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Energy Conservation by Energy Efficient Motor (Case study of Paper Industry)

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Abstract - *The electric motors consume a significant amount of electricity in the industrial and in the Service sector. In Power Sector facing a huge amount of energy demand, by improving energy efficiency by employing energy efficient device such as Energy Efficient Motor(EEM). The electric motor manufacturers are seeking methods for improving motor efficiency, which resulted in a new generation of electric motors that are known as energy efficient motors(EEM). Because of its simplicity and robustness, the three-phase squirrel-cage induction motor such as standard motor may be replaced by Efficient Motor(EEM) give more efficiency and better Performance. This paper involves energy conservation by installing energy efficient motor (EEM) instead of standard efficiency motor. Therefore, there are different practical cases in EEM is compared with standard motors rang 11HP and more rating of the motor. In all these cases energy savings can be achieved and the simple payback is less of five years. So, it is very interesting the implementation of EEM in the industry refers to paper factory Gujarat, and case study has been discussed.[1]*

Key Words: Three phase Induction motor, Energy efficient motor, energy consumption, Efficiency, payback.

1. INTRODUCTION

Electric Motors are the basic need of industry. These motor consume about 70% or more of the electricity used in the Industrial sector. The Three phase Induction motor is a prime source of Energy Consumption in Industry. The cost of energy will increase due to environmental problems and limited resources. The electric motors consume a more power of the electric energy in the industry. The induction motor is the main driven system in the modern industrial society.[1] It would also reduce the Production of greenhouse gases and push down the total environmental cost of electricity generation. Also, these motor can minimize maintenance costs and boost operation in the industry. So we have adopted and benefits of energy efficient motors to be applied in the industry.[3] Implementing energy efficient motor could save India a significant amount of electricity.

2. ENERGY EFFICIENT MOTOR(EEM)

Definition: An EEM generates the same shaft output power, but uses less input power than a standard efficiency motor. Energy efficient motors apply less electricity and last longer than NEMA (National Electrical Manufacturers Association) motors of the same size. To effectively evaluate the benefits of high-efficiency electric motors, we must define "efficiency". For an electric 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%.Thus, a motor that is 85 percent efficient converts 85 percent of the electrical energy input into mechanical energy. The remaining 15 percent of the electrical energy is dissipated as heat, evidenced by a rise in motor temperature.

Fig 1: Three phase Induction Motor

Energy efficient electric motors utilize improved motor design and high-quality materials to reduce motor losses, therefore improving motor efficiency. Figure-1 Shows the three-phase induction motor.

The improved design results in less heat dissipation and reduced noise output. Most electric motors manufactured prior to 1975 were designed and constructed to meet minimum performance levels as a trade-off for a low purchase price. Efficiency was maintained only at levels high enough to meet the temperature rise restrictions of the particular motor. In 1977, the (NEMA) recommended a procedure for labeling standard three-phase motors with average nominal efficiency. These efficiencies represent an industry average for a large number of motors of the same design.[4] Energy-efficient motors are constructed with improved manufacturing techniques and superior materials, they usually have higher service factors, longer insulation and bearing lives, lower waste-heat output, and less vibration all of which increase reliability.

There are a lot of terms in order to name this kind of motors. For example “energy efficient”, “energy premium” or “energy saving”. These motors are available in TEFC construction for use in safe areas and also in the flameproof enclosure for use in Hazardous areas.[3]

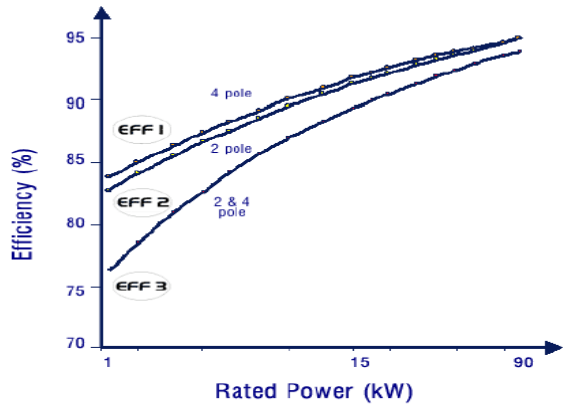

Fig 2 :Curves Efficiency –Rated Power [3]

Fig 2 related the efficiency for these types of motors The term energy efficient is preferred by manufacturers in the USA because it is recognized by NEMA as defined in NEMA Standards Publication MG 1-1993 Motors and Generators, and because it most clearly describes the feature of interest: energy efficiency.[3]

2.1 Special Design Feature[7]

Higher efficiencies are achieved by following special features

- Low loss special grade of thinner laminations. This reduces the Iron loss even at partial loads.
- Thicker conductors and more copper contents reduce copper loss due to lower resistance.
- Longer core length, reduced and uniform air gap between stator and rotor to reduce stray losses.
- Special design of fan and fan cover to reduce windage losses.

2.2 Constructive description

EEM is manufactured using the same frame as a standard motor.

But they have some differences:

- Higher quality and thinner steel laminations in the stator.
- More copper in the winding.
- Optimized air gap between the rotor and the stator.
- Reduced fan losses.
- Closer machining tolerances.
- A greater length.
- High-quality Aluminum used in the rotor frame.

2.3 Benefits

- Improved efficiency is available from 60 % to 100 % load. The efficiency curve is almost flat resulting in higher energy savings as in most of the cases the motor is not always fully loaded.
- The special design features also result in lower operating temperatures which enhance the life of the motor and reduce the maintenance cost..
- These motors have inherently low noise and vibration and help in conservation of the environment. These motors are with highest power factor in the industry due to the special exclusive designs available.
- The higher power factor reduces the currents in the cables supplying power to the motor and this reduces cable loss, improving the system efficiency sometimes by even 2 %.
- Sometimes this allows even a lower cable size saving tremendously on capital costs. Saving is also made by reducing capacitors required to improve power factor.

2.4 Demerits

There are many misunderstanding about the characteristics of energy efficient motors. Some of them lead users to expect more than they will deliver.

- An oversized motor is less efficient.
- A more efficient motor also has a higher power factor.
- More efficient motors run cooler.
- An energy efficient motor develops less torque, and may not accelerate the load

2.5 Energy Efficient Motor VS Standard Motor[3]

The same frame is used for manufacturing of as a standard motor as well as EEM, but the following points are differentiated them from each other:

- Grater quality and thin laminations of steel used in the stator.
- More copper in the winding.
- Optimized air gap between the rotor and the stator.
- Reduced fan losses.
- Closer machining tolerances.
- A greater length.
- High quality aluminum used in the rotor frame.

2.6 Energy losses of electric motors fall into various categories[6]

- Electrical losses (Joule losses): Due to an electrical resistance of the windings, Conductor bars, and end rings.
- Magnetic losses: Due to hysteresis and eddy currents of the magnetic field in the steel laminations.
- Stray load losses: Due to imperfections in the flux (leakage, harmonics, irregularities, etc.)

- Mechanical losses: Due to friction Brush Contact losses.

2.7 Several technical solutions exist to improve the energy efficiency of a motor system[6]

- Reducing the electrical losses in the windings, by increasing the cross-sectional area of the conductor or by improving the winding technique.
- Reducing the magnetic losses by using better magnetic steel.
- Improving the aerodynamics of the motor to reduce mechanical losses.
- Minimizing manufacturing tolerances.
- Using an electrically commutated system to eliminate brush contact losses.
- Using a Variable Speed Drive (VSD) if the motor operates regularly at other than its nominal speed/ torque.

2.8 Benefits when implementing Energy Efficient Motor[3]

(1)Environmental benefit

- One of the major current environmental concerns is the greenhouse gas emission (Co2, N2O…). After signing the Kyoto protocol, it must reduce overall greenhouse gas emissions over the period of time.

(2) Micro economical benefits

- The micro economic benefits are non-energy benefits that achieve due to implementing energy efficient motors such as:
- A better process control.
- A reduced disruption process,
- An improved product quality.
- Sometimes reliability is improved.

(3) Macro-economical benefits

- It is possible to consider three direct macro-economic benefits
- Increased competitiveness.
- Raised employment.
- Reduced dependency of fossil fuels.

2.9 Recommendations when applying EEM[1]

- EEM should be considered in the following cases:
- For all new installations.
- When major modifications are made to existing facilities or processes.
- For all new purchases of equipment packages that contain electric motors.
- When purchasing spares or replacing failed motors.
- Instead of rewinding old standard motors.
- To replace grossly oversized and under loaded motors.
- As a part of energy management or preventive maintenance schedule.
- When utility conservation programs, rebates or incentives are offered that make energy efficient motor retrofits cost-effective.

3. Productive Evaluation[1]

Generally, energy efficient motors cost an average of 15 to 30 percent more than standard motors. But it depends on the specific motor manufacturers and market competition. It is often possible to obtain a lower price premium when purchasing a large quantity of energy efficient motors. The price premium per horsepower is lower for the large motor ratings. The different prices between an energy efficient motor and a standard motor. An energy efficient motor is always more expensive than a standard motor, and this difference increase with size. The payback period varies according to the purchase scenario under consideration, cost difference, hours of operation electrical rates, motor loading and difference in motor efficiencies. For new purchase decision or the replacement of burned –out and un-rewind able motors. The simple payback period for the extra investment associated with an energy efficient motor purchase is the ratio of the price premium less any available utility rebates. To the value of the total annual electric savings.[4] [5]

$$\text{Simple payback year} = \frac{\text{Price premium} - \text{Utility rebate}}{\text{Total Annual cost Savings}} \text{ ------- (1)}$$

For replacement of operational motors, the simple payback is the ratio of the full cost of purchasing and installing a new energy efficient motor relative to the total annual electrical savings.

Simple payback year =

$$\frac{\text{New motor cost} + \text{Installation charge} - \text{Utility Rebate}}{\text{Total Annual cost savings}} \text{ ---------- (2)}$$

Practical Cases

The case study of Ram Paper Mill.

3.1 Objectives of Study

(a) To find out percentage energy saving by Crompton make New Motors. (b)To Search out the other energy conservation opportunities in the company.

3.1.1 General remarks

4 Motor of 11KW,415V, 4 Pole Induction motor (2 Siemens Electric motor & 2 Old Motor) was Tested. The speed of 5 old motors & 2 Siemens Electric motor were measured. In this paper, only 11KW (15HP) Induction motor data are discussed.

3.1.2 Observations

(1) SPEED: As the old motor's are rotated, the speed range was around 1435 to 1440 while in case of Siemens motor the range is 1464 - 1470. There is a difference in RMP is 30 to 40 RPM. There should be increased in production in case of a new motor. As the speed is higher, new motor supposed to draw more power because of higher speed and higher production
(2) The efficiency of motor: There is a difference of 3 % in efficiency in old motor and new motor were calculated with the new motors having higher efficiency.
(3) Power Factor: - There were no power factor correction measures were taken at the section level.

3.2 CALCULATION OF ENERGY SAVING & PAY BACK[1]

(A) Existing Old motor

81% Efficiency, 75% Loading

$$\text{Input Power(KW)} = \frac{11KW*75\%}{81\%\ \text{Efficiency}} = 10.19KW$$

Energy usage = 10.19*8760 hours/year

= 89264 KWh/year

(B) Siemens New motor

84.7% Efficiency, 75% Loading, Energy Charges Rs.5/KWh (approx)

$$\text{Input Power(KW)} = \frac{11KW*75\%}{84.7\%\ \text{Efficiency}} = 9.74KW$$

Energy usage = 9.74*8760 hours/year
= 85322 KWh/year

Saving Per motor= (89264-85322)*5
= 19710 KWh/motor

$$\text{Simple Payback} = \frac{\text{Cost of motor}}{\text{Saving}} = \frac{38500\ (\text{Approx})}{19710} = 2\ \text{year}$$

(C) Energy Efficient motor as per IS-12615

91% Efficiency, 75% Loading, Energy Charges Rs.5/KWh (approx)

$$\text{Input power(KW)} = \frac{11KW*75\%}{91\%\ \text{Efficiency}} = 9.07KW$$

Energy usage = 9.07*8760 hours/year
= 79453 KWh/year

Saving Per motor= (89264-79453)*5
= 49055 KWh/motor

$$\text{Simple Payback} = \frac{\text{Cost of motor}}{\text{Saving}} = \frac{40000\ (\text{Approx})}{49055}$$

= 0.8 year= 10 month

4. CONCLUSION

The paper presented shows that energy efficient motors are an opportunity for improving the efficiency of motor systems, large cost-effective energy savings, improving the industrial economic efficiency and reducing the environmental impacts with the practical cases, it can be noticed that EEM is more efficient than the standard motor and rewound motor. Also, energy savings can be achieved and the extra cost of their purchase can be regained in five years or less.

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