Seshasayee Paper and Boards Limited
Erode

Maintenance Strategies For Cost Reduction and Quality Improvement

AT SPB

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ABSTRACT

- In today's Scenario, all corporate are mainly focusing on cut down in input cost in their operational functions. They are inclined to adapt changes in their routine method with the use of updated technologies in all fields.

- Paper industries having more and more revolving equipments by its functional requirements are liable to get into defects with so many variables behind them. Machineries as that of fixed cost in costing should perform at its optimum efficiency. Deterioration needs to be monitored day in and day out so that corrective action can be taken at the right instance.

INTRODUCTION

- Manufacture of pulp, paper, and paperboard consumes over $7 billion worth of purchased fuels and electricity per year.

- Energy efficiency improvement is an important way to reduce these costs and to increase predictable earnings, especially in times of high energy price volatility.

- At a time when research on the economics of all measures as well as on their applicability to different production practices is needed to assess their cost effectiveness at individual plants, it is very important to share our bad experiences and how we had successfully overcome.

- **This can contribute mutually of our paper curriculum for which IPPTA is one of the QC tool.**

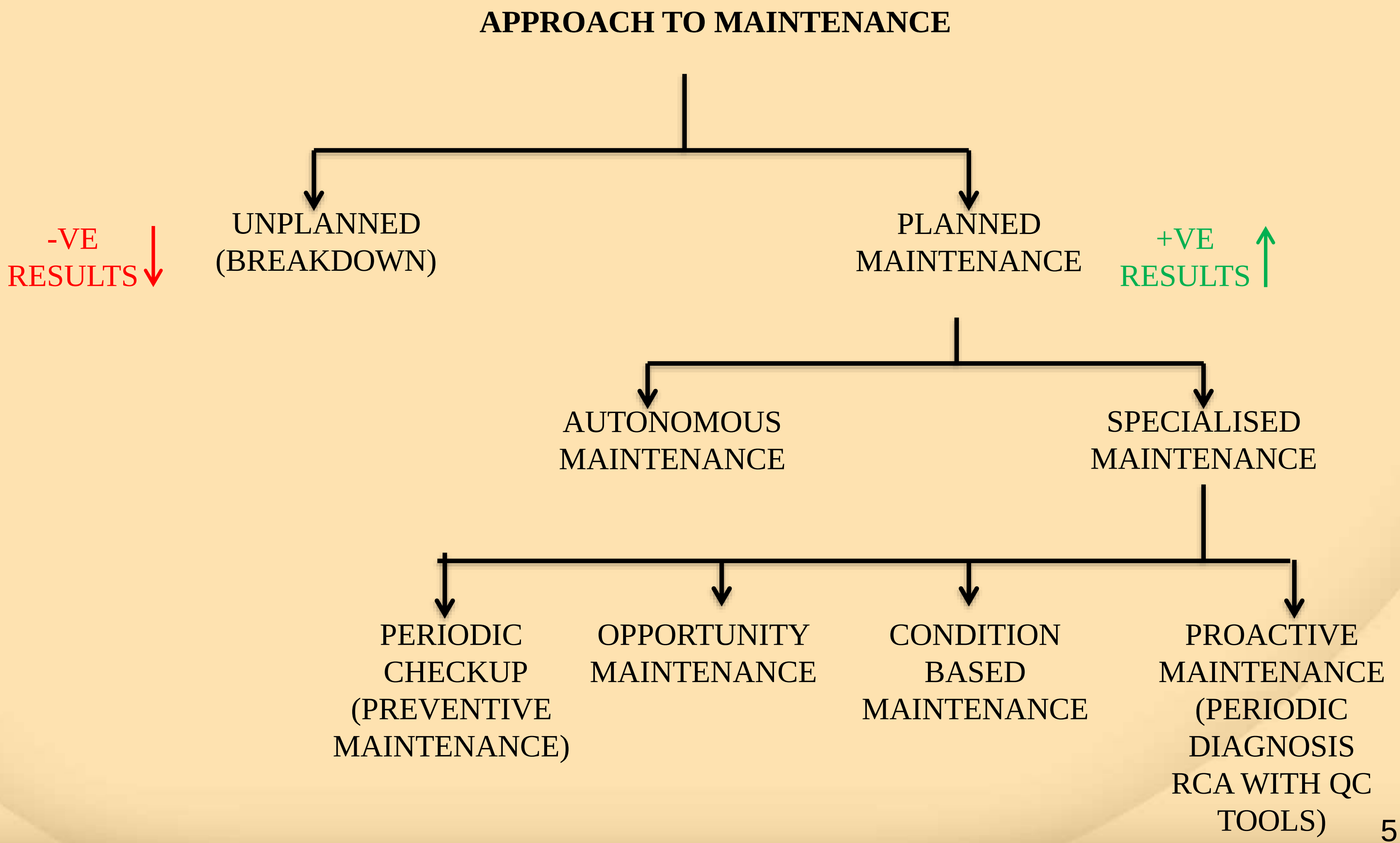
INTRODUCTION(Contd)

- The challenge of maintaining high product quality while simultaneously reducing production costs can often be met through investments in energy efficiency.
- Energy efficient technologies can often offer additional benefits, such as quality improvement, increased production, and increased process efficiency, all of which can lead to productivity gains.

For the above challenges, contribution of a service department plays a major role.

Approach towards a Zero Accident, Zero Breakdown, Zero Customer complaint inspired to take on good maintenance practices.

MAINTENANCE REGIMES



PREVENTIVE MAINTENANCE

Preventive maintenance activity is a systematic inspection, detection, correction and prevention of incipient failures before they become major failure.

Preventive maintenance activity is based on,

- Mandatory recommendation from the supplier.
- Based on MTBF(Mean Time Between Failures)
- Frequent parts change

This maintenance practice is purely random. This is also one of the costlier maintenance practice.

PREDICTIVE MAINTENANCE

Predictive maintenance techniques approach promises cost saving over routine or time based preventive maintenance because tasks are performed only when they are warranted.

Predictive maintenance technique includes,

- Vibration Monitoring
- Thermographic inspection
- Oil analysis
- Shock pulse (Identification of Lubrication characteristics)
- Ultrasonic testing
- Time and frequency analysis

PROACTIVE MAINTENANCE

- The purpose of proactive maintenance is to view machine failure and similar problems that can be anticipated and dealt with before problems occur.

- All predictive maintenance observations should be assessed and cause of concern should be eliminated in proactive maintenance.

- **Proactive maintenance primarily defines the root cause of machine failure and dealing with those issues before problems occur.**

PRO ACTIVE STEPS TAKEN AT SPB

Condition Monitoring cell was developed in SPB

Comprising of 4 Mechanical engineers and 1 Electrical engineer to execute the departmental activities headed by AGM Mechanical.

- Vibration analysis
- Thermography
- Laser alignment
- Ultrasonic thickness testing
- In house dynamic balancing of rolls
- Ultrasonic leak detecting

PRO ACTIVE STEPS TAKEN AT SPB

SPB having nearly about 1500 rotary equipments need to be covered in our condition monitoring activity.

Equipments are broadly classified as,

HIGHLY CRITICAL EQUIPMENTS

- Production will come to stand still
- No erected spares available
- Pose unsafe condition to personnel and equipment.
- High cost involving for restarting
- Time taken for restarting equipment will be depending on severity of the problem.

CRITICAL EQUIPMENTS

- Production will come to stand still.
- Erected spare available.
- Time taken for restarting the system prevails.

NON-CRITICAL EQUIPMENTS

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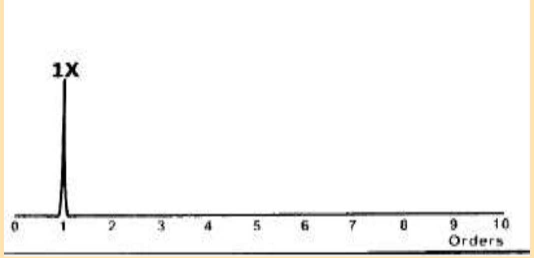
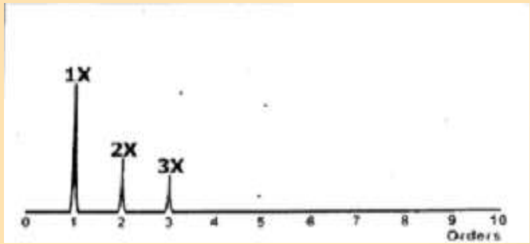
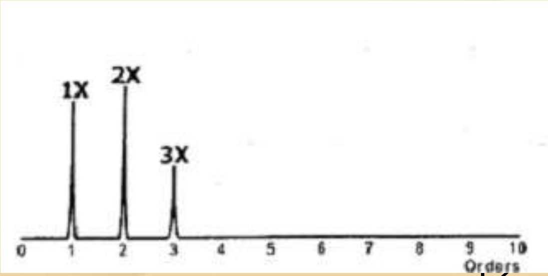
- Equipment whose failure will not affect production.
- Equipment can be put up in service without any expenditure.

A literature review on Vibration measurements – ISO guidelines

ISO 10816 - 3 VIBRATION SEVERITY CHART - VELOCITY

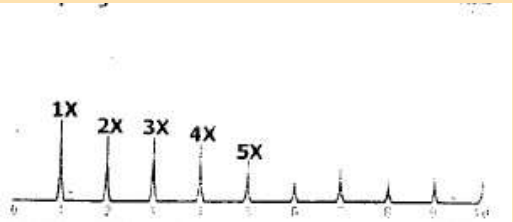
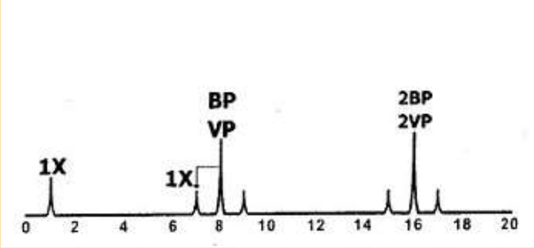
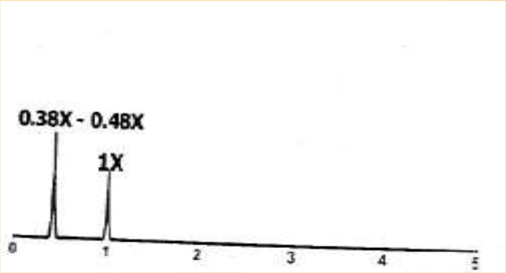
VIBRATION GUIDELINE CHART

With the Spectrum analysis preliminary findings are obtained

SYMPTOM	MOST LIKELY	OTHER POSSIBLE CAUSES	SPECTRUM
1x Running Speed	Imbalance	Misalignment Bend shaft Looseness Journals, gears or pulleys	
2x Two times or First Harmonic	Misalignment (High axially)	Looseness: Just 1x, 2x & 3x Looseness: Lots of harmonics Bent shaft	
3x Second Harmonic	Misalignment	Cocked bearing Rotating element (vane, blade, etc.,)	

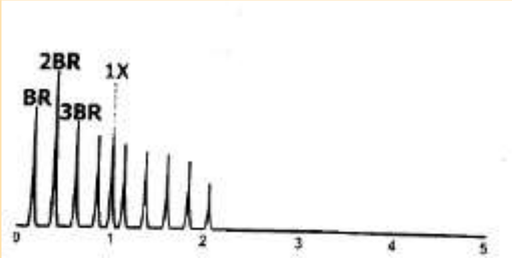
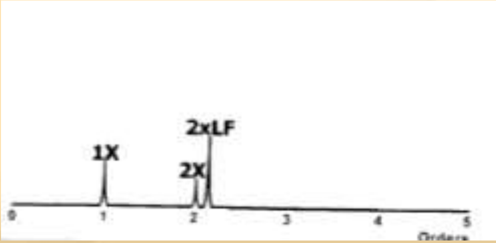
VIBRATION GUIDELINE CHART

With the Spectrum analysis preliminary findings are obtained

SYMPTOM	MOST LIKELY	OTHER POSSIBLE CAUSES	SPECTRUM
4x Fourth Harmonic	Coupling problem	Coupling problem Severe misalignment Rotating element (vane, blade, etc.,)	
5x - 8x	Vane passing	Rotating element (vane, blade, etc.,)	
0.39x - 0.48x	Oil whirl	Oil whip	

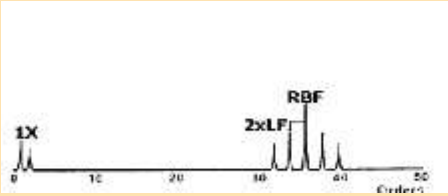
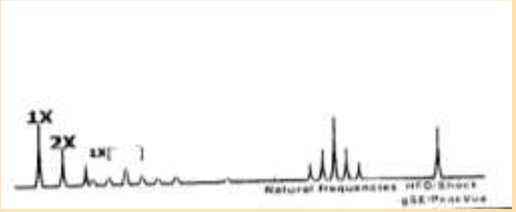
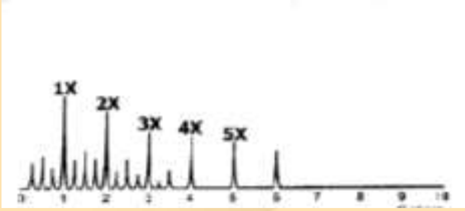
VIBRATION GUIDELINE CHART

With the Spectrum analysis preliminary findings are obtained

SYMPTOM	MOST LIKELY	OTHER POSSIBLE CAUSES	SPECTRUM
0.5x Half Running speed	Rub	Rotor rub (Sleeve bearing) Severe looseness (0.5x, 1x, 1.5x...) Drive belt resonance (could be >1x)	
Sub synchronous	Belt wear Harmonics	FFT Fundamental train frequency Flow turbulence Transducer problem (Ski slope) Eccentric rotor (pole pass frequency)	
100 or 120Hz Line synchronous frequency	Rotor problem	Stator eccentricity Eccentric rotor (pole pass sidebands) Shorted laminations	

VIBRATION GUIDELINE CHART

With the Spectrum analysis preliminary findings are obtained

SYMPTOM	MOST LIKELY	OTHER POSSIBLE CAUSES	SPECTRUM
Synchronous Higher frequencies	Gears	Fan speed x # blades (Aerodynamic) Cavitations, Impeller x # vanes	
Non - Synchronous Higher frequencies	Bearing defects Lubrication	Inner race - BPI (1x side bands) Outer race BPO Ball spin - BS (FT side bands) Cage FT (Sub-synchronous)	
Harmonics	Looseness	Bearing wear (Non-synchronous) Misalignment (1x - 4x) Rotor rub Journal bearing wear Belt wear (BR harmonics)	

VIBRATION PHASE MEASUREMENT CHART

Precise analysis for specific problems based on spectrum analysis

Problems	Symptoms	Phase Checking
Dynamic Imbalance	1X radial (V&H). Levels highest in horizontal axis (due to greatest flexibility)	0-180 Deg phase difference across machine. 90Deg±40Deg between vertical and horizontal
Static Imbalance	1X radial (V&H)	In phase across machine 90 Deg±30 Deg between vertical and horizontal
Couple Imbalance	1X radial (V&H)	Out of phase across machine 90 Deg±30 Deg between vertical and horizontal
Imbalance: Overhung Machines	High 1X axial, 1X radial (V&H)	Axial phase readings in-phase
Imbalance: Vertical Machines	1X radial (horizontal)	Phase readings similar in same direction at different points on machine
Eccentric Rotor or Gear	1X radial (V and H)	

VIBRATION PHASE MEASUREMENT CHART

Precise analysis for specific problems based on Spectrum Analysis

Problems	Symptoms	Phase Checking
Misalignment	1X and 2X (and 3X and 4X...). Axial and radial (V&H)	
Angular Misalignment	High axial vibration: 1X strong but 2X and 3X can also be strong	180 Deg across coupling in axial direction
Parallel Misalignment	2X radial, smaller 1X radial (V&H)	180 Deg across coupling in radial direction
Bent Shaft	1X axial	Close to 180 Deg phase difference between bearings
Cocked Bearing	1X, 2X and 3X axial	180 Deg phase difference on either side of the shaft
Rotating Looseness	1X harmonics radial (0.5X harmonics when severe)	
Structural Looseness	1X horizontal	180 Deg phase difference between the machine and the base in the vertical direction
Pedestal Bearing Looseness	1X, 2X and 3X radial (0.5X peak when severe)	180 Deg phase difference between the bearing and the base
Rotor Rub	1X harmonics (0.5X harmonics when severe)	

CONDITION MONITORING PRACTICES AT OUR MILL SITE

VIBRATION ANALYS

Vibration analysis is a non-destructive technique which helps early detection of machine problems by measuring vibration.

Following problems can be indentified and rectified using Vibration analyser.

- Improper lubrication/un appropriate lubrication
- Imbalance
- Misalignment
- Weak structures / Mechanical Looseness
- Bend shaft
- Antifriction Bearing Defects
- Problems of Hydrodynamic & Aerodynamic Machines.
- Gear Problems

TIMELY CORRECTIONS BY CONDITION MONITORING

CASE STUDY-1

A STUDY ON PAPER MACHINE AT TIRUNELVELI

Problem Identification:

- Severe vibrations of the rolls and structure of the press section in the paper machine speeds at and more than 680 meters per minute (MPM) were reported.
- Machine production was low.

TEST CARRIED OUT TO FIND SOLUTION FOR PROBLEM

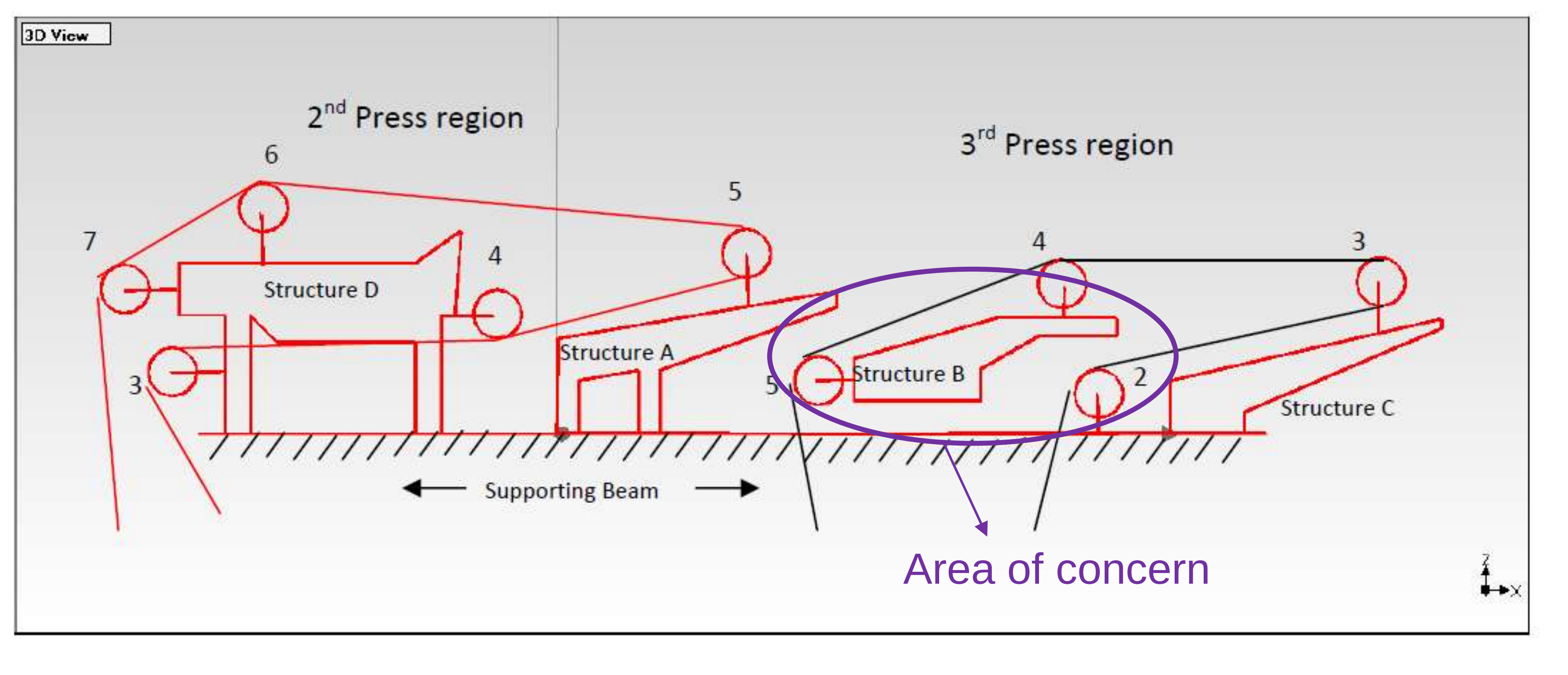
- Overall vibration measurement taken Vibration spectral analysis done at steady state operating conditions.

- Frequency response function measurements on various structures when machine is in OFF condition taken.

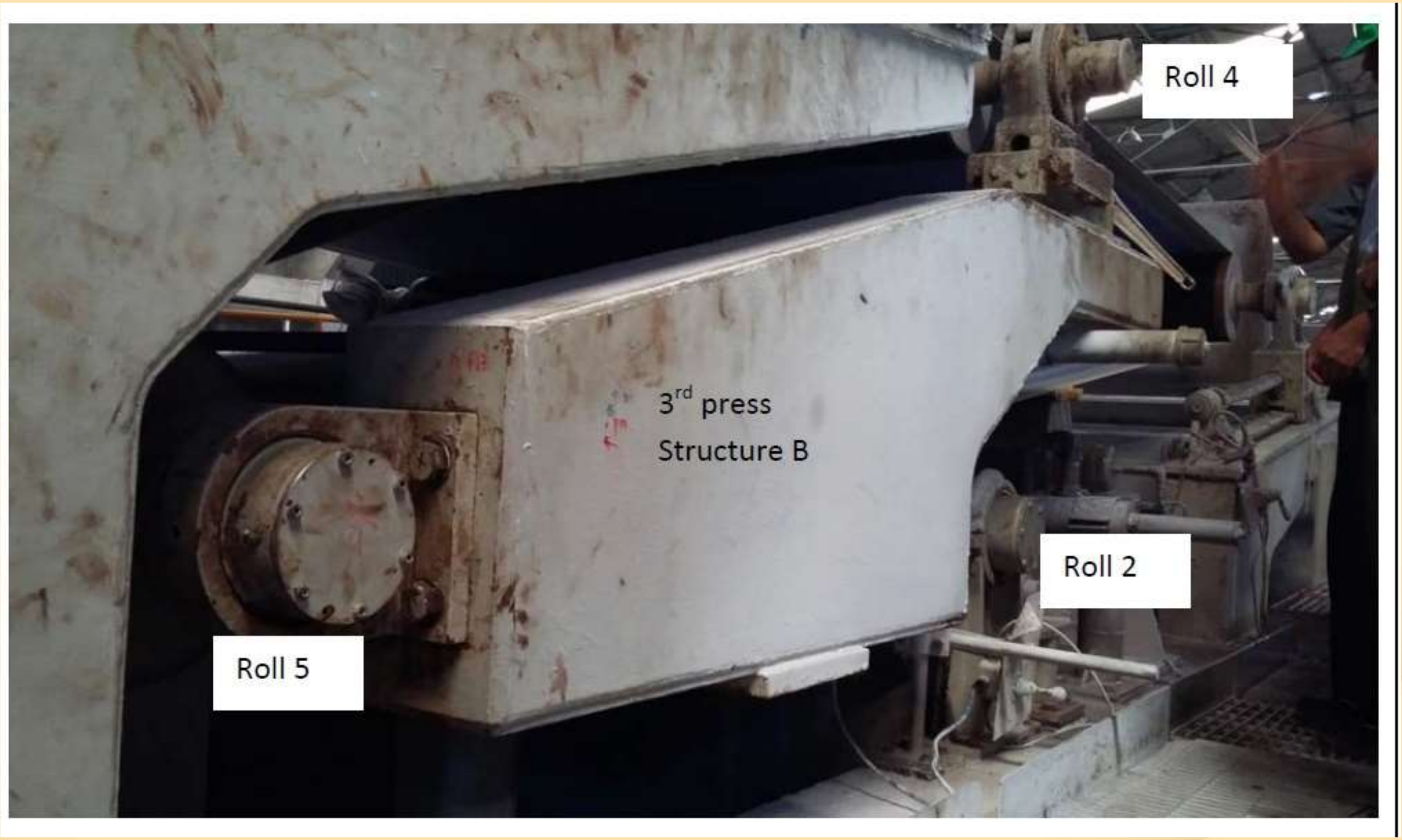
- Coast down measurements when machine speed is decreased from maximum possible operating speed to zero speed taken.

- Operational deflection shape (ODS) analysis is carried out from the FFT spectrum data at steady state operating conditions to visualize the deflection pattern of various structures of press section.

TYPICAL PRESS SECTION ARRANGEMENT



PHOTOGRAPH OF 3RD PRESS SECTION VIEWING FROM NDE SIDE

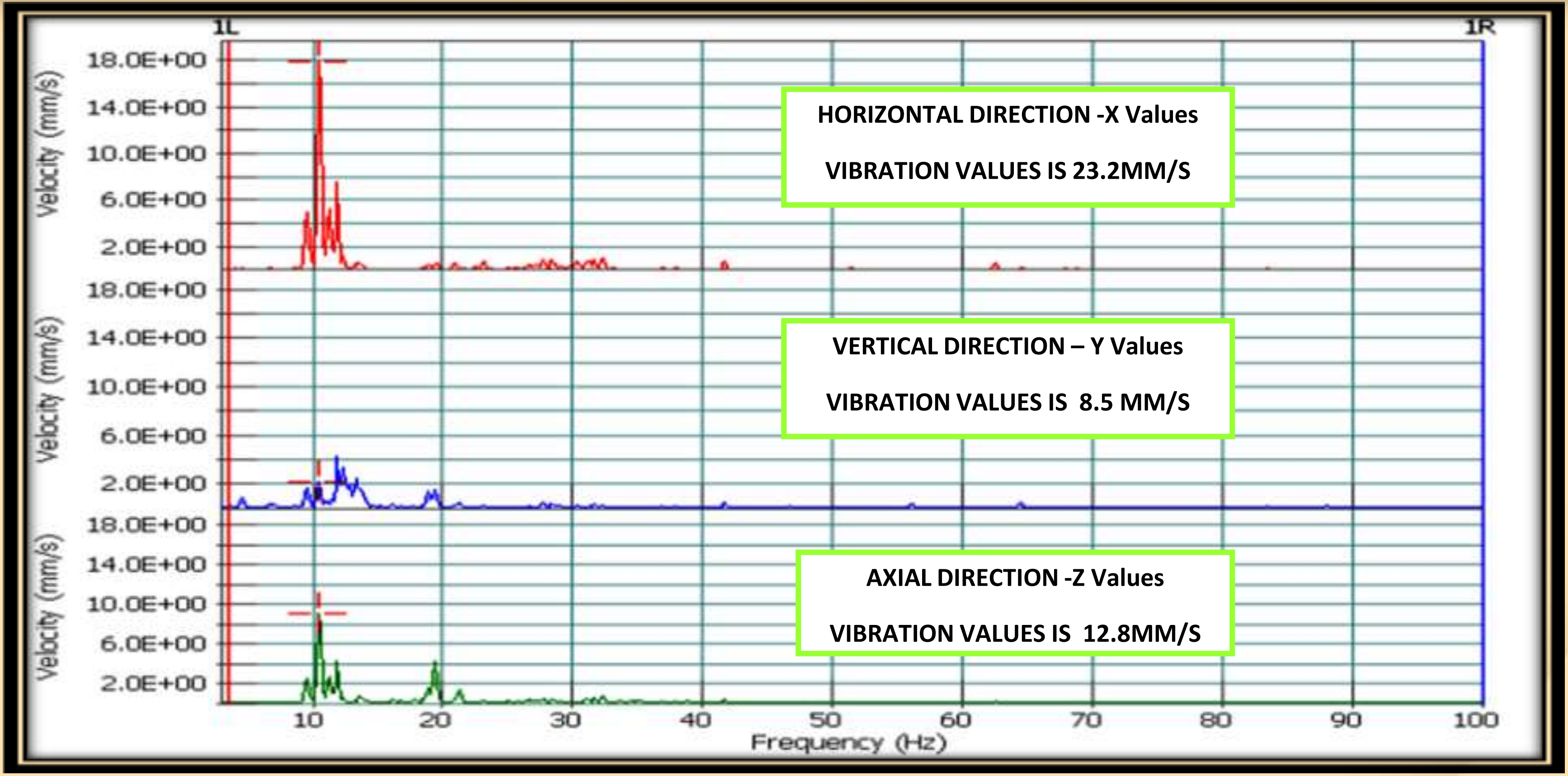


INITIAL VIBRATION MEASUREMENT RESULTS IN 3RD PRESS ROLLS@680MPM

EQUIPMENT NAME	NON DRIVE END			DRIVE END		
	X(H)	Y(V)	Z(A)	X(H)	Y(V)	Z(A)
ROLL NO 2	4.6	3.7	2.6	4.2	3.1	1.4
ROLL NO 4	23.2	8.5	12.8	9.7	10	6.3
ROLL NO 5	16	2.7	6.4	3.6	2.1	2.6

NOTE: Threshold limit for vibration is 4.8 mm/sec

SPECTRUM OF ROLLS IN 3RD PRESS IN X Y AND Z DIRECTION



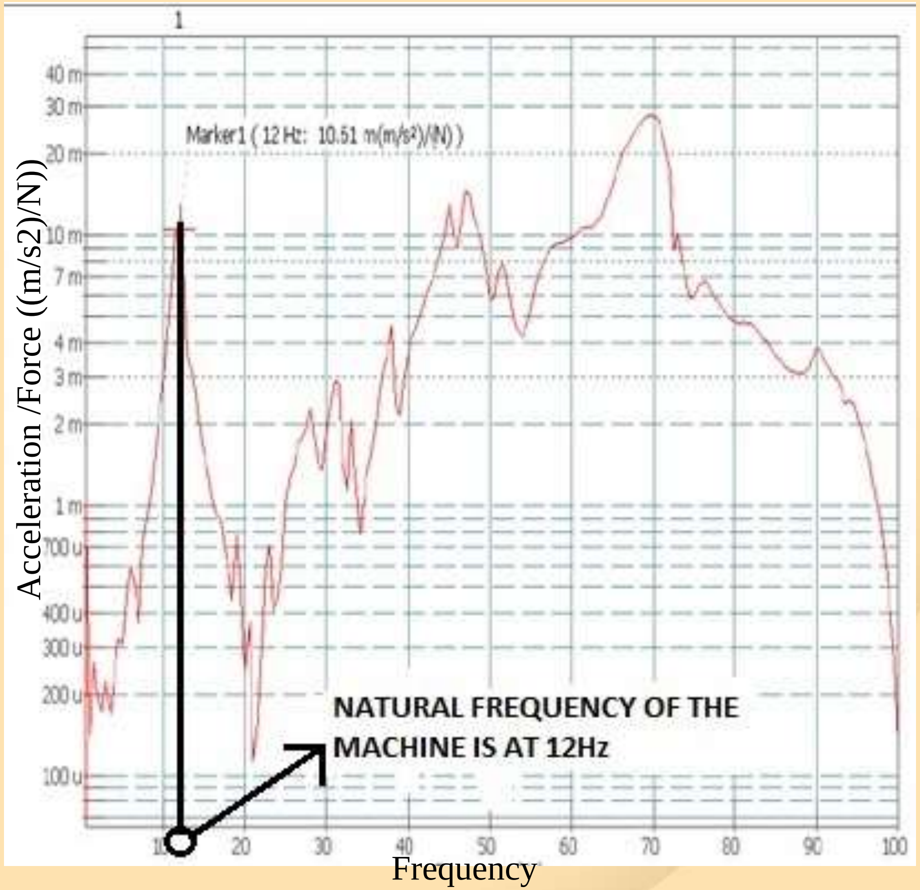
NOTE:

- **Major values are at the frequency of 10.5 hz in x direction in the above spectral data.**
- **Threshold limit for vibration is 4.8 mm/sec**

FREQUENCY RESPONSE FUNCTION (FRF) BUMP TEST FINDINGS

- Since vibrations are predominant at one frequency (10.5 Hz), structural resonance was suspected to be one of the reasons.

- Frequency Response Function (FRF) for each structure was measured with an instrumental hammer at various structural locations, including the location of high vibrations.



FREQUENCY RESPONSE FUNCTION (FRF)MEASUREMENTS (CONTD.,)

In a nut shell

- **Roll vibration frequncy is 10.5 Hz**
- **Structural resonance is also 12 Hz**
- **Since they are close M/c vibrations are seen.**

- **Decision taken to improve the structural strength and accordingly action plans were worked out,**

REMEDIAL ACTION

- As a temporary measure, **two jacks** were provided for the structure with overhang at NDE, to improve the rigidity.
-
- From the after measurements

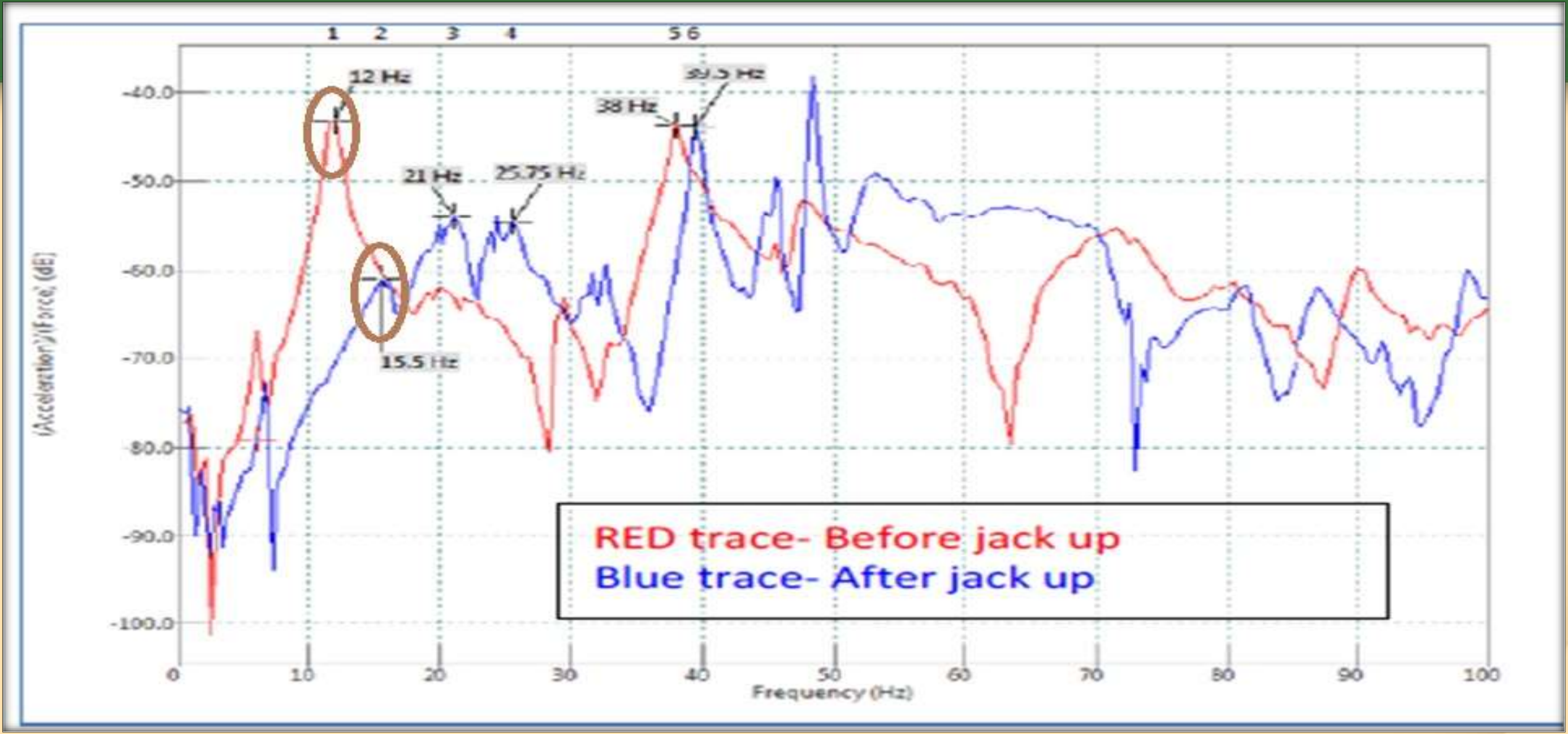
Significant reduction in vibration levels, from 16.8 mm/s to 5.8 mm/s, was observed giving a positive sign

Photo showing support with two jacks for the structure B at NDE to increase the stiffness

FRF MEASUREMENTS TAKEN ON STRUCTURE AFTER CORRECTION ON THE STRUCTURE B

- Bump test at the jacked condition was taken to find the structural behaviour.
- It was observed that the 12 Hz resonance frequency got shifted to 15 Hz .
- Permanant supports were made ready and fitted.
- Typical FRF spectrum for structure B are shown in fig.,

FRF SPECTRUM OF STRUCTURE B BEFORE AND AFTER JACKING UP



From frequency response test on structure ,12hz is observed equals to 720Rpm .At 680 mpm of machine speed ,Most rolls run at 635 rpm which is close to 720 rpm and if the machine speed is increased beyond this ,all roll speed will reach 720 rpm which is natural frequency of structure. After jacking the frequency got shifted to 15.5 Hz that is 930 rpm. So the press section is safe to run till 993 mpm

RESULTS AFTER RECTIFICATION

EQUIPMENT NAME	DRIVE END			NON DRIVE END		
	X	Y	Z	X	Y	Z
ROLL NO 2	2.6	2.7	1.6	1.2	2.1	1.4
ROLL NO 4	3.5	2.8	3.2	2.7	2.8	3.3
ROLL NO 5	3.2	2.7	3.4	3.6	2.1	2.6

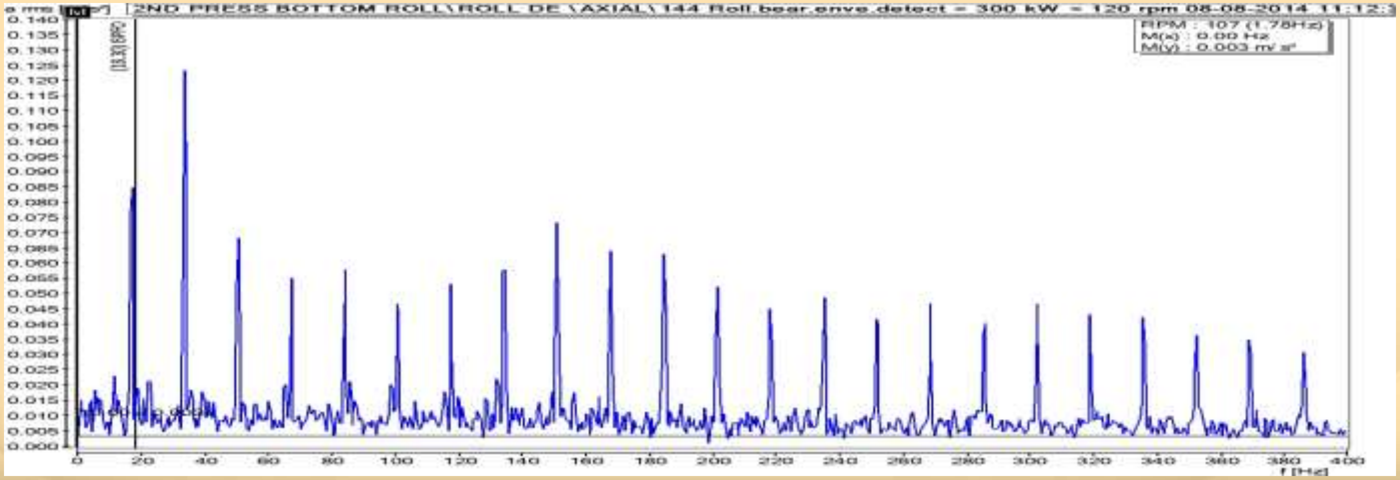
- From vibration severity point of view, with permanent support provided for structure B,
- From the spectrum (15Hz) machine is safe to run at 850mpm
- The machine speed increased to 730 mpm from 680 mpm.

CASE STUDY-2

Equipment Name: Paper Machine-1 2nd Press Bottom Roll

Vibration level and spectrum at abnormal condition:

LOCATION	VIBRATION VELOCITY IN MM/SEC.		
	HORIZONTAL	VERTICAL	AXIAL
ROLL DE	3.05	2.19	8.26
ROLL NDE	3.36	2.31	9.33



OBSERVATION AND RECOMMENDATIONS

Observations:

- Heavy vibration observed.
- Bearing outer race coincides in the spectrum.

Recommendations:

- To change the bearing.

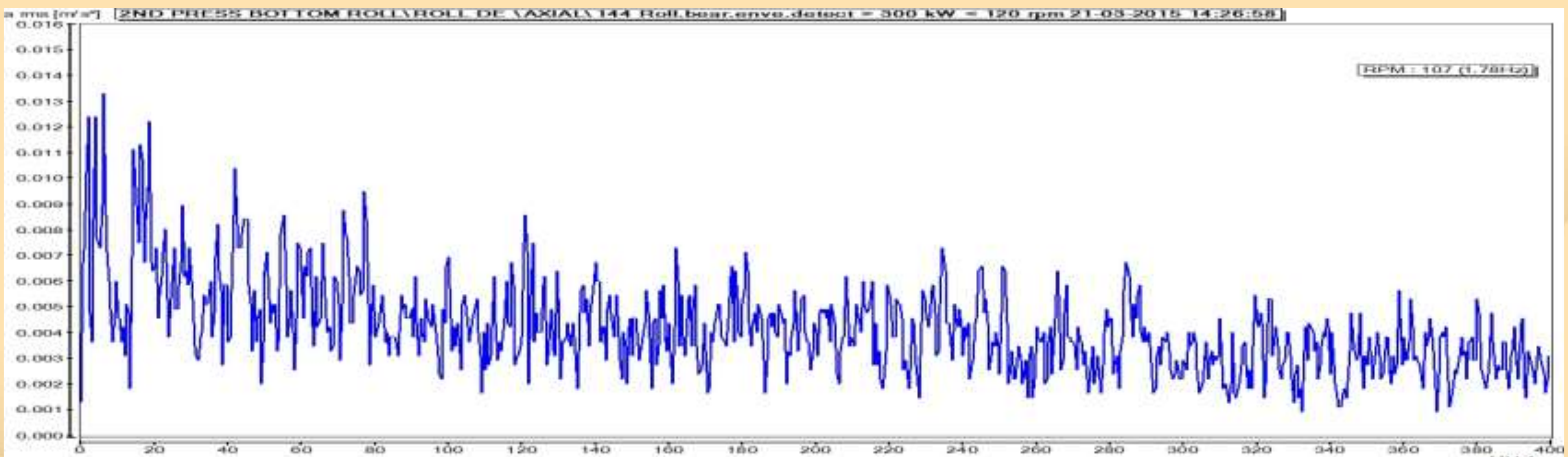
Corrective Action:

- Roll Changed with the new bearings.

(Removed bearing after dismantling seems to have a crack in the outer race)

AFTER RECTIFICATION

Location	Vibration Velocity In mm/sec		
	Horizontal	Vertical	Axial
ROLL DE	0.97	1.26	**1.23**
ROLL NDE	1.36	1.28	**1.16**



CASE STUDY-3

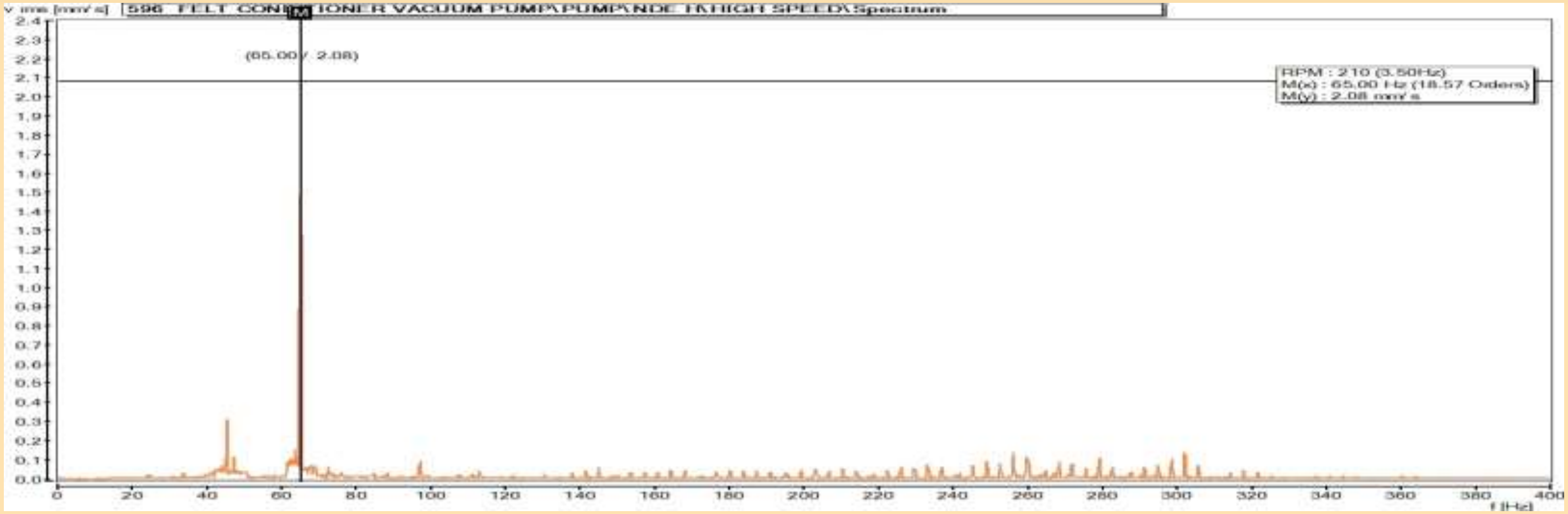
Equipment Name: Felt conditioner vacuum pump in PM-5

OBSERVATIONS

- Vibration with knocking sound.
- Peak observed at 65Hz.

LOCATION	VIBRATION VELOCITY IN MM/SEC.		
	HORIZONTAL	VERTICAL	AXIAL
PUMP DE	3.52	**5.01**	3.10
PUMP NDE	**9.81**	**10.27**	**6.30**

OBSERVATIONS AND FINDINGS



From the spectrum

VANE PASS FREQUENCY (VPF) = NO:OF:VANES * RPM / 60

NO:OF:VANES: 18 ; RPM : 222

VPF = 18*222 / 60

VPF = 66.5Hz WHICH IS COINCIDING WITH THE SPECTRUM PEAK, CONFORMING VANE PASS FREQUENCY

CAUSES AND RECOMMENDATIONS

Attributed Causes from the findings:

1. Crack in the vanes.
2. Rotor looseness

Recommendations:

- First Step - To check for any cracks on Rotor Vanes
- Second Step – To check the looseness

1.Corrective Action:

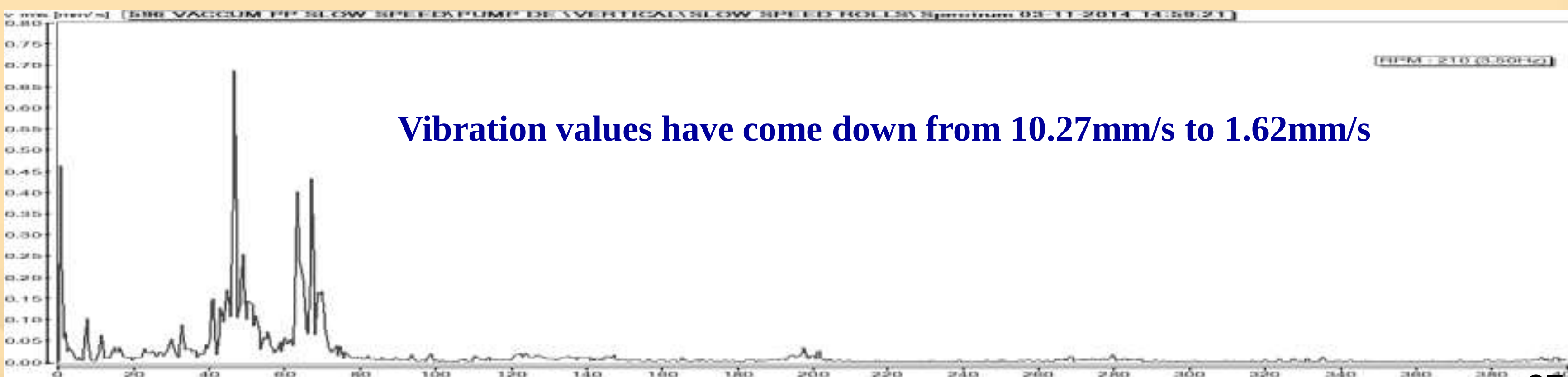
X-ray test carried out in rotor .No cracks found.

2. Corrective Action Suggested:

- Blue match was checked between rotor and its shaft.
- Observed looseness between shaft and rotor.
- Shaft was reconditioned by the department.

Spectrum:

- After shaft correction, pump was running normal. Vibration values are within the allowable limit.

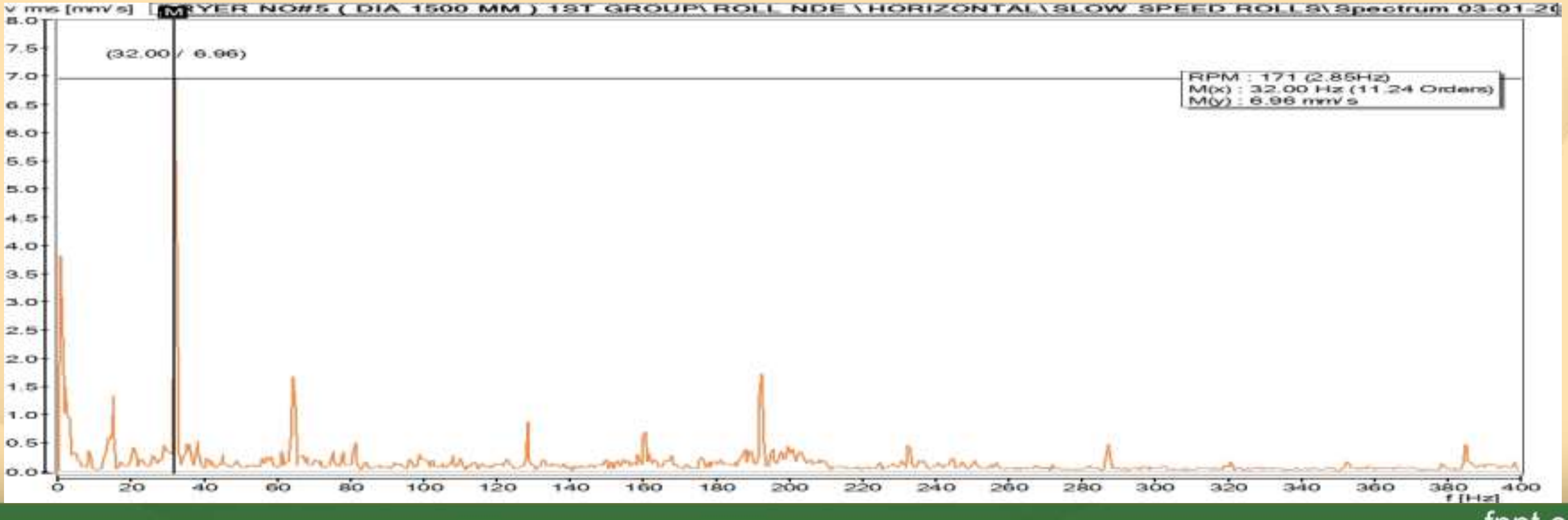


CASE STUDY-4

Equipment Name: PAPER MACHINE -5 / Dryer No:5

Vibration Level and Spectrum at abnormal condition

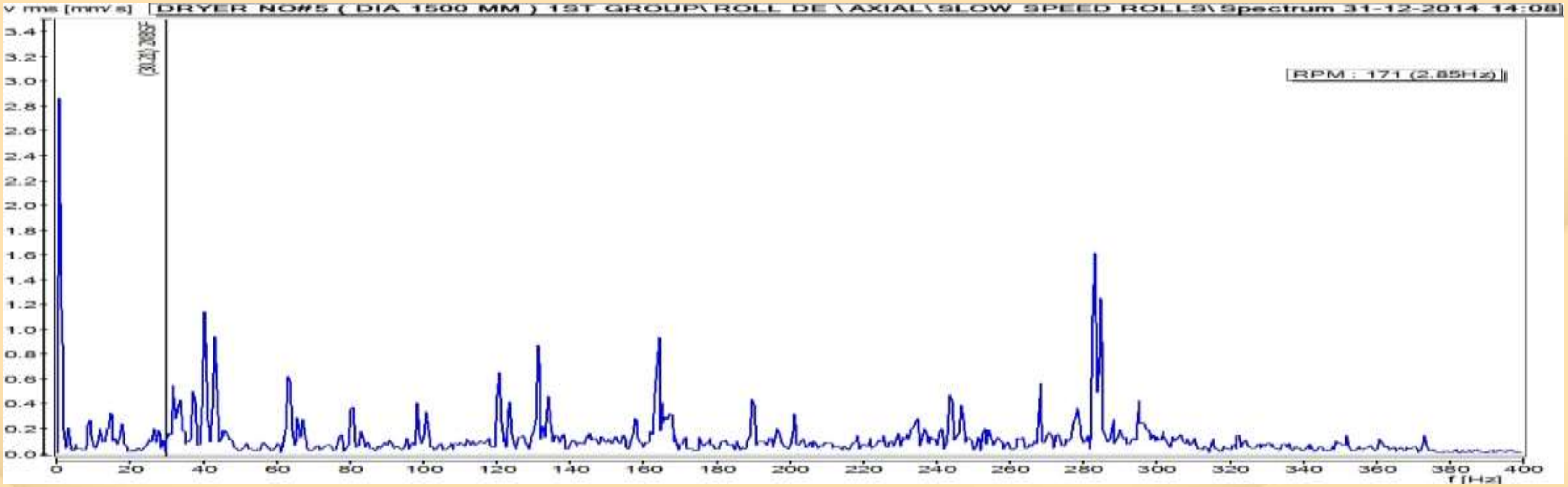
LOCATION	VIBRATION VELOCITY IN MM/SEC.		
	Horizontal	**Vertical**	**Axial**
Roll NDE	**10.16**	**10.76**	**7.86**



AFTER RECTIFICATION

After changing the bearing dryer was running normal

LOCATION	VIBRATION VELOCITY IN MM/SEC.		
	Horizontal	**Vertical**	**Axial**
Roll NDE	2.25	1.46	2.02



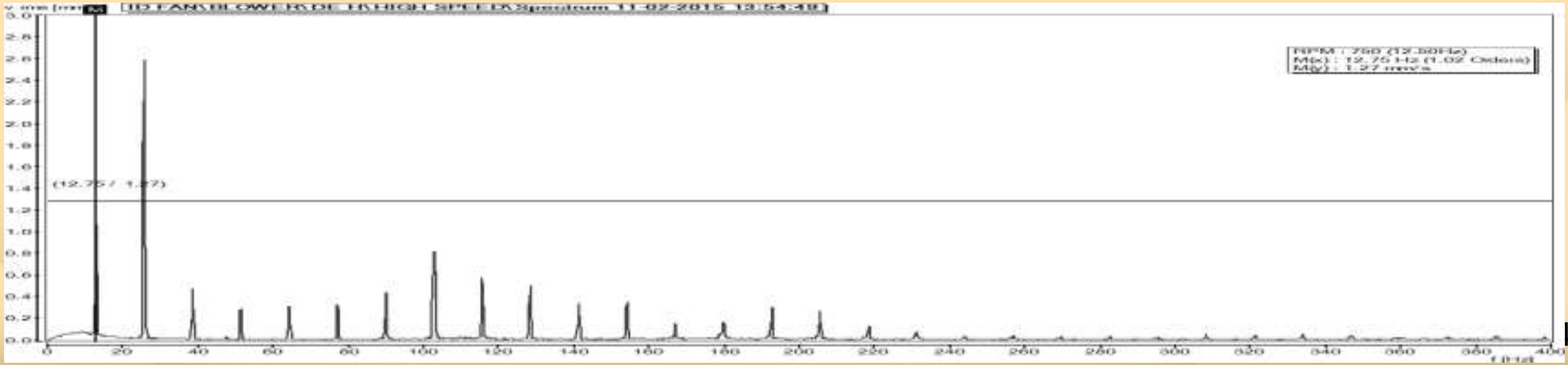
(Removed bearing after dismantling seems to have a crack in the outer race)

CASE STUDY-5

Equipment Name- SRP Boiler ID fan

Vibration level and Spectrum at abnormal condition

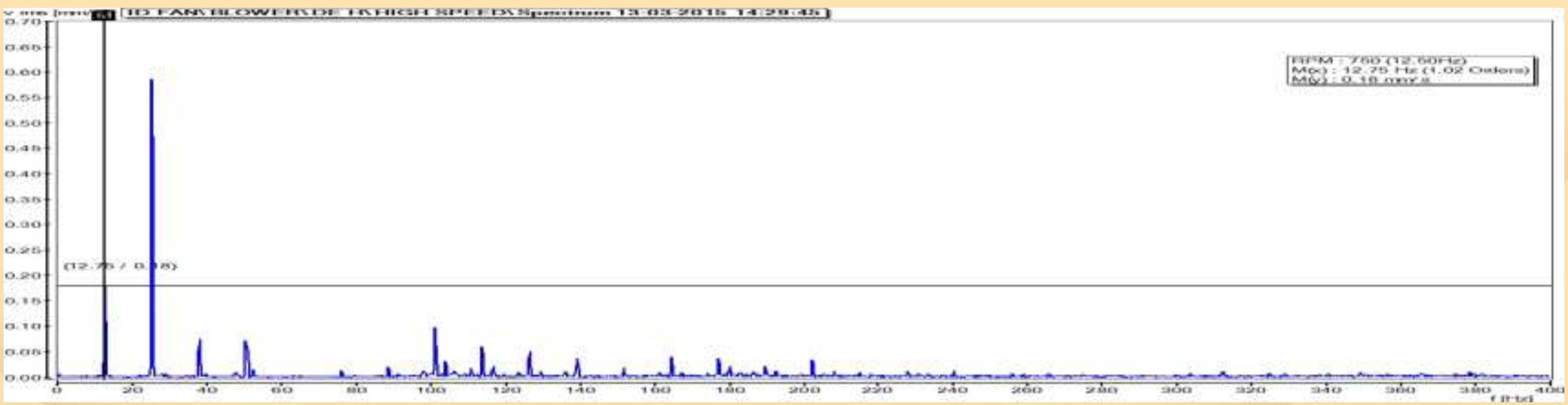
LOCATION	VIBRATION VELOCITY IN MM/SEC.		
	Horizontal	**Vertical**	**Axial**
Fan DE	4.40	1.82	2.65
Motor DE	3.73	1.35	2.76



AFTER RECTIFICATION

- After rectification blower is running normal.

LOCATION	VIBRATION VELOCITY IN MM/SEC.		
	HORIZONTAL	VERTICAL	AXIAL
Blower NDE	1.18	0.57	0.86
Blower DE	0.6	0.14	0.62



CONCLUSION

- Spectrum analysis is the most commonly used vibration analysis tool – the peaks usually relate to the components within the machine.
- We look for changes in the pattern to determine if the condition of the machine may have changed.
- We look at the amplitude of the peaks to assess the severity of the fault condition.
- But don't forget about time waveform and phase analysis, and the other condition monitoring technologies – get the complete story!

THANK YOU