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ENERGY SAVING USING 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 a sugar mill situated at Budhewal, Ludhiana, Punjab has been taken. The load for the various motors at the mill 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.MATLAB software has been used for making the calculations easier.

KEY WORDS: Payback, energy efficient motors(EEM), electric energy savings, Standard Induction Motor(SIM).

1. INTRODUCTION

Nowadays electric energy & electric motors are extremely important, as motors consume large amount of electrical energy .Therefore they need to be considered importantly. 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%. [1] .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 three phase induction motors are mostly used in industries because of their versatility and ruggedness nature.[2] 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 sugar mill . In this sugar mill there are 191 motors used for different purposes in the sugar making process. In this work, we have surveyed a sugar manufacturing unit in order to fulfill the objective of saving energy by improving the efficiency with the replacement of standard induction motors used in the unit with energy efficient motors. First of all, a data has been collected for different types of processes involved in sugar manufacturing unit and the corresponding electrical motors that have been installed at the Budhewal Co-Operative Sugar Mill Ltd which is situated at village Budhewal, Ludhiana. .The main objective is to save electric energy by improving the efficiency by replacing three phase induction motor with high efficiency motors . Then based on the calculations a purposal has been made for the replacement of SIM with EEM.

1.1 Electric Motor Efficiency (Ƞ)

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.

efficiency Ƞ-%

$$= \frac{Mechenical\_Energy\_Output}{Electrical\_Energy\_Input} * 100 = \frac{746 * hp * 100}{VI\ cos\Phi}$$

2. LOSSES DISTRIBUTION IN A MOTOR

The only way to improve efficiency of a motor is to minimize the losses. The loss distribution of standard efficiency motors variesat different horsepower ratings. It is very important to understand the loss distribution in order to make the design modifications for efficiency improvement. 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 distribution that occur in a motor.[4]

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

3. 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.[5] 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.

3.1 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.

3.2 Energy Efficient Motors Design

For obtaining high efficiency some modification in motor design.They owe there higher performance due to following factors :

- 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: more aerodynamic cooling fan
- Closer machining tolerances: more accurate techniques used
- A greater length.
- High quality aluminium used in rotor frame

Figure 1 shows inside view of EEM.

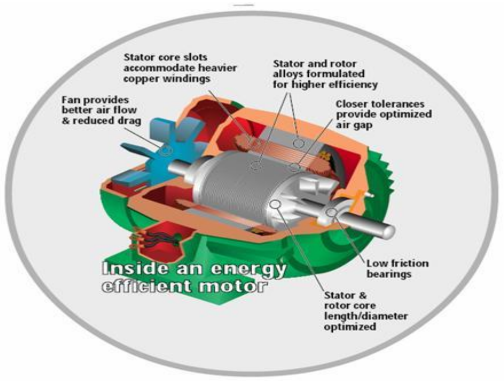

Figure 1 Inside view of EEM.

• **Improved steel properties:** Standard motors use low-carbon laminated steel for the rotor and stator. This steel typically has electrical losses of 6.6 watt per kg. High efficiency motors are built with high-grade silicon steel, which typically reduces hysteresis and eddy current losses by half, i.e. about 3.3 watt per kg.

• **Thinner laminations:** Reducing lamination thickness in rotor and stator steel also lowers eddy current losses.

• **Increasing conductor's volume:** Standard-efficiency motors employ aluminum or copper conductors of a size no longer than that needed to deliver the required horsepower. High-efficient motors utilize bigger copper conductors to lower the winding resistance with the conductors sized 35 to 40% larger than needed to simply satisfy the motor output horsepower requirement.
• **Modified slot design:** To accommodate the longer volume of copper in the windings and required additional slot insulation, the winding slot cross-sectional area is increased and the stator core is lengthened. A longer core yields an important additional benefit in the form of improved motor power factor.
• **Narrowing airgap:** When the airgap between stator and rotor decreases, the intensity of the magnetic flux will increase, thereby improving the motor ability to deliver the same torque at a reduced power. Increasing the length of the stator and rotor increases the net flux in the airgap, to the same effect.
• **Improved rotor insulation:** Some losses are incurred because of unintentional, spurious condition paths established in the motor manufacturing process. Such a path commonly occurs between rotor bars when the rotor is skewed. Skewing is a normal design practice intended to reduce noise and torque pulses in small motors. In high efficiency motor manufacturing the edges of the rotor slots are treated with high-temperature insulation to reduce these losses.
• **More efficient fan design:** Because motors designed for high efficiency inherently run cooler than standard types, the design can incorporate a smaller cooling fan, reducing windage losses and resulting in quieter operation.
Induction motors normally comply one of the following efficiency testing methodologies:
1. IEEE 112 method B (used in the USA)
2. IEC 60034-2 (mainly used in Europe)
3. JEC-37 (mainly used in Japan)
There are some differences among them but the main difference is in the determination of stray load losses. IEEE 112 method B determines the stray load losses through an indirect process. The IEC standard assumes stray load losses to be fixed at 0.5% of input, while JEC standard assumes there are no stray load losses. It is widely accepted that, among the three, IEEE 112 currently gives the most accurate efficiency values.**[6]**

3.3 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

3.4 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.

3.5 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. [5]

3.6 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

$$X = [(KW/E_1) - (KW/E_2)]$$

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

$$\text{Simple Payback Period} = \frac{Price\ Premium - Utility\ Rebate}{Annual\_Savings}$$

For Replacement

$$\text{Simple Payback Period} = \frac{Motor\ Price + Installation\ Charge - Utility\ Rebate}{AnnualSavings}$$

3.7 MYTHS ABOUT ENERGY EFFICIENT MOTORS

1) “Energy efficient motors have shorter life because they have been designed with less margin.” A review of some of the more popular motors made by various manufacturers indicate that the opposite statement is more accurate. They generally have more active material, a higher quality electrical steel, and run cooler; hence, they have a longer life.

2) “Due to the reduction in slip and the corresponding increase in revolutions per minute, energy efficient motors use more energy on variable torque applications such as pumps and fans that follow the affinity laws; i.e., hp is proportional to the cube of the load.” For most applications of this type, the goal is to move a specific amount of fluid or air from point A to point B (a demand whereas the total energy required is approximately the same (assuming that both conditions are operating on the optimum part of the pump or fan curve). The increased speed of 5 or 10 r/m has negligible impact on bearing life for these types of loads. The assumption that the energy efficient design A or B motors develop significantly less locked-rotor torque is not valid. [7]

4. 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 benefits of using an EEM instead of SIM the information needed is :

- **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.[8]
- **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.

With this information annual energy and cost savings can be calculated.

- **Determining annual energy savings**

Energy efficient motors save a significant amount of energy over the life of motor even though they cost more than the standard motors initially. High efficiency motors give lower operating cost per hour. There is a time when the savings are equal the cost difference of two motors, this point is known as breakeven point. High efficiency motors reach this point within two years of operation. Operation of motors after breakeven point will add to further savings in term of energy saved. This is justified the motors having high utilization factors. In the calculation of payback periods over the whole life of motors, average life of different horse-power motors is required. To determine annual cost savings, firstly we need to calculate annual energy savings. Energy efficient motors require fewer input kilowatts to provide the same output as standard-efficiency motor. To determine the kilowatt savings, the difference in efficiency between high-efficiency and a comparable standard motor, is required. For two similar motors operating at same load, but having different efficiencies, the following equation is used to calculate the reduction in kilowatts;

KW_{saved} = hp x Lx 0.746 x (100/ E_{std})-(100/E_{HE})

hp = Motor nameplate power rating

L- Load factor

E_{std} = Standard motor efficiency under actual load conditions

E_{HE} = energy-efficient motor efficiency under actual load conditions

The annual energy savings can be calculated as follows:

kWhsavings = KW saved * Annual operating hours

The total annual cost savings = (kWsaved x 12 x monthly demand charges) + (kWh savings x energy charges)

Payback years = price premium /annual savings

Here price premium is the initial cost difference of the energy efficient motor and the standard efficiency motor.

There are various payback methods which deal with variation in power costs.

5. OPERATION OF A SUGAR MILL

First of all, a data has been collected for different types of processes involved in sugar manufacturing unit and the corresponding electrical motors that have been installed at the Budhewal Co-Operative Sugar Mill Ltd which is situated at village Budhewal, Ludhiana. There are number of processes involved which has been briefed as under along with a flowchart of processes involved.

5.1 Different Processes in Sugar manufacturing unit

- **Cane receiver**

Once harvested cane arrives at the mill, it is weighed and officially received at an automated cane receiving station. The name of the farm from where the cane came and the weight of each cane bin has been recorded automatically.

- **Shredder**

The cane billets are tipped out of the cane bin and on to a cane carrier, which transports them to a shredder. The shredder reduces and shreds the cane into fibrous material and ruptures the juice cells.

- **Extraction station**

Pairs of rollers feed the cane through a series of mills. Each mill comprises large rollers. This process separates the sugar juice from the fibrous material, called bagasse. The juice is pumped away for processing into raw sugar. The bagasse is recycled as fuel for the mill boiler furnaces, Or for cogeneration plant. This bagasse becomes highly efficient source of enrgy.it is used to produce power and processed steam.

- **Juice Sulphiter**

The juice now falls from 10 m high tower . A sulphor dioxide wipers rise through it .this process bleaches the juice .then it moves to a device that measures its PH level.

- **Heaters**

Juice extracted from the crushing mills contains impurities which are removed by adding lime , the juiceand lime are mixed for 6 hours and heating the limed juice. The juice color changes from brown to yellow.The lime neutralizes acids and precipitates impurities that settle out in large, specially designed vessels called clarifiers.It takes two hours for juice to settle .

- **Clarifier**

The clear sugar juice is run off from the top of each clarifier. Muddy juice extracted from the bottom of the clarifiers is mixed with fine bagasse and then filtered using cylindrical rotating vacuum filters to recover the sugar. The mud and bagasse mix commonly known as mill mud-extracted by the filters is used as a fertilizer on cane farms and in gardens.

- **Evaporators**

The clear juice from the clarifiers is concentrated by boiling it under vacuum in a series of connected vessels, called evaporators. The concentrated juice is called syrup.

- **Pans/crystallizers**

The syrup, which is about 65-70 per cent sugar, is further concentrated through boiling in a vacuum pan, where it is seeded with small sugar crystals in a process called crystallization. The sugar crystals are grown to the required size by adding more syrup while boiling continues. When the crystals reach the required size (about 1mm), the mixture of syrup and crystals is discharged from the pan.

- **Centrifugal pumps**

Syrup is separated from the raw sugar crystals in centrifugals that contain perforated baskets. They spin at high speed in a casing, similar to a household washing machine.The dark syrup surrounding the crystals is thrown off and passes through the perforations. It is boiled again and more raw sugar crystals are recovered. This procedure is repeated until the amount of sugar obtained is too small to make further extractions economical. The syrup left over from the final centrifuging is called molasses.

- **Sugar dryer**

The raw sugar from the centrifugals is dried by tumbling through a stream of air in a rotating drum.

- **Sugar storage**

The raw sugar is then transferred for short-term storage in bulk bins at the mills

These machines are driven with common long shaft driven by a large capacity motor..Here 191 motors are taken for the study .The load for the various sections 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.

5.2 Case Study

Calculations have been worked out for the comparion of reactive power and the losses in the SIMs and EEMs. Take an Example of 93 KW , 2 pole, 2960rpm motor :

A. Detailed specifications and parameters of SIM.

Rating of the motor 93 KW , 2 pole, 2960rpm

KW= 93 KW

HP = KW/.746 = 93/.746 = 124.664
Full load efficiency = 93%
Full load power factor = 0.859 lagging
Voltage = 415 Volts

Input power $= \frac{124.664 \times 746}{0.93}$ = 100000 Watts

Output power = 93% of 100000 = 93000
Total losses = 100000 - 93000 = 7000Watts

Based on John C Andreas Loss segregation table, the loss distribution is as under:

Stator power loss = 1960Watts
Rotor power loss = 1260 Watts
Magnetic loss = 910 Watts
Friction and windage loss = 980 Watts
Stray load loss = 1890 Watts

Full load current= $\frac{IP}{\sqrt{3} * V * \cos phi}$ = = 161.956 A

Apparent power = $\sqrt{3} \times 415 \times 161.956$ = 116414.435 VA

Reactive power = $\sqrt{3} \times 415 \times 161.956 \times \sin(\cos^{-1} 0.859)$ = 59601.348 VAr

B. **Proposal for the replacement of existing Standard efficiency induction motors with Energy Efficient induction motors.**

KW= 93 KW
HP = KW/.746 = 93/.746 = 124.664
Full load efficiency = 94.1 %
Full load power factor = 0.914 lagging

Voltage = 415 Volts

Input power $= \dfrac{124.664 \times 746}{0.941} = 98831.031$ Watts

Output power = 94.1% of 98726.114 = 93000

Total losses = 98726.114 - 93000 = 5831.03 Watts

Based on John C Andreas Loss segregation table, the loss distribution is as under:

Stator power loss = 1632.688 Watts

Rotor power loss =1049.5885 Watts

Magnetic loss =758.034 Watts

Friction and windage loss = 816.344 Watts

Stray load loss = 1574.378 Watts

$$\text{Full load current} = \frac{IP}{\sqrt{3} * V * \cos phi} = \frac{98831.0301}{\sqrt{3} * 415 * 0.914} = 150.431 \text{ A}$$

Apparent power = $\sqrt{3} \times 415 \times 150.431 = 108130.230$ VA

Reactive power = $\sqrt{3} \times 415 \times 150.431 \times \sin(\cos^{-1} 0.914) = 44105.207$ VAr

Table 2 Comparison Table for 93 KW , 2 pole, 2960rpm motor

Parameters	**Standard Motor**	**Energy-Efficient motor**	**Difference**
Efficiency(FL) %	93	94.1	-1.1
P.F. (FL) (lagging)	0.859	0.914	-0.055
Current (FL) A	161.9563991	150.4313681	11.52503093
Voltage V	415	415	0
kVA (Input)	116414.4354	108130.2307	8284.204735
kW (Input)	100000	98831.03082	1168.969182
kVAr (Input)	59601.3487	43869.96842	15731.38029
Price (Rs.)	564690	575080	10390

Life of Motor	15 yrs
Energy rate per Kwh	Rs. 7/-
Working hours	22
Working days in a year	245
Savings Per Year (Rs)	44105.20723
Extra_Amount For EEM(Rs)	10390
Payback_Period (Yrs)	0.235573091
Payback_Period (Mnths)	2.826877093
Savings_Lifetime (Rs)	661578.1084
Kvar Savings	15731.38029

Above calculations has been made based on the following formulas:

Savings = $\left(\dfrac{kW}{E_1} - \dfrac{kW}{E_2}\right) \times$ ***(Working hours)x (Working days)x (Tariff)***

kW = Output of motor in kW

E_1= Efficiency of standard motor

E_2= Efficiency Of Energy-Efficient Motor

Annual Savings For 93 KW Motor= $\left(\dfrac{93}{0.93} - \dfrac{93}{0.941}\right) \times (22) \times (245) \times (7) = (100 - 98.83103) \times 22 \times 245 \times 7$

= 44105.2072

Extra amount for efficient motor = 10390

Payback period = Extra amount / annual savings = 10390 / 44105.2072 = 0.2356 Yrs or 2.82 months

Savings for 15 years = 15 **x** 44105.2072 =Rs. 661578.1084/-

kVAr savings = kvar- kvar (EEM) = 59601.3487-43869.96 = 15731.38

6. RESULT AND DISCUSSION

The replacement of existing normal efficiency motors of with Energy Efficient Motors will be resulting in saving in reactive power and energy consumption. The calculations for the savings and payback period for the Budhewal Co-Operative Sugar Mill Ltd which is situated at village Budhewal, Ludhiana,Punjab are presented in table 3

Various parameters for the standard induction motors and energy efficient motors have been calculated by method shown above for 93KW,2 Pole ,2960rpm motor above.. These calculations were done for a all the hp ratings of motors in the Budhewal Co-Operative Sugar Mill Ltd which is situated at village Budhewal, Ludhiana. Now these parameters are being presentenced graphically and in a tabulation form systematically.

As we know the energy efficient motors have improved power factor so the inductive reactive power (kVAr) drawn by these motors is lesser than that of standard efficiency motors.

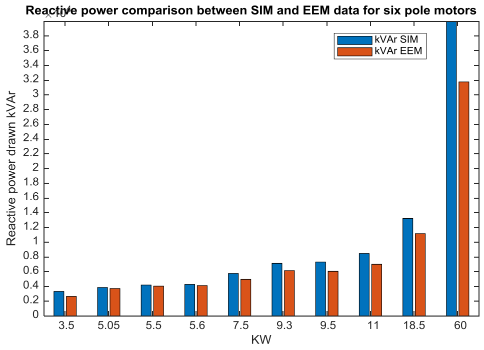

Figure 2 Reactive power comparisons between SIM and EEM

The reactive power requirement for the SIM and EEM for different power ratings is shown in figure 2. The additional cost of power factor improvement capacitors can be reduced by these kVAr savings. This also helps in improving the voltage regulation of the power system.

For the same output power the energy efficient motors draw lesser active power (kW), the losses in EEM are small.

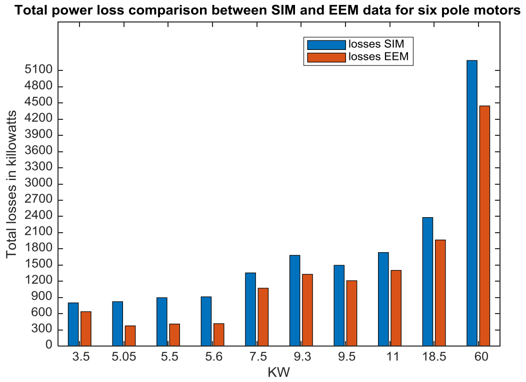

Figure 3 Loss comparison between SIM and EEM

Figure 3 depicts the total loss comparison of the two types of motors.

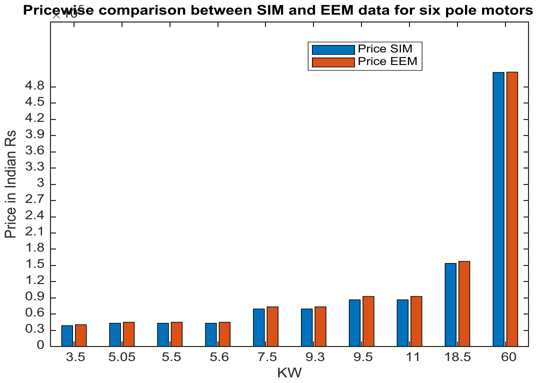

Figure 4 Price difference in SIMs and EEMs

The price of energy efficient motors is l5% - 30 % more than that of standard efficiency motors, but this additional price can be recovered by the savings in the energy consumption bills, when we replace the standard efficiency motors with the energy efficient motors. The results are shown in figure 4

The figure 5 below shows the annual energy bill savings by the replacement of standard efficiency motors with energy efficient motors. The annual energy bill savings depend upon the difference of efficiencies of SIM and EEM and the rating of the motor. Savings are more for higher rating motors. The figure below depicts that the change in the annual savings and the payback period with respect to increase in hp rating is not uniform; the reason is the uneven difference in the efficiencies of SIMs and EEMs.

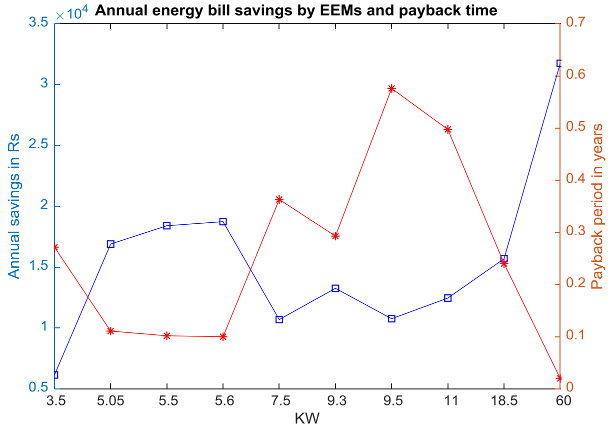

Figure 5 Annual energy bill savings by EEMs and payback time

Table 3 Sugar Mill Data , Savings and Payback calculations

S.No	KW	Voltage	RPM	Poles	Kvar/yr	Price difference	Total Saving/yr	Payback period (M)	No. of motors
1	0.5	415	1440	4	1709.259	1050	4963.553826	2.53850375	2
2	0.75	415	1440	4	3106.934	1068	7445.330739	1.721347305	2
3	1.1	415	1440	4	11919.58	2416	17403.38739	1.665882587	4
4	1.5	415	1440	4	11035.09	2010	14874.40865	1.62157707	3
5	1.5	415	2830	2	2160.827	668	3697.039367	2.168221435	1
6	2	415	1440	4	3433.507	896	5166.408433	2.081136275	1
7	2.2	415	1440	4	30214.87	7168	45464.39421	1.891942068	8
8	2.2	415	2800	2	6119.554	834	4381.228284	2.284290923	1
9	3.5	415	950	6	8090.857	1667	6136.349115	3.259918825	1
10	3.5	415	1440	4	137353.5	19261	109182.4661	2.116933316	17
11	3.5	415	2800	2	7414.227	1045	5000.694252	2.507651812	1
12	5.05	415	925	6	3297.698	3740	33792.35006	1.328111242	2
13	5.5	415	925	6	1795.776	1870	18401.77479	1.219447595	1
14	5.5	415	950	6	3591.552	3740	36803.54957	1.219447595	2
15	5.5	415	1440	4	170025.5	49664	268187.0011	2.222210612	32
16	5.6	415	925	6	3656.853	3740	37472.70502	1.197671745	2
17	7.5	415	950	6	9521.399	3882	10690.90909	4.357346939	1
18	7.5	415	1440	4	391693.7	63525	350556.3239	2.17454357	35
19	7.5	415	1450	4	11191.25	1815	10015.89497	2.17454357	1
20	9.3	415	960	6	11806.53	3882	13256.72727	3.513989467	1
21	9.5	415	950	6	30287.64	12392	21514.48129	6.911809677	2
22	10.5	415	720	8	14351.02	1500	10190.39464	1.766369276	1
23	11	415	950	6	35069.9	12392	24911.50466	5.969290176	2
24	11	415	960	6	87674.74	30980	62278.76164	5.969290176	5
25	11	415	1440	4	103125.5	38286	69642.27965	6.597027012	6
26	12.5	415	2800	2	11040.54	6706	10839.96047	7.42364331	1
27	14.5	415	725	8	16741.96	1500	12981.87355	1.386548708	1
28	14.5	415	750	8	16741.96	1500	12981.87355	1.386548708	1
29	15	415	725	8	17319.27	1500	13429.52436	1.340330418	1
30	15	415	1440	4	190148.1	70830	120426.5812	7.057910238	9
31	18.5	415	960	6	24691.4	3767	15686.60231	2.881694781	1

32	18.5	415	1440	4	66045.89	19350	48852.53359	4.753079992	3
33	18.5	415	2800	2	51075.76	16010	27516.49857	6.981992985	2
34	22.5	415	1440	4	27812.01	3200	17525.20389	2.19113	1
35	24	415	2830	2	63249.98	5748	30890.54773	2.232916056	2
36	30	415	1440	4	277577.3	28357	151431.8034	2.247110529	7
37	30	415	2940	2	75909.04	9066	35268.44351	3.084683904	2
38	55	415	587	8	65909.87	1500	38474.11266	0.467847047	1
39	55	415	1440	4	861345.5	160601	236158.9066	8.160657703	7
40	55	415	1470	4	246098.7	45886	67473.9733	8.160657703	2
41	55	415	1480	4	861345.5	160601	236158.9066	8.160657703	7
42	60	415	970	6	196519.1	1260	63501.51767	0.238104545	2
43	93	415	1460	4	481840.5	27849	144191.0828	2.31767453	3
44	93	415	2960	2	377553.1	20780	88210.41445	2.826877093	2
45	187	415	587	8	224093.5	1500	130811.983	0.137602073	1
46	187	415	1440	4	356429.3	263662	86818.58961	36.44316285	1
47	187	415	1440	48	29702.44	263662	86818.58961	36.44316285	1
					467427.98	1120664	2781060.85	3.47	191

We can see replacing SIM by EEM in the mill is giving us an annual saving of 27.8 Lakhs approximately and reactive power savings of 467 kVAr. The extra amount which we have spent in buying EEM can be recovered in a small span of time only.

7. CONCLUSION

In this research work the diagnosis of the Standard Induction Motors (SIM) running in a Sugar Mill and Energy Efficient Motors has been introduced. The work includes the proposal for energy and cost saving by the use of energy efficient motors in a sugar mill .Introduction of the energy efficient motors used for various purposes in a sugar mill saves large amount of energy. By analyzing the collected data from a sugar mill, it has been obtained that the standard induction motors which runs in a sugar mill are less efficient and consumes large amount of energy of the plant. Standard induction motors also have low power factors and consumes large amount of current and consumes extra energy. Due to this increase in energy consumption the cost of energy usage has been increased and running cost of plant is also increased. The Mill under study has 191 motors of different ratings. The work presented in this research examines the use of extra energy by various standard induction motors in a sugar mill. The research has been carried out by calculating various parameters. The parameters are rated % efficiency, input power (kW), power factor, kVA consumed, annual energy (kWh) consumed. annual saving (Rs.) ,payback period calculations .

From the results and calculations we have seen by all aspects EEM is better .They saves cost , energy, decrease loading and also returns extra amount spent (at the time of purchasing) in small amount of time . In the end the study we have found that by introduction of energy efficient motors, the total motor load of the plant becomes less as compared to previous arrangement. EEM leads to cost saving and this has also led to increase in the efficiency of the mill. The payback period is also economical for plant. Same yield is obtained at lower motor load and lower running costs. Therefore the running cost defeats initial cost of EEM.

There are many sugar mills in India ,also other type of process plants ,paper industry and other petro chemical industries where heavy machines are used EEM can lead us to save huge money and Energy

8. 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..In modern world 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 people. So that maximum number of manufacturers take advantage of these motors thereby benefitting the country's economy . As energy prices is increasing day by day and environmental laws continue to strengthen, it is necessary have a close check on equipment efficiency. This research work depicts the preliminary study done on the electrical energy and cost saving by using energy efficient motors. Optimization of the motor design for more and more reduction of losses and less motor cost should be done
- ✓ There is a significant scope of the future work in the field of use of energy efficient motors. Other industries like paper mills, sugar mills, textile mills etc. can be considered .In this way Indian Govt Dream of Electricity to all can be fulfilled.
- ✓ MATLAB has been used to make the calculations. Better tools can be used to make the calculations more easier

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