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A BRIEF REVIEW OF THE APPLICATION OF THE SPM METHOD IN ORDER TO IMPROVE PREVENTIVE MAINTENANCE OF BEARINGS

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Abstract: One of the most important aspects of preventive maintenance is reducing the cost of maintaining and extending machines' service life. Any downtime of a particular machine entails the costs caused by the machine's inactivity as well as the costs of corrective maintenance, which are often many times more expensive than the application of some of the methods of preventive maintenance. By applying diagnostics as a preventive method, it is possible to predict the future failure of a particular element or assembly before a machine downtime/failure, which significantly simplifies maintenance, both on organizing maintenance and on the economic side. Today's tendency of diagnostics is the use of methods that do not require stopping the induction motor, and one of those methods is the shock pulse method - SPM method. This paper gives a brief review of the SPM method's use to diagnose the bearing failure and its advantages.
Keywords: SPM method, bearing, preventive maintenance, vibrations

INTRODUCTION

Maintenance policies are categorised into two main strategic streams: corrective and preventive. Condition Based Maintenance (CBM) is a subdivision of preventive methodology and is based on the belief that 99 per cent of equipment will evidence some sort of indicators prior to a fault develops. Through the utilisation of science and technology, CBM exploits the operating condition of assets to diagnose faults at early stages of occurrence, thus triggering proactive maintenance based on the need, [1].

One of the benefits of preventive maintenance is planning the moment of maintenance. By correctly choosing the method of testing the condition of an element, we can predict the replacement of an element that is currently operating within the allowable limits but is approaching the critical condition. This prevents the occurrence of major machine failures, reduces the cost of corrective maintenance as well as the cost of machine downtime due to the fault.

Proactive technical maintenance aims reducing the total volume of technique required servicing and maximizing service life equipment (i.e. the ideal creation of a "perpetual" machine that do not require technical services), systematic elimination of the source of the defect [2]. Diagnostics of asynchronous motors is an area that is developing very intensively in world technical practice. The literature mentions various methods by which it is possible to establish a whole range of failures of asynchronous motors. Today's tendency of diagnostics is the use of methods that do not require stopping the induction motor, and one of those methods is the shock pulse method - SPM method [3,4].

BASIC CONCEPTS IN SPM METHOD

— Vibrations

Vibrations are mechanical oscillations relative to the reference position. Vibrations occur as a result of dynamic forces in the moving parts of an asynchronous motor. The basic parameters of vibration are amplitude, speed and acceleration of vibration.

Vibrations in asynchronous motors are generally undesirable because [4,5]:

- intensify the process of wear of all moving elements,
- cause breakage of mechanical components,
- lead to the weakening of separable ties,
- lead to the failure of electronic components and systems,
- damage the insulation of the cables being touched,
- cause noise and
- cause damage and disease in humans.

— Diagnostic

The basis of diagnostics is the comparison of actual and desired behaviors, i.e. engine parameters. Diagnostic parameters help us in that, and that is why it is crucial to choose the right ones. The diagnostic parameter is a measurable physical quantity (vibration, noise, temperature, etc.) present in the process of engine operation.

The parameter must meet the following requirements [3,6]:

- unambiguity of change,
- sufficient sensitivity to change and
- accessibility and ease of measurement.

The main benefit of diagnostics is reflected in [3, 6]:

- transition from corrective to proactive
- maintenance,
- reduction of the risk of material damage,
- increasing operational reliability,
- increasing the mean time between failures and
- minimizing unplanned downtime.

— Bearings

Ball and roller bearings are among the most common and important elements in rotating machinery. Every rolling

element or anti-friction bearing has a limited life which is strongly influenced by installation, operating condition and the maintenance it receives. Machine reliability, efficiency and safety depend on bearings functioning correctly [7].
Great attention is paid to the study of bearings and their improvement. Furthermore, if in production the dimensions of the bearings deviate minimally from the ideal dimensions, due to the action of forces acting on the bearing, over time there are deformations in the bearing which leads to an increase in vibration.
The service life of roller bearings is limited. Even if the loads they are exposed to are within the projected limits, sooner or later there will be material fatigue and bearing failure. The time period until the appearance of the first signs of fatigue is a function of the number of cycles and the magnitude of the load. The life of roller bearings is defined by the total number of cycles that the bearing can perform before the first signs of damage appear. This does not mean that the bearing is unusable after that moment. As a rule, from the onset of the first signs of damage to the final stop, there is a sufficiently long period of time to plan and prepare for bearing replacement [8].
Moreover, if it is expendable, it is rare for the bearing to perform its intended service life. Other factors often cause bearing failures. An overview of the reasons for bearing failure is given in Figure 1:

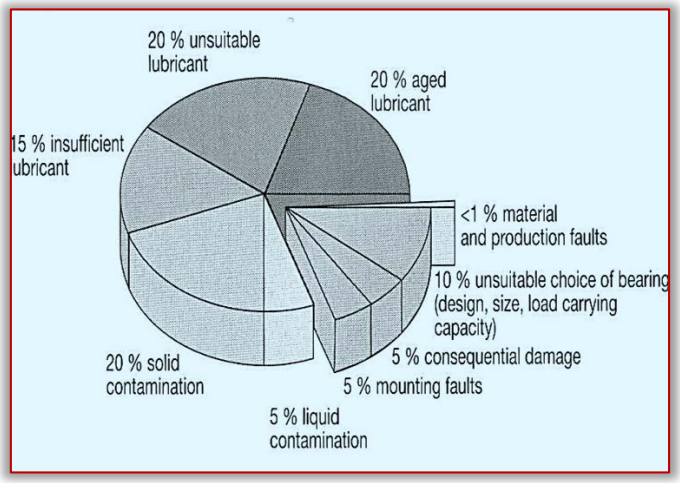

Figure 1. Causes of failure in rolling bearing [9]

SPM Method

The SPM Method (S-Shock, P-Pulse, M-Method / Measurement) or shock pulse method is one of the methods used to monitor the condition of bearings. As it rotates, the bearing acts as a pulse generator. This method is based on extracting these impulses and monitoring their behavior.
In practice, this method has proven to be reliable. After years of testing through this method, the results obtained on all types of bearings and regardless of the age of the bearings were of the same quality [10].
In the shortest terms, the SPM method, i.e. the device (SPM meter), is used to detect the development of mechanical shock waves caused by the collision of two masses. The SPM method is based on phenomena in the material that occurs in a brief period of time immediately after the first contact of body particles [8, 7].
Figure 2 shows one of the SPM meters.

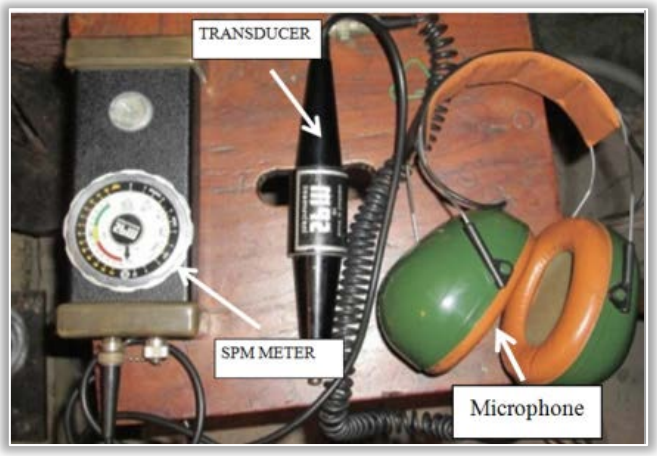

Figure 2. Shock pulse meter 43A with transducer and microphone [11].

ANALYSIS OF PREVIOUS RESEARCH

In the Automobile factory "Zastava" in Kragujevac, 180 asynchronous motors were repaired in 2005. More than a quarter of the share in these failures was bearing failure. Table 1 shows the percentage of failures in asynchronous motors [3]:

Table 1. Percentage of asynchronous motor failures in the Automobile Factory, 2005

Failure	% of failures
Stator winding	12,94
Rotor winding	29,65
Stator assembly	11,34
Rotor assembly	13,25
Bearing	26,5
Other	6,32

Failures of asynchronous motors used in industry have a 40 to 90% share in failures and downtime due to bearing failures. The percentage of failures depends, of course, on the size of the machine [12].
In order to prevent machine downtime, it is necessary to react on time and to determine the condition of the bearings in an easy and tested way before the machine malfunctions/downtime. The SPM method can easily, and without interruption in engine operation, give the result of the bearing condition.
By applying the SPM method and obtaining results that show the values of bearing malfunctions or bearing failure, the cause of bearing failure should be discovered and analyzed. Not infrequently, even if the obtained values show poor bearing performance, the reason does not have to be the failure of the bearing itself.
Bearing damage is just one of the possible causes of poor operating condition. Therefore, when inspecting the bearings, generally speaking, the following basic elements should be kept in mind [3]:

- Carry out a detailed visual inspection of the bearing itself, with control of the clearance (wear of the bearing elements). Inspect other elements of the bearing assembly, ie. whether the connections of the parts are loose, whether there is a contact of the rotating parts on the housing or the bearing cover, whether there is damage to the parts and the like.
- Imbalance of rotational masses, work in the area of critical speed, preload or high load of the rolling bearing leads to poor operating condition. It is needed on the basis
- information on the existing vibration levels on the bearing housing, which are inspected, eliminate the cause of any increased vibrations (imbalance, mismatch, loosening of mechanical connection, etc.).
- Contamination of lubricants also leads to high values of the shock impulse. In any case, the lubricant should be replaced before the final decision on bearing replacement is made.

Less than 1% (0.35%) of all bearings perform their intended service life, and as many as 55% of the causes of premature bearing failure are inadequate lubrication. From this, we conclude that premature bearing failure could have been avoided by proper preventive maintenance [9]. Damages of bearings indicate most often downtimes of the production cycles and cause the high costs and losses, especially in the more expensive equipment [13]. Timely detection of a bearing defect can avoid unwanted conditions, primarily due to operative delays of machine systems and direct and indirect costs in this regard [14].

After obtaining results that indicate poor bearing performance, it is not necessary to replace the bearing immediately. We conclude from the above that we should first check other aspects that may affect obtaining this type of result.

After the checks, a new measurement must be performed. Depending on the obtained values, three cases can occur [3]:

- The measured value decreases to an acceptable level and no longer increases. The cause was not the bearing,
- The measured value decreases, but after a few hours it increases again. The cause is damage to the bearing,
- The measured value does not decrease. The causes are greater bearing damage.

CONCLUSION

The prevalence of bearings in the industry is enormous. There is almost no machine that does not have a bearing in it. Therefore, maintenance, and especially preventive maintenance, is an essential thing in extending the service life of the bearing and thus the part or machine in which it is located. Proper preventive maintenance entails savings by avoiding corrective maintenance, machine downtime, or major machine failure caused by bearing failure.

With little investment in a preventive maintenance system, verified bearing condition results can be obtained quickly and safely by applying the SPM method. Also, we must keep in mind the reasons for the failure of bearings, which in most cases can be removed very easily as a precaution.

The training and expertise of the person using the SPM method must be at a high level because early bearing replacement does not solve the specific problem of high impulse results, which will lead to a repeated replacement of the newly installed bearing in a short time, and thus unnecessary maintenance costs.

Note:

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