Condition Monitoring of Antifriction Bearing Using Shock Pulse Method

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ABSTRACT

Traditional approaches to maintenance involve either letting machines run to breakdowns, or scheduling repairs at predetermined time intervals. The first approach cannot be accepted at all. With the second approach, there is a danger that machines in perfect working order can be taken out of service, or even worse, that machine on the verge if failure can be unwittingly left to breakdown. To overcome this dilemma, a new and innovative approach to maintenance system must be found to measure the condition of a machine while in operation and to carry out repairs only when it is required. This approach of maintenance is called 'Condition -based-maintenance' or predictive maintenance. Today condition monitoring is practiced extensively throughout the world including, India.

INTRODUCTION

It is well known that to increase production in shortest time industry must utilize its existing installed capacity to its maximum potential. This means the availability of existing plant and machinery for production must be maximized and this can be achieved by maintaining it in best of health with modern and better maintenance practice. Any investment made to modernize and improve maintenance practices will pay back in thousands in thousands fold in the form of increase in production and reduction in maintenance costs.

Rolling bearings are the heart of any machinery and is vital in order to monitor condition or/rolling bearings. In a constinuous processing industry, a premature failure in bearing can cause a huge loss of production from the unscheduled break down over and above the cost of maintenance and the cost of spares and bearings are simply replaced. As a result, inherent primary cause is left within the machine which causes the bearing to run less than the optimum life/machine.

Thus, this requires an effective and adequate evaluation method to identify the condition of bearing at regular intervals. So that action can be taken or planned well in time. Only proven and accepted method world wide for this is Shock Pulse Method.

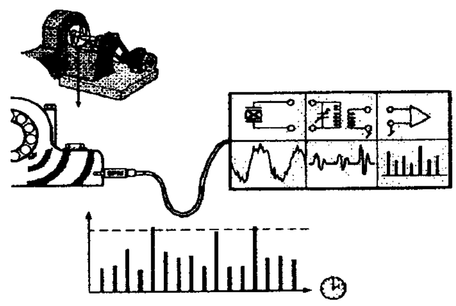
The Maintenance Technique

In simple terms, the Shock Pulse Method detects development of a mechanical shock wave caused by the impact between the masses. At the instantaneous moment of impact, molecular contact occurs and a compression (shock) wave develops in each mass. The SPM is based on the events occurring in the mass during the extremely short time period after the first particles deformation of the material has yet occurred. The molecular contact results in infinitely large particle acceleration at the impact point.

Specifically let us examine, what happens during a mechanical impact (Fig.1). Before the impact, the bar is at rest and the ball has a certain velocity (V). At the very instant of bar surface and ball surface will meet with a velocity equal to the ball velocity. At the point of impact, a large local acceleration of material is initiated. During this initial phase of the magnitude of this acceleration is solely dependent upon the impact velocity and is not influenced on the relative sizes of the ball and bar on any mechanical vibration. The acceleration of the material at the impact point sets up a compression wave, which propagates ultrasonically in all directions through the bar. Another wave also travels through the ball. The magnitude of the wave tools is an indirect measurement of the impact velocity (v).

During the second phase of the impact (2) the ball and bar surfaces will deform and the energy of motion will deflect the bar and set up vibration in it. This is the vibration normally detected by vibration analysis. The SPM thus detects and measures the magnitude of a mechanical impact on detecting and measuring the resultant compression wave fronts (Shock Pulse).

The SPM system uses a piezo-electric accelometer to measure the mechanical impacts or shock pulse without being influenced by other factors such as background vibrations and noise. This transducer is turned mechanically and electronically to a resonant frequencies of 32 k H_2. The compression wave front (Shock Pulse) caused by a mechanical impact sets up



Schematic Representation of SPM Method

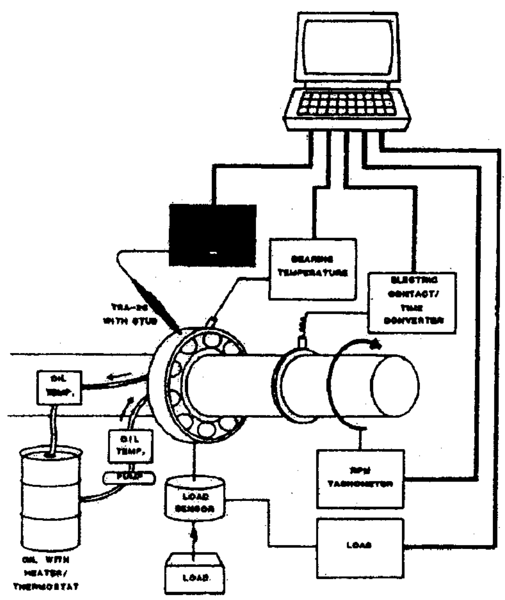


Fig. 1

a dampened oscillation in the transducer at its resonant frequency. This is shown in Fig. 1 as the dampened transient electrical output caused by the impact. The peak amplitude of this oscillation (4) is therefore directly proportional to impact velocity (v).

Because the dampened transient is well defined and of a constant decay rate, it is possible to electronically filter out all other signals i.e. vibration signals. The measurement and analysis of the maximum value of this dampened transient (a) is the principle behind SPM technique for testing the condition of antifriction bearing.

Monitoring antifriction bearing using SPM technique

A bearing's running surface always has a degree of roughness or a surface defect will cause mechanical impacts between the rolling elements. These mechanical impacts cause shock pulse so the bearing is a "Shock Pulse Generator". The magnitude of these shock pulse are dependent upon the surface condition and peripheral velocity of the bearing (size & rpm) using the SPM technique, it is possible to measure the shock pulses caused by the above surface roughness and thus follow the progress of a bearings conditions form new installation through the various stages of deterioration, until ultimately, the bearing has to be replaced the Sensitivity of the SPM technique to bearing condition is best shown by the fact that the shock pulses generated by a typical bearing increase upto 1000 times from when the bearing is in good condition to when it needs replacement. To simplify the readouts of this large range, the decibel scale (dB) is used. Thus, the intensity of the shock pulses generated by the bearing is measured and expressed in dBsv decibel shock value).

Relationship between shock pulses and lubrication data collection

To determine the effectiveness of the shock pulse method detection of lubrication film thickness a research programme was conducted by SPM instrument US inc. the research team being headed by the President of Research Mr. Eivind school.

The project required the construction of a psecial test machine equipped with computer controlled readout and mass storage capacity and with the ability to collect the following selection on date.

- Shock Pulse value with four different dBf. 3 occurrence frequencies.
- Rotational speed (range 40-35,000) RPM
- State load (range 2-5,000) lbf
- Time fraction with a no electric contact through the bearing % TIME
- Temperature of outer ring C

Tester ISO bearing type and sizes were : 6300, 6302, 6305, 6306, 6212, 1302, 1308, 1213, NU305, NU308, NU312, 21305, 21308, 21312, NA4900, NA4902, NA4905, NA4908 and NA4912.

A minimum of three units of each bearing type and size were often of different brand names. The bearings were tested with a load equal to 10% of their rated static load capacity and circulation lubricated with MOBIL DTE3, OIL at a controlled constant injection temperature of 45 C. Each signal bearing was tested over the whole speed range in logarithmic steps in increase and the same steps in decrease of RPM. To avoid collecting data during temperature gradient, consuming process was controlled by a computer which was stepping through the whole speed range gathering all the reading, and storing them on magnetic tape.

In addition each bearing type was tested with other lubricants: MOBILTEL. MOBIL SHC 630, KEROSENE, KENDALL GREASE LO416 AND LO427. Each combination of bearing type and lubricant (Except for KEROSENE) was tested with load settings of 5%, 25%

and 50% of the rated load capacity over the whole RPM range. Altogether this gave 9,943 sets of real time related data.

RESULTS AND DISCUSSION

The recorded data of the time fraction without electrical contact through the bearing was measured in accordance with a method practiced by T.E Tallian in 1965. To check the validity of our data, the theoretical lamda value was computed from equation (1) shown in the enclosed nomentclature and then compared with the real time related of on contact.

The lowest spread in no contact reading was found in the data collected form ball bearing with plastic cages. The plotted readings taken from different sizes of ball bearings with nylon cages 6300TN, 6305TN, the corrlealations with T.E. Tallian's findings are obvious.

Shock Pulse measurements were collected from all types and sizes of bearing lubricated with kerosene and loaded, so that no interruption occurred in the electrical contact through the bearings. This data is form a practical point of view, to be considered as representing dry running. In order to isolate the effect of lubrication on the Shock Pulse measurements the readings for dry running condition were subtracted from those of the fully lubricated bearings. The different values are plotted as a function of the % no contact. It is easy to see that the shock Pulse readings treated this way are a very sensitive and coherent. method of detecting lubrication film thickness in the rolling interfaces.

By a simple mathematical conversion of the DB difference value, the readings can be given the proportion of the film (thickness). We have named this converted data LUB no. It is scaled so that one unit LUB no. is approximately 1 micro-inches of lubricant film thickness. The reason for this sensitivity to the influence film thickness is the fact that Shock Pulse Measurement is a direct image of the random interaction between the surface asperities in the rolling interface. Important to note is that the lubricant film in the rolling interface carries the load, and therefore acts like a part of the bearing and thus the surface asperities generate Shock Pulses even if the rolling interface is completely separated by a lubricant film. The contact area is physically very small, in the range of microns, but still fairly large when compared to the film thickness, which has a dimension of microns.

Comparing the measured LUB no. (from different types of bearings) with different prediction of lubricant film thickness and lubricant starvation. The measured LUB NO.'s seem to verify the trend in Y.>P.> chiu's starvation theory as well as match the theories of F.K. Orcutt and H.C. Cheng.

The influence of load on measured LUB no. is by flooded lubrication, mild starvation and severe starvation. It can be noted that with fully flooded lubrication the influence of load is as predicted by Orcutt and Chent (ref. 4) with mild starvation that load lubricant film become more sensitive to load and gradually reduces load sensitivity as the starvation becomes more severe.

Example of application of lubrication monitoring

To long lubrication intervals cause insufficient oil supply. By shortening the lubrication intervals estimated bearing service life is increased as the oil film thickness increases.

Over the lubrication with grease can actually cause a dry-running condition. Lubrication grease has two components, a liquid lubricant (oil) mixed with a thickener which has no lubricating properties ideally the thickener acts as a "Sponge" releasing the oil as needed. Friction in the grease from over lubrication causes a temperature rise, which reasults in a high bleeding rate, and a rapid los of oil from the grease. This condition can also be detected using the follow-up form.

The instrument can also be used to determine whether the lubricant type is suitable for a given applicati0on. Which lubricant film thickness is insufficient and cannot be increased and where the code no. indicates starvation, a change in lubricant type may be necessary. The A2010 output data recorded on the SPM follow-up will indicate change of lubricant.

Shaft misalignment and intallation faults can cause newly replaced bearings to fail without warning. Shaft misalignment may stress the oil film in the bearing, a condition which can be detected with the A2010. The follow-up form can indicate those problem before bearing damage sustained.

An overview of SPM bearing condition analysis in a paper plant.

CASE STUDY AT A GLANCE

Location : Kagithapuram, Karur, Tamil Nadu, India

Facility : Tamil Nadu News Print and Paper Ltd.

Equipment : Paper Machine

SPM analysis: Impending bearing failures detected.

Savings : Money and lost production due to downtime.

Maintenance function is getting oriented towards a new philosophy owing to the emphasis on optimum capacity utilisation. The days of traditional approach of corrective and time based maintenance have given way to condition based maintenance. This is to predict the performance based on certain telltale symptoms that develop during operation and effect the maintenance as per need and at appropriate moment. This helps in avoiding secondary failures and curtailing administrative and technical delay. It also helps in planning spare part stock just in time. This need based maintenance definitely demands more involvement from the maintenance personnel through planning usage of measuring aides, recording data and evaluating valuable data for analysis.

The following management case study throws light on the condition monitoring of rolling element bearings or otherwise antifriction bearings, based on the information collected from the maintenance personnel of Tamilnadu Newsprint and Papers Ltd. (TNPL).

Any rotating machinery depends on the functional efficiency of ball and roller bearings in order to give the most optimum performance. Therefore, it becomes imminent to monitor the state of their health. Time based maintenance of bearings is inefficient because the length of service life for individual bearings cannot be predicted. If replacement schedules are based on L10 life, 90% of potential bearing life will be wasted.

Case : 1

Equipment Name Bottom felt roll

Bearing No. : 22318E

SPM	M/C Speed (mpm)	Drive End
25/06/94	580	5 dbm
02/07/94	700	12 dbm
09/07/94	660	30 dbm

SPM reading using A 2010 analyser on 11/07/94

Code	: D	LR	: 36
Lube No	:-	HR	: 17
Cond	: 43	Zone	: Red

- Bearing changed on 13/07/94

Heavy pitting marks on the inner surface of outer race were noticed.

Case : 2

Equipment : Vacuum pump No. 7 Gearbox (2C 250)

Input Bearing : 22315 Ec3

Inner Bearing : NJ 2316 C3

Outer Bearing : 22226 E

SPM Meter : 43A

Date	InDe (dbm)	In Nde (dbm)	OuDe (dbm)	OuNde (dbm)
12/05/94	15	16	29	31
19/05/94	11	19	28	33
02/06/94	11	09	38	37

- Gear Box changed with spare on 03/06/94.

In the removed unit is was found that intermediate bearing cage broken.

Case : 3

Equipment Name : Pickup Circuit Felt roll - D

Bearing No. 22318 E

SPM Meter : 43 A

Date	M/C speed (mpm)	Drive End (dbm)
02/07/94	700	14
09/07/94	600	14
16/07/94	600	15
19/07/94	600	28

SPM reading using A2010 Analyser

Code	: D	LR	: 27
Lub	: -	HR	: 05
Cond	: 55	Zone	: Red

-Roll changed on 20/07/94

Drive End bearing found damaged. (Balls (cameout)

Condition monitoring is the only efficient means to anticipate bearing failures. This helps us to avoid routine replacement of serviceable bearing and to improve the life expectancy of rolling bearings. Only a small amount of bearings fail because the natural fatigue limit of steel is reached. Actually, material fatigue starts early because of unfavourable operating conditions such as incorrect lubrication, improper mounting, too much preload, passage of electric current etc. If bearings are simply replaced, the problems causing bearing failure remain undetected. Inherent primary cause for the failure is left with the machine which indicts the bearing to run less than the optimum life. Thus this requires an effective and adequate method to identify condition of bearing at regular intervals.

Tamilnadu Newsprint and Paper Ltd. is a Tamilnadu state Govt. undertaking mill producing 300 tpd Newsprint or 280 tpd printing and writing paper. The machine is a twin wire former Belbaie-II supplied by Beloit Walmsley of U.K. with 6.8 m deckle and 750 meters per minute running speed. Raw material used is bagasse and Wood the mill has started commercial production in 1985.

Several methods are available for the detection of incipient failure in rolling element bearings. Shock Pulse Method is the only reliable method which has gained the most industrial acceptance.

Given the small mass of the bearing in relation to the large mass of the machine, it is difficult to isolate the bearing problem using vibration analysis. The warning time derived between fault detection and actual failure, as far as the antifriction bearings are concerned, is very less. And also, setting up an exclusive system for vibration study or any other related method to detect defective antifriction bearings may not be feasible owing primarily to the specialised knowledge required for interpretation and prediction of faults. on extensive research and development.

The present paper attempts to project the efficiency of Shock Pulse Method for condition monitoring of antifriction bearings. If the problems detected by using SPM specialised maintenance tools, which are mentioned in the following annexure has gone undetected, unseen abnormal wear could have progressed to catastrophic failure and cause major damage without warning.

Mentenance history of TNPL

TNPL has a well organised maintenance programme. These are so designed that the maintenance personnel attend to specific machines regularly and have a better knowledge about the condition of the equipment. At present TNPL is using SPM 43A and SPM A-2010 analyser for bearing condition monitoring and IRD 811 meter for vibration measurement The realiability of SPM technique has motivated the maintenance team of TNPL to develop a software based on d-Base IV to record and give high value trend report for SPM readings.

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CONCLUSION

Condition monitoring using Shock Pulse Analyser A-2010 helps. To avoid unnecessary overhauls of machines in good working order. To avoid routine replacements of serviceable bearings. To improve the life expectancy of rolling bearings by optimizing their lubrication and leading to savy in foreign exchange due to reduced import of bearings. To detect trouble sports in time for planned repairs and replacement avoiding both breakdowns and unnecessary production stops.