Energy and Cost Saving by Replacing Standard Induction Motors with Energy Efficient Motors: A Case Study

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ABSTRACT
In today's world in order to meet the increasing demand –supply gap , we need to transform the way energy is produced, delivered and consumed across all regions of the world. Energy efficiency gives a promising future to all viz. savings for consumers and utilities, improvements in industrial productivity, intensified international competitiveness and reduced environmental impacts. Energy Efficient motors (EEM) are truly premium motors. The efficiency gains are obtained through the use of refined design, better materials, and improved construction. In this paper a case study of several rice mills have been taken. The load for the various rice mills have been taken into account .The parameters associated with already installed induction motors have been noted for efficiency and cost saving calculations. A proposal have been made to replace standard induction motors with EEM.

Keywords
Payback, energy efficient motors(EEM), electric energy savings, Standard Induction Motor(SIM).

1. INTRODUCTION
Today is the day of energy efficiency. In good old days, when electrical power was a cheap commodity, the efficient use of power was not considered as an important topic. However, situation is changed to a large extent. Now Power is not cheaper anymore and for most of the industries, electrical energy has become almost a raw material. If we analyses the Indian power scenario, it is being reported that the transmission and distribution losses is about 25-30% or even more. At the same time, a critical analysis of the performance of electrical motors reveals that the power loss due to in-efficient electrical motors is also as high as 25-30%. [4]Improving energy efficiency is the cheapest, fastest and most environmentally friendly way to meet the world's energy needs. Energy efficiency is further related to energy saving. When we save a unit of electrical energy it implies that we are generating two unit of electrical energy.

The most general consumers of electric energy in different industries are induction motors. Electrical motors are the driving mechanism for majority of operations in industries, agriculture, commercial complexes etc. In India, 80% of the electrical power consumed in industries, 50% of power consumed in domestic and commercial connections and about 90% of power consumed in agricultural connections are through electrical motors. Most of the motors used in industry are oversized. This result into poor efficiency which leads to more power consumption and energy cost .Therefore improvement of efficiency of the motor must be an important part of any comprehensive energy conservation programmed.[3] Most of our traditional industries like sugar, textile, etc. are dying down due to the inefficiency in operation and the comparatively high operating cost, which makes the product incompetent in the current global market. The only way to improve motor efficiency is to reduce motor losses. A small gain in efficiency can produce significant energy savings and lower operating costs over the life of the motor.

Here in this paper our main consideration is rice mill . In the Rice- Mill the outer husk of rise grains is removed then the rice grains are whitened and polished with the help of various machines. Traditionally Rice pounder was used. Later more efficient machinery was developed. This was used throughout Asia where the most famous type was Engelberg huller. Another type of huller was disk huller. Later Rubber rollers were used. Now a days semi –automatic and fully automatic Rice –mills are used. In most rice mills the group drive system is being used .In this system various machines used in the process are driven with a single large capacity three phase electric induction motor These mills work for 7 to 8 months in a year. During this period machines work for day and night .Large capacity motors are used and average monthly electric bill of a mill costs in lakhs.

Therefore , a survey has been done on several rice mills .The main objective is to save electric energy by improving the efficiency by replacing three phase induction motor with high efficiency motors .

1.1 ELECTRIC MOTOR EFFICIENCY (Η)

It is measure of ability of an electric motor to convert electrical energy to mechanical energy. KW of electrical power are supplied to motor at its electrical terminal and HP of mechanical energy is taken out at rotating shaft.

$$\text{efficiency } \eta\text{-}\% = \frac{\text{mechanical energy output}}{\text{electrical energy input}} \times 100$$

$$= \frac{746 \times hp \times 100}{VI \cos \Phi}$$

1.2 LOSSES IN A MOTOR
The only way to improve efficiency of a motor is to minimize the losses A typical standard motor have five major components of loss viz. iron loss, copper loss ,frictional loss, windage loss ,stray loss.Table 1 depicts the various losses that occur in a motor.[6]

Table 1: John C Andreas Loss Segregation Table For Induction Motors:

Loss	Percentage of total loss				
	1-4 hp	5-24hp	25-49 hp	50-99 hp	100-199 hp
Stator I^2R	43	40	42	38	28
Rotor I^2R	13	20	21	22	18
Core Losses	28	29	15	20	13
Windage & Friction Loss	9	4	7	8	14
Stray Loss	7	7	15	12	17

2. ENERGY EFFICIENT MOTORS

An EEM produces the same shaft output power, but uses less input power than a standard efficiency motor. Standard motor generally competes on price, not efficiency. On the contrary, EEM competes on efficiency, not price.[1] EEM are 2 to 8% more efficient than standard motors. Nearly all energy-efficient motors are induction motors. In general, they will be longer-lived than standard motors under otherwise identical conditions, because they typically run cooler. This translates into fewer winding failures, increased bearing life, longer periods between scheduled maintenance, and fewer forced outages. These motors withstand stalling and overloads better and usually run quieter and operate with lower no-load losses. They are also less sensitive to abnormal conditions such as impaired ventilation, under and over voltage, and phase imbalance. Many motors, however, fail because of mechanical damage, hostile environments, or poor alignment.

Factors Affecting the Efficiency of a Motor

Starting characteristics :Direct online, star delta, auto transformer and soft starter are the methods used for starting the motor. In DOL starters the starting current is 5-6 times the full load current and for star delta starters the stating current is 2-3 times the full load current.

Load factor : Standard motors are designed for maximum efficiency at full load. Efficiency and power factor decrease with decrease in load factor resulting in increased distribution losses. Motors which operate at partial load can be operated through energy saver.

Operating voltage : If the motor is operated at a lower voltage then magnetizing current, flux density and iron loss will become less and power facto will be improved but stator and rotor current sill increase resulting in more stator and rotor losses

Speed : single winding multi - speed motors are more efficient than multi - winding motors

Duty cycle : if a non duty cycle motor is selected for varying load it will consume more power, similarly a duty cycle motor will consume more energy for normal operation.

High Efficiency Motor Design

For obtaining high efficiency some modification in motor design are needed which are:-

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

2.1 ADVANTAGES WHEN IMPLEMENTING EEM

Energy-efficient motors are a proven technology in terms of durability and reliability, therefore reduces losses because of their better design, materials, and manufacturing. Saving of electrical energy and efficiency of motor can be achieved by making some changes in design .Following are the advantages when implementing Energy Efficient Motor:

Environmental benefits: reduction CO2 equivalent emissions.
Increase in productivity.
Less maintenance due to improved motor design.
EEM usually have high power factors
Increased lifetime of their bearings and windings.
Extended lubrication cycles due to cooler operation
Extended warranty by manufacturer

Disadvantages

Their primary disadvantage is their higher cost.
Secondly these motors sometimes have lower starting torque and/or power factor. If these factors are critical to a customer's application, energy-efficient motors are not appropriate.

Economics of EEM

Generally, energy efficient motors cost an average 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. [1]

2.2 COST AND PAYBACK ANALYSIS OF INDUCTION MOTOR

The amount of money which can be saved by using an EEM instead of SIM depends on motor size, annual hours of use ,load factor and serving utility's charges for electrical demand and energy consumed .

To evaluate the economic feasibility of using an EEM instead of SIM the information needed is :

Utility's rate schedule ,Load factor , number of motor operating hours at rated load .With this information annual energy and cost savings can be calculated.

Utility's rate schedule : The cost of electricity is composed of four factors consists of Basic Charges, Energy Charges , Demand Charges ,Power Factor Penalty or Reactive Power Charges.

Load factor : To calculate the load factor, the power drawn which is obtained through measuring instruments, can be compared with the nameplate rating of the motor.

Operating Hours : The number of motor operating hours at rated load can be calculated .electrical energy savings are directly proportional to the number of hours of a motor is in use.

Efficiencies: The electrical energy savings are proportional to the difference of energies of both motors being compared. Also the savings are proportional to the motor size.

3. BASIC REQUIREMENTS AND OPERATION OF A RICE MILL

The land required for rice mills should be hard, the building should be spacious and airy. Large space is required for parking, loading and unloading of goods vehicles and storage of paddy and rice. The rice mill and its accessories are always placed under a waterproof building. Various types of machinery and equipment are used to clean, de-husk, polishing and grading of rice. One supervisor and two technicians are required for the

operation of the standard capacity mill, at least fifteen unskilled workers are required for the process.

In a Rice-Mill there are different machines used for various operations .These are explained as follows

Pre cleaner – Firstly moisture is removed from paddy before putting it to pre-cleaner .the Pre-cleaner removes dust,stones and extra foreign material from the paddy **.**

De-husker –It is also known as huller .it removes husk or chaff from rice grain

Paddy separator – It separates the paddy and rice

Thick and thin grader – It grades the rice according to its thickness

Whitener – It is used to provide the whiteness to surface of rice

Polisher – This machine gives the glazy finish to the surface of rice

Length grader – It grades the rice according to its length

These machines are driven with common long shaft driven by a large capacity motor. The grains are shifted from one section to another with the help of power driven elevators_Rice mill is potential energy saving area .In the rice mills induction motors are the main energy consumers which offers opportunity of energy savings .Here 12 Rice –Mills are taken for the study .The load for the various rice mills have been taken into account .The parameters associated with already installed induction motors have been noted for efficiency and cost saving calculations .Then a proposal have been made to replace standard induction motors with EEM.The losses and efficiency of EEM are calculated and are compared with already existing SIM.

4. RICE MILL ANALYSIS

Savings and Payback calculations

EXPECTED SAVINGS

Savings are calculated as follows:

KW output of motor in kW

E_1 - efficiency of standard motor

E_2 - efficiency of energy efficient motor

$$\mathbf{X = [(KW/E_1) – (KW/E_2)]}$$

Saving = X*(Working Hours)*(Working Days)*(Tariff)

Payback Period: It is length of time required for incoming returns to come equal the cost of investment.

For a New Motor

Simple Payback Period = Price Premium-Utility Rebate / Annual Saving

For Replacement

Simple Payback Period = Motor Price+ Installation Charge –Utility Rebate / Annual Saving

Table 6.1 Rice Mill Data &Savings and Payback calculations

S.No	Rice –mill	Address	Motor ratings	Load In KVA	kVAr savings/Yr	Price Difference	Total savings /Yr	Payback period
1	Bhawani Rice Mill	Samrala	60 hp 20hp 5 hp	93.80	2.517	22890	73487	4.8 Months
2	Swastika Agro Ind	Village Shamspur	75 hp 20 hp 10 hp	174.92	5.901	40330	66567	7 Months
3	G.N Agro Ind	Village Shamspur	75 hp 30 hp 10 hp 5 hp	243.90	8.756	46560	113814	5 Months
4	Sun Star Agro Ind	Village Shamspur	75 hp 20 hp 5 hp	231.00	5.250	38390	59720	8 Months
5	Harkrishan Agro Ind	Village Shamspur	60 hp 10hp 5 hp	142.80	2.220	18350	74591	3 Months
6	Bala Ji Agro Ind	Village Nagra	75 hp 10 hp 5 hp	224.00	4.947	33790	62814	7 Months
7	Lord Rama Agro Ind	Village Landhran	60 hp 10 hp 5 hp	149.70	2.208	18350	75589	3 Months
8	United Rice Mill	Village Bondli	75 hp 30 hp 10 hp	296.85	8.585	43700	108754	5 Months
9	Malwa Agro Ind	Village **B**ondal	75 hp 30 hp 10 hp	370.51	8.585	43700	108754	5 Months
10	Krishna Rice	Village	60 hp	98.19	2.220	18350	74589	3 Months

	Mill	Urna	10 hp 5 hp					
11	Jandiali Rice Mill	Village Jandaili	75 hp 30 hp 5 hp	278.00	7.915	41910	98719	5.1 Months
12	Ganeshai Overseas	Village Latton	100 hp 60 hp 30 hp 5 hp	745.30	8.159	42460	206451	3 Months
					59.104 KVAr	**40780**	**1123849**	**4.3 Months**

The use of EEM in 12 mills only is resulting in annual saving of 11 lakhs approximately and reactive power saving of 60 kVAr. From payback analysis it is clear that extra amount required for EEM can be recovered in approximately 4 months only.

5. CONCLUSION

Mostly developing countries are facing a power crunch today. The gap between power supply and power demand is widening nowadays. Increase in demand for power has led to an increase in fossil fuels use, which leads to green house gas emissions and adverse impacts on environment .Even small efficiency improvements can produce very large savings ,more savings means less power demand and hence less generation ,thus narrowing the power gap . By using EEM a significant amount of electricity bill which is spend in powering motor loads, operating and maintenance costs, can be saved. A typical payback period of 6 months to three years is other feature which makes EEM a sound investment. In Indian industries EEM is not a widely used concept. A major part of total electrical energy is consumed by motor load applications in the industrial and agriculture fields. Three phase induction motors are used for this purpose. Improvement of efficiency of electrical drives can play a very important role in energy conservation. Replacing standard efficiency motors with energy efficient motors may result in huge saving in electrical energy consumption bills, as well as in reactive power. The saving in kVAr by the use of energy efficient motors improves the voltage profile of electrical transmission system. A huge amount of money can be saved by the use of energy efficient motors in rice mills. The savings and payback calculations are worked out for the commonly used power ratings of the induction motors.

6. FUTURE SCOPE

The additional cost related with selecting energy efficient motors may be easily returned in the form of lowered energy cost and high performance. Social media has become an important part of our lives. It is widely used all over the world nowadays and can be used to spread awareness among the masses. So that maximum number of manufacturers take advantage of these motors thereby benefitting the country's economy . As energy prices continue to increase and environmental laws continue to strengthen, it is necessary to look closely at equipment efficiency. This paper reflects upon the preliminary study done on the electrical energy saving by using energy efficient motors. Work should be done to optimize the motor design for more and more reduction of losses and the motor cost.

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