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Review of Detection of Faults in Induction Motor

Snehal O. Gulhane[1],M. R. Salodkar[2]

[1]G.H.Raisoni college of Engineering, Amravati, India

[2]Assistant Professor at Electrical engineering department, G. H. Raisoni college of engineering, Amravati, India

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Abstract: *Induction motor plays a very important role in industrial, commercial and residential sectors because of its enormous advantages over the other types of motor. These motors have to work under various operating conditions which cause deterioration of motor resulting in the occurrences of faults. There are various techniques available in order to detect the fault. This paper presents the review of current monitoring techniques in order to detect the faults occurring in induction motor.*

Key Words: **Induction motor, Wavelet transform, Types of various faults, Fault diagnosis methods, Current signature analysis.**

1. INTRODUCTION

Induction motor is an electromechanical device which converts an electrical energy into mechanical energy. Induction motors are most widely used electrical machines for industrial, commercial and residential sectors because of their advantages such as robustness, simple in construction, highly reliable, low cost, low maintenance etc.

Induction motor is an asynchronous motor which is made up of two main parts i.e. stator and rotor. Stator is a stationary part and rotor is a rotating part. The energy is transferred from stator to rotor by electromagnetic induction principle. There are two types of induction motor according to the type of construction of rotor.

1) Squirrel cage induction motor
2) Slip ring induction motor

Squirrel cage induction motor is made up of conducting bars which are short circuited by end rings. The material used for conducting bar is copper, aluminium, magnesium etc. These bars are non insulated as these bars carry large amount of current. The another type of induction motor that is slip ring induction motor is made up of polyphase winding. The terminals of the polyphase winding are connected to slipring which are mounted on the shaft of rotor. With the help of slip ring, one can add an external resistance into the circuit because of which one can limit the starting current of the motor.

The squirrel cage induction motor is simple, more economical and rigid as compared to that of slip ring induction motor. Again squirrel cage induction motor is having constant speed when supplied with constant voltage and constant frequency power supply. Squirrel cage induction motors are mostly preferred because these motors are cheap, rugged, having no commutator, suitable for high speed application etc.

Since induction motors are undoubtedly reliable but the occurrences of faults in it cannot be avoided. There are many faults occurring in induction motor which are categorized into two main types as :-

1) Electrical faults
2) Mechanical faults

Due to the occurrences of faults, the induction motor may lead to failure and the failure in the motor may lead to large revenue losses and increased maintenance. Thus, in order to avoid the occurrences of such failures, it is required to diagnose the fault as early as possible. If these faults are not diagnosed on time, it may affect the motor's performance very badly.

1.1 Various Types of Faults

The faults occurring in induction motor are mainly grouped into two categories:-

1) Electrical faults
2) Mechanical faults

1.1.1 Electrical Faults

Following are the various faults which are very common in three phase induction motor:

Rotor Faults

Rotor faults are nothing but the asymmetries in the rotor due to technological difficulties or melting of bars and end rings. The asymmetry in the rotor cage results in the asymmetrical distribution of the rotor currents. Because of which, damage of one rotor bar can cause damage of the surrounding bars and thus damage can spread, which results into multiple bar fractures. In case of a crack in bars, the cracked bar will overheat because of which bar may break. Thus, the surrounding bar will carry higher currents and are subjected to larger thermal and mechanical stress and may start to crack.

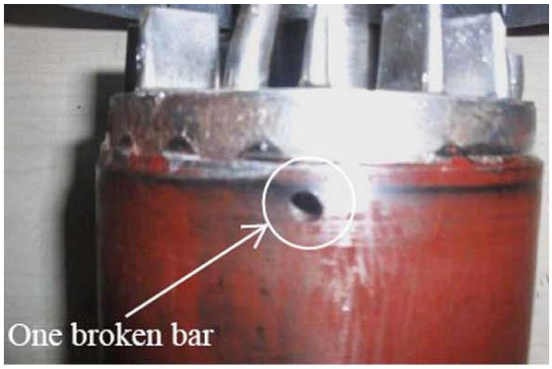

Fig. a) Rotor Fault (broken bar)

Short Circuit in Windings

Short circuit in windings includes interturn winding faults caused by the failure of insulation. The faults may be like turn to turn, phase to phase faults if the insulation between two turns or phases fails respectively. Thus, failure of insulation will result in increased amount of induced currents which ultimately produces extra heat and causes an imbalance in magnetic pull.

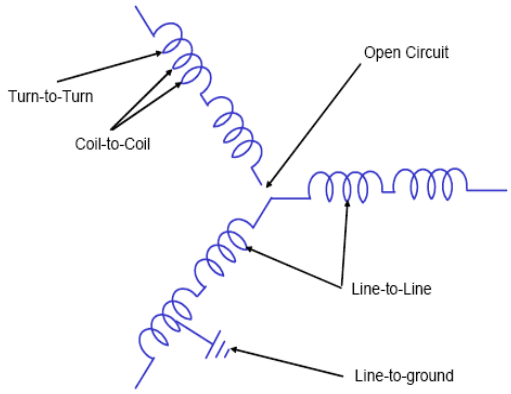

Fig. b) Short circuit in winding

1.1.2. Mechanical Faults

Following are the mechanical faults which occur in three phase induction motor.

Air Gap Eccentricity

In a healthy machine, the rotor's center of rotation is same as that of center of stator's bore. When the rotor is not center aligned, the unbalanced radial forces can cause a stator to rotor rub, which results into the damage to the stator and rotor. Vibration and noise is produced by this fault.

Bearing Fault

Bearing are used to provide the rotary motion to the shafts. A continued stress on the bearings causes fatigue failures. Small pieces break loose from the bearings which result in rough running of the bearings. It generates detectable vibrations and increased noise level. High temperature at bearing is also one of the reason for bearing faults.

Fig. c) Bearing Fault

2. VARIOUS MONITORING TECHNIQUES

There are several methods which we can use in order to detect the faults occurring in induction motor:-

1) Vibration monitoring
2) Noise monitoring
3) Thermal monitoring
4) Partial discharge monitoring
5) Voltage monitoring
6) Current monitoring

2.1 Vibration Monitoring

The vibration monitoring is one of the most important methods used for fault diagnosis. Effective utilization of the vibration signals depends upon the effectiveness of the applied signal processing techniques. This vibration monitoring was most widely used in the past for diagnosing the mechanical faults. But this method of

monitoring was limited to small rating induction motors only.

2.2 Noise Monitoring

By measuring the noise spectrum, one is able to perform noise monitoring. Air gap eccentricity is responsibility for the production of noise and this noise is used for the detection of fault in induction motor. But this technique is not much accurate for detection of fault because of the noisy background from other machines.

2.3 Thermal Monitoring

This technique depends upon the measurement of temperature of the motor. When there is a short circuit in stator winding, the stator current increases tremendously and hence it produces excessive heat. If this heat is not dissipated it will result into the destruction of motor. Thermal monitoring technique has been used for bearing and stator fault detection. But it offers limited fault diagnosis capability as it is too slow to detect the fault before it spreads into more severe faults.

2.4 Partial Discharge Monitoring

This method is used for detecting stator insulation faults in higher voltage motors. It consists of detecting the low amplitude, ultrafast pulses produced by electric discharges in small voids in the insulation. Partial discharge occurs even in healthy machines. However an increase in the amount of partial discharge activity can be associated with insulation degradation.

2.5 Voltage Monitoring

This can be safely measured using high frequency differential voltage probe or isolation amplifier. It has been used to calculate the instantaneous power, instantaneous torque and negative sequence impedance.

2.6 Current Monitoring

Current monitoring includes frequency components which can be related to a variety of faults such as mechanical, broken rotor bars, and shorted turns in stator winding. Now a days, this technique is most widely used for the fault detection.

3. CURRENT MONITORING TECHNIQUES

Now a days, current monitoring technique is most widely used. According to Electric Power Research Institute (EPRI), near about 40% of faults of induction motor are due to the stator faults. Motor Current Signature Analysis (MCSA) is one of the most widely used technique in the fault detection of induction motor. MCSA has been successfully used in the detection of broken rotor bars, bearing damage and dynamic eccentricity caused by a variable air gap. In this, we calculate the relative amplitude of current harmonics that appear due to this defect.

Wavelet Transform is another current monitoring technique. The idea of wavelet transform was introduced by Jean Morlet in 1982 and provided a new mathematical tool for wave analysis. Wavelet transform is having excellent feature as it is able to diagnose the fault in transient condition also. Wavelet theory provides a unified framework for a number of techniques which have been developed for various signal processing applications. The advantages of using wavelet transform for diagnosing the induction motor faults are as follows:

1) The main advantage of Wavelet Transform is that, it can work both in time and frequency domain.
2) Wavelet transform is computationally very fast.
3) By using wavelet transform, it is possible to decompose a signal into component wavelets.

4. CONCLUSION

In this paper, the review of induction motor fault detection methods presented. Among all these methods, Wavelet transform method is most suitable for the detection as it can diagnose the fault in transient condition and it has more advantages than that of any other method.

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