2.6 ENERGY EFFICIENT MOTORS

An energy efficient motor (EEM) is a motor that gives you the same output strength by consuming lesser amounts of power. EEM is manufactured using the same frame as a standard motor, but they have some differences:

1. Higher quality and thinner steel laminations in the stator
2. more copper in the winding
3. Optimized air gap between the rotor and the stator
4. Reduced fan losses
5. Closer machining tolerances
6. High quality aluminum used in rotor frame

STANDARD MOTOR EFFICIENCY

Standard motor efficiency is the ratio of mechanical power delivered by the motor (output) to the electrical power supplied to the motor (input).

% Efficiency = (Mechanical power output/Electrical power input) x 100%

EEM utilizes improved motor design and high-quality materials to reduce motor losses, therefore improving motor efficiency.

NEED FOR EFFICIENT MOTORS

In the future, the cost of energy will increase due to environmental problems and limited resources. The electric motors consume a major part of the electric energy in industries. Thus, implementing energy efficient motor could save a significant amount of electricity. It would also reduce the production of green-house gases and push down the total environmental cost of electricity generation. Also, these motors can reduce maintenance costs and improve operations in industry. Efficient energy use is achieved primarily by means of a more efficient technology or process rather than by changes in individual behavior.

Average Full Load Nominal Efficiencies Standard and Energy Efficient Motors		
Rated hp	**Standard Motor**	**High-Efficiency Motor**
10.0	85.2	90.1
20.0	87.8	91.9
30.0	89.1	92.7
50.0	90.5	93.8
100.0	91.8	94.7
150.0	92.9	95.5
200.0	94.0	95.4

An EEM produces the same shaft output power, but uses less input power than a standard efficiency motor. A standard motor is a compromise between efficiency, endurance, starting torque, and initial cost. Standard motor generally competes on price, not efficiency. On the contrary, EEM competes on efficiency, not price. Shortly, EEM is needed

a) When there is a new installation or modification to your plant.
b) When old motors are damaged and need rewinding.
c) When existing motors are underloaded or overloaded.
d) While protecting other devices.

WAYS OF IMPROVING EFFICIENCY

The various ways of improving efficiency includes:

a) Reduction of iron losses
b) Reduction of flux density
c) Usage of low loss magnetic material
d) Reduction of stator and rotor copper losses
e) Increasing the copper section i.e., the stator slot area or rotor bar section
f) Increasing stator yoke
g) Reducing rotor diameter
h) Increasing the speed of starting current
i) Reducing the starting torque
j) Increasing core length for maintaining the starting torque

k) Increasing the thickness of the copper wires wound around the core of the motor. This reduces both the electrical resistance losses in the wires and the temperature at which the motor operates.

l) Using more and thinner high-quality steel sheets for the main fixed and rotating parts of the motor. This also minimizes electrical losses.

m) Narrowing the air gap between the spinning and stationary motor components, increasing the strength of its magnetic field. This lets the motor deliver the same output using less power.

Construction of EEM

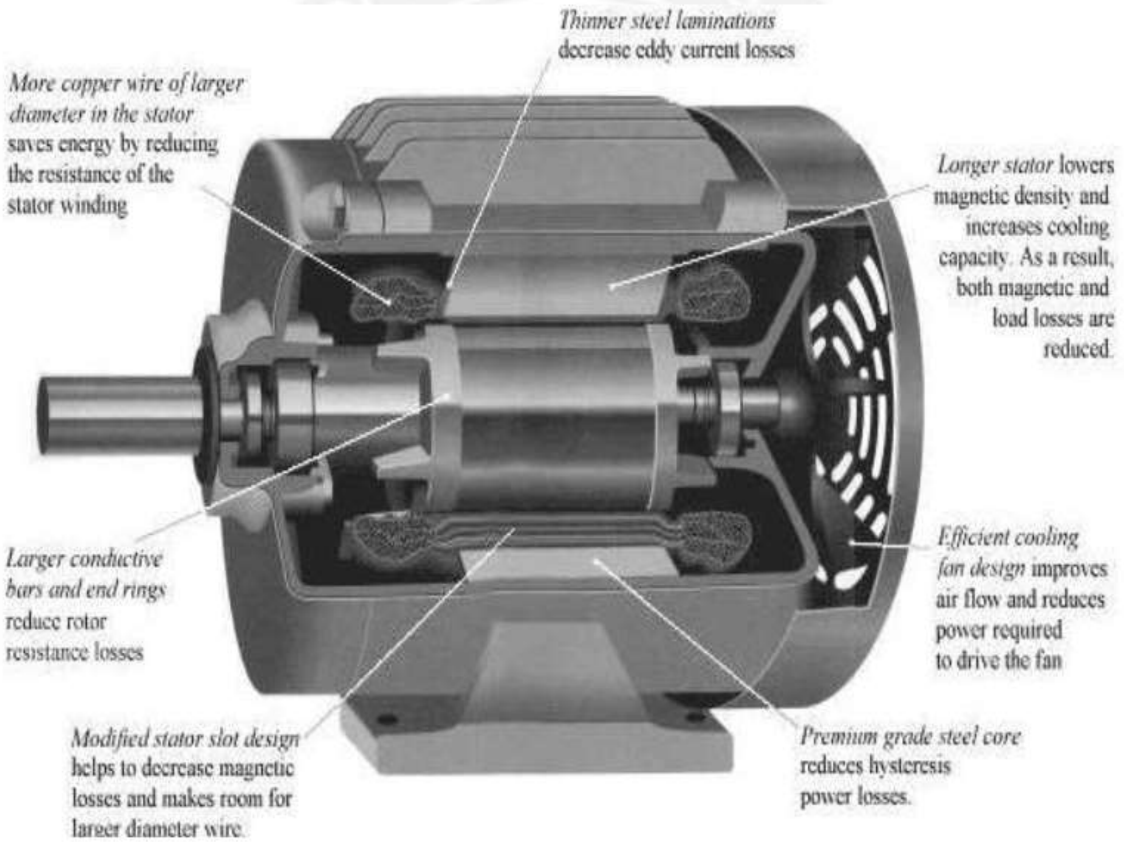

Figure 2.6.1 Energy efficient motor

[Source: "Energy-Efficient Electric Motors" by John C. Andreas, Page: 3]

MOTOR LIFE CYCLE

Motor efficiency details:

Standard → Eff3

Improved → Eff2

Energy efficient → Eff1

Eff1 motors are expensive to buy, be deployed for 24/7 working. Eff2 motors can be installed in all cases.

DIRECT SAVINGS and PAYBACK ANALYSIS

In many new installations, the extra cost of a premium-efficiency motor is justified by the energy and demand savings.

Consider a new application of a 50 hp motor with the following specifications:

- 6,000 hours of annual use at 75% load
- Cost of electricity = $.06/kWh
- Demand charge = $70/kW-yr
- Efficiency of EPAct motor = 93.9% at 75% load
- Efficiency of premium-efficiency motor = 94.8% at 75% load
- Extra list cost of premium-efficiency motor = $470
- Price is 65% of list
- Actual extra cost = $305

The yearly savings afforded by the premium-efficiency motors are as follows:

- Demand savings = 50 hp x (1/0.939 -1/0.948) x 0.75 x 0.746 kW /hp = 0.283kW
- Energy savings = 0.283 kW x 6,000 hr/yr = 1,697 kWh
- Cost savings = $.06/kWh x 1,697 kWh + $70/kW-yr x 0.283 kW = $122/year
- Simple payback period = $305/$122 = 2.5 years

The most common method used by equipment buyers to evaluate conservation investments is the simple payback, or the time that it will take for the savings to pay back the cost of the in-vestment. The simple payback is calculated by dividing the incremental cost of the efficient equipment by the value of the expected annual energy savings. For example, if an efficient motor costs $500 more than a standard motor and is expected to save $400/year, the simple payback will be 1.25 years. The use of the simple payback introduces some errors into the calculation by assuming that inflation is zero and utility rates are constant. It also ignores the life of the measure. A device with a 6-month payback may seem like a good investment, but it's not if it lasts only 8 months. Because of the short payback requirements of most motor users, however, and the relatively low cost of installing efficient motors and drives, the errors in simple payback analysis are generally minor.

EFFICIENCY EVALUATION FACTOR

Efficiency evaluations attempt to relate the results obtained from a specific programme to the resources expended to maintain the programme. Efficiency evaluations are receiving increasingly greater attention as programmes must compete with the limited resources.

Energy efficiency index

- Cooling tower
  - Fan efficiency
  - Cooling efficiency
  - Water loss of cooling tower
- Heat exchanger
  - Surface heat flux intensity
  - End temperature difference
  - Power and heat ratio
- Water pump
  - Pump efficiency
  - Water loss of pump
  - Operating efficiency
- Pipe
  - Surplus coefficient of pipe
  - Coefficient of heat loss
- Valve
  - Surplus coefficient of valve

Advantages:

1) EEM has a lower slip so they have a higher speed than standard motors.
2) EEM can reduce maintenance costs and improve operations in industry due to robustness and reliability. It is of low cost than standard motor.
3) Increasing the productivity.
4) Efficiencies are 3% to 7% higher compared with standard motors.
5) Design improvements focus on reducing intrinsic motor losses.

Benefits of energy efficient motors:

Motor	Efficiency class-III	Efficiency class-II	Efficiency class-I
Rating	30 HP	30 HP	30 HP
Efficiency	88%	91.4%	93.2%
Load (KW)	16.5	16.5	16.5
Motor Input, KW	18.75	18.05	17.7
Annual KWh used	1,64,250	1,58,118	1,55,052
Annual KWh saved	-	6,132	9,198
Annual Rs saved	-	30,660	45,990

Characteristics of energy efficient motors

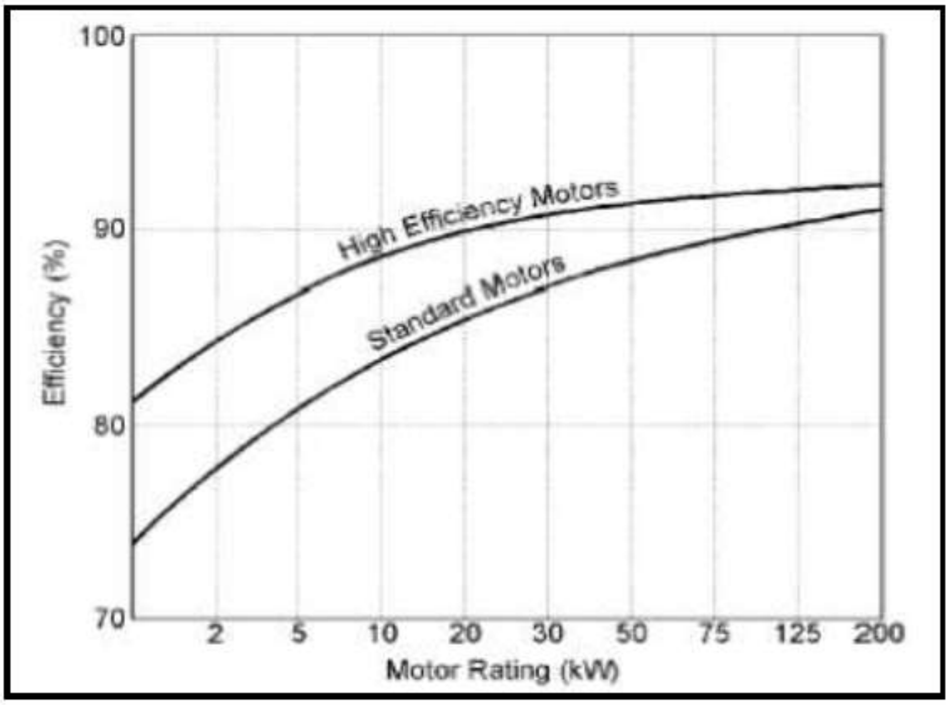

Figure 2.6.2 Characteristics of standard and energy efficient motor

[Source: "www.beeindia.gov.in," Page: 33]