The Performance of Thermal Based Condition Monitoring System in Induction Motor

Gopal Singh
Dept of Electrical Engineering
AP Goyal Shimla University (H.P.)

Abstract- *In Today's world, Three phase induction motor are mostly popularly used motor specially in industrial areas because of its reliability and simplicity. The operation of thermal diagnosis for induction motors is of paramount importance and these Faults led to minimize the downtime and improve its reliability and availability of the systems. Although, these electromagnetically devices are extremely dependable, they are disposed to various faults. These electro-mechanical properties hydrodynamic lubrication are derived by using the Reynolds equations. The fluid bearing is one of the most vital parameters and has a significant impact on the operation as well as the performance of induction motor. In this the hydrodynamic lubrication is varied which results in force variation. However, in an initial stage in order to prevent the complete failure of an induction motor and unexpected production costs also causes the fault in the induction motor. Induction motors has several advantages over another motors i.e. higher power density and good efficiency. The Induction motors configuration is considered for various applications. In this study; the operation condition monitoring system using thermal performance of machine observed.*

Keywords- Thermal Analysis, Condition Monitoring System, Hydrodynamic Lubrication, Fluid bearings, Origin Lab project files, Reynolds model.

I. INTRODUCTION

The bearing's loads based on a thin layer of liquid or gas is supported by the Fluid bearings. The contact between the moving parts of machine is broadly absent. Hence there is no any type of sliding friction. They can be generally categorized as fluid dynamic bearings or hydrostatic bearings. In the Hydrostatic bearings are visibly forced fluid bearings, where the fluid is usually in hard disk drives etc. Hydrodynamic bearings rely on the high speed of the journal self-pressurizing the fluid in a wedge between the faces. In high load, high speed or high precision application the rate of Fluid bearings are frequently. These are applied to most of the spindle motors of computer hard disk drives, since they provide better dynamical characteristics than ball bearings. However, one of the weaknesses of fluid bearing is the instability arising from the air bubble trapped in the oil lubricant of Bearing. Air bubbles are formed and trapped in oil lubricant by the in appropriate process of oil injection or the external shock. It is a modified to started sleeve bearing to improve the lubrication and increase the life span of the fan while rotating[2]. Where the result in short life or high noise and vibration performed on the ordinary ball bearings. So effectiveness of the cost highly reduced. In Fluid bearings, the bearing faces between the thin layer of liquid and gas fluid varied around or under the rotating shaft. There are two principal ways of getting the fluid into the bearing: (i) Static Fluid Bearing (ii) Dynamic Fluid Bearing. The power required by that in various application that are contributes to system energy loss just as bearing friction otherwise would. Better seals can reduce leak rates and pumping power, but may increase friction. Hydrodynamic bearings rely on bearing motion to suck fluid into the bearing and may have high friction and short life at speeds lower than design or during starts and stops. The secondary bearing may be used for beginning and ending to prevent damage to the hydrodynamic bearing. The operating life of a secondary bearing may have short and high friction, but overall service life is good.

*Faults in induction motors:*There are different types of faults during their operations these faults are classified as internal and external faults:

1. Overloading
2. Single phasing
3. Unbalanced supply Voltage
4. Locked rotor

1. Overloading: Overload fault occur when the mechanical torque exceed the threshold point by applying mechanical load to the motor greater than full load.

2. Single phasing: Single phasing is one of the unbalance cased of the motor. It occur when one of the three line are open. The current faults through the other two lines and more heat is generated in the stator winding.

3. Unbalanced supply voltage: There are many causes of unbalance supply voltage such as unbalanced leading, open delta transformer and unequal setting. The conditioning loads to reduction in motor efficiency, rises the motor temperature and excessive unbalance full load current.

4. Locked rotor: Locked rotor occurs when the voltage is applied to unknown rotor motor. The stator current may be almost six times its rated value during these conditions. There are many causes fir these faults, to occur for instant, if the rotor shaft connected to heavy load the motor experiencing locked condition.

Review of Hydrodynamic lubrication: when two mating surfaces are completely separated by a cohesive film of lubricant the term Lubrication is created. The thickness of the film thus exceeds the combined irregularity of the surfaces [3]. The term of Hydrodynamic lubrication is a defines a condition in which two rubbing planes are separated by a thin film of a lubricant. This situation is often beneficial and lubrication is used to reduce friction and/or wear of rubbing solids with the relief of liquid lubricant. In industry sector, a vast majority of the surfaces encountered is used; the source of friction is the imperfections of the surfaces. Hence, the term Reynolds equations can be used to derive the governing principles for the fluids. Note that when gases are used, their derivation is much more involved. The thin films can be thought to have pressure and viscous forces acting on them. Because there is a difference in velocity there will be a difference in the surface traction vectors. Because of mass conservation we can also assume an increase in pressure, making the body forces different.

*Operating principle:*Fluid bearings can be relatively cheap compared to other bearings with a similar load rating. The bearing can be as simple as two smooth surfaces with seals to keep in the working fluid. In contrast, a conventional rolling-element bearing may require many high-precision rollers with complicated shapes. Hydrostatic and many gas bearings do have the complication and expense of external pumps. Most fluid bearings require little or no maintenance, and have almost unlimited life [4]. Conventional rolling-element bearings usually have shorter life and require regular maintenance. The bearing designs retain low friction down to zero speed and need not suffer start/stop wear, provided the pump does not fail. Fluid bearings generally have very low friction—far better than mechanical bearings. One source of friction in a fluid bearing is the viscosity of the fluid. Hydro static gas bearings are among the lowest friction bearings. However, lower fluid viscosity also typically means fluid leaks faster from the bearing surfaces, thus requiring increased power for pumps or seals.In practice, when bearing surfaces are pressed together, the fluid outflow is constricted. This significantly increases the pressure of the fluid between the bearing faces. As fluid bearing faces can be comparatively larger than rolling surfaces, even small fluid pressure differences cause large restoring forces, maintaining the gap. Fluid bearings are typically quieter and smoother (more consistent friction) than rolling-element bearings [5]. For example, hard disks manufactured with fluid bearings have noise ratings for bearings/motors on the order of 20-24 dB, which is a little more than the background noise of a quiet room. Tilting pad bearings are used as radial bearings for supporting and locating shafts in compressors.

Disadvantages: The power consumption is atypically higher compared to ball bearings. Power consumption and stiffness or damping greatly varies with thermal, which complicates the design and operation of a fluid bearing in wide thermal range situations. Fluid bearings can catastrophically seize under shock situations. Ball bearings deteriorate more gradually and provide acoustic symptoms. Like cage frequency vibration in a ball bearing, the half frequency whirl is a bearing instability that generates eccentric precession which can lead to poor performance and reduced life, fluid leakage, keeping fluid in the bearing can be a challenge. Oil fluid bearings are impractical in environments where oil leakage can be destructive or where maintenance is not economical.

Some fluid bearings:

1. Foil bearings: Foil bearings are a type of fluid dynamic air bearing that was introduced in high speed turbine applications in the 1960s by Garrett Air search. They use a gas as the working fluid, usually air and require no external pressurization system.

2. Journal bearings: Pressure-oiled journal bearings appear to be plain bearings but are arguably fluid bearings. For example, journal bearings in gasoline (petrol) and diesel engines pump oil at low pressure into a large-gap area of the bearing[6].

*3. Air bearings:*Unlike contact-roller bearings, an air bearing (or air caster) utilizes a thin film of pressurized air to provide an exceedingly low friction load-bearing interface between surfaces. The two surfaces don't touch. Being non-contact, air bearings avoid the traditional bearing-related problems of friction, wear, particulates, and lubricant handling, and offer distinct advantages in precision positioning, such as lacking backlash and striation, as well as in high-speed applications[7].

*4. Reynolds law:*Reynolds number is the ratio of inertia force and viscous force, and hence fluid flow problems where viscous forces alone are predominant. The models are designed for dynamic similarity on Reynolds law, which states that the Reynolds number for the model must be equal to the Reynolds number for the prototype.

II. SIMULATION

The test machines which are installed in the research laboratory of the faculty of mechanical engineering, machine design and maintenance department. It was built in earlier era then has been modified many times. It is used for different kinds of research both scientific and industrial. Test rig PG II 1Ł is used for testing static characteristics of journal sliding bearings. General view of the rig is shown below. The stand is fully computer controlled with internal feedback loop for input parameters adjustment and has a computerized data acquisition (high repeatability of test conditions and immunity to interference). Radial force and rotational speed can be changed according to a pre – programmed function. Bearings can be tested both with oil, water lubrication (important for ceramic and composite bearings). The stand is equipped with an accurate friction force sensor.

Fig.1. view of three phase induction motor.

The stand is fully computer controlled with internal feedback loop for input parameters adjustment and has a computerized data acquisition. Radial force and rotational speed can be changed according to a pre-programmed function [8]. It guarantees the repeatability of the tests. The each and every test parameters (the function of load change and function of rotational speed change) are saved as computer file. A special computer program for automatic control and data acquisition is used. The computer system controls parameters. The radial load and the tilting torque of the tested bearing, the rotational speed of journal shaft, limit values of signals (for emergency stop) and thermal of lubricating oil.

III. THERMAL ANALYSIS

The thermal sensors are inserted on bearing circumference to measure journal thermal at 45 degrees apart on the bearing circumference at start, middle and end positions. The ends of sensors are terminated on metal box from there cables carries signal to controller [9]. Another thermal sensor is fixed before pressure gauges to measure inlet thermal of oil. As journal thermal increases under load when rotated, it is acquired and displayed on PC.

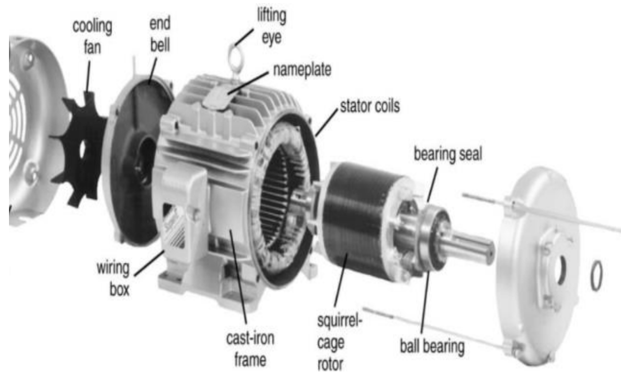

Fig.2. various parts of induction motor.

IV. RESULTS

In the software, Origin Lab is a proprietary computer program for interactive scientific graphing and data analysis. It is produced by Origin Lab Corporation, and runs on Microsoft Windows [10]. It has inspired several platform-independent open-sources. Graphing support in Origin includes various 2D/3D plot types. Data analyses in Origin based on the Levenberg–Marquardt algorithm include statistics, signal processing, curve fitting graphic representation. Origin imports data files in various formats such as ASCII text, Excel, NI etc [11]. It also exports the graph to various image file formats such as JPEG, GIF, etc.

Features: Origin is primarily Graphic User Interface software with a spreadsheet front end. Unlike popular spreadsheets like Excel, Origin's worksheet is column oriented. Each column has associated attributes like name, units and other user definable labels. Instead of cell formulae, Origin uses column formulae for calculations.

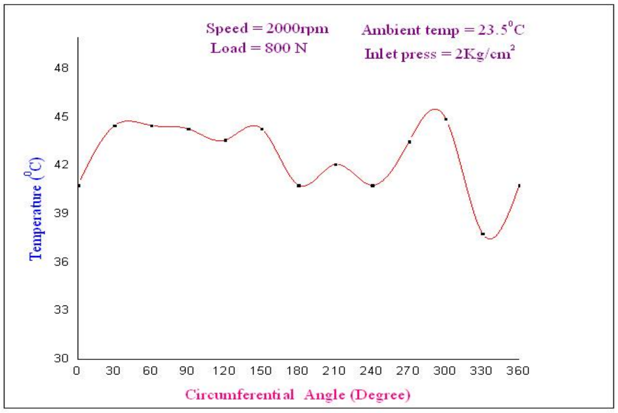

Fig. 3. Speed of induction motor at 2000 rpm.

From the result observation tables we can observe that as the speed of the motor increases then the thermal is also increasing which are observed by the sensors. If we set a relay between the motor and the circuit with desired limits, it will keep the motor safe from the abnormal conditions.

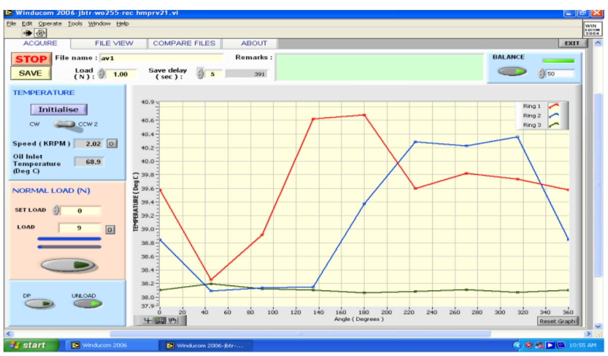

Fig. 4. Thermal of the bearings at no-load condition.

IV. CONCLUSION

An investigation of the rotor fault modes of the three phase induction motor and the other cascade drive has been carried out by using thermal analysis. The fault detection has been investigated based on journal bearing test rig to find out the different rotor faults of three phase induction motor. The variation in thermal effect of the machine is analyzed by using various approaches. The developed numerical model was verified by comparison with the Reynolds model. The monitoring of temperature in grooved journal bearing is mostly determined by surface tension and the pressure difference due to the wedge effect of groove.

REFERENCES

[1] Y.-R. Kim, S.-K. Sul and M.-H. Park, "Speed sensor less vector control of induction motor using extended Kalman filter," IEEE Transactions on Industry Applications, vol. 30, pp. 1225-1233, 1994.

[2] K. M. Jung, Y. H. Jung, J. H. Lee, H. K. Jang, and G. H. Jang “Motions of Air Bubbles Trapped in Grooved and Plane Journal Bearings of Operating Fluid Dynamic Bearings” IEEE Transactions on Magnetics, Vol. 49, No. 6, June 2013.

[3] R. Blasco-Gimenez, G. M. Asher, M. Sumner, and K. J. Bradley, "Performance of FFT-rotor slot harmonic speed detector for sensor less induction motor drives," in Proceedings of the IEEE Electric Power Applications, vol. 143, pp. 258-268, 1996.

[4] R. Blasco, M. Sumner, and G. M. Asher, "Speed measurement of inverter fed induction motors using the FFT and the rotor slot harmonics," in Proceedings of the Fifth International Conference on Power Electronics and Variable-Speed Drives, pp. 470-475, 1994.

[5] K. D. Hurst and T. G. Habetler, "Sensor less speed measurement using current harmonic spectral estimation in induction machine drives," IEEE Transactions on Power Electronics, vol. 11, pp. 66-73, 1996.

[6] J. Holtz, "Sensorless position control of induction motors-an emerging technology," IEEE Transactions on Industrial Electronics, vol. 45, pp. 840-851, 1998.

[7] A. V. Oppenheim and R. W. Schafer, Discrete-Time Signal Processing, 2nd ed. New Jersey: Prentice-Hall, 1999.

[8] M. Aiello, A. Cataliotti, and S. Nuccio, "An induction motor speed measurement method based on current harmonic analysis with the chirp-Z transform," IEEE Transactions on Instrumentation and Measurement, vol. 54, pp. 1811-1819, 2005.

[9] A. Ferrah, K. J. Bradley, and G. M. Asher, "An FFT-based novel approach to non-invasive speed measurement in induction motor drives," IEEE Transactions on Instrumentation and Measurement, vol. 41, pp. 797-802, 1992.

[10] A. Ferrah, K. J. Bradley, P. J. Hogben, M. S. Woolfson, and G. M. Asher, "A transputer-based speed identifier for induction motor drives using real-time adaptive filtering," in Proceedings of the Thirty-First IAS Annual Meeting, vol. 1, pp. 394-400, 1996.

[11] M. T. Johnson, R. J. Povinelli, A. C. Lindgren, J. Ye, X. Liu, and K. M. Indrebo, "Time-domain isolated phoneme classification using reconstructed phase spaces," IEEE Transactions on Speech and Audio Processing, vol. 13, pp. 458-466,2005.