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Review of Energy Conservation using Energy Efficient Motor

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Abstract: ***About 65% of the total energy supplied to the industry is consumed by electric motor, which is a prime mover of the industry. Standard electric motor is known for low efficiency due to compromise made on the materials during manufacturing. This has also resulted in the high maintenance and running costs, high energy losses and greenhouse emission. Improved performance of energy efficient motor is attributed to better design, manufacturing and material techniques which are seen in high magnetic properties, reduced rotor and stator gap, high laminated stator winding, reduced heating and fan losses as well as better insulation. Energy consumption is low and maintenance and running cost is low as well. Energy efficient motor is suitable for high ambient temperature condition as well as application that requires high power factor.***
Keywords: energy efficient motor, energy saving, energy conservation, tongue, efficiency, standard motor

I. INTRODUCTION

Energy is integral to human existence, although it comes at the cost of the environment. It would be very hard to consider our modern life without energy. Natural resources are used to generate energy, but these resources are at the verge of depletion. However, the demand for energy cannot be overemphasized. Industries are known as heavy consumption of energy. Hence, the need to improve and sustain energy efficiency in the industrial sector has been a major concern in our modern society. Energy efficiency is the most important factor to consider when thinking about electric motors, as it is what drives the industrial sector. Climate change has stirred a global concern in recent years, for this reason, it is imperative for industries to adopt energy efficient techniques in order to conserve energy, and at the same time curb greenhouse effect, Industrial sectors, among others, contributes significantly to greenhouse gas emission. In response to the impact of the greenhouse gas emission by standard electric motors, some industries in the developed world have developed and implemented energy efficient technology, which not only has it achieved improvement in environmental protection, but also gain economic and social dividends. Implementing energy efficient option could reduce the impact of climate change to a tolerable limit [1]. Improving energy efficiency is the panacea for addressing the threat of global warming and reducing cost of energy by reducing energy consumption of utilities. In order to actualise more efficient use of energy, there is need to determine the actual amount of energy used and the losses as well. Statistics shows that over 65% of the total energy that is supplied to the industry is used to drive electric motors. This further implies that any improvement on the efficiency of electrical machines could have a significant impact on the amount of energy that is consumed. Country's level of industrialization determines amount of energy consumed in the industrial sector. Since motor driven systems consume most of the energy generated in the country, cost of energy to operate motors is of great concern. Hence, implementing high efficiency motors, such as energy efficient motors in the industries would reduce cost and conserve the environment by optimizing the efficiency of the entire system. Energy efficient motor integrates low-loss materials to reduce losses, such as core losses and copper losses. Induction motor has been revealed to have consumed majority of the energy generated [2]. The use of energy efficient motors has been described as one way of mitigating global warming and optimizing energy consumption [3]. Improved performance of energy efficient motor is attributed to better design, manufacturing and material techniques which are seen in high magnetic properties, reduced rotor and stator gap, high laminated stator winding, reduced heating and fan losses as well as better insulation [4].

II. RELATED WORKS

Energy efficient motor is an electro-mechanical device which uses less electrical energy to generate more mechanical energy. it is a re-engineering of standard electric motor, which has high energy consumption, high maintenance cost and greenhouse gas emission [5]. Energy efficient motors hold a promise of environmental protection, low maintenance cost, low energy consumption and high energy efficiency. Low grade materials used for windings and lamination are responsible for low power factor, high energy consumption and low efficiency of standard electric motor. With about 3% efficiency improvement in energy efficient motor, there is high tendency of attaining sustainable energy and demand reduction, as well as shorter payback time [6]. Comparative studies done by prominent researchers revealed that comprises were made on materials during design and manufacturing of standard electric motors; hence, low efficiency, low power factor and high losses were results of the final product which made it very expensive to run. The author exhaustively concluded that adoption of energy efficient motor is a better option due to its energy saving capacity and reduction in load demand in the industry. Better design, material and manufacturing approach were responsible for the

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improved efficiency of the energy efficient motor [7]. Gain in initial cost was the main reason for compromise in efficiency, endurance and starting torque. Adopting energy efficient motor as standard in the industries will bring about both economic and environmental benefits [8]. Application of energy efficient motors in Europe has yielded much dividend, as findings revealed that Europe enjoyed 202 billion kWh electricity consumption which amounts to 10£ billion annually in operating cost for industry. It was also revealed that motor driven systems in the industry consumes about 65% of electricity generated annually, there is energy saving of 27 billion kWh or 4.33% annually, which also implies energy saving potential of more than 1.04% of the overall electricity consumption in Europe [9]. 37% of global energy consumption according to findings is attributed to the industry. Energy consumption is projected to increase from 86,919,000 TW in 1980 to 198,654,000 TW in 2030. Meaning that as the demand of energy by the industries increase, there will be a corresponding increase in energy losses which will adversely impact on the environment. For this reason, there is need to implement energy efficient technology that will reduce energy consumption and at the same time improve efficiency [10]. Radical increase in the use of electrical machines efficiently and renewable energy resources is significant in mitigating climate change, as research revealed that electrical machines consume about 679 TWh of electricity and that any slight improvement in efficiency would lead to significant energy saving. Replacing standard electric motors with low with energy efficient motors could save all categories of motors of 1575GWh of energy annually as well as 105-million-dollar reduction in electric utility bill.

III. IMPORTANCE OF ENERGY EFFICIENCY IN THE INDUSTRY

As industries keep growing globally, there will be corresponding increase in energy use which will result in more emission of greenhouse gas, such as carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen Oxide (NO_x) and carbon monoxide (CO). These dangerous gases affect the climate adversely by raising the temperature, flood, drought as well as economic chaos. If the current practices in most industries in the world continue, greenhouse emission will increase. Energy efficient technology offers great opportunity in trimming down energy budget by utilizing high efficiency with corresponding growth in the economy, as well as environmental protection. Three approaches have been suggested as means of improving energy efficiency: energy saving by management, energy saving by technology and energy saving by regulation.

A. Energy Saving By Management

Energy management has been an integral component of industrial management tree since 1970s due to fear of impending exhaustion of world energy deposit and increasing price of fossil fuels. Management main objective is to devise means of optimizing energy using systems and procedures that will minimize cost without affecting production and quality and at the same time preserving the environment. This strategy has the potential of meeting energy needs of the nation at any point in time.

B. Energy Saving By Technology

Implementation of technologies may hold a great potential of saving energy by reducing consumption. One of such technologies is the use of high efficient motor. The bulk of energy consumed in the industry is by electric motor as majority of the activities depend so much on it. Although standard electric motor has high efficiency, replacing it with energy efficient motor will further increase the efficiency by about 3% which will lead to lower cost of running the machine, with corresponding energy saving.

C. Energy Saving By Regulation

Efficiency of electric motors can be improved if there are regulations guiding the equipment. Regulation can specify regular energy audit and mandate that energy manager be employed or energy management system be adopted. Fiscal policy is also a way of improving energy efficiency by taxation, imposition of taxes, investment tax credit and establishing investment tax lending. This bank lending can place priority on projects that would improve energy efficiency. This will in turn save energy by reducing consumption rate.

D. The Need To Increase Efficiency Of Induction Motor

In order to increase the importance of improving on the efficiency of electric, there are important considerations that should be made. Electric motors currently consumed between 40% and 50% of energy generated globally. Electrical motors consume energy equivalent to 120% of its purchase price. Though the efficiency of standard electric motor ranges between 65% and 95%, increasing efficiency by 0.5% will lead to saving a huge amount of energy. It is also expected that in 30 years' time, demand for energy would have doubled. With the aforementioned facts, it is reasonable that implementing energy efficient motors would save a lot of energy to meet the growing energy demand.

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IV. FACTORS AFFECTING EFFICIENCY AND LOSS DISTRIBUTION

Losses in electrical motor are the reason why they have poor performance and efficiency. When an electric motor has high efficiency, it means such a motor has losses. Factors that affect losses in electrical motor are associated with design consideration of the manufacturer with respect to the size of air gap between the stator and the rotor. Option lies with the manufacturer to either compromise with efficiency while improving on the power factor or maximizing efficiency at the expense of power factor. Losses can be classified as fixed and variable losses.

1) *Fixed Losses:* These losses are associated with magnetic core and friction and windage losses. These type of losses are independent of motor load. The extent of these losses with depend to a great extent on the type of material the core is made of, the structure of the rotor and stator, as well as the input voltage. Magnetic core losses are caused by eddy current and hysteresis, whereas friction and windage losses are caused by friction in the bearings of the motor.

a) *Windage Losses:* these losses are associated with moving parts, such as friction in the bearing at each end of the rotor and cooling fans that are attached to the rotor; air gap between rotor and stator. They are almost constant from no load to full load. They are in most cases small for slow speed motor, and large for high speed motor.

b) *Magnetic Core Losses:* this loss occurs in the steel component of the motor. Factors responsible for this type of loss are eddy current and hysteresis effects in the laminations, which are significantly influenced by the motor flux and frequency. This loss can remain constant from no load to full load for fixed input voltage, but varies with square of input voltage.

2) *Variable Losses:* These type of losses are hugely influenced by the motor load. Resistance in the rotor and stator is the major cause of variable losses. When current flows through the resistance, heat is generated in the process, which is directly proportional to the square current (I^2R), where R can either be the stator winding resistance or the rotor winding resistance. Another aspect of variable losses is the stray losses, which though are hard to estimate are also proportional to the square of rotor current.

a) *Stator Losses:* these apply to energy loss in the stator winding; these losses appear as heat when current passes through the resistance of the stator winding. These losses happen to be major losses in motor.

b) *Rotor Losses:* these apply to energy losses in the rotor winding. When current flows through the rotor winding, energy is lost in the form of heat generated in the winding. Significant factor that determines extent of losses in the rotor conductor.

c) *Stray Loss:* this particular loss occurs due to leakage fluxes through the resistance of the stator winding, as well as rotor winding. It manifests when motor is working at under load. These losses are hard to quantify, hence unaccounted for. They could occur at stator, as well as rotor windings.

Table 3.1: losses and their % Distribution

FIXED LOSSES	TYPICAL % LOSS	FACTORS AFFECTING LOSS
Core losses	15%-25%	Type and quality of magnetic material
Friction and windage loss	5%-12%	Selection and designs of fans and bearings
VARIABLE LOSSES		
Stator I^2R losses	25%-40%	Stator conductor size
Rotor I^2R Losses	15%-25%	Rotor conductor size
Stray load losses	10%-20%	Manufacturing and design method

Table 3.1 describes loss distribution and various factors responsible for the losses. It is observed that no load losses constitute core losses and friction and windage losses. Core losses contributes to 15% - 25% of the total losses that occur in the motor. These losses depend so much on the characteristics of the magnetic material such as type and quality of materials. Friction and windage losses constitutes 5% to 12% of the total losses in the motor. These losses depend hugely on the selection and design of fans and bearings.

Under loaded condition, it is also observed that stator losses (I^2R_R) contributes to 25%-40% of the losses. Rotor losses (I^2Rr) accounts for 15%-25% of the losses. Stray load losses contribute to 10%-20% of the total losses recorded in the motor. Losses under this condition depend on rotor and stator conductor sizes.

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A. Effects of Harmonics on Motor Efficiency

Harmonics are distortions in voltage and current waveforms which impact greatly on the efficiency of a motor. With the development in power electronics, impact of harmonics in the industrial loads has been significant. These are harmonics are non-linear in nature, and as such, non-sinusoidal currents are drawn by motors

B. Energy Efficiency and the Environment

Currently, there is a growing concern of global warming which has driven passion towards designing machines with capacity to conserve the environment. With an improvement in energy efficiency conversion, dangerous gases such as CO_2 would be reduced drastically as more energy would be produced. This will also lead to large amount of energy saving.

C. Motor Efficiency Variation with Load

Design specification requires that electric motors operate between 50% and 100% of the rated load. Usually, maximum efficiency is achieved close to 75% of rated load. Efficiency of a motor decreases below 50% of rated load. Nevertheless, efficiency varies with type of motor. Motor appears to be under- loaded if efficiency decreases drastically as load decreases. Also, when motor is overloaded, efficiency decreases. Efficiency of motor can be maintained over a wide range of loads, below as well as above rated loads.

Mathematically, relationship between torque and angular speed can be expressed thus:

$T = Kw^2$ 1

Where K = (Nm/A) is the torque constant of the motor

W= angular speed of motor in rad/s

$PiEE = PO_{EE}/\Pi_{EE} = Kw^3/\eta_{EE}$ 2

D. Energy Efficiency Improvement Techniques

Several techniques have been adopted towards improving efficiency of energy in motor. One of such approach is improving of material design such as adding copper with less steel material. Electrical losses in the winding can be reduced by increasing the cross sectional area of the conductor. Better magnetic steel offers potential of reducing magnetic losses. Aerodynamic of motor is also improved in order to reduce mechanical losses in the motor. Maximization of tolerance also add to improvement of energy efficiency of motor.

1) *Core Losses:* in order to reduce core losses, high grade silicon steel is used instead. The silicon content is up to 4%. This also results in reduced magnetic loss. Silicon content also reduces hysteresis and eddy current losses. Using very thin lamination for the core further reduces eddy current losses.
2) *Copper Losses:* stator winding can be designed to minimize copper losses. This is achieved by increasing the copper section of wire which is to be wound on the core. This reduces resistance and also reduces I^2R losses. In this case, maximum utilization of slot is done. Rotor copper losses are reduced by increasing the section of the rotor bars and end rings. the bar.
3) *Friction and Windage Losses:* losses due to rotating parts of the motor can be reduced by using improved bearings and optimal designs of fans. In energy efficient motor, less heat is generated, therefore fan size can be reduced to lower the windage losses.
4) *Stray Losses:* these losses are function of many design elements and processing of the motor and can be reduced by careful manufacturing process control. This implies careful selection of slots number, slot geometry, air gap length, etc. System. Aforementioned properties are what make energy efficient motor unique in its efficiency improvement.

E. Characteristics Features of Energy Efficient Motor

1) Energy efficient motor has better performance characteristics than standard motor under full, partial and no load condition. Due to high efficiency, energy efficient motor not only save energy in their own and contribute to reduced demand, but also energy in the cables and transformer that supply the motor.
2) Energy efficient motor runs cooler; as the thermal stress becomes low, cooling requirement correspondingly becomes low too. Energy efficient motor's bearings run about 10^0C cooler than standard motor's bearing. This increase the lifespan of the insulation by two. Energy efficient motor's winding runs about 20^0C, which increases the lifespan of insulation by four.
3) With lower losses, energy efficient motor has lower slip than standard motor. This lower slip also causes them to have lower starting torque than the standard motor. Hence, energy efficient motor is not used where higher starting torque is required.

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4) When slip is small, speed of motor is high. This higher speed causes more power to be drawn by the motor as power increases with cube of the speed in some loads. Hence, saving obtained by energy efficient motor may be lost.
5) Generally, energy efficient motor operates at higher power factor than the standard motor. As a result, low losses are recorded. Cost of correcting power factor is saved also.
6) Starting current is more in case of an energy efficient motor than standard motor. Hence, there is a tendency of short circuit protection to trip.

F. Benefits of Adopting Energy Efficient Motor

So many benefits abound when implementing energy efficient motor. It is observed that in energy less fuel needs to be burnt and fewer plants need to be installed when using energy efficient motors.

1) *Economic Benefits:* Industry is the main beneficiary of energy efficient motor as the system improves their process and reduce their cost. Energy efficient motor consumes less energy and still maintains productivity, if not more. This in turns lead to energy saving. Europe enjoys 27 billion kWh energy saving annually, which is more than 1.04% of overall electricity consumption in Europe
2) *Environmental Benefits:* Climate change has become a great concern in our world today. Adopting energy efficient motor, among other techniques, will reduce global warming and safe the society from disaster.
3) *Micro Economic Benefits:* Study showed that payback time for energy efficient motor is shorter compared to standard electric motor. It takes between three months and three years to recover cost of investment. Energy efficient will assure better process control, reduced disruption and improve power quality.
4) *Macro Economic Benefits:* Energy efficiency will ensure sustained competitiveness of the economy, since a greater percent of energy supplied the industry is consumed by the efficient motor.
5) *Employment Opportunity:* There is a great potential of job opportunities with implementation of energy efficient systems. These opportunities could found in energy service companies, engineering consultancy, contactors, manufacturing of motors and variable speed drives, compressors, fans and pumps and other system components.

G. Factors Inhibiting Development of Energy Efficient Motor

Wide application of energy efficient motor is influenced by various factors such as ignorance, mental structure of consumers and international standards.

1) *Ignorance:* electric motors are electro-mechanical devices which convert electrical energy to mechanical energy. Two significant factors that should be considered in the functionality of electric motors are torque and speed. For any application, there should be synchronization of torque and speed between driven equipment and motor that drives the equipment, else there would be major faults that could affect the efficiency of the motor.
2) *Mental Structure of Consumers:* attitude of consumers determines what product they get at the end of the day. If consumers patronize low cost motor, there is every tendency that the motor efficiency will be low, as cost is known to be directly proportional to motor efficiency.
3) *International Standard:* many standards abound that guide design considerations of electric motors. These standards influence decision of manufacturer when it has to do with making important changes in the design, other than reduction in cost and improvement in efficiency. Such standards include: IEC (International Electromechanical Commission), NEMA (National Electrical Manufacturer Association).

V. CONCLUSION

Various energy saving strategies such as saving by management, technology and regulation have been observed to have great impact in improving efficiency of the industries.

Energy efficient motor offers improvement in efficiency of motor system, which leads to energy conservation, environmental protection and cost effectiveness.

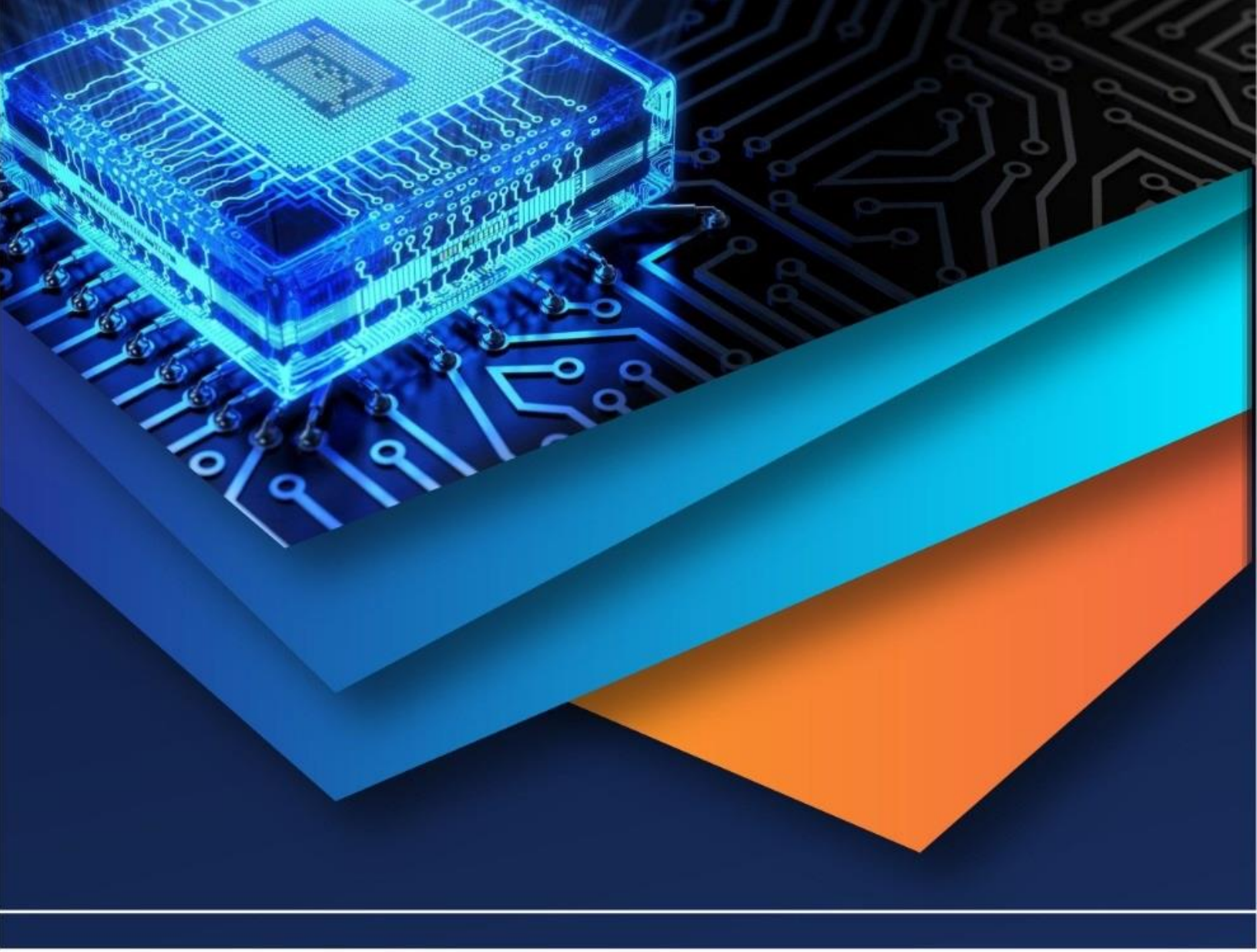
In spite of the numerous advantages, efficient motors encounter barrier in the market place due to ignorance and attitude of the consumers.

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REFERENCES

[1] Saidur, R. (2010). Energy, Economics and Environmental Benefits of Using High-efficiency Efficient Motors to Replace Standard Motors for the Malaysian Industries. Energy Policy, Vol. 38, pp. 4617-4625
[2] Gajendra Singh, Sharma, N.K., Tiwari, P., Pankaj, Mishra and Sumeet Kumar (2010). Energy Efficient Industrial Motors. International Journal of Science and Technology, Vol. 2(12), pp. 7904-7913
[3] Cepoi Radu Daniel, Jascau Flavia Florina and Zsabo Roland (2017). Current Trend in Energy Efficient Electrical Machine. Journals of electrical and Electronics Engineering
[4] Mahesh Rathi, Faheemullah, Shaikh, Pervez Hameed Shaikh and M. Aslam Uquilli (2012). Energy Conservation through Motors in Parkistan's Industrial Sector-Need to Use of Energy Efficient Motors. International Journal of Computer Applications (0975-8887), Vol. 54, No. 5, September.
[5] Brijesh, R. Tansdel and Chinmay, D. Shukla (2019). Energy Conservation by Energy Efficient Motor: Case Study of Paper Industry. International Research Journal of Engineering and Technology, Vol 6, Issue 2, February
[6] Brijesh, R. Tansdel and Chinmay, D. Shukla (2019). Energy Conservation by Energy Efficient Motor: Case Study of Paper Industry. International Research Journal of Engineering and Technology, Vol 6, Issue 2, February
[7] Singh, A., and Singh, B. (2014). Energy Saving in Steel Industry by Replacing Standard Induction Motor with Energy Efficient Motor. International Journal of Engineering Research Technology, Vol. 3, PP. 1533-1536, March.
[8] Devangi, J. Jain and Shweta, Y. Prajapati (2014). Energy Conservation by Energy Efficient Motor in Industry: Case Study of Polyplast Industry. International Journal of Advanced Engineering and Research Development (IJAERD), Vol.1, Issue 3, April.
[9] Corino, S., Romero, E., and Mantilla, F. (2008). Energy Saving by Means of Energy Efficient Motor.
[10] Abdelaziz, E.A., Saidur, R., Mekhilef (2011). A Review on Energy Saving Strategies Industrial Sector. www.elsevia.com/locate.rser
[11] Petrecca G (1992). Industrial Energy Management: Principles and Applications. USA: Kluwer Academic Publisher
[12] Mehmet Akbaba (1999). Energy Conservation by Using Energy Efficient Electric Motors. Applied Energy 64 (1999)149-158. www.elsevier.com/locate/apenergy

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