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SMART CITIES

ELECTRICAL POWER SYSTEMS - CEM

REFRESHER TRAINING

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FOR ENERGY MANAGEMENT AND EFFICIENCY PROFESSIONALS

ENERGY MANAGEMENT SPECIALIST

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ELECTRIC MOTORS - 3

FOR ENERGY PROFESSIONALS

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ENERGY SPECIALIST CURRICULUM

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WHAT SHOULD YOU LEARN



Factors Affecting Energy Efficiency & Minimising Motor Losses in Operation

Speed Control of AC Induction Motors

Motor Speed Control Systems

FACTORS AFFECTING ENERGY EFFICIENCY & MINIMISING MOTOR LOSSES IN OPERATION



Power Supply Quality

Motor performance is affected considerably by the quality of input power, that is the actual volts and frequency available at motor terminals vis-à-vis rated values as well as voltage and frequency variations and voltage unbalance across the three phases. Motors in India must comply with standards set by the Bureau of Indian Standards (BIS) for tolerance to variations in input power quality.

Motor Loading

Measuring Load
% Loading of the motor can be estimated by the following relation:
 $\% \text{ loading} = \frac{\text{Input power drawn by the motor (kW)}}{\text{Name plate full load kW rating / name plate full load motor efficiency}}$
or
 $\% \text{ loading} = \frac{\text{Input power drawn by the motor (kW)}}{\sqrt{3} \times \text{kV} \times \text{I Cos}\phi}$
• Never assume power factor
• Loading should not be estimated as the ratio of currents.

The BIS standards specify that a motor should be capable of delivering its rated output with a voltage variation of +/- 6 % and frequency variation of +/- 3 %. Fluctuations much larger than these are quite common in utility-supplied electricity in India. Voltage fluctuations can have detrimental impacts on motor performance.

FACTORS AFFECTING ENERGY EFFICIENCY & MINIMISING MOTOR LOSSES IN OPERATION



Reducing Under-loading

Probably the most common practice contributing to sub-optimal motor efficiency is that of under-loading. Under loading results in lower efficiency and power factor, and higher than necessary first cost for the motor and related control equipment. Under-loading is common for several reasons.

Sizing to Variable Load

Industrial motors frequently operate under varying load conditions due to process requirements. A common practice in cases where such variable-loads are found is to select a motor based on the highest anticipated load. In many instances, an alternative approach is typically less costly, more efficient, and provides equally satisfactory operation. With this approach, the optimum rating for the motor is selected on the basis of the load duration curve for the particular application.

FACTORS AFFECTING ENERGY EFFICIENCY & MINIMISING MOTOR LOSSES IN OPERATION



Power Factor Correction

As noted earlier, induction motors are characterised by power factors less than unity, leading to lower overall efficiency (and higher overall operating cost) associated with a plant's electrical system. Capacitors connected in parallel (shunted) with the motor are typically used to improve the power factor.

The impacts of PF correction include reduced kVA demand (and hence reduced utility demand charges), reduced I²R losses in cables upstream of the capacitor (and hence reduced energy charges), reduced voltage drop in the cables (leading to improved voltage regulation), and an increase in the overall efficiency of the plant electrical system.

It should be noted that PF capacitor improves power factor from the point of installation back to the generating side. It means that, if a PF capacitor is installed at the starter terminals of the motor, it won't improve the operating PF of the motor, but the PF from starter terminals to the power generating side will improve.

FACTORS AFFECTING ENERGY EFFICIENCY & MINIMISING MOTOR LOSSES IN OPERATION



Maintenance

✓ Inadequate maintenance of motors can significantly increase losses and lead to unreliable operation. For example, improper lubrication can cause increased friction in both the motor and associated drive transmission equipment. Resistance losses in the motor, which rise with temperature, would increase. Providing adequate ventilation and keeping motor cooling ducts clean can help dissipate heat to reduce excessive losses. The life of the insulation in the motor would also be longer : for every 10°C increase in motor operating temperature over the recommended peak, the time before rewinding would be needed is estimated to be halved



FACTORS AFFECTING ENERGY EFFICIENCY & MINIMISING MOTOR LOSSES IN OPERATION



A checklist of good maintenance practices to help insure proper motor operation would include:

- ✓ Inspecting motors regularly for wear in bearings and housings (to reduce frictional losses) and for dirt/dust in motor ventilating ducts (to ensure proper heat dissipation).
- ✓ Checking load conditions to ensure that the motor is not over or under loaded. A change in motor load from the last test indicates a change in the driven load, the cause of which should be understood.
- ✓ Lubricating appropriately. Manufacturers generally give recommendations for how and when to lubricate their motors. Inadequate lubrication can cause problems, as noted above. Over- lubrication can also create problems, e.g. excess oil or grease from the motor bearings can enter the motor and saturate the motor insulation, causing premature failure or creating a fire risk.
- ✓ Checking periodically for proper alignment of the motor and the driven equipment. Improper alignment can cause shafts and bearings to wear quickly, resulting in damage to both the motor and the driven equipment.
- ✓ Ensuring that supply wiring and terminal box are properly sized and installed. Inspect regularly the connections at the motor and starter to be sure that they are clean and tight.



FACTORS AFFECTING ENERGY EFFICIENCY & MINIMISING MOTOR LOSSES IN OPERATION



Age

✓ Most motor cores in India are manufactured from silicon steel or decarbonized cold rolled steel, the electrical properties of which do not change measurably with age. However, poor maintenance (inadequate lubrication of bearings, insufficient cleaning of air cooling passages, etc.) can cause a deterioration in motor efficiency over time. Ambient conditions can also have a detrimental effect on motor performance. For example, excessively high temperatures, high dust loading, corrosive atmosphere, and humidity can impair insulation properties; mechanical stresses due to load cycling can lead to misalignment. However, with adequate care, motor performance can be maintained



SPEED CONTROL OF AC INDUCTION MOTORS

Traditionally, DC motors have been employed when variable speed capability was desired. By controlling the armature (rotor) voltage and field current of a separately excited DC motor, a wide range of output speeds can be obtained.

DC motors are available in a wide range of sizes, but their use is generally restricted to a few low speed, low-to-medium power applications like machine tools and rolling mills because of problems with mechanical commutation at large sizes. Also, they are restricted for use only in clean, non-hazardous areas because of the risk of sparking at the brushes. DC motors are also expensive relative to AC motors.

Because of the limitations of DC systems, AC motors are increasingly the focus for variable speed applications. Both AC synchronous and induction motors are suitable for variable speed control. Induction motors are generally more popular, however, because of their ruggedness and lower maintenance requirements. AC induction motors are inexpensive (half or less of the cost of a DC motor) and also provide a high power to weight ratio (about twice that of a DC motor).

MOTOR SPEED CONTROL SYSTEMS

Multi-speed motors Motors can be wound such that two speeds, in the ratio of 2:1, can be obtained. Motors can also be wound with two separate windings, each giving 2 operating speeds, for a total of four speeds. Multi-speed motors can be designed for applications involving constant torque, variable torque, or for constant output power. Multi speed motors are suitable for applications, which require limited speed control (two or four fixed speeds instead of continuously variable speed), in which cases they tend to be very economical. They have lower efficiency than single-speed motors

Adjustable Frequency AC Drives:

Adjustable frequency drives are also commonly called inverters. They are available in a range of kW rating from fractional to 750 kW. They are designed to operate standard induction motors. This allows them to be easily added to an existing system. The inverters are often sold separately because the motor may already be in place. If necessary, a motor can be included with the drive or supplied separately.

MOTOR SPEED CONTROL SYSTEMS +

Direct Current Drives (DC) :

The DC drive technology is the oldest form of electrical speed control. The drive system consists of a DC motor and a controller. The motor is constructed with armature and field windings. Both of these windings require a DC excitation for motor operation. Usually the field winding is excited with a constant level voltage from the controller.

Wound Rotor AC Motor Drives (Slip Ring Induction Motors):

Wound rotor motor drives use a specially constructed motor to accomplish speed control. The motor rotor is constructed with windings which are brought out of the motor through slip rings on the motor shaft. These windings are connected to a controller which places variable resistors in series with the windings. The torque performance of the motor can be controlled using these variable resistors. Wound rotor motors are most common in the range of 300 HP and above.


