



**ELECTRICAL POWER SYSTEMS - CEM
REFRESHER TRAINING**

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FOR ENERGY MANAGEMENT AND EFFICIENCY PROFESSIONALS





**ELECTRIC MOTORS - 2
FOR ENERGY PROFESSIONALS**

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WHAT SHOULD YOU LEARN





Motor Selection

Factors affecting motor performance

Rewinding and motor replacement issues, Energy saving opportunities with energy efficient motors.

MOTOR SELECTION

✓The primary technical consideration defining the motor choice for any particular application is the torque required by the load, especially the relationship between the maximum torque generated by the motor (break-down torque) and the torque requirements for start-up (locked rotor torque) and during acceleration periods.

✓The duty / load cycle determines the thermal loading on the motor. One consideration with totally enclosed fan cooled (TEFC) motors is that the cooling may be insufficient when the motor is operated at speeds below its rated value.

✓Ambient operating conditions affect motor choice; special motor designs are available for corrosive or dusty atmospheres, high temperatures, restricted physical space, etc.

MOTOR SELECTION +

✓An estimate of the switching frequency (usually dictated by the process), whether automatic or manually controlled, can help in selecting the appropriate motor for the duty cycle.

✓The demand a motor will place on the balance of the plant electrical system is another consideration - if the load variations are large, for example as a result of frequent starts and stops of large components like compressors, the resulting large voltage drops could be detrimental to other equipment.

✓Reliability is of prime importance - in many cases, however, designers and process engineers seeking reliability will grossly oversize equipment, leading to sub-optimal energy performance. Good knowledge of process parameters and a better understanding of the plant power system can aid in reducing oversizing with no loss of reliability.

MOTOR SELECTION +

✓Inventory is another consideration - Many large industries use standard equipment, which can be easily serviced or replaced, thereby reducing the stock of spare parts that must be maintained and minimizing shut down time. This practice affects the choice of motors that might provide better energy performance in specific applications. Shorter lead times for securing individual motors from suppliers would help reduce the need for this practice.

✓Price is another issue - Many users are first-cost sensitive, leading to the purchase of less expensive motors that may be more costly on a lifecycle basis because of lower efficiency. For example, energy efficient motors or other specially designed motors typically save within a few years an amount of money equal to several times the incremental cost for an energy efficient motor, over a standard-efficiency motor.

ENERGY-EFFICIENT MOTORS

Energy-efficient motors (EEM) are the ones in which, design improvements are incorporated specifically to increase operating efficiency over motors of standard design. Design improvements focus on reducing intrinsic motor losses. Improvements include the use of lower-loss silicon steel, a longer core (to increase active material), thicker wires (to reduce resistance), thinner laminations, smaller air gap between stator and rotor, copper instead of aluminum bars in the rotor, superior bearings and a smaller fan, etc.

Energy-efficient motors now available in India operate with efficiencies that are typically 3 to 4 percentage points higher than standard motors. In keeping with the stipulations of the BIS, energy efficient motors are designed to operate without loss in efficiency at loads between 75 % and 100 % of rated capacity. This may result in major benefits in varying load applications. The power factor is about the same or may be higher than for standard motors. Efficient motors have lower operating temperatures and noise levels, greater ability to accelerate higher-inertia loads, and are less affected by supply voltage fluctuations.

ENERGY-EFFICIENT MOTORS

Stator and Rotor I²R Losses :

These losses are major losses and typically account for 55% to 60% of the total losses. I²R losses are heating losses resulting from current passing through stator and rotor conductors. I²R losses are the function of a conductor resistance, the square of current. Resistance of conductor is a function of conductor material, length and cross sectional area. The suitable selection of copper conductor size will reduce the resistance.

Core Losses Core losses are those found in the stator-rotor magnetic steel and are due to hysteresis effect and eddy current effect during 50 Hz magnetisation of the core material. These losses are independent of load and account for 20 – 25 % of the total losses.

Friction and Windage Losses Friction and windage losses result from bearing friction, windage and circulating air through the motor and account for 8 – 12 % of total losses. These losses are independent of load. The reduction in heat generated by stator and rotor losses permit the use of smaller fan. The windage losses also reduce with the diameter of fan leading to reduction in windage losses.

ENERGY-EFFICIENT MOTORS

Stray Load-Losses

These losses vary according to square of the load current and are caused by leakage flux induced by load currents in the laminations and account for 4 to 5 % of total losses. These losses are reduced by careful selection of slot numbers, tooth/slot geometry and air gap. Energy efficient motors cover a wide range of ratings and the full load efficiencies are higher by 3 to 7 %. The mounting dimensions are also maintained as per IS1231 to enable easy replacement.

A summary of energy efficiency improvements in EEMs is given in Table 2

Power Loss Area	Efficiency Improvement
1. Iron	Use of thinner gauge, lower loss core steel reduces eddy current losses. Longer core adds more steel to the design, which reduces losses due to lower operating flux densities.
2. Stator I ² R	Use of more copper and larger conductors increases cross sectional area of stator windings. This lowers resistance (R) of the windings and reduces losses due to current flow (I).
3. Rotor I ² R	Use of larger rotor conductor bars increases size of cross section, lowering conductor resistance (R) and losses due to current flow (I).
4. Friction & Windage	Use of low loss fan design reduces losses due to air movement.
5. Stray Load Loss	Use of optimized design and strict quality control procedures minimizes stray load losses.


