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STATOR WINDING AND BROKEN ROTOR BAR FAULT IDENTIFICATION FOR INDUCTION MOTOR IN MCC

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Abstract: In commercial and industrial application quite a few electric motors are required, which can be geographically dispersed, and it is often desired to control some or all the motors from central location. The apparatus designed for this function is called as Motor Control Centre (MCC). Traditional MCC only provides start and stop operations of the motors as it contains starters, and fuses and protective relays to provide preventive action by tripping in case of motor fault. Adding intelligence to this traditional MCC will provide the preventive maintenance as the fault will be identified and distinguished prior to its occurrence. Thus necessary action can be taken to avoid the unnecessary unplanned downtime.

***Index Terms* - Broken rotor bar, stator fault current, fault frequency, condition monitoring.**

I. INTRODUCTION

Motor plays a vital role in large commercial and industrial applications, and also in day-to-day life. In commercial and industrial application quiet, a few electric motors are required, which can be geographically dispersed, and it is often desired to control some or all the motors from central location. The apparatus designed for this function is called as Motor Control Centre (MCC). A group of motors are being operated together during execution of a process. In many cases an under-load condition is associated with a mechanical failure or problem. Thus, a controlled shutdown is not possible because of reaction time of conventional protection device. This can result into serious damage to the process and production, with further mechanical damage possibly leading to extend plant downtime. Under overload condition, the tripping action of overload relay disconnects the power to drive resulting in further increase in unplanned downtime.

II. TYPE OF FAULTS

The induction motors experience different types of faults during its operation. This may be due to heavy duty cycle, unmaintained working environment, inappropriate installation.
Electrical motor may have various source for fault occurrence. It may be classified as Internal and External Faults. Also, the classification may be based on Electrical and mechanical faults[1]. Under Internal faults we have coil and lamination movement, Bearing faults, Rotor strike, eccentricity as mechanically originated faults; whereas Dielectric failure, rotor bar cracks, magnetic circuit faults under Electrical faults. The external faults may be classified as Electrical, Mechanical and Environmental faults. The transient voltages, unbalanced voltages or so referred as unbalanced voltage comes under Electrical faults[3]. Pulsating load, poor mounting and mechanical overload contributes to mechanical source for faults. The environmental factors like humidity, temperature, cleanliness or maintenance factor aids in environmental originated faults.

These faults can be characterised as mechanical faults and electrical.

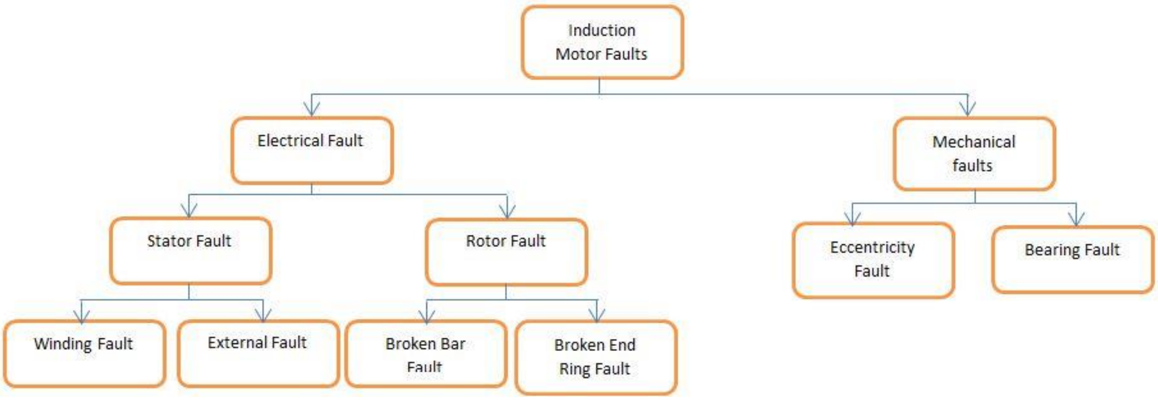

Figure 1: Types of induction motor faults

III. FAULT DIAGNOSIS

Existence of backward rotating field indicates the ill health of motor. For a healthy motor, only the forward rotating magnetic field rotating at synchronous speed is witnessed. Occurrence of any fault results in generation of rotating field having backward motion i.e., opposing the originally generated forward rotating field, in the air gap, thus the spectrum of stator current changes.

In [2], vibration spectrum analysis is used for detection of bearing faults for 0.75kW Induction motor. The spectrum magnitude was standardised for a bandwidth of 0.2 Hz, thus stating a +0.2 Hz deviation from frequency is indicating the initiation of fault. The detection of stator fault can also be done using Park's Vector approach.

Analysing the faults encountered in Induction Motor can be approached by analysing time harmonics analysis or by space harmonic analysis[4]. Major techniques involved in condition monitoring are based on frequency analysis of the obtained signal from induction motor, example, magnetic flux, stator voltage/current etc. frequency analysis based on time domain signal is generally followed method concentrating on different fault signature frequencies [6].

By finding the anomalies in motor voltage, current, flux leakage, fault diagnostics can be investigated. Various techniques and methods used for investigation are FFT based spectral signature analysis, vibration analysis, harmonic analysis for speed instability, machine heat monitoring, air gap flux analysis, acoustic noise classification, analysis of magnetic field.

IV. INDUCTION MOTOR

An induction motor or asynchronous motor is an electric motor in which the electric current obtained by electromagnetic induction from the magnetic field of stator winding produce torque in the rotor.[7] It can also be defined as an asynchronous machine comprised of magnetic circuit which interlinks with two electric circuits, and rotates with respect to each other, transferring power from one circuit to another by electromagnetic induction. Hence it is an electromechanical device that converts electric energy into mechanical energy.

Induction motors can be classified into two groups.[3]

- Squirrel cage
- Wound-rotor type

Almost 80% of the industrial motors and drives use squirrel cage induction motors. Squirrel cage induction motors are preferred more over wound-rotor type or slip ring type because of its following advantages.

- Compared to Slip Ring Induction motors, they are cost effective.
- It shows rugged construction due to absence of slip rings and brushes, thus resulting in less maintenance.
- Conductor material required in Squirrel Cage Induction Motors comparatively less compared to slip ring motor, thus copper losses occurred is comparatively less in squirrel cage, thus showing higher efficiency.
- Due to the absence of brushes slip rings, Squirrel cage motors are explosion proof and also have zero risks of sparking too.
- Cooling is better in Squirrel Cage motors compared to slip ring induction motors.
- speed of operation is constant, provides high over load capacity, and has improved power factor.

V. EQUIVALENT CIRCUIT OF A THREE PHASE INDUCTION MOTOR

The equivalent circuit of an induction motor is very similar to the equivalent circuit of a transformer. Equivalent circuit enables the performance characteristics of an induction motor to be evaluated for steady-state condition by simple network calculations. The equivalent circuit of an induction motor is only drawn for one phase.

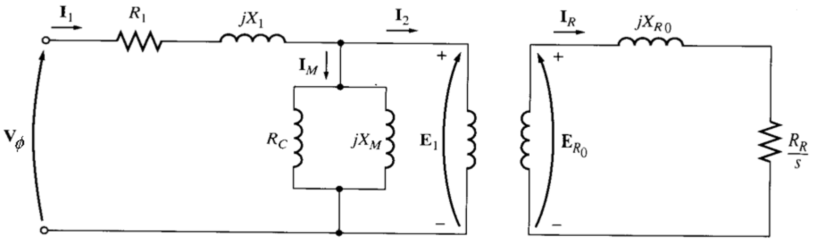

Figure 2: Equivalent circuit of a three-phase induction motor

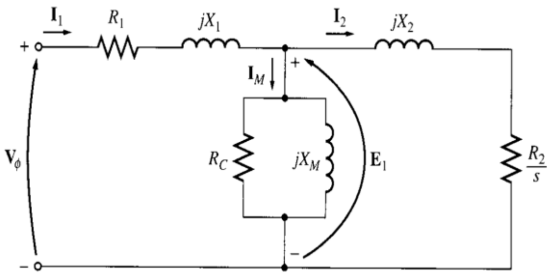

Figure 3: per phase equivalent circuit

$R_2 = n_{eff}{}^2 R_R$

$X_2 = n_{eff}{}^2 X_{R0}$

VI. CONDITION MONITORING TECHNIQUE

Condition monitoring of an induction motor is very important in order to detect and analyze the fault in the motor during its operation in order to prevent the failure and breakdown of the motor and the critical processes carried out by it. There are different condition monitoring techniques like, thermal monitoring, torque monitoring, noise monitoring, vibration monitoring, electrical monitoring.[4] The advantage of electrical monitoring technique is that, the stator current of an induction motor is readily available using sensor-less detection method that can be implemented without any additional hardware [1]. In other methods mentioned above, we need to include special type of sensors which increases the overall cost. Space harmonic technique of air gap flux monitoring may introduce error signals due to stray flux present around the shaft.

In electrical monitoring, we monitor the frequency of the stator current. The stator current has a specific frequency i.e the frequency of the supply voltage. Occurrence of any fault will introduce a specific fault frequency in the stator current. This fault frequency is unique for different faults. Thus we can identify the fault by analyzing the stator frequency.

VII. BLOCK DIAGRAM FOR FAULT DIAGNOSIS OF INDUCTION MOTOR

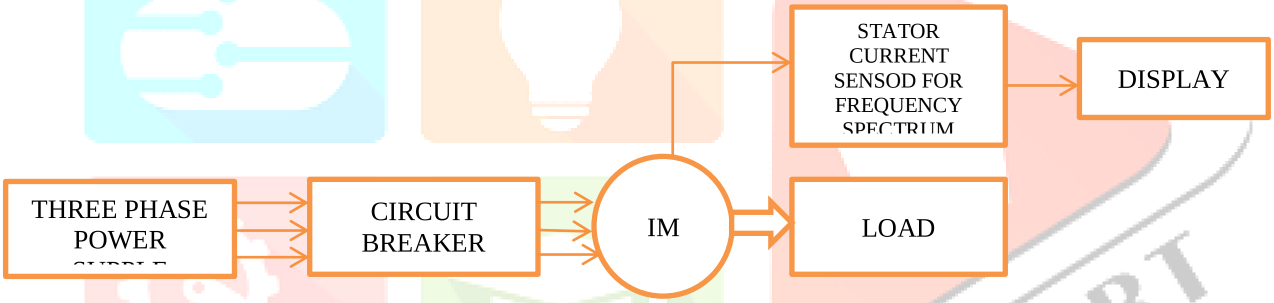

Figure 6.1: Block diagram of diagnosis of an induction motor

VIII. RESULTS

a. For Broken Rotor Bar

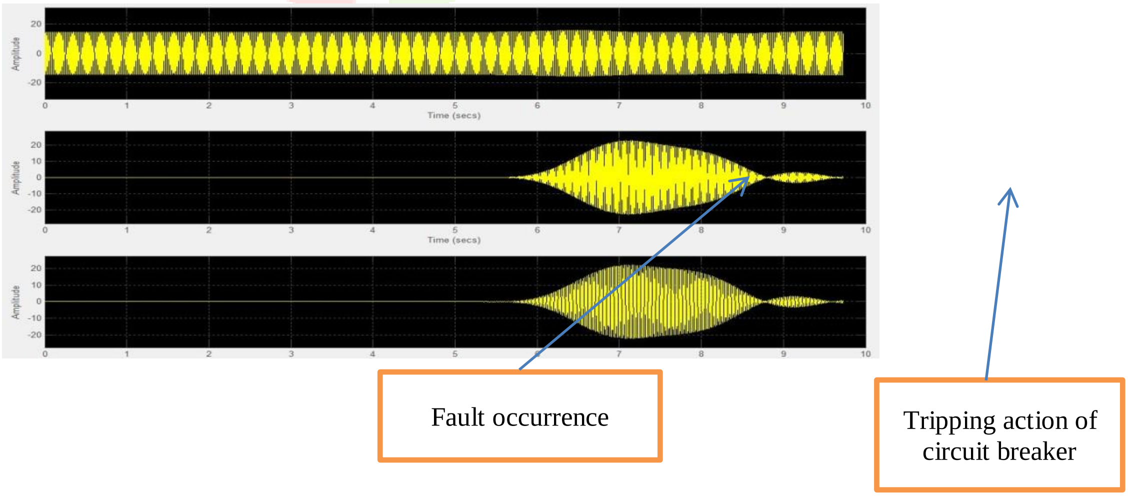

Figure 7.1: waveform of 50Hz, 58Hz and 42Hz band pass filter respectively

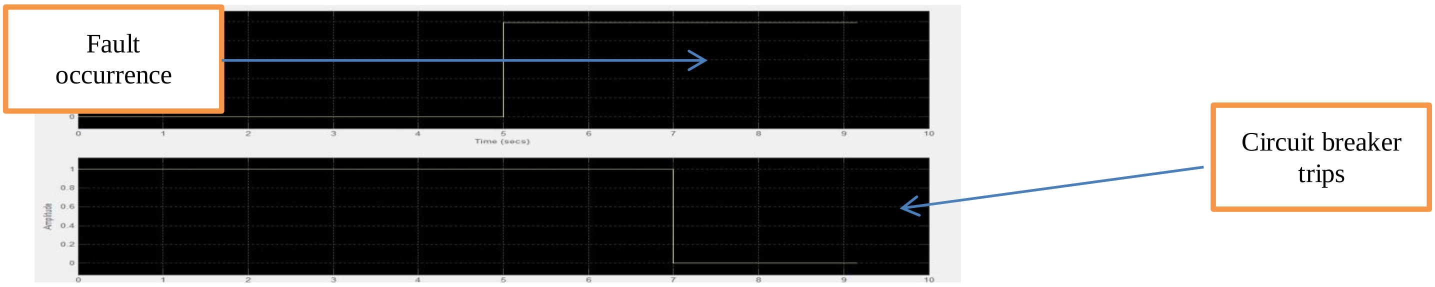

Figure 7.2: occurrence of broken rotor fault and tripping action of circuit breaker

b. For Stator Winding Fault:

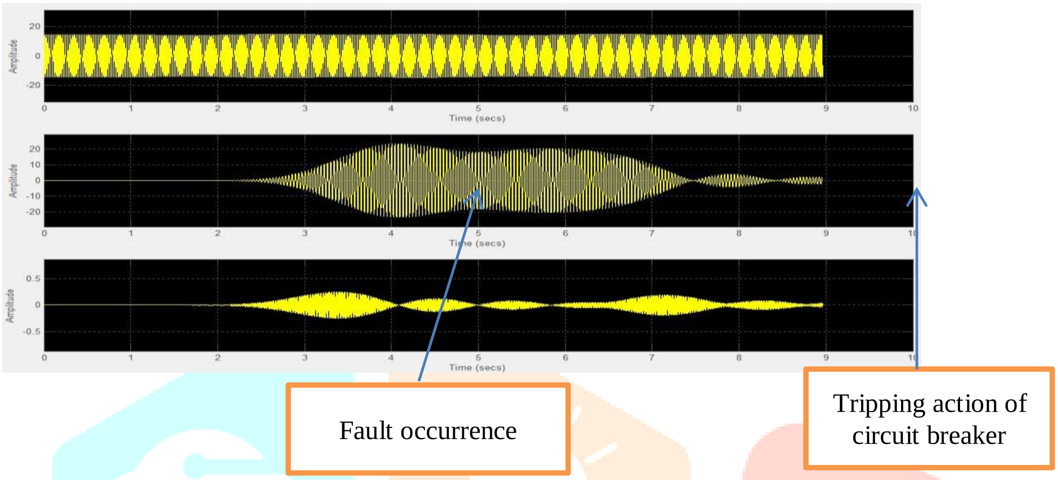

Figure 7.3: waveform of 50Hz, 27Hz and 73Hz band pass filter respectively

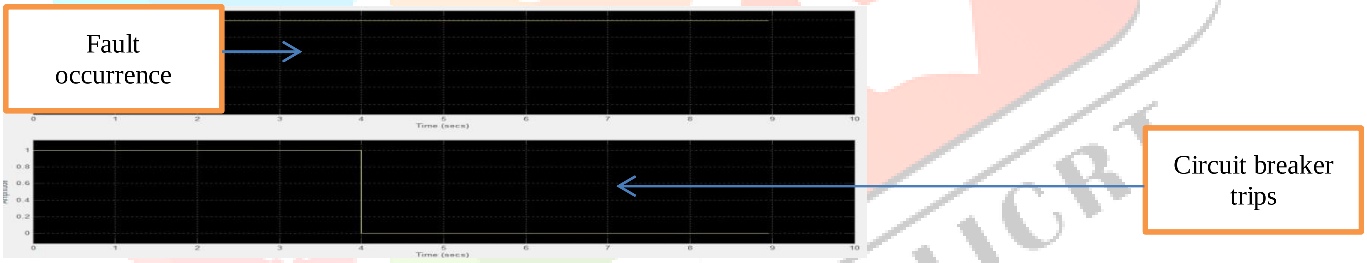

Figure 7.4: occurrence of stator winding fault and tripping action of circuit breaker

IX. Conclusion

The simulation for the broken bar fault and stator winding fault in an induction motor is executed successfully and proper tripping action is performed with identification of fault. Also study of different types of faults was done.

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