearing in horizontal direction

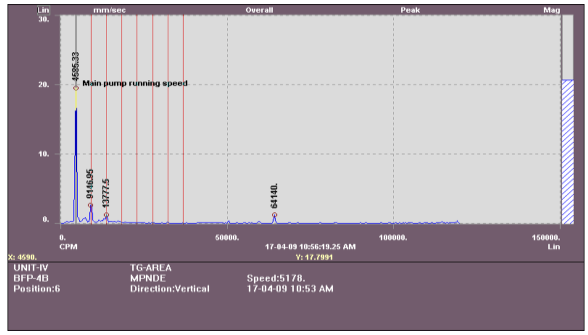

Fig: 5 Velocity spectrum of MPNDE bearing in vertical direction

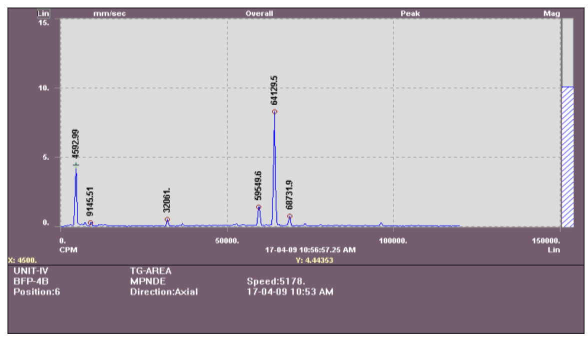

Fig: 6 Velocity spectrum of MPNDE bearing in axial direction

OBSERVATIONS FROM THE SPECTRUMS:

1. In all the spectrums of MPDE and MPNDE 1x running speed harmonic are present
2. In all the spectrums of MPNDE 1x running speed frequency peak is predominant and having higher value armed 19.9 mm /see
3. In all the spectrums of MPNDE &MPNDE pump vane passing frequency and its harmonics are found and 2x of v p f peak is predominant having value 7.9 mm /see
4. In all the spectrums of MPNDE side bank to v p f peak harmonics are found
5. In all the spectrums of MPDE both the booster pump and main pump vane passing frequency peaks are found
6. In all the spectrums of MPDE no bearing defective frequency are found.

CONCLUSIONS:

1. All the vibration values of BPNDE, BPDE MMBPE, and MMNDE are in the good zone. But MPDE and MPNDE are in alarm level.
2. Here 1x is predominant frequency peak in the MPDE & MPNDE spectrums Misalignment/ Looseness of the main pump bed were suspected.
3. A harmonic with vpf of the main pump are found and is having predominant peak value. So the looseness of the pump impeller was suspected.
4. In all the spectrums bearing defective frequency peaks are not found so, bearings are in good condition.
5. The main pump casing and bed bolts are checked for looseness and must be tightened.
6. The impeller casing of the shelter of the main pump was checked for looseness and adjusted so that the vibration must be reduced.

4.3 Action taken

Due to high vibration on pump side (at NDE vertical) pump stopped on 18-04-2009 and attend for the rectification. Pump NDE side bed bolts were tightened and thrust bearing top cover is lifted by 0.01mm. After attending the work pump taken into the work on 21-04-2009 and vibration readings were taken and observed that vibration readings were reduced to normal value i.e. in the good zone.

Table: 2. Data collection after rectification

DATE	SUPPORT POINT	DISPLACEMENT (um)		VELOCITY (mm/sec)	
		H	V	H	V
		A		A	
21st	1	16.3	6.65	3.21	2.53
APRI	2	9.05		2.02	
L	3	13.4	3.84	2.26	1.10
2009	4	9.40		1.55	
	5	12.4	7.99	1.63	1.61
	6	9.17		1.59	
		10.9	5.94	1.50	1.14
		4.71		1.52	
		16.4	19.7	5.27	5.61
		12.6		6.19	
		33.1	23.2	8.44	6.20
		8.35		6.34	
28th	1	19.0	9.08	3.19	3.19
APRI	2	11.0		2.30	
L	3	15.5	3.60	2.26	1.26
2009	4	9.68		1.51	
	5	11.4	7.08	1.48	1.27
	6	9.18		1.98	
		9.24	5.29	1.92	1.34
		4.29		1.11	
		20.4	15.2	5.52	6.54
		6.25		5.82	
		30.0	19.3	8.10	5.29
		6.38		14.2	
12th	1	25.0	10.8	5.40	4.10
MAY	2	12.0		3.10	
2009	3	18.4	4.60	3.20	2.50
	4	10.8		3.00	
	5	12.6	9.00	2.50	2.10
	6	10.8		2.90	
		12.2	6.00	3.40	1.80
		5.20		2.40	
		22.0	20.8	9.30	11.6
		15.0		11.4	
		36.4	28.0	13.9	9.70
		18.2		10.1	

IV. SPECTRUMS AFTER RECTIFICATION

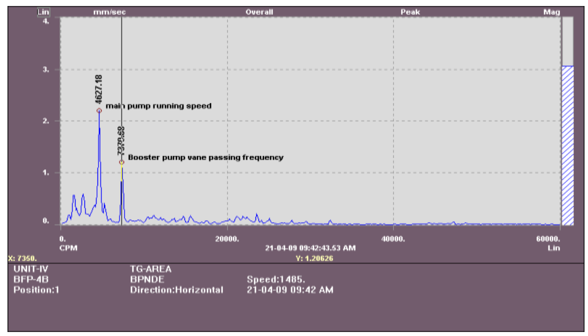

Fig: 7 Velocity spectrum of BPNDE bearing in horizontal direction

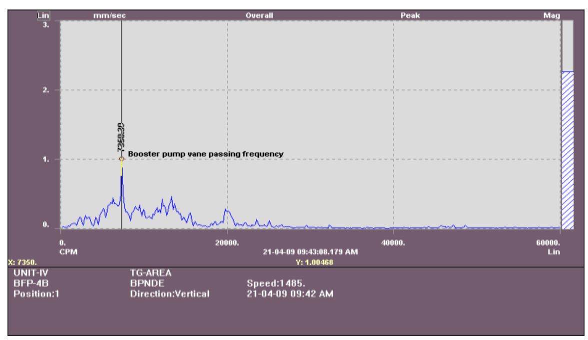

Fig: 8 Velocity spectrum of BPNDE bearing in horizontal direction (Booster pump vane passing frequency peak)

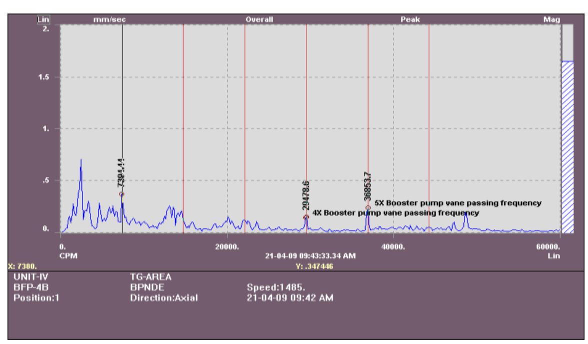

Fig: 8 Velocity spectrum of BPNDE bearing in horizontal direction (Booster pump vpf & harmonics)

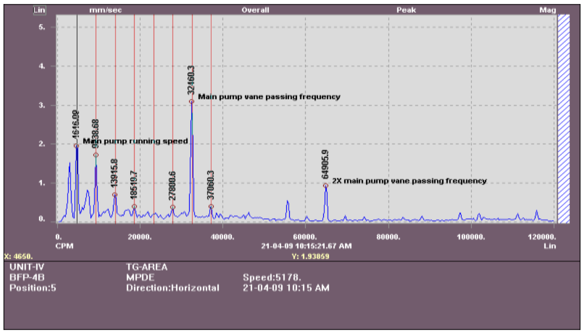

Fig: 9 Velocity spectrum of MPDE bearing in horizontal direction (1x main pump harmonics &vane passing frequency and its harmonics)

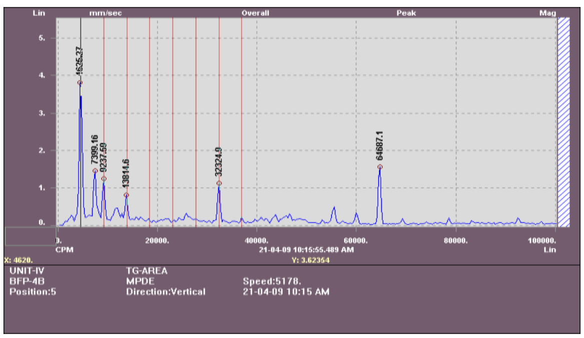

Fig: 10 Velocity spectrum of MPDE bearing in vertical direction (1x harmonics)

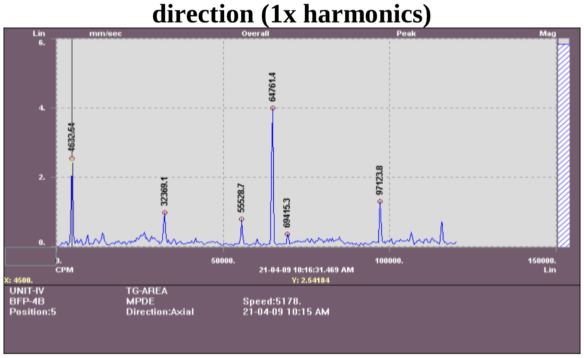

Fig: 11Velocity spectrum of MPDE bearing in axial direction

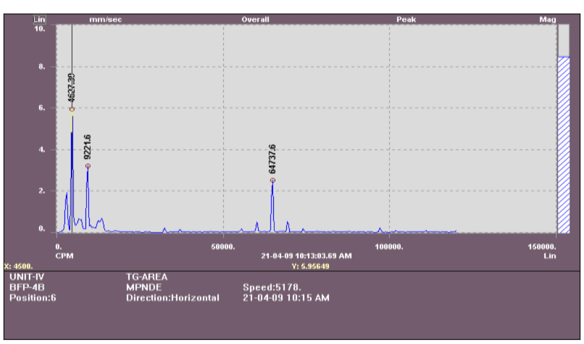

Fig: 12 Velocity spectrum of MPNDE bearing in horizontal direction

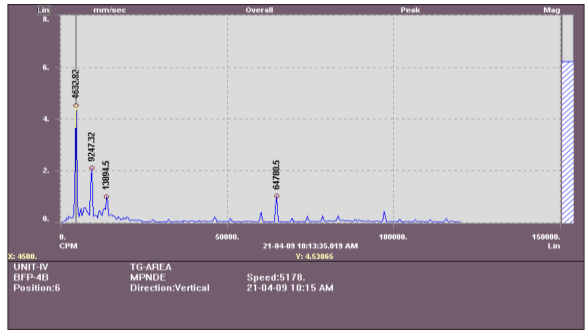

Fig: 13 Velocity spectrum of MPNDE bearing in vertical direction

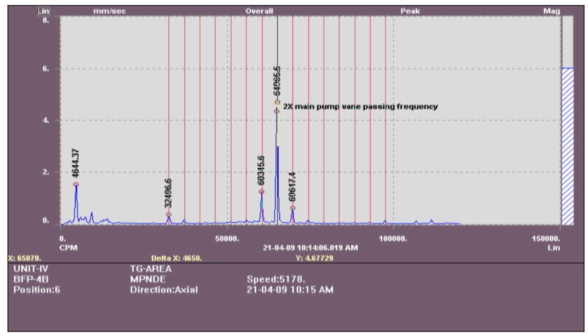

Fig: 14 Velocity spectrum of MPNDE bearing in horizontal direction (side bands of main pump vpf)

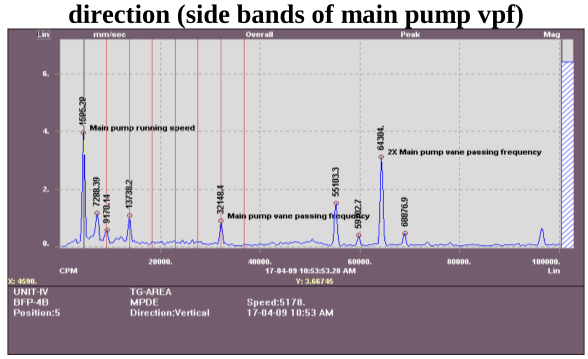

Fig: 15 Velocity spectrum of MPDE bearing in vertical direction (main pump vpf & harmonics)

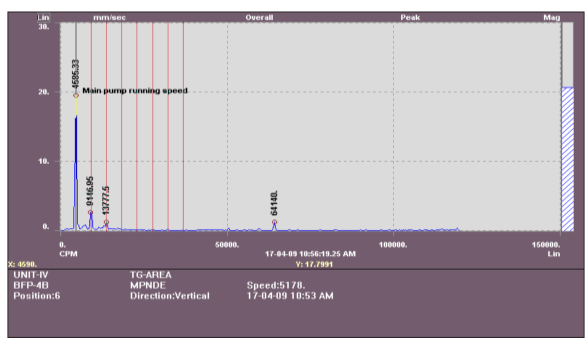

Fig: 16 Velocity spectrum of MPNDE bearing in vertical direction (1x harmonics)

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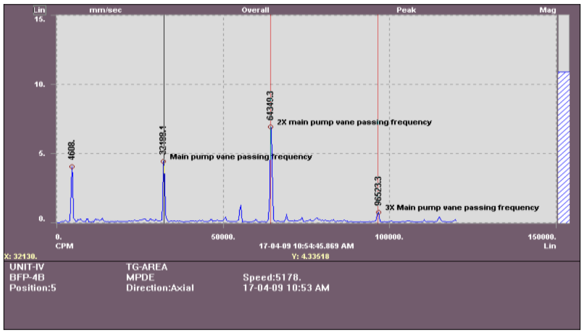

Fig: 17 Velocity spectrum of MPDE bearing in axial direction (main pump vpf & harmonics)

V. RESULTS AND DISCUSSIONS

The reason for the frequent increase in vibration was found to be due to looseness problem in the main pump bed bolts and it is also the fact that, the vibrations may arise due to looseness of the main pump impeller casing. This problem was conformed using the spectrum analysis. The spectrums were collected using DATAPAC 1500.

In order to rectify this problem various operations were performed. It was found that the main pump bed bolts and the impeller casing of the main pump are not properly tightened and having some looseness. To rectify this, the main pump bed bolts were tightened and the impeller casing of the shelter of the main pump was checked for looseness and adjusted so that the vibration must be reduced.

After the operations were performed the vibration readings and spectrums were taken using the analyzer. The readings were found to be feasible to satisfy ISO standards.

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