Early Warning and Fault Detection of Rotating Machinery by Condition Monitoring Methods as a Part of the Plant Maintenance Strategy

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ABSTRACT

Integration of Condition Monitoring with Preventive Maintenance undoubtedly enhance the reliability of the equipment in-turn increasing the equipment availability which is the pressing need of the industries in the present competitive market scenario.

Condition monitoring and vibration analysis forms a part of total productive maintenance programme of any industry. This paper discusses a case study, how regular and meticulous practice of condition monitoring has helped in identifying the troubles in APP Mills in high speed machines.

CONCEPT

The concept of preventive and break-down maintenance which was predominant in the last 10-15 years has undergone a sea change in the immediate past. Most of the mills have switched over to predictive type maintenance specially for critical equipments. Today when profitability is so often, on marginal, effective maintenance planning and practising a suitable maintenance strategy are the prime factors in minimizing the cost of the maintenance.

INTRODUCTION TO CONDITION BASED MAINTENANCE

As the name implies, it is, maintaining the equipment based on the condition analysis obtained by monitoring the equipment for specific parameters at regular intervals, trending the development and identifying the out-of-limit condition using simple instruments and reporting the same well in advance so as to take up necessary repairs.

We are aware that the rolling bearings are the most common machine parts liable to cause breakdowns. Due to impacts and pressure variations in the rolling interface, bearings emit shock pulses throughout their life time. With the help of shock pulse and vibration severity monitoring, it is possible to check the general machine condition and bearing condition regarding lubriation level and deterioration of the bearings and to detect imbalance, misalignment, axial play, structural weakness or loose parts, etc.

The above Fig. No. 1 illustrates the advantage of condition monitoring using shock pulse and vibration

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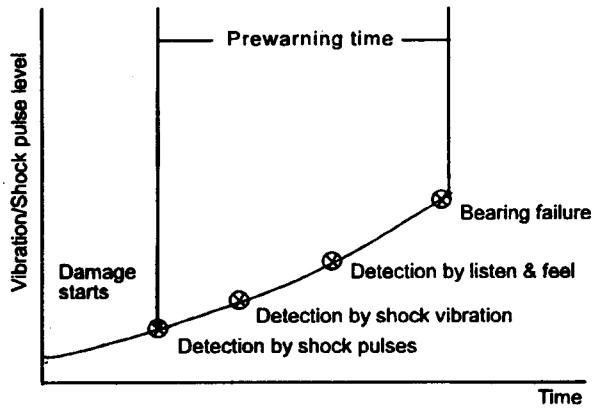

Fig. No. 1

analysis. The art of efficient monitoring relies on early detection of bearing problems leading to scientific maintenance management and avoiding possible catastrophic failures, contributing to economy. The early warning provided by condition monitoring means the time available for the corrective actions is long and replacement can be well planned.

CONFIRMING BEARING DAMAGE

On receiving the typical bearing damage signal, the strongest signal on the bearing housing -confirm one of the following causes for the reading:

- tapping of loose parts against the bearing housing
- excessive bearing play in combination with vibration
- particles in the lubricant
- bearing damage

Interference can be detected by a careful inspection, including a vibration reading.

LUBRICATION TEST

A lubrication test is the best means to reach a conclusion:

- Examine the grease or oil for contamination with hard particles.
- Grease or oil the bearing and repeat the measurement.
- Measure immediately after lubricating and again a few hours later

Make sure that the grease or oil reaches the bearing. Following will be the results :

- The shock pulse level remains constant
- The signal is caused by interference or cross talk from other bearing.
- The shock pulse level drops immediately after lubrication and remains low.
- Foreign particles in the bearing were removed by the fresh lubricant.
- The shock pulse level drops immediately after lubrication but rises again with in few hours
- The bearing is damaged.

OVERVIEW OF CONDITION MONITORING IN APPM

In 1995, during the first phase of introduction of the SPM Condition Monitoring system, one Shock Pulse Analyzer (Model : A 2010) was procured and the monitoring technique was initially adopted for the break-down prone equipment like dryer felt rolls to establish the credibility of the system. There were about 300 measuring points monitored every month. Slowly the system started yielding results and the break-downs were minimized.

Gradually all the equipment of Paper Machine No. 5 were included in the monitoring schedule in a phased manner. The Shock Pulse Analyzer, model: A 2010 was upgraded to Datalogger, model : A 2011 to work with the computer on PRO 32 condmaster software.This enabled us to monitor more bearings and manual errors of misinterpretation of measuring results was avoided. The periodicity of monitoring was also increased to have more data about the condition of the equipment. The datalogger facility has enhanced the capability of making more rounds and number of measuring points were increased to around 600 per month.

Subsequently 101 Nos. Permanent Mounting Transducers (PMTs) were installed on critical bearings which are not accessible to monitor by hand held probe, dangerous to reach and located in very hot

Table : 1 Measuring results of equipment before and after maintenance

S. No.	EQUIPMENT	BEFORE REPLACEMENT		AFTER REPLACEMENT		REMARKS & OBSERVATIONS
		DATE	READINGS	DATE	READINGS	
1.	PM - 5 Pick up Roll NDE	30.08.95	D-65 41/25 VH : 5.3 VV : 3.2 VA: 3.2	02.09.95	A-5 7/3 VH: 1.8 VV: 1.2 VA: 1.0	Outer race broken into pieces. Roll replaced on 02.09.95
2.	PM-5 Dryer Felt Roll No. 52 NDE	09.01.96	D-49 29/8 VH: 9.1 VV: 7.8 VA: 22.4	27.05.96	A-8 9/6 VH: 3.0 VV: 3.5 VA: 3.0	Bearing Cage broken & journal worn out.
3.	PM-5 Pick up Press Gear Box	22.01.97	D-44 35/30 VH: 1.8 VV: 1.2 VA: 3.6	30.09.97	B-26 29/20 VH: 1.5 VV: 1.2 VA: 1.8	Gear box intermediate gear is loose on its shaft Gear Box replaced on 28.07.97.
4.	PM-5 Top Press Roll NDE	22.01.98	D-65 45/34 VH: 4.7 VV: 4.6 VA: 8.3		A-3 11/8 VH: 1.8 VV: 2.0 VA: 1.9	Deep groove developed in outer race. Roll replaced on 06.02.99
5.	PM-5 Dryer No.15 DE	28.01.99	D-65 32/22	19.02.99	A-5 4/-2	Inner race was damaged. Bearing replaced on 08.02.99

RMS VELOCITY IN MM/SEC FOR VH: VIB. (HOR), VV: vIB. (VER) & VA: VIB. (AXI).

Table : 3 Drying bearing failure results.

Date	Time	LR	HR	LUB	COND	CODE	MPM
1999-01-12	10:53	32	20		65	D	477
1999-01-06	08:32	36	22		65	D	496
1999-12-21	08:53	31	12		65	D	402
1999-11-27	08:50	30	12		59	D	468
1999-07-09	14:33	29	12		53	D	496
1999-05-22	11:00	28	12		53	D	472
1999-04-08	15:15	25	10		44	D	477
1999-03-27	11:18	24	11		41	D	477
1999-03-24	09:07	13	1	4		A	472
1999-03-17	08:39	19	0		42	D	435
1999-03-10	10:55	5	-2	3		A	335
1999-03-02	11:41	12	3	3		A	482
1999-02-27	15:32	9	1	4		A	472

Table No. 2 Drying bearing failure resutls.

Date	Time	LR	HR	LUB	COND	CODE	MPM
1999-04-19	08:42	2	-4	4		A	416
1999-04-10	11:08	6	-3	6		A	506
1999-04-06	08:37	7	-4	5		A	435
1999-03-29	08:48	7	-3	6		A	496
1999-03-27	10:04	1	-4	6		A	496
1999-03-20	15:43	2	-4	6		A	501
1999-03-08	09:04	3	-4	6		A	496
1999-02-26	14:15	8	-2	4		A	439
1999-02-23	08:54	10	-3	6		A	501
1999-02-19	18:32	4	-2	5		A	496
1999-02-15	09:32	47	10		65	D	435
1999-02-13	18:01	39	19		65	D	425
1999-02-10	09:04	34	12		65	D	463

THE ANDHRA PRADESH PAPER MILLS LIMITED (C) 1992-93 SPM INSTRUMENT AB LR/HR -> PM-5 OM DRYER NO. 15 DE A-115.01 TYPE : 7 COMP : 4

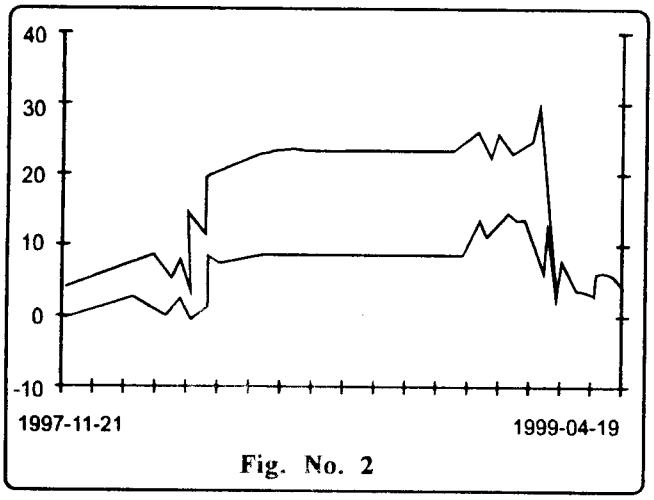

Fig. No. 2

surroundings. They were connected to junction boxes at a safe distance via coaxial cable to enable data collection.

The following Table no. 1 shows the measuring results of equipment before and after maintenance with observations which depicts the advantage of condition monitoring for early warning and fault detection of the equipment.

CASE STUDY 1

Prediction of Dryer bearing failure of Paper Machine No. 5 shown in Fig. No. 2 and Table 2 and 3.

It is noticed that the shock pulse level is gradually increasing and alerted the maintenance department well in advance and as a follow up action on 8.2.99 the bearing was replaced during a planned shut down.

On opening the bearing it was found that the inner race was severely damaged and deep cracks were noticed.

CASE STUDY : 2

Prediction of Dryer Felt Roll bearing failure on PM # 5 shown in Fig. No. 3, 4 and Table No. 4.

It is noticed that the shock pulse level increased and CODE and COND NO. are D 38, then due to slippage of inner race on the journal the shock pulse dropped where as the vibration levels were still shooting up which prompted an emergency planned shut down to replace the roll on 6.5.97.

On opening the bearing it was found that the journal was severely worn out and the inner race was slipping over it.

PERFORMANCE OF THE EQUIPMENT

The following table no. 5 shows the performance of Dryer Felt Rolls on Paper Machine No. 5 :

Since the implementation of Condition Monitoring activity in 1996 the number of roll failures while in operation has come down drastically. This is so achieved by rescheduling the lubrication intervals as per SPM levels, using the large clearance bearings

Table No. 4 Failure results of Dryer felt roll bearing.

Component:
Measuring point: A-432.02 PM-5 Dryer Felt Roll No. 32 NDE (Stretch)

Date	Time	LR	HR	LUB	COND	CODE	MPM	VIBH	VIBV	VIBA
1999-05-07	10:10	18	10	3		A	479	2.50	2.90	3.10
								Roll changed (Shut Down)		
1999-04-28	14:25	23	17	1		A	500	4.60	4.30	12.40
1999-03-08	14:36	23	19	0	17	B	500	3.60	4.00	4.50
1999-01-22	11:44	30	18		18	D	494	2.30	3.00	4.00
1999-10-12	11:38	28	17		35	C	479	2.10	3.00	3.50
1999-07-14	09:04	25	11		29	C	465	2.20	3.10	3.30
1999-04-15	11:35	23	20	0	17	B	505	2.80	0.70	0.90
1999-03-02	15:56	25	20	0	23	B	489	3.70	2.60	2.30
1999-01-20	15:18	27	24	0	29	B	500	2.60	2.40	3.10
1999-10-15	11:15	17	8	3		A	151	4.00	7.00	16.00
								Roll changed (Shut Down)		
1999-07-23	10:26	20	7	4		A	470	5.80	7.70	19.20
1999-05-07	10:14	21	8	3		A	460	6.30	7.50	15.40
1999-01-29	09:16	18	10	3		A	496	6.50	7.60	15.30
1999-11-06	09:05	35	11		59	D	522	8.40	8.40	20.60

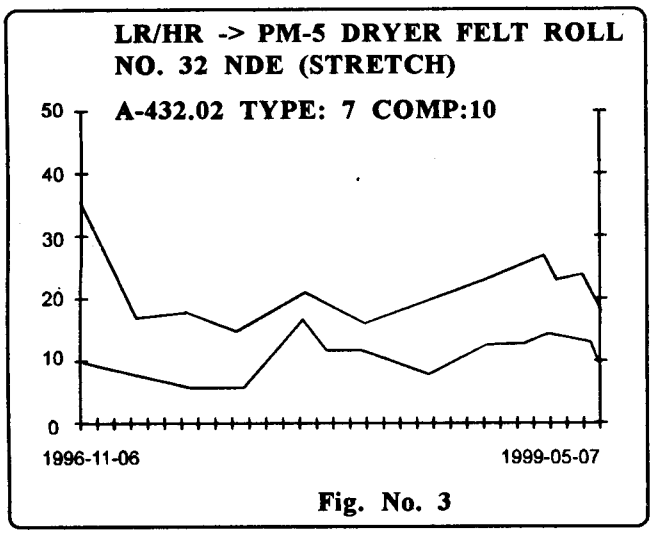

Fig. No. 3

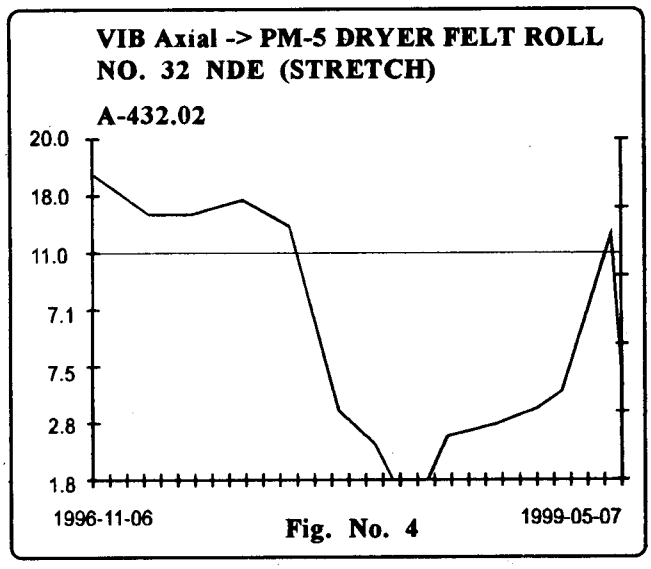

Fig. No. 4

Table No. 5 The performance of Dryer Felts on Paper m/c No. 5

YEAR	NO. OF FELT ROLLS FAILED	DOWN-TIME IN HOURS	PRODUCTION LOSS IN TONS
1995-1996	7	14	70
1996-1997	2	5	25
1997-1998	2	5	25
1998-1999*	1	3	15

*upto April 1999.

and modifying the bearing housing tolerances.

ACKNOWLEDGEMENT

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