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A Case Study of Energy Saving Using Energy Efficient Motors in a Process Plant

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Abstract - Energy conservation is a most talked subject in the today's world because energy consumption in various industries in India is a great issue. The standard induction motors in a process plant consume large amount of energy due to low efficiency. To save energy consumption in a process plant, the use of energy efficient motors are chosen over standard induction motor. Energy efficient motors have better efficiency and power factor than standard induction motors. The use of energy efficient motors reduces energy consumption of the plant. The plant under study has 40 motors of different ratings. The work presented in the paper examines the usage of extra energy in various standard induction motors in a process plant and encourage the use of energy efficient motors over standard induction motors. For this objective, a comparison of standard induction motors with energy efficient motors based on efficiency, (kW) motor input power, (kVA) apparent power, power factor, energy consumed (kWh) according to running hours in a year and current. The payback period for energy efficient motors has also been calculated. In the end the study found that replacing standard motors with energy efficient motors is better and overall plant motor load also reduces.

Keywords – Standard induction motor, energy efficient motor, efficiency, kilowatt, power factor, energy conservation

I. INTRODUCTION

In India the growing cost of energy due to limited stock of energy sources calls for power saving at each possible step in an industry. The three phase induction motors consumes about 70% of the electricity used in an industry. Hence the running cost of these induction motors is a real matter. In earlier period, the induction motor design was based more with the initial cost of the motor rather than the energy it consumes. The materials such as aluminum or copper wires and steel laminations, were selected at the minimum level required to meet the performance requirements of the motor. Hence the induction motors have low power factors, more losses and low efficiency. After 70's the cost of energy starts increasing and these motors becomes more costly due to low efficiency. And this leads the customers to search for other more efficient motors. Therefore the manufacturers look forward for different methods to increase the efficiency of motors. To achieve these manufacturers starts use of good and thin steel lamination materials having low losses and more amounts of copper wires in windings to increase the efficiency of induction motor.

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The motors having high efficiency, good power factor and fewer losses are called energy efficient motors. Energy efficient motors have efficiency 2-3% more than standard motors. In the improvement of energy efficient motors different technologies are made. The changes in slot shape increase the efficiency and thus reduce the internal motor losses [1]. The use of energy efficient motors offers the utilities the possibility of achieving sustainable energy and demand reduction [2]. The energy efficient motors save demand and energy and results in acceptable payback period [3]. Also the energy management systems results in 10 - 40% reduction in bills and energy [4]. Bonnet compares the various parameters of standard motors and energy efficient motors. The comparison includes %efficiency, power factor, current, torque and temperature, results the advancement of energy efficient motors [5]. Hamer performs characteristics and life cycle cost comparisons for centrifugal loads of energy efficient motors and conclude that the standard induction motors should not operate at higher voltages than rated but the energy efficient motors operate at higher voltages than rated [6]. F. Parasiliti and M.Villani study and compares the three phase induction motor efficiency with die cast copper rotor and premium steel [7]. A.biglietti and L.Ferraris study the energy efficient motor parameters according to the rotor materials [8]. The energy efficient motors are better than rewound motors because they have less payback period and more efficient than rewound motors [9],[11]. Comparison of standard motor with energy efficient motor has been done on the basis of parameters like %efficiency, voltage, current, power factor. Payback period of motors is also calculated [12].

II. ENERGY EFFICIENT MOTOR (EEM)

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 (with strong emphasis on the initial cost). Standard motor generally competes on price, not efficiency. On the contrary, EEM competes on efficiency, not price. There are mostly three phase induction motors are used in the industry.

A. Types of induction motors:

- Squirrel Cage induction motor
- Phase wound or Slip ring induction motor

A. Squirrel cage induction motor:
Squirrel cage induction motor is comprised of a number of thin bars, usually aluminium, mounted in a laminated cylinder in rotor. The bars are arranged horizontally and almost parallel to the rotor shaft. At the ends of the rotor, the bars are connected together with a shorting ring.

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B. Slip ring induction motor:

Slip ring rotor motor is a type of induction motor in which slip rings are connected with rotor winding. And in the rotor there is also a copper wire winding is place rather than copper rods. Starting torque of slip ring motor can be increased by inserting external resistance in rotor circuit [10].

B. Advantages:

- The EEM has a greater efficiency than a standard motors; therefore they have less operating costs.
- EEM has a lower slip so they have a higher speed than standard motors.
- EEM can reduce maintenance costs and improve operations in industry due to robustness and reliability.
- Increasing the productivity
- Higher quality and thinner steel laminations in the stator.
- More copper in the windings.
- Optimized air gap between the rotor and the stator.
- Reduced fan losses.
- Closer machining tolerances.
- A greater length.
- High quality aluminium used in rotor frame.
- Reduction in greenhouse gases emission

III. MOTOR PARAMETERS:

Comparison of energy efficient motor with standard motor have been done on the basis of parameters like %efficiency, energy consumed and saving in a year, current, power factor, input power and kVA.

A. *Efficiency*: The efficiency is defined as useful power output divided by the total electrical power consumed.

$$\text{Efficiency} = \frac{\text{Useful power output}}{\text{Total power input}}$$

B. *Power factor*: Power factor is defined as the ratio of the real power flowing to the load, to the apparent power in the circuit. Real power (kW) is the capacity of the circuit for performing work in a particular time. Apparent power (kVA) is the product of the current and voltage of the circuit. Power Factor = Real Power (kW)/Apparent Power (kVA)

C. *Input Power*: Input power is the amount of power that a motor actually takes including losses.

D. *Current:* An electric current is a flow of electric charge. It is different for standard an energy efficient motors.

E. *Annual energy saving*: It is defined as the difference of annual energy consumption of standard induction motor and energy efficient motor.

Payback Period: Payback period is defined as the period in which the cost of a newly installed (EEM) motor is recovered.

Payback Period = Premium Cost/ Annual cost saving

IV. DATA COLLECTION

In this case study, data of 40 standard induction motors operating in a process plant has been taken. We have taken only one standard induction motor data and the table below shows the comparison of this motor with energy efficient motor of same horse power and compares there results. The data includes rating of motor, speed, current and power factor. There are 22 (4 pole) motors and 18 (2 pole) motors. In this paper we discuss the calculations and results of a 20hp, 2 pole motors (Standard induction motor and Energy efficient induction motor). The data of 20hp, 2 pole induction motors (standard and energy efficient) are shown in the Table 1.

Table 1: 20hp, 2pole - Standard induction motor data operating in a process plant under study and Energy efficient motor data

Parameters	Standard induction motor	Energy efficient motor
Rpm	2940	2945
Voltage	415V	415V
Current	26.5A	26A
Efficiency	88%	91.5%
Power Factor	0.88	0.90
Energy Rate per kwh	Rs.7.25/kwh	
Frequency	50Hz	

The standard induction motors operating in a process plant are old and have poor efficiency. The working time for motor is 21 hour daily. Due low power factor and high losses a standard induction motor consumes more energy. The total load of 40 standard induction motors is 511kW. So to reduce industry load and for energy conservation we use energy efficient motors. Working days are 365 days. Average life of an induction motor is 20 years.

V. DATA CALCULATIONS AND RESULT

Calculations for 20hp, 2 pole motors:

a) *Motor input power of induction motor= (hp*0.746)/efficiency.*

Motor input power of standard induction motor = (20*0.746)/0.88=16.95kW

Motor input power of Energy efficient motor = (20*0.746)/0.915=16.30kW

b) *kVA for induction motor=kW/p.f*eff.*

kVA consumed for Standard motor= (20*0.746)/0.88*0.88= 19.26kVA

kVA consumed for Standard motor for 20 years= 19.26*20= 385.2kVA

kVA consumed for Energy efficient motor= (20*0.746)/0.90*0.915= 18.12kVA

kVA consumed for Energy efficient motor for 20 years= 18.12*20= 362.2kVA

c) *Annual energy consumption by induction motor= 0.746*hp*working hours*working days/efficiency.*

Annual energy consumption by Standard motor= 0.746*20*21*365/0.88= 129956.59kWh

Annual energy consumption by Energy efficient motor= 0.746*20*21*365/0.915=
124985.57kWh

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Annual energy saved by energy efficient motor replacing over standard induction motor= 129956.59 – 124985.57= 4971.02kWh

d) Annual cost saved by energy efficient motor

Annual cost saved by energy efficient motor replacing over standard induction motor= 7.25*4971.02= Rs.36039.89
Cost of a new Energy efficient motor = Rs.62215
Salvage value = Rs.13000

e) Payback Period=Premium Cost/Annual Saving.

So, Payback Period of 20hp, 2P energy efficient motor = 62215 - 13000/36039.89= 1.36 years.

From above calculations of 20hp, 2pole energy efficient motor, it is found that the annual energy saving from one energy efficient motor is 4971.02 kWh and annual cost saving from one energy efficient motor is Rs.36039.89.

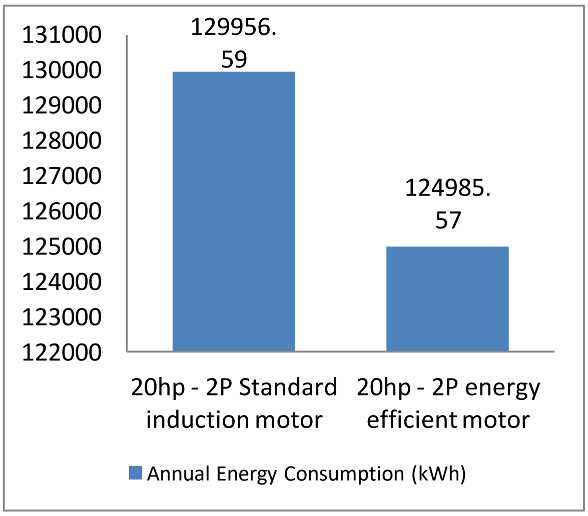

Fig.1: Comparison of annual energy consumption of standard induction motor and energy efficient motor.

Analysis of remaining energy efficient motors replacing over standard induction motors of same rating can be done in the same way. And it is found that the total motor load of energy efficient motors is 499kW as compared to 511 kW of standard motor. The initial cost of energy efficient motor is high as compared to standard motors but leads to large energy saving in process plant. The payback period of all other rating motors varies from 1.36 to 3.4 years is calculated as above and it is economical for plant. For other motors a large amount of energy also saves.

VI. CONCLUSION

From the results and observations we come to know that energy efficient motors bring a world of benefit to the organization. Proposal for replacing standard motors with energy efficient motors has been carried out. From calculations it is seen that there is large amount of energy saves (kWh) with energy efficient motors because of reduction in motors load. The running cost of plant also reduces. Due to this same yield is produced at lower loads and lower cost. Running cost defeats the initial cost.

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