Knowledge Based Diagnosis of Faults in Induction Motors

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Induction motors are in use since the second half of the 19th century. They are now responsible for about 85% of the worldwide energy conversion from electrical to mechanical. Induction motors are robust, need little maintenance and can be operated from widely available supply. However failure occurs, with undetected reason at the first instance. Research in the field of the diagnosis of faults in induction motors has received a lot of attention in the recent decades. Recently with the progress in artificial intelligence techniques, these techniques started to be implemented in this field.

Faults in induction motors may occur either in the drive supplying the motor, in the stator of the motor or in its rotor. Drives' faults may be treated separately as the output of the drive can indicate the nature of the fault even before the power reaches the motor. Hence we are concerned here about the faults in the stator or in the rotor only. In this case the motor fault diagnosis is to be performed in a non destructive way without even opening the motor cover. Often the trend of changes in the external performance of the motor may give indications of possible occurrence of fault even before it actually occurs. Hence it may enable overcoming expected damages.

Stator faults may be a result of opening or short circuit of the stator winding(s) or a fault in the connection of the windings. Wound rotor in slip ring type of induction motors may be subjected to such faults too. In squirrel cage motors, rotor faults may be mainly mechanical. Broken rotor bars or/and cracked end-rings are frequent faults. Other faults may be in the form of static and/or dynamic airgap irregularities, bent shaft, bearing and gearbox failure. Collection of the maximum possible information about the performance of the motor may help a lot in reaching the correct conclusion about the exact fault(s) nature and its location. With the recent improvement in signal processing, it is now possible to locate specific harmonics in the line current of the motor. Each set of the harmonics may indicate different type of fault. Such technique is often called motor current signature analysis. Power measurements may give further indications about faults by separation of power components using what is

called two wattmeters method. Other signals such as speed, torque, noise, vibration and thermal measurements can give more accurate picture of the fault nature and location.

One of the methods used to diagnose faults in induction motors is based on stator current Parks Vector approach. The distortion of the circular shape of $I_d - I_q$ for healthy motors can indicate different kinds of faults in induction motors.

Other methods of verification of faults use the Fast Fourier Transform to deduct different harmonics from stator current and power waveforms. However human judgments by direct inspection may fail short of reaching the correct reason for the fault.

Artificial intelligence techniques have been used in verifying the nature of the fault from the information gathered about the motor. Expert system emulating human expertise can give indications of the nature of faults. Rule based frequency filters have been used to filter frequency components leading to the nature of fault causes. Fuzzy logic is also used to give a more precise decision about many faults by analyzing information deducted from the waveform analysis of the stator current, power or other signals measurements. Neural networks have also been used for diagnosis of faults after supplying the network with enough training data. Neural fuzzy inference is also used in many cases. Genetic algorithms have also been used in some reported cases. Hence knowledge based diagnosis of faults in induction motors can form an example for the use of artificial intelligence techniques in diagnosis of faults in many other systems.

The paper describes how different artificial intelligence techniques are used to help in diagnosis of motor faults and how different techniques interact to give better distinction between faults of similar effects on measured values. A survey of publication in this field is to be given and the future trend in the research in this field is given.