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Implication of Condition-based Maintenance in Roller Bearing of the Paper Industry

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Abstract - *Condition monitoring, also known as predictive maintenance is the best approach to improve efficiency and reliability in processing industries. This industrial science can be used to measure variations and evaluate the condition of plant equipment and resource; allowing smart decisions in contemplating maintenance projects. Maintenance strategies are being adopted by all processing industries and as a result, they are going well with preventive maintenance, but we cannot implement condition monitoring strategies to practice in the small and medium scale industries. Maintenance done by adopting condition monitoring techniques increases machine efficiency, industrial safety and will help in reducing maintenance costs.*

This paper looks at the different maintenance ideologies and the significance of vibration analysis in predictive maintenance. Today almost all processing industries use rotational machine equipment, therefore vibration analysis plays an important role in determining machine defects and flaws developed before the equipment fails and potentially vandalize other connected equipment and hence we can avoid unwanted breakdowns and downtime. Vibration analysis can help in increasing the overall lifetime of machine equipment when the faults are determined and corrected at the right time. Vibration analysis of the press section in the paper industry is also done to show that some faults might exist even though they are not visible to the naked eye.

Key Words: CBM, monitoring, vibration

1. INTRODUCTION

Vibration is the behavior of machine's rotating components as they react external or internal forces. Vibration analysis or CBM for paper industry offers wide range of advanced solutions for machine defects and other mechanical issues faced every day in the industry. Condition-based maintenance is the process of using vibration analysis to detect and diagnosis mechanical defects in machine components. Most rotating component issues are indicated as excessive vibrations, signals are often used as manifestation of machine's mechanical condition. However, early detection of machine problems avoids costly loss of operations due to unplanned machine stoppages. An important key for early detection is by monitoring and analysis of machine vibrations. Vibration analysis for paper machine rolls generally follows guidelines and normal patterns which could be effectively detected by using Condition based maintenance strategies that are valid for rotating equipment i.e., misalignment, looseness, unbalance, bearing defects, etc., as shown, as usual, many components concerned with rotation.

The primary assets include rotating equipment, rotating equipment, paper machine rolls, pumps, fans and much more. All these machines are important in keeping operations of the plant running up. Condition Based Monitoring is a maintenance strategy used for monitoring actual conditions of the machine assets, by understanding the machine lifetime, wear and other relevant changes that might occurred in it. A CBM system detects 24/7 vibrations and noise of a component, by evaluating their probability of breaking and residual lifetime.

In industries, excessive variations in machine components often result in declined output, and hence plant effectiveness is also reduced. At times a simple vibration measurement with very limited potential can help in decreasing the impact of lost production before getting help from an expert. This is explained with the help of a case study in which the measured vibration spectrum was used to detect the unbalancing in felt rolls due to vibration instabilities in the press section in the paper industry.

1.1 Vibration Measurements

Vibrations are measured utilizing different types of sensors. Based on different vibration technique, there are sensors designed accordingly to measure displacement, velocity and acceleration, with various measuring technologies, such as piezoelectric (PZT) sensors, micro electro mechanical sensors (MEMS), proximity probes, laser Doppler, vibrometer etc. PZT sensors is the most commonly used sensor, it generates voltages when under deformation. The voltage signals generated are then digitalized and transmitted to represent in form of vibrations. While selecting a suitable vibration sensor, the vibration levels or dynamic range and maximum frequency range or bandwidth are to be considered, we should also check other operating environment such as temperature, humidity and pH level. Installation of detector is crucial for highest quality knowledge recording. suggested methodology for installation of detectors is by victimization stud mounts that attaches the sensor on a flat and clean surface on the machine. ensuring that a broad and sleek frequency spectrum is being captured. currently once stud

mount isn't applicable, magnet holders, wax or glue is used as replacement with vibration levels and frequencies thought-about.

2. VIBRATION MEASUREMENT OF CENTRE PRESS ROLL

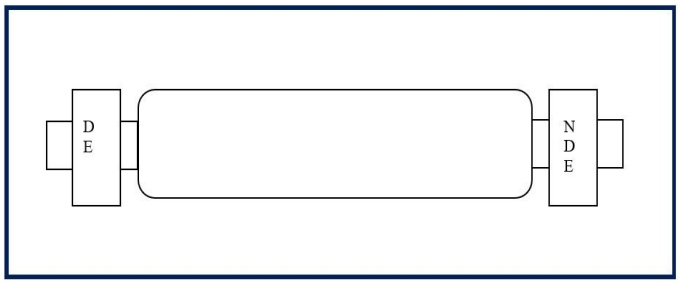
Vibration amplitude of Centre press roll was measured as shown in the chart given below.

Equipment:	CENTER PRESS ROLL				
Roll Diameter:	1000	Equipment Condition:		ALARM	
Roll Bearing No:	DE 23192K C3, NDE 23192K C3				
Roll Speed:	243				
SR NO		ROLL DE			
	Date	Demodulation	Horizontal	Vertical	Axial
		Mg	mm/sec	mm/sec	mm/se
1	05-11-2020	9.3	0.58	NA	NA
2	06-11-2020	10.2	0.74	NA	NA
3	07-11-2020	11	0.85	NA	NA
4	09-11-2020	12.25	0.86	NA	NA
5	10-11-2020	15.6	0.98	NA	NA
6	11-11-2020	19.25	1.02	NA	NA
7	12-11-2020	21.25	1.04	NA	NA
8	17-11-2020	23.5	1.08	NA	NA
9	18-11-2020	24.6	1.14	NA	NA
10	19-11-2020	25.4	1.25	NA	NA
11	20-11-2020	30.8	1.36	NA	NA
12	21-11-2020	32.8	1.45	NA	NA
13	23-11-2020	38.4	1.56	NA	NA
14	24-11-2020	42.6	1.68	NA	NA
15	25-11-2020	44.5	1.9	NA	NA
16	26-11-2020	45	2.41	NA	NA

Chart -1: Vibration measurement of Centre Press roll

Vibration amplitude measured was recorded and stored in excel sheet. After observing table, we saw increasing trend in vibration amplitude (may be caused due to defect present in component). To identify this defect, we collected vibration data in time waveform, this time waveform is then converted into FFT spectrum using Fourier transform.

Equipment: CENTER PRESS ROLL Roll Dia: 1000 Roll Bearing no: DE 23192K C3 , NDE 23192K C3 Roll Speed : 243	Equipment Condition: Alarm



Alarm: 4.85 mm/sec/500mg Danger: 12.15 mm/sec/1000 mg

Fig -1: Equipment Layout

Table -1: Vibrations in Centre Press roll

Location	Demodulation mg	Horizontal mm/sec	Vertical mm/sec	Axial mm/sec
ROLL DE	45	2.41	-	-
ROLL NDE	68	2.27	0.82	0.69

Calculations:

$$BPFI = (N/60)\ (n/2)\ (1+(B/P)\ (\cos \Theta))$$
$$= 13.350 \text{ Hz}$$

$$BPFO = (N/60)\ (n/2)\ (1-(B/P)\ (\cos \Theta))$$
$$= 10.650 \text{ Hz}$$

Where, Θ = contact angle

N = rotational speed, n = number of rollers

p = pitch diameter

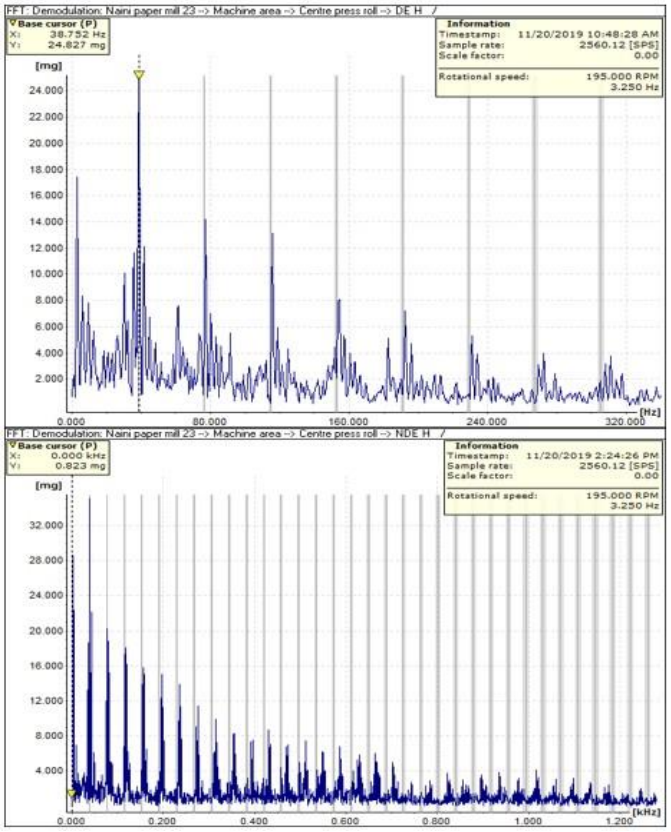


Fig -2: FFT - Demodulation spectrum of roll DE &NDE side

FFT – Demodulation spectrum of roll DE & NDE side. Which are showing fault frequency matched at initial damage start at bearing inner race.

2.1. Analysis

From frequency analysis at Drive End & Non-Drive End side fault frequency was matched at initial damage at bearing inner race i.e., higher amplitude of vibration is observed at BPFI.

2.2. Corrective Action

Roll DE & NDE side bearing should be checked for rotation looseness and raceway related abnormalities should be checked.

3. VIBRATION MEASUREMENT OF FILM PRESS TOP ROLL

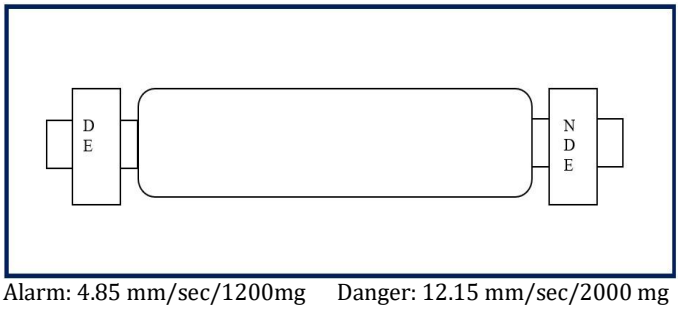
Vibration amplitude of Film Press Top roll was measured as shown in the chart given below.

Equipment:	FILM PRESS TOP ROLL				
Roll Diameter:	950	Equipment Condition:		ALARM	
Roll Bearing No:	DE 23244K C3, NDE 23244K C3				
Roll Speed:	84				
SR NO		ROLL DE			
	Date	Demodulation	Horizontal	Vertical	Axial
		Mg	mm/sec	mm/sec	mm/sec
1	05-11-2020	6	1.23	NA	0.13
2	06-11-2020	6.1	1.22	NA	0.14
3	07-11-2020	5.9	1.12	NA	0.12
4	09-11-2020	5.8	1.25	NA	0.11
5	10-11-2020	6.3	1.1	NA	0.1
6	11-11-2020	6	1	NA	0.13
7	12-11-2020	6.1	1.2	NA	0.14

Chart -2: Vibration measurement of Film Press Top roll

Vibration amplitude for Film Press Top roll was measured and recorded again, stored in excel sheet. After observing table, we saw increasing trend in vibration amplitude (may be caused due to defect present in component).

Equipment: FILM PRESS TOP ROLL Roll Dia: 950 Roll Bearing no: DE 23244K C3, NDE 23244K C3 Roll Speed :84	Equipment Condition: Alarm



Alarm: 4.85 mm/sec/1200mg Danger: 12.15 mm/sec/2000 mg

Fig -3: Equipment Layout

Now after determining defective components from vibration measurement, we further provide the analysis by calculating BPFO and BPFI of the component.

Table -2: Vibrations in Film Press Top roll

Location	Demodulation mg	Horizontal mm/sec	Vertical mm/sec	Axial mm/sec
ROLL DE	6.1	1.23	-	0.14
ROLL NDE	487	0.41	0.12	0.18

Calculations:

BPFI = (N/60) (n/2) (1+(B/P) (cos□□))

= 11.366Hz

BPFO = (N/60) (n/2) (1-(B/P) (cos□□))

= 8.634 Hz

Where, □□□□□□contact angle

N = rotational speed,

n = number of rollers

p = pitch diameter

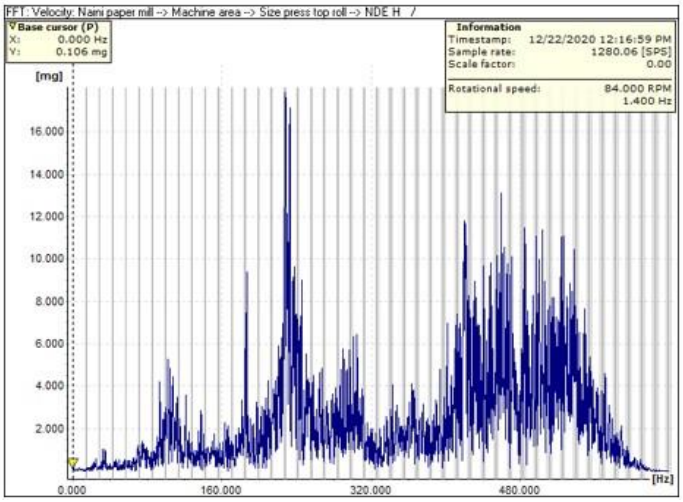


Fig -4: FFT - Demodulation spectrum of roll DE &NDE side

FFT – Acceleration spectrum of roll NDE side bearing. Which are showing fault frequency matched at bearing inner and outer raceway.

3.1. Analysis

From FFT spectrum an increasing trend of demodulation was observed at bearing Non-Drive End side. And from frequency analysis observed at fault frequency matched at bearing outer & inner raceway.

3.2. Corrective Action

Planning should be done to replace roll NDE side bearing. While replacing bearing shaft & housing tolerances should be checked.

4. CONCLUSIONS

This study shows the use of simple analysis of vibration measurements to detect mechanical detects in machine components. Vibration analysis is predominantly applied for the condition monitoring on machinery and their key rotating parts, including but not limited to bearings, shafts, gears, rotating machines, reciprocating machines, etc. CBM also helped in reducing the cost of machine assets and improved component reliability. This study also revealed the CBM performance while the component is working, the chances of disruption is minimized in normal operations and unscheduled downtown due to catastrophic failures.

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