

ANALYSIS OF INDUCTION MOTOR EFFICIENCY DECREASE DUE TO CAGE BALL BEARING DAMAGE

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ABSTRACT

Induction motors, which convert electrical energy into mechanical energy using electromagnetic principles, are widely used in various applications from households to large industries. The performance of these motors is important for the smooth running of industrial production processes. Mechanical damage, such as bearing failure due to overload, can reduce their efficiency. This study aims to monitor and analyze the decrease in induction motor efficiency due to defects in the bearing cageball, using a literature review method. The results show a decrease in efficiency of around 2-3%, which is observed through the efficiency graph against the overall RMS.

Keywords: Induction Motor, Overload, Electromagnetic.

INTRODUCTION

Induction motor, a type of alternating current motor, converts electrical energy into mechanical energy using electromagnetic principles, widely used from households to large industries because of its advantages such as simple construction, affordable price, constant rotation, and easy maintenance. Motor efficiency can decrease due to damage such as overload that damages bearings, especially cageball. This study aims to analyze the decrease in power and efficiency due to such damage, determine the performance curve, and diagnose motor damage based on the decrease in efficiency.

METHODS



Figure 1. Research Flow Diagram

RESULTS AND DISCUSSION

Bearing aging using the temperature recommended by IEEE (IEEE std 117: IEEE Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound AC Electric Machinery Degradation and Testing Plan): Heat the bearing in an oven at 140°C for 72 hours.



Figure 2. Bearing Heating Process

After the Rig is prepared, the next step is to collect data. The first stage of testing is carried out using standard bearings, the second stage with standard bearings that have undergone thermal aging treatment, and the third stage with bearings that have defects in the bearing balls and thermal aging treatment. The process in these three stages of testing is identical, including: connecting the tool by connecting the motor to the dynamometer, installing various necessary sensors such as accelerometers, tachometers, thermocouples, and powermeters, activating the sensors on the test rig circuit, turning on the motor, waiting until the motor reaches a stable condition, observing and recording the I and V values of the 3 phases on the powermeter to calculate the pin value. Next, observe the load that occurs on the dynamometer to calculate the pout value, observe the stator and dynamometer temperatures, and the rpm of the electric motor. Finally, record vibration signal data. Machine efficiency indicates the ability of the machine to convert incoming electrical energy into output mechanical energy. This efficiency is closely related to the losses that occur in induction motors, regardless of the design of the machine.

$$\eta = \frac{P_{mech}}{P_{elec}} = \frac{P_{mech}}{P_{mech} + \sum \text{losses}}$$

Efficiency calculation can be done simply by dividing the measured output power by the input power. Since this calculation involves dividing two nearly identical measured values, a small error in measurement can result in a large error in the final efficiency result.

Table 1. Mechanical Frequency of Bearing Failure

Kerusakan rumah <i>bearing</i> (FTF)	$= \frac{1}{2} fr \left(1 + \frac{d}{D \cdot \cos \alpha} \right)$
Kerusakan lintasan luar (BPFO)	$= \frac{N}{2} fr \left(1 - \frac{d}{D \cdot \cos \alpha} \right)$
Kerusakan lintasan dalam (BPF1)	$= \frac{N}{2} fr \left(1 + \frac{d}{D \cdot \cos \alpha} \right)$
Kerusakan bola <i>bearing</i> (BSF)	$= \frac{D}{2d} fr \left(1 - \frac{d^2 \cos^2 \theta}{D^2} \right)$

CONCLUSIONS

From the results of the research that has been conducted, it can be concluded that the decrease in efficiency in three types of induction motor bearings—namely non-thermal normal bearings, thermal normal bearings, and bearings with cageball defects—is recorded at around 1-2%. This can be seen from the graph comparing the average efficiency with the average

overall RMS, where bearings with cageball defects show lower efficiency than the other two types of bearings. Although there is an insignificant difference in efficiency between the three types of bearings, bearings with cageball defects still show the lowest efficiency.

In terms of other performance such as power, torque, and rotational speed (rpm), these three types of bearings have insignificant differences. Specifically in vertical channel measurements, cageball bearings show FTF characteristics at a frequency of 91.3 Hz with an amplitude of 0.01 g which is two times the harmonic. While non-thermal normal bearings have the highest peak at a frequency of 36.15 Hz with an amplitude of 0.17 g which indicates unbalance. Thermal normal bearings show the highest peak at a frequency of 31 Hz with an amplitude of 0.27 g.

In the horizontal channel measurement, the cageball bearing shows the characteristic of 11x harmonic FTF at a frequency of 311 Hz with an amplitude of 0.7 g. The non-thermal normal bearing shows the highest peak amplitude of 0.2 g at a frequency of 1011 which is close to the 4x harmonic BPFI. In the axial channel, the cageball bearing shows the characteristic of FTF at 6x harmonic at a frequency of 141 Hz with an amplitude of 0.081 g, while the non-thermal and thermal normal bearings show insignificant differences in their highest frequencies and amplitudes.

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