Fault Detection and Health Monitoring in Induction Motor: A Review

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ABSTRACT

Nowadays, induction motor has become the most popular type of motor in industrial application. Induction motor especially three-phase induction motor plays a vital role in the industry due to their advantages such as self-starting, low-cost, high-power factor, high reliability, and high efficiency. If any faults and failures occur in the motor it can lead to excessive downtime and generate great losses in terms of revenue and maintenance. To identify motor faults, sophisticated techniques are required for quick fault detection and isolation. The real-time health monitoring technique for induction motor using Arduino has been proposed. The parameters of induction motor such as voltage, current, temperature, humidity, vibration can be monitored because faults in these parameters cause severe damage to the motor and also cause a problem for the application that use the induction motor.

Keyword: - *Induction Motor, Induction Motor Faults, Health Monitoring, Identification and Detecting Techniques*

1. INTRODUCTION:

In today's manufacturing industries, mechanical and electromechanical systems are mostly driven by electrical motors [1]. With the invention of AC induction motors due to their higher performance attributes over DC motor, industrial automation is being frequently done with it. About 50% of global electrical power consumption is due to the induction motor. In industry 90% of uses the induction motor because of necessary characteristics such as it is inherently self-started motor, it does not require permanent magnet, no brushes, no commutator rings, no position sensors. The essential advantage part of an induction motor is that its speed can be control easily as it has good speed regulation, sustainable overload capacity, and high starting torque. Due to all of these advantages, induction motor is frequently used in all over application like industry, electric train, electrical vehicles, crane, elevators, etc.

Induction motors often operated twenty-four seven in a hazardous environment and are subjected to premature failures. The downtime costs of these motors are very high and the sudden failure could even cause disastrous consequences [2]. Induction motors lose efficiency and generate vibrations due to ageing continuous running, friction, wear and tear and design manufacturing flaws. Sometimes induction motor generates serious damage like short circuit, voltage unbalance which can affect surrounding object [3]. Voltage unbalance occurs due to unbalance in load current and unbalance in supplying network. Faults and failures of induction motor can lead to excessive downtimes and generate large losses in terms of maintenance and lost revenues. Even small excessive heating can

cause increased losses, reduced efficiency, change in vibration, reduces lubrication and bearing life span [4]. Any breakdown of induction motor may bring the entire process to halt [5].

The operators of induction motors drives are under continual pressure to reduce maintenance costs and prevent unscheduled downtime that result in lost production and financial income [6]. Early detection of abnormalities in the motors will help to avoid expensive failures. The task of condition monitoring system is to detect an in order to save expensive manufacturing processes or to replace faulty parts. Therefore, it is important to monitor parameters of induction motors with respect to smooth running of the plant and achieving production targets [7]. To prevent catastrophic failures of machine and reducing maintenance costs, condition monitoring has been proved to be a viable means of improving systems reliability and reducing overall system cost, especially in large machines [8].

1.1 FAULTS IN INDUCTION MOTOR:

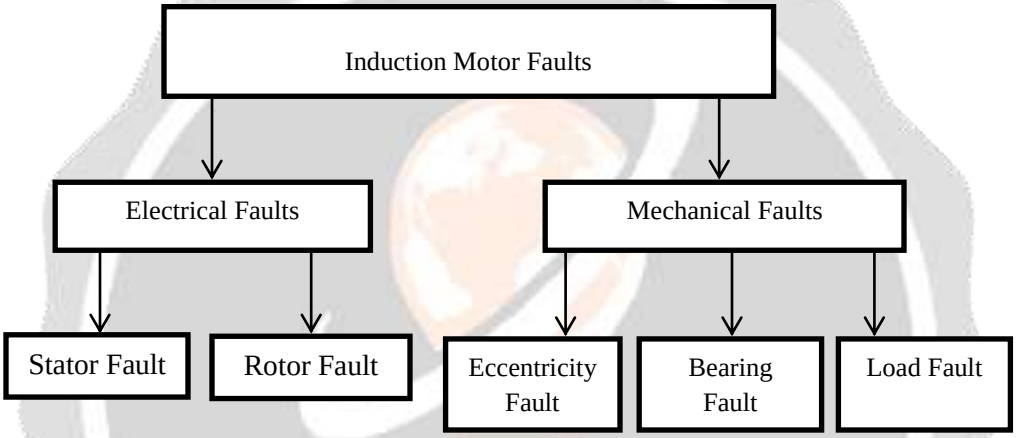

Fig. Classification of Induction Motor Faults

ELECTRICAL FAULT:

1) **Stator Fault:**
The most common type of faults related to stator winding of induction motor are phase to ground, phase to phase and short circuit of coils of the same or different phase. All these faults are classified as isolation faults and have several causes: hotspot in the stator winding resulting in high temperature, oil contamination, moisture and dirt, etc[6]. Asymmetrical inter turn short circuit in stator windings constitute a category of faults that is most common in induction motor. Typically, short circuit in stator windings occur between turns of one phase or between turns of two phases or between turns of all phases. Moreover, short circuit between winding conductor and stator core also occur[9].

2) **Rotor Fault:**
Under normal conditions of working, a three-phase induction motor with symmetrical stator winding, fed from a symmetrical supply voltage will produce a resultant forward rotating magnetic field at synchronous speed and if exact symmetry exist there will be no resultant backward rotating field. When rotor defect appears, it creates in addition of the direct rotor field and inverse field that turns to the speed. Rotor faults occur about almost 10% of total induction motor faults. These faults are caused by rotor winding the rotor faults are mainly broken rotor bars because of pulsating load and direct online starting[9].

MECHANICAL FAULT:

1) **Bearing Fault:**
In induction motor a common fault is ball bearing and it is primarily due to abnormalities of mechanism in assembly. The faults of bearing are generated due to ball defect, outer race defect and inner race defect[10]. Bearing fault are still considered to be a measure contributor to induction motor failures[11].

2) **Eccentricity Fault:**
The eccentricity of air gap is inherited dynamic and static eccentricity which produces speed pulsation, ripple torque, stress and acoustic noise between rotor and stator part. For that reason it is essential for air gap eccentricity early detection[12]. There are three main types of air gap eccentricity:
   i. Dynamic eccentricity
   ii. Static eccentricity
   iii. Mixed eccentricity

3) **Load Fault:**
A load trouble, like a torque dip, affects machine supply current[10]. It is one type of mechanical fault. In some application such as air crafts, the reliability of gears may be critical in safeguarding human lives. For this reason, the detection of load fault has been an important research area in engineering.

1.2 NEED OF HEALTH MONITORING:

Though induction motors are reliable and strong, it is not free from failure and might give rise to production loss or risky operating conditions[12]. With the passage of time, induction motor starts producing vibrations, temperature, sparks and also causes increase in power consumption. Sometimes, induction motor generates serious damage like short circuit which can affect surrounding objects[3]. Also, large rating of induction motor generates a significant heat. The heat is produced in motor due to different types of loss inside the motor. So, one healthy and proper cooling system is very essential to maintain temperature within comfort limit[4].

Faults of induction motor could result in extreme downtimes and create huge losses with regards to repairs and lost profits and these encourage inspection of condition monitoring[12]. It is very important to detect fault in very beginning as sudden outage can cause an economical losses and upset deadlines[13]. The early detection of potential motor failure could reduce unexpected downtime and increase motor efficiency. Extra energy consumption induced by motor faults could also be reduced[2]. To obtain higher accuracy in diagnostic for predictive maintenance of induction motor health monitoring system plays an important role to improve system reliability and availability. Predictive maintenance by condition based monitoring of electrical machine is a scientific approach that becomes new strategy for maintenance management[14]. Also, condition monitoring has become area of increasing interest and importance to electrical utilities and process industries[8].

2. HEALTH MONITORING TECHNIQUES:

1) **Vibration Monitoring:**

Vibration monitoring includes signal acquisition, signal transduction and prognosis which is done through computational analysis. In recent times developments, MEMS (Micro-Electro mechanical system) are widely used because of its advantages low cost, reduce weight, reduce volume, low power consumption, increase reliability, MEMS allow easy interface between software and hardware. The vibration signatures allows detecting many faults at their inception and allow avoiding damages which may occur due to fault like long running of the motor. Vibration measurement system is cost effective and reliable for low power induction motor. It allows avoiding damages which could occur due to long running, friction and other faults. System could be used for effective monitoring motors used in elevators, conveyor belts, compressors and machine tools. System could help to avoid faults at their inception as vibration is the very first indicator of faults[7].

2) Efficiency Monitoring:

There are different methods to measure efficiency in induction motor which are based on dynamometer, duplicate machines and equivalent circuit approaches. There are some simple methods for in-service efficiency estimation. In ORMEL 96 method, efficiency is obtained from an equivalent circuit. In OHME, the efficiency estimation is performed from input power measurement. The air-gap torque (AGT) is used for energy efficiency estimation. AGT is also used to measure efficiency in much less invasive manner. This method is generally more accurate than other methods[15].

3) Temperature Monitoring:

For low voltage and medium voltage induction motor, overheating is one of the vital causes of stator winding insulation degradation process. Therefore, to ensure long lasting of insulation life, is very important to monitor stator winding temperature and protect motor under thermal overloading conditions such as motor stall, jam, overloading and condition where cooling ability of motor is accidently reduced. The diagnosis of cooling system faults in three phase induction motor through analysis of online temperature characteristics, current and vibration signature at a different operating conditions[4]. In many electric drives, internal motor temperature is measured using sensor placed inside windings[16]. It is a fault detection system for cooling which is provided in motor itself for its cooling.

3. PROCESS OF HEALTH MONITORING:

Fig. Health Monitoring Process of Induction Motor

The different parameters of induction motor such as voltage, current, temperature, speed, efficiency, humidity, etc are monitored through specific sensor signals. The motor fault blocks shows the faults occur in induction motor, sensor block shows to choose a suitable signal for detection purpose. With the help of sensor monitoring the condition parameters of motor and gives the current status of induction motor to the processing unit, which it processes according to the instructions. In case of any fault takes place in induction motor it should be automatically disconnected from the supply through the relay contact.

4. CONCLUSION:

In this paper, a review of induction motor faults and their monitoring techniques have been carried out. The accurate health monitoring technique of induction motor can improve the reliability and reduce the maintenance cost. It has been observed from previous year research papers that the fault detection in the motor is still challenging task for researcher and academicians. Monitoring and control of induction motor is very essential to increase reliability, maintaining performance condition monitoring means to monitor real time data of machine as well as in assessment of health of machine through its operative life. Due to this, operating efficiency of machine will increase and ultimately electricity bill will reduce due to continuous monitoring. The unexpected failure occurring on machine will reduce and life of machine will increase, most important human efforts will reduce. Development in technologies now give a fresh opportunity to obtain automation and monitoring system suited to diverse plant development scenarios that would not previously have been possible.

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