Selection of Proper Maintenance Strategy for Paper Industry

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INTRODUCTION

In any continuous manufacturing process, maintenance is of the upmost importance. Loss of production due to forced outage of the production facility, or even part of the production facility, can have considerable effects on profitability. Specifically, in the pulp and paper industry, with its inherently high production costs and small operating margins, the need for efficient, cost-effective and practical monitoring systems is more pronounced than ever before. In our paper mills, we spend about Rs. 1500/=, Rs. 2300/= & Rs. 3000/= per ton of paper production towards cost of maintenance, labour cost and energy cost respectively. The cost of down time due to breakdowns is estimated at 4% of the fixed assets. The average capacity utilization of Indian paper industry is about 80% as against world bench mark of 92% and the plant availability is about 85% as against world bench mark of 96%. Therefore, in order to achieve a competitive edge in the present economic scenario, our paper industry has to select proper maintenance strategy for their survival.

MAINTENANCE STRATEGIES:-

✦ Traditionally paper mill machinery maintenance was on a run to breakdown basis. This meant allowing the breakdown to occur, shutting the production facility down, and repairing the fault. This was not an economic method of maintenance, the financial losses from a single bearing failure on one of the paper-machine's at the plant can exceed Rs. 1,50,000/= per hour.

⦿ Nowadays, one of the most widely used methods of machine maintenance is time-based preventive maintenance, using planned production stop to replace all critical components, at regular intervals. While this method is an improvement on the previous one, the planned production stops still generate financial penalties due to lost production and critical components are often replaced regardless of having a considerable life-expectancy. Further, no amount of regular, planned maintenance, can remove the threat of catastrophic failure of a component between checks.

➢ A third method of machine maintenance involves regularly monitoring the machine while it is in a good condition, employing more advanced maintenance methods while the machine is deteriorating and using the collected data to predict when the machine is about to fail. It is called condition-based maintenance. Condition-based maintenance can accurately identify incipient rolling-element failure before the component reaches a catastrophic condition, allowing the production manager/maintenance team to decide when he/they want to replace worn components and alleviating the necessity for stripping-down machines in search of faults.

➢ Different Condition Monitoring techniques such as vibration monitoring & analysis, Shock Pulse analysis, Thermography, Oil/Wear debris analysis, Corrosion monitoring, Thickness monitoring, Different Non-destructive testings (NDT), Noise monitoring & analysis have been developed for machine fault diagnosis. A recent British study reveals that the process industry could save about $ 1.3 billion a year by adopting CBM strategy. In a petrochemical industry in UK., the maintenance cost could be brought down by $ 9-10/HP/YR by implementing CBM. By implementing CM programme, Canadian navy saved $ 100,000 per ship per year in maintenance cost.

➢ A survey conducted by National Productivity Council (NPC) revealed that, our paper industries are not implementing Condition Based Maintenance to the level which is desired. 14% of the plants use Vibration Measurement and only 6% of the units carryout Vibration Analysis. About 14% of units implement Shock Pulse Analysis. About 3% of units carryout Corrosion Monitoring. About 8% of units carryout Noise Measurement. About 70% of units carryout Thickness Monitoring by ultrasonic gadgets. 57% of units carryout Non-Destructive Examinations by Dye Penetrant Testing (DPT). Less than 2% of units carryout Thermography and Wear Debris Analysis and non perform Acouistic Emission Testing in our Paper industry.

➢ The full potential use of the above highly versatile diagnostic tools and techniques should be explored in our paper mills to achieve higher operational reliability, safety and quality at manimum cost to become competitive in the global market.

❍ The forth strategy of machine maintenance is called Reliability Centred Maintenance (RCM). It is defined as a process used to determine the maintenance requirements of any physical asset in its operating context.

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- The seven basic questions asked in RCM are given below:-

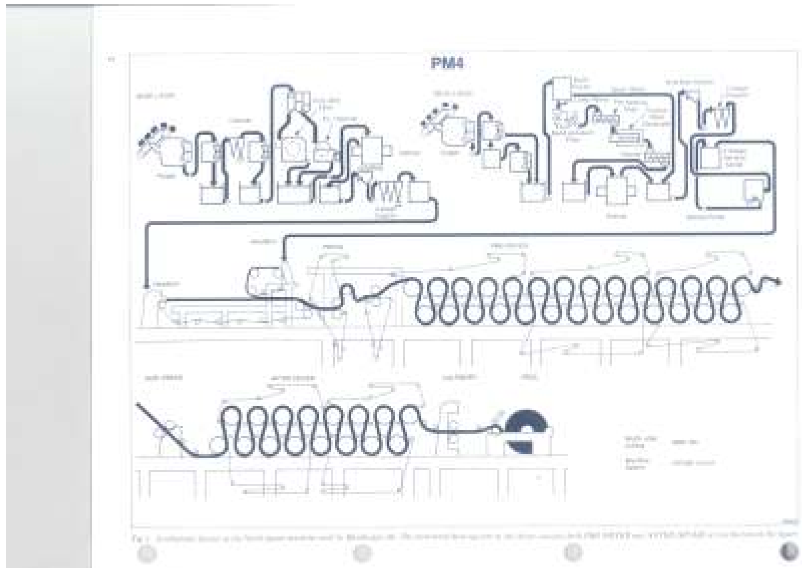
- What are the functions & associated performance standards of the asset in its present operating context?
- In what ways does it fail to fulfil its function?
- What causes each functional failure?
- In what ways does each failure matter?
- What can be done to prevent each failure?
- What should be done if a suitable preventive task can not be found?

- RCM requires designing for the following Protective Devices:-

- To draw the attention of operators to abnormal conditions Sensors, Alarms, Warnings etc.
- To shout down the equipment in the event of failure Relays and Circuit Breakers.
- To eliminate or relieve abnormal conditions which follow a failure Safety Valves, Fire-Fighting Equipment.
- To take over from a function which has failed-Stand by system, redundant system.
- To prevent dangerous situations from arising in the first place-Guards.

- The latest strategy of Plant Maintenance is called Total Productive Maintenance (TPM). It involves corporate cultural change with commitment from the Chief executive officer of the company aiming to achieve zero breakdowns, zero defects and zero accidents. It emphasizes on Overall Equipment Effectiveness (OEE), Life Cycle Approach (LCA), Autonomous Maintenance (AM), Enterprise wide Participation in asset management (EWP) and Group working (GW).

- The expectations from TPM activities in a paper mill are given below:



- Increase in value added productivity
- Reduction of breakdowns
- Reduction in defects
- Reduction of customer complaint
- Reduction of maintenance cost
- Reduction in inventory
- Reduction in accidents and pollution
- Intangible benefits and moral gains

2.6 Condition-Based Maintenance - A case study :

- The condition-based monitoring system described in this case is designed to monitor rolling-element bearings in harsh environments, such as those found throughout the pulp and paper industry. The necessity for installing the system was due to the unusually high failure-rate among bearings on the dryer section of Voith paper-machine. Between 2000 and 2005 these sudden failures cost the company in the region of Rs. 10 crores in terms of lost production alone. Inclusion of the costs incurred in overtime payment to the maintenance personnel, ancillary damage caused to other components by a sudden bearing failure and financial losses due to inability to deliver on schedule would considerably increase the estimate of the losses given above.

- In this case, of monitoring system, since installation in 2001, there has been no loss of production due to sudden bearing failure on the monitored section of the machine. While it is difficult to estimate the exact savings to the plant in terms of increased production, a conservative estimate would place them in the range of Rs. 85 lakhs per annum.

- The company recycles waste paper, producing corrugated packing paper. They run 1 Voith and 1 Erwepa paper-machine, manufacturing 24 hours a day at full capacity. They employ 250 people and produce 150,000 tonnes of corrugated packing per year. Fig. 1 shows a schematic layout of the monitored paper-machine
- The paper-machine contained over 1500 bearings of which 400 were deemed critical from the outset, a failure amongst any of these bearings would result in the immediate shutdown of the whole machine. The monitoring system used initially, involved 3 to 4 personnel who listened regularly to the

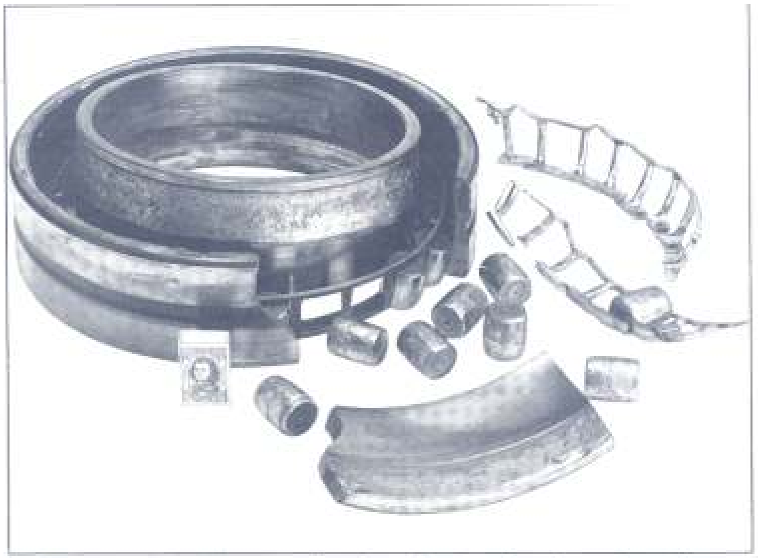


Fig. 2 Unexpected breakdown of a rolling-element bearing, such as the one shown above, can be an expensive surprise. Regular monitoring of the vibration signature from the bearing could have prevented it occurring

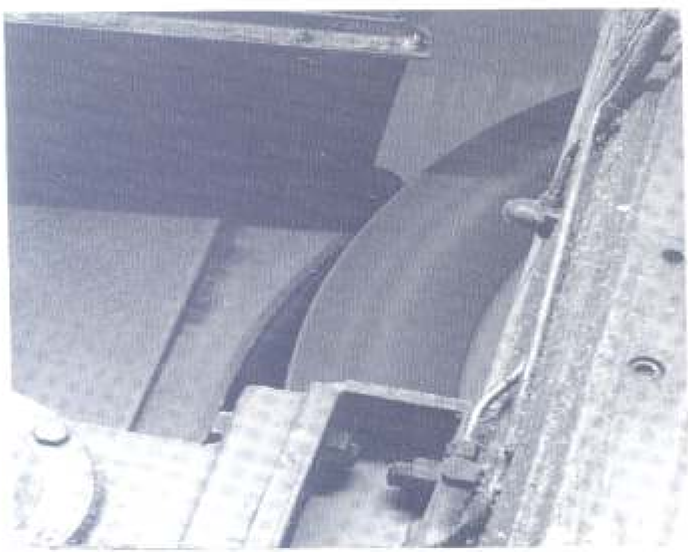


Fig. 3 A Brüel & Kjær accelerometer mounted on the bearing housing of one of the paper-machine's drying cylinders

critical bearings using a stethoscope. The average down-time of the machine was about 5% per annum and the number of maintenance personnel engaged in down-time repairs was 6.

- After a period of time, it became apparent that particular difficulties were being encountered in monitoring the bearings attached to the heated cylinders in the drying section. These 43 cylinders are 1,5 m in diameter and 6 m long, rotating at a speed of 100 rpm. Steam, at a temperature of 150° C, is fed into the cylinders at one side of the machine, passed along the length of the cylinder, and extracted at the same side again. The paper is passed over the cylinders and dried.

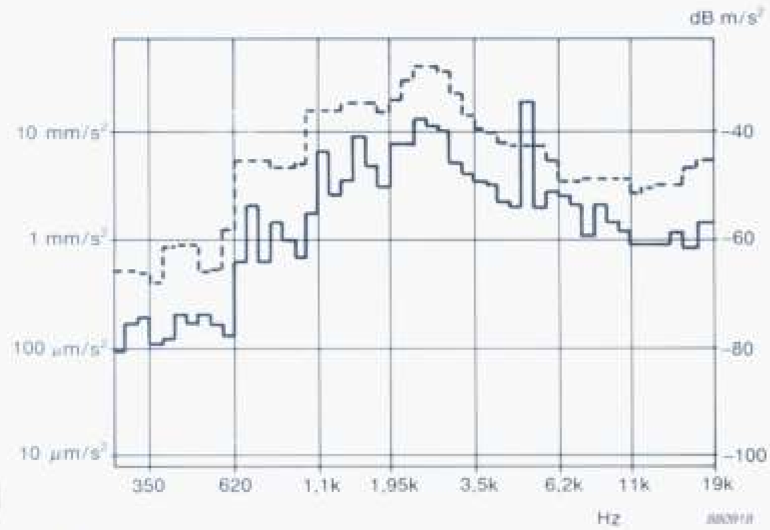
- The bearings attached to these rollers exhibited a very high failure-rate. These bearings were all at the hot-end (the side at which steam is fed into and out of the rollers). The average down-time due to a bearing failure on this section of the machine was 30 hours (due to the difficulty in accessing them) at a cost of Rs. 1.5 lakhs per hour in lost production.

- The company recorded the vibration signals from each of the critical bearings using a Type 7005 Portable Tape Recorder and using a technique called envelope detection. The analysis was to be completed before the annual maintenance shutdown to allow them to assess the validity of the results while stripping the bearings down.

- The analysis concluded that 2 of the bearings, TS 11 and TS 17, had rolling element faults and while not critical, they should be replaced at the next available opportunity. The rest of the bearings exhibited no signs of terminal wear.

- At the annual maintenance shut-down all bearings on the paper-machine's dryer section were stripped down and examined by maintenance personnel. While a number of bearings throughout the paper-machine were found to exhibit signs of advanced wear, only 2 of the bearings in the dryer section were deemed to be at such an advanced state of wear that replacement was considered necessary. These were bearings number TS 11 and TS 17. The company then requested supplier to design and install a permanent monitoring system.

- Permanent monitoring by means of the Type 2505 Monitors and Type 2514 Multiplexers will monitor the overall vibration level of the bearings. It is expected that the overall vibration level would increase dramatically in the last few hour's of bearing life. The permanent



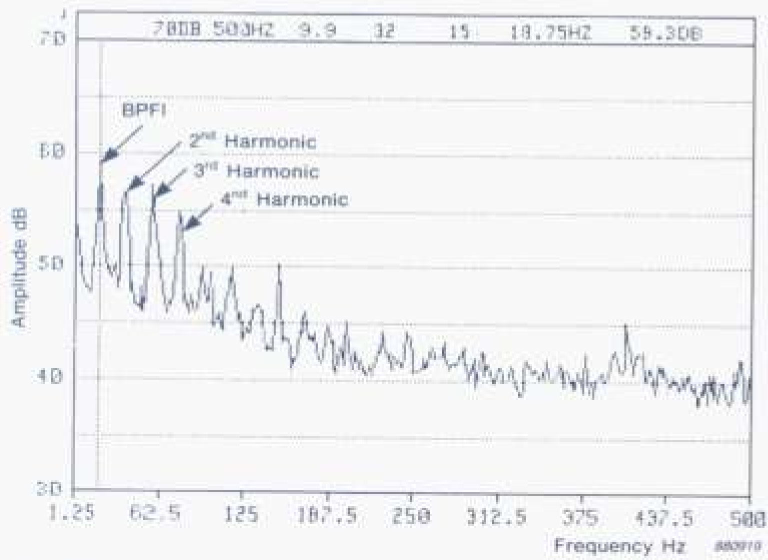


Fig. 5 The envelope spectrum for bearing TS 20. The cursor (dotted line) is positioned at the peak (18,75 Hz), where the inner-race fault is readily identifiable

system can then be used to shut the machine down before catastrophic failure.

- Automatic spectrum comparison of each vibration signal with an appropriate reference spectrum should occur at least every 3 to 4 hours. Systematic monitoring of an increase in the vibration level at one of the bearing resonance frequencies should give at least several weeks warning of an impending failure. Operator-supervised trend analysis will aid in estimating the lead-time to failure.

- On detection of changes in the spectrum, or at any other time where a fault is suspected, an envelop analysis can be performed. Detected fault-repetition frequencies could then be compared with calculated fault-repetition frequencies for various bearing faults i.e. inner-race, outer-race etc.

- Presently the Company operate a policy of shutting down production only when the system indicates a serious bearing fault. They use a very simple chart, to calculate the bearing frequencies, and on cross-checking these calculated frequencies with the detected repetition frequencies, they can make a judgement on the seriousness of the bearing fault.

- The broadband system cyclically scans the overall vibration levels of each of the critical bearings, providing them with the security of permanent monitoring. The broadband monitors quickly step through each channel (each channel in the system is connected to an accelerometer mounted on one of the critical bearings) comparing the overall vibration level of the channel against preset limits. Any increase in vibration above these limits will trigger relays to activate alarms, allowing the operator to shut the paper-machine down before the fault becomes critical.

- A software package works in parallel with the broadband system. For each channel, it produces a frequency spectrum of the machines vibration levels for comparison with a similar spectrum taken when the machine was in a known "healthy" condition. As soon as a fault begins to develop, the shape of the frequency spectrum changes and this change will be detected by the spectrum comparison. The spectra are created by transforming the vibration signals into their frequency components, compounding the components into percentage bandwidths, and displaying the result on logarithmically scaled axes.

- The "first" spectrum recorded for each bearing is stored as the "Reference Spectrum". The reference spectrum is then used to create the "Reference Mask". The mask is made by widening the bands of the reference spectrum (to allow for small speed fluctuations) and adding tolerances to the result.

- The monitoring software steps contiguously through each channel and generates a new "Comparison Spectrum" which is compared with a mask of the corresponding reference spectrum "Exceedances" over the mask by the comparison spectrum are noted by the on-line printer and the "Exceedance Spectrum" and measurement parameters are stored. See fig.4.

- The first indications of a problem with bearing TS 20 were exceedance warnings given by the on-line printer, which were in the 2 kHz to 20 kHz range. Fig. 4 shows two separate exceedance spectra which were generated during this period. When the exceedance level reached 10 dB, the engineer in charge of maintenance decided to perform an envelope analysis. The bearing frequencies were calculated.

- For the type of bearing used in this section of the paper-machine the relevant figures are:

n = 25, d = 36 mm,
D = 326 mm, ϕ = 15°,
F = 1,35Hz, this gives:
BPFO = 15,1 Hz, BPFI= 18,7 Hz,
BSF = 6,0Hz, FTF = 0,6 Hz.

Where: n = number of balls or rollers
f = shaft speed
d = diameter of balls or rollers
D = pitch diameter of balls or rollers
ϕ = contact angle from the radial direction

As can be seen from the plot of the envelope spectrum in Fig. 5, the fault was identified as a flaw in the bearing's inner-race.

- Since the system was installed there has been no unscheduled production stop due to bearing failure on the monitored section of the machine.