Health Monitoring of Rotating Electrical Machine Using Soft Computing Techniques: A Review

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Abstract- Induction motor is mostly utilized in industrial application due to its favorable, economical and technical reasons. It has been observed that during the operation of drive system, motor faces different types of abnormal condition which in turn create various types of faults and failures in machine thereby affecting the production system. Hence to avoid such faults health monitoring of induction machines have become necessary. Different techniques are used for motor health diagnosis. Basically this techniques are classified into model based technique, signal based technique and soft computing technique. By using these techniques motor can be prevented from various catastrophic failures which in turn increase the efficiency and production. This literature presents a review of various techniques used for fault diagnosis.

Index Terms- Induction motor, health monitoring, fault diagnosis, catastrophic failures, different techniques.

I. INTRODUCTION

In this paper, an overview of fault detection of induction motor has been analyzed. Health monitoring allows us to distinguish the type of fault and its severe effect on the drive system, thereby reducing the catastrophic failure and damage. As in most of the drive system, induction motor is generally used as the basic P.M ,with the help of such analysis and health prediction we can pre justify the sudden failure, and can prevent the large industrial system from heavy losses thereby reducing the cost occurring for machine maintenance and repairment. As a result, one can pre-decide the maintenance schedule to reduce or prevent such failure. However complete prevention of losses cannot be estimated out but one can increase the efficiency and reliability of motor by analyzing the faults. In this literature some on-line diagnostic techniques have been reviewed for the fault diagnostic of electric machine. Various on-line fault detection techniques can be used as a valuable tool for the pre-detection of faults of the prime mover. Some of these technique are fuzzy logic technique (9) , artificial intelligence technique(9) , wavelet transformation technique, artificial neutral network based and mat lab simulation based online computation technique s (17), Negative sequence components of motor terminal quantities ,broken rotor bars(8), stator current spectrum and motor current signature stator winding inter turn short(5).With the help of such technique one can estimate the motor parameter and can prevent the machine or the drive system from severe failure ,because it is useless to perform practical experiment to verify any fault. In the early times motor were supervised by then noise, vibration & temp, but this method were expensive, consume lot of times & does not discriminate all types of faults aswell. Hence advance in sensor algorithm and computational and simulation technique may lead to ease and effective fault prediction. The use of advance sensors measure not only stator voltage and currents but also measures the air gap eccentricity, flux, flux densities, rated output torque & various harmonics & vibration of the motor.

Fault: The induction machine faces various types of stresses during the operation. These stresses might lead to the various severe faults that a motor faces. Hence condition monitoring becomes necessary to avoid such catastrophic failures. A brief classification related to stator, rotor, bearing and other system related fault has been introduced in this context along with various online techniques to overcome those faults.

Various types of faults in induction machine:

1 Faults relate to stator: it includes faults related to stator core and stator winding.

2. Faults related to rotor: it includes broken rotor bars, broken rotor end rings and shorted rotor field windings.

3. Gear box abnormalities.

4. Cracked or bent shaft.

5. Bearing faults.

6. Miscellaneous faults: It includes faults in next devices which regroup the accessories of the drive system.

Faults related to stator: From the graph above it constitutes almost 40 % of the overall faults. The stator winding fault occurs when the insulation between the two adjacent turns in a coil fails. This is called shorted or turn to turn fault. The resultant induced current causes heating up of the surroundings and damage to the stator insulation. The heat so produced by the resultant current create imbalance in the magnetic field which produces vibration that severely affects the bearings.

Another type of fault in case of stator is stator inter turn short circuit. Which is also caused due to the voltage transients which occur by the successive reflection resulting from cable connection between motor and ac drives. This drives produce extra voltage stress on stator winding which are produce due to the inherent pulse width modulation of voltage applied to the stator winding.

Faults related to rotor: Rotor faults contribute about 10% of the overall fault. Broken rotor bars can be either partially or fully cracked. This cracking can be due frequency or sudden start at rated voltage or due to high temperature, vibration, mechanical

stress caused by bearing faults and sometimes due to manufacturing defects. This broken rotor affects the motor health very severely.

Bearing faults: A major portion of all the faults is bearing faults. It contributes about 40% of overall faults in the induction machine. The bearing used in the induction machine consists of an inner race and outer race with a set of balls on the rolling elements. Since ball bearing support the rotor, any bearing defect will produce a radial motion between rotor and stator of the motor.

Another problem caused by the bearing fault is the installation problem caused due to the imbalanced or improper alignment of the bearing onto the shaft. This produces false brinelling of the raceways thereby affecting the motor physically.

Gearbox abnormalities: It also covers some percentage of the overall faults in the induction machine. Gearboxes may also give rise to current components of frequencies close to or similar to those of broken bar components. In gearboxes, load fluctuations on the gearbox and gear defects are two major sources of vibration. The main components in gear vibration spectra are the tooth-meshing frequency and its harmonics, together with sideband structures due to modulation effects. Sideband structures can be used as an important diagnostic symptom for gear fault detection. Hence, in order to perform a reliable diagnosis of a rotor winding for motors connected to a gearbox, the influence of gearbox components in the spectrum need be considered and analyzed.

Cracked or Bent shaft: Bent shaft results in a rub between the rotor and stator, causing a serious damage to the stator core and windings.

Various soft computing techniques:-With the help of soft computing technique, the analysis of fault becomes more accurate and easier. It gives an improved performance of the machine.Hence the validity of a simulation based database of the fault can be verified with this technique. Such an analysis can reduce the sudden machine damages .Hence these techniques prove to be a good tool for improved and efficient production system. Some of the techniques are summarized below.

Artificial Neural Network: It is basically an artificial intelligent (AI) technique. ANN is a computational method of brain, which assumes that computation contribute over several sample units called neurons, which are interconnected and operate in parallel known as parallel distributed processing system. By using ANN in induction motor one can identify the particular phase of induction motor where the fault namely interturn short circuit fault occurs. Thus ANN synthesizes the interconnection between different input variables with output variables which indicate fault severity. These variables can be current, voltage or slip.

Fuzzy Logic system: It involves making decision based on classifying signals into a series of fuzzy values rather than healthy or faulty. It is also known as an Artificial Intelligent Technique. Fuzzy logic allows combining fuzzy information from different signals together to make more accurate decision. The fuzzy sets are based on a set of rules whose value lies between 0 to 1. In case of induction motor, the fuzzy sub sets and corresponding membership function describe parameter amplitude. The fuzzy rules and member function are constructed by observing the data set.

Genetic Algorithm(GA): It is also an artificial intelligent technique which is used to elect best set of feature set from the available set of features.GA are based on natural selection an natural genetics. Genetic algorithm use the reproduction, crossover and mutation operators.GA belongs to the optimization methods for solving set of non –linear equations and they do not need an initial guess for the unknowns,ie.. they do not require any problem-specific auxiliary knowledge such as derivative of the function

Wavelet Transform: It is used for transforming analogue sensor signals into frequency spectra. Wavelets can model irregular data patterns such as impulse sound elements better than the Fourier transform. The wavelet transform is a frequency analyzing method which decomposes the signals into a set of non-sinusoidal reference waveforms. It is generally applied to pulse type waveform.

CBR: Another artificial intelligence method is CBR methodology which has the ability to explicitly how example of solutions through past case and its dynamic and reversible storage base enables system performance to continuously be enhanced by adding new, and revising old cases. The CBR then itself naturally to fault diagnosis of machine by representing sensor data as the problem and the repair action as the solution. Once the fault is identified and repaired it is added to the to the case library. Finally the technician can make correct decision based on earlier classification of similar sensor signal.

Expert system:-This artificial intelligence technique is based on knowledge of a human expert by representing a series of rules from which results can be conclude.ES is an important tool which is expressed as any combination of IF-THEN rule. It's an interference mechanism which manipulates the stored knowledge to produce the solution.

II. CONCLUSION

In this literature various technique namely, knowledge based systems, fuzzy logic, artificial neural network and genetic algorithm expert system and some online techniques for fault diagnostics of induction machines has been reviewed.

III. FUTURE ASPECTS

Along with these soft computing techniques remote monitoring and use of multiple sensors can be more reliable and efficient.

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