CHAPTER II
METHODS OF DETECTION

2.1 INTRODUCTION

Motors are critical components for electrical utilities and process industries. A motor failure can result in the shutdown of a generating unit or production line. The operators of motors or electrical drive systems are under continual pressure to reduce maintenance costs and prevent unscheduled downtimes, which result in lost production and financial income.

Early detection of fault within a motor prior to complete failure provides an opportunity for maintenance to be performed on scheduled routine without loss of production.

This arises the need for condition based maintenance strategies i.e monitoring the condition of motors and planning the maintenance based on an indication that a problem is about to occur. Condition monitoring implies monitoring various parameters of a machine in order to assess the health of the machine. Condition monitoring is akin to cardiogram analysis of the human heart. A cardiogram assesses the state and health of the human heart. Similarly the various parameters measured during the condition monitoring of the electrical equipment assess the health of the machine.

Condition monitoring can be broadly classified into two categories viz Offline and Online.

Online condition monitoring has certainly many advantages over offline condition monitoring.

1. Avoids the unexpected catastrophic breakdowns with expensive or dangerous consequences.

2. Reduces the number of overhauls on machines to a minimum, thereby reducing maintenance costs.
3. Eliminates unnecessary interventions with the consequent risk of introducing faults on smoothly operating machines
4. Allows spare parts to be ordered in time and thus eliminate costly inventories
5. Reduces the intervention time, thereby minimizing production loss. Because the fault to be repaired is known in advance, overhauls can be scheduled when most convenient.

Many operators now use online condition based maintenance strategies in parallel with conventional planned maintenance schemes. This has reduced unexpected failures, increased the time between planned shutdowns and reduced operational cost. During past fifteen years there has been substantial amount of research into the creation of new condition monitoring techniques. New methods have been developed which are now being used by the operators and research is continuing with the development of new and alternative online diagnostic techniques.

This basic objective of this work is to diagnose the different types of motors faults online through processing and analysis of motor current. This technique is often called "current signature analysis / Electric signature analysis."

2.2 METHODS OF DETECTION

Due to variety of diagnostic techniques now available it is difficult to make selection of the most appropriate and effective monitoring systems to suit the particular induction motor drive systems. There are several condition monitoring techniques for diagnosis as given below

2.2.1 Flux Monitoring

This technique involves the inspection of a search coil induced voltage either as a time function or in the frequency domain. The search coil is a coil of around 300-400 turns mounted concentrically around the shaft to measure the axial flux or mounted over the body of the motor [16, 23].

The different types of faults give rise to different frequency components in the induced voltage in the search coil. These induced voltages are captured by the fast data acquisition system. Their frequency spectra are analyzed to detect the fault.

2.2.2 Vibration analysis

It is a well known fact that vibration measurements are by far the most effective method of determining machine health while the machine is in operation. Though many faults can be easily diagnosed using this method of analysis, skills are needed to interpret the attained data[18]. The following are some of the faults that can be determined using vibration analysis

Unbalance

- Misalingment
- Mechanical looseness
- Bearing defects
- Lubrication problems
- Bent shaft
- Eccentric rotor and stator
- Broken rotor bars

- Loose stator laminations
- Air gap related problems

This requires the expensive vibration sensors to be mounted on the motors.

2.2.3 Induced voltage in Stator

This technique involves the inspection of the induced voltage in the stator after the motor is disconnected from supply. The stator itself acts as a search coil. The motor is disconnected from the supply and the induced voltage in stator due to only rotor flux is utilized to detect the fault[17]. Using this approach, the effect of non-idealities in source and non-linearity of magnetizing characteristics of machine due to saturation can be avoided.

The only disadvantage of this method is that this is an offline method, as it involves the inspection of induced voltage in the stator after the motor is disconnected from the supply

2.2.4 Partial discharges (for HV motors)

This type of monitoring is only used for HV motors. This involves monitoring of the partial electric discharges within the insulation of the HV motors. Research has proved that PD monitoring can identify insulation degradation prior to complete breakdown. This technique is widely applied in the industry for condition monitoring of HV motors.

2.2.5 Electric / Current Signature Analysis

Electric signature analysis is the procedure of acquiring the motor current and voltage signals, performing signal conditioning and analyzing the derived signals to identify the various faults.

Motor current acts as an excellent transducer for detecting fault in the motor. Spectrum analysis of the motor's current and voltage signals can hence detect various faults without disturbing its operation.

Advantages of Electric signature analysis

Online diagnosis, no stoppage required
Remote monitoring, no need to approach the motor
Accurate detection of electrical and mechanical faults

Electric signature is the representation of current and voltage in the frequency domain. A motor current signal is ideally a perfect sinusoidal wave at 50Hz. pictorially it can represent the current in terms of time as well as frequency as shown in figure 2.1. Here the first picture shows the current v/s time, while the second shows the current v/s frequency.

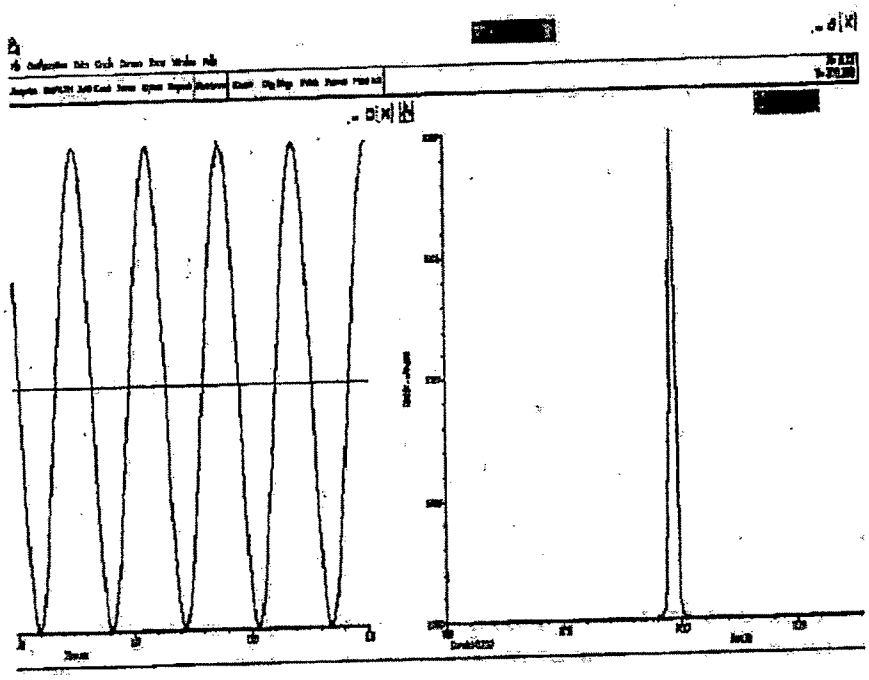

Figure 2.1: A Perfect 50Hz signal in both time and frequency domains[5]

The amplitude of the peak in frequency is equal to RMS amplitude of the sine wave. As this is a theoretical situation with no harmonics, we see only one peak in the frequency spectrum. The conversion of the current from time to the frequency domain is achieved by using an algorithm called the Fast fourier Transform (FFT).

During actual operation, may harmonics will be present in the motor signal, thus an actual signal will show many peaks including line frequency and its harmonics as shown in figure 2.2. This is know as the Motor current signature. Analyzing these harmonics after amplification and signal conditioning will enable identification of the various motor faults.

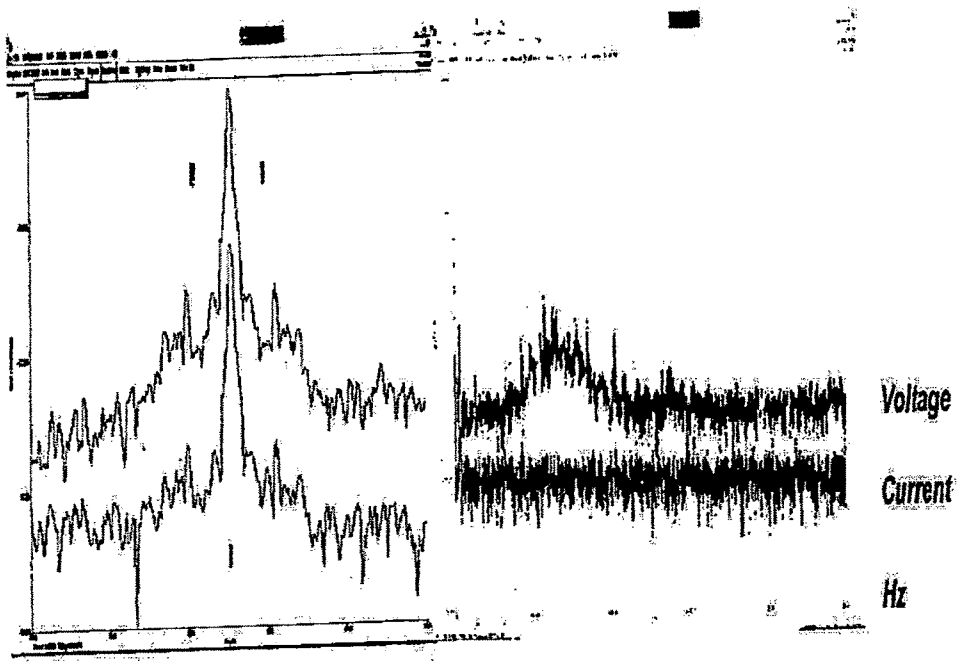

Figure 2.2: Typical frequency spectra of a good motor

The basic reason behind so many peaks in an healthy machine is because, the power supply is not a pure sine wave. Hence time harmonics are always present in the both Voltage and current. Motor and Load Problems also give rise to harmonics due to changes in air gap permeance which show up in the current only.

The frequency spectrum enables to see all the harmonics of voltage and current. All the electrical and mechanical fault changes the flux distribution inside the machine and hence generates the harmonics in the current.

Superimposing the voltage and current spectrum enables us to distinguish between the supply harmonic and fault harmonic. Now the harmonics generated by each fault

are different. Thus studying the distribution of these fault harmonics enables us to identify the fault.

2.3 CONCLUSION

Information on the application of specific condition monitoring techniques in industry is not available and evidence of diagnosing problem via reference to actual on site case histories are also not considered. There is no clear distinction made between monitoring techniques, which are at the R & D stage in comparison to those which are being successfully applied in industry. It is a fact that the operator of induction motor requires evidence of the successful application of monitoring systems to assist him in their selection of appropriate systems.

At present an operator is treating each induction motor drive as a unique entity and the potential failure modes, fundamental causes, mechanical load characteristics and operational condtions have all to be taken into consideration when a condition monitoring system is being selected. The focus has been on the use of online condition monitioring to detect degradation processes and failure mechanism. Figure 2.3 presents an overview of problems and possible online monitoring techniques.

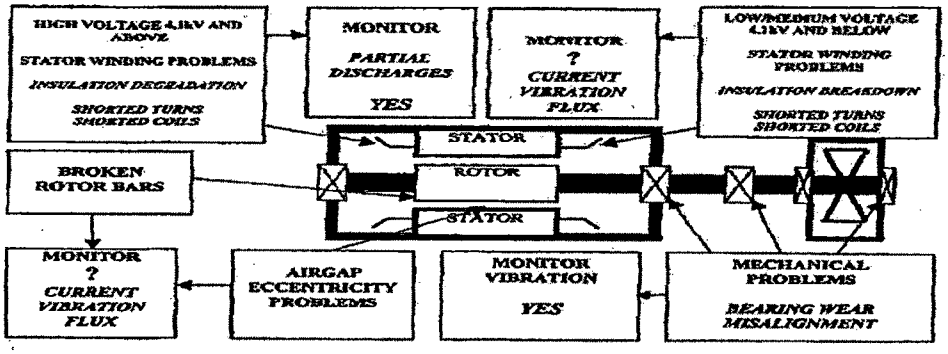

Figure 2.3: Problems, failures and possible online monitoring Technique for Induction motors[5]

At this stage it is suffice to state that a user of critical induction motor drives should select a condition monitoring system based on evidence of its reliability to diagnose problem in industrial drive and on its applicability to the particular industrial installations.

The present attempt aims at developing the technology for commercial use of Motor current signature analysis for all types of faults within the induction motor through series of experimentation and quantifying the severity of fault. The thesis also aims at developing the commercial equipment (both hardware and software) for carrying out current signature analysis and validate the same by laboratory trials and field trials.