RESEARCH ARTICLE OPEN ACCESS

Energy Auditing Of Induction Motor

Manoj Verma*, Vijay Kr. Garg**
*(Department of Electrical Engineering, University Institute of Engineering and Tech, Kurukshetra University, Kurukshetra (Haryana), India)
** Department of Electrical Engineering, University Institute of Engineering and Tech., Kurukshetra University, Kurukshetra (Haryana), India)

ABSTRACT
Energy crisis is one of the crucial problems faced by all the countries in the world due to depletion in natural resources used for energy generation and the huge investment for generating energy from alternate resources. This article suggested some of the major areas of energy conservation practices so that there may be a chance to see the state of Andhra Pradesh as “NO POWERCUT” state in India. A viable and immediate solution in this juncture is the energy conservation as cited by the slogan “Energy conserved is Energy Generated”. Optimum use of electrical energy, not only results in cash savings, but also improves the economy of the country substantially. Hence there is an urgent need for energy management and control, which ultimately concludes with the practice of energy conservation. Energy as we all know is a crucial input in the process of economic, social and industrial development. Energy consumption is increasing at a very fast rate. With growing demand for energy ithas become essential to minimize energy leakages. This article suggest some of the methods to make the gap between power generation and demand is equal to Zero.
***Keywords* -** Energy audit, induction motor, Neural network, Payback period calculations, Rewound motors

I. INTRODUCTION

The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effect. The term energy management means many things to many people. One definition of energy management is: *“The judicious and effective use of energy to maximize profits (minimize costs) and enhance competitive positions”*(Cape Hart, Turner and Kennedy, Guide to Energy Management Fairmont press inc. 1997)

Another comprehensive definition is “The strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems”

The objective of Energy Management is to achieve and maintain optimum energy procurement and utilisation, throughout the organization and:

- To minimise energy costs / waste without affecting production & quality
- To minimise environmental effects.

When the object of study is an occupied building then reducing energy consumption, while maintaining or improving human comfort, health and safety, are of primary Concern. Beyond simply identifying the source of energy use, an energy audit seeks to prioritize the energy uses according to the greatest to least cost effective opportunity for energy savings. An energy audit serves the purpose of identifying where a plant facility uses energy and identifies energy conservation opportunities.

This chapter aims to analyze the efficiencies of the in-house rewound induction motors in the rice manufacturing plant under study and to minimize (or conserve) energy usage by improving the efficiencies of these motors. The electrical energy audit process in rewound induction motors is evaluated in process stages. The choice of stages is due to the nature of the process and as well, the details of rewound induction motors in the rice manufacturing plant. As far as possible the same structure will be used for all the different rated motors to facilitate comparison between the rewound induction motor and new motor.

II. METHODOLOGY

The methodologies adopted for conducting the detailed energy audit are:

- List of electrical motors of different horse power and operating parameters.
- Measurement of operating parameters of various equipments under different conditions, to estimate their operating efficiency.
- Analysis of data collected to develop specific energy saving proposals.

2.1 Problem formulation:

In this study the subject of investigation (or say under study) is a major rice manufacturing plant Dunar Rice industry This plant includes a 22KV substation and 1 MW diesel plant. The installed capacity is 16,425Tons Per Annum (TPA).

- In the method, energy auditing is done by calculating the rated and actual efficiency, total capital cost and net savings of different rewound motors. With the help of these parameters, the payback period can be calculated and on the basis of payback period calculations, energy auditing can be done.
- Neural network will be used for data validation of calculated parameters of rice mill. Once a neural network has been trained it must be evaluated to see if it is ready for actual use. This final step is important so that it can be determined if additional training is required. To correctly validate a neural network, validation data must be set aside that is completely separate from the training data. In my work rewound motors parameters are data to be validated and rest motors parameters are training data.

2.2 Analysis on rewound motor

With the help of tables different parameter of rewound motor are explained, it is compared with new motor. Following results are found.

Table1. Calculated Parameters of 50 HP Rewound Motors

MOTOR IDENTIFY	Sync Speed	Stator Resistance at no laod	Stator cu Loss	F& W Loss	F.L. rotor loss	Stray Loss	F.L o/p Power
New	2480	0.7942	0.2274	1.29E+03	213.282	615	3.89E+04
R.M. 1	2480	0.7831	0.3395	659.8105	242.172	628.5	4.04E+04
R.M. 2	2480	0.7684	0.4902	659.6788	210.9375	630	4.05E+04
R.M. 3	2480	0.7749	0.4497	679.7253	204.2415	619.125	3.98E+04
R.M. 4	2480	0.791	1.918	2.00E+03	161.472	615.75	3.83E+04
R.M. 5	2480	0.7394	2.1879	1.80E+03	210.357	645	4.03E+04
R.M. 6	2480	0.7534	2.0062	1.70E+03	209.677	664.5	4.17E+04

III. RESULTS AND DISCUSSION

The above explained work is carried out using MATLAB as a tool. A graphical user interface is developed which facilitated the selection and analysis of all types of motors used in rice mill. A backward propagation neural network approach is used for training the calculated parameters of new rewound motor with other motors. Parameters of new motors are our desired parameters.

Neural networks are composed of simple elements operating in parallel. These elements are inspired by biological nervous systems. As in nature, the connections between elements largely determine the network function. You can train a neural network to perform a particular function by adjusting the values of the connections (weights) between elements. Typically, neural networks are adjusted, or trained, so that a particular input leads to a specific target output. There, the network is adjusted, based on a comparison of the output and the target, until the network output matches the target. Typically, many such input/target pairs are needed to train a network. Neural networks have been trained to perform complex functions in various fields, including pattern recognition, identification, classification, speech, vision, and control systems. Neural networks can also be trained to solve problems that are difficult for conventional computers or human beings. The toolbox emphasizes the use of neural network paradigms that build up to--or are themselves used in-- engineering, financial, and other practical applications.

Properly trained backpropagation networks tend to give reasonable answers when presented with inputs that they have never seen. Typically, a new input leads to an output similar to the correct output for input vectors used in training that are similar to the new input being presented. This generalization property makes it possible to train a network on a representative set of input/target pairs and get good results without training the network on all possible input/output pairs. There are two features of Neural Network Toolbox software that are designed to improve network generalization: regularization and early stopping.

In our model ,no. of epochs and learning rate is set to 700 and 0.3 for neural network training. A gui figure for 15 hp motor is shown in figure 1.

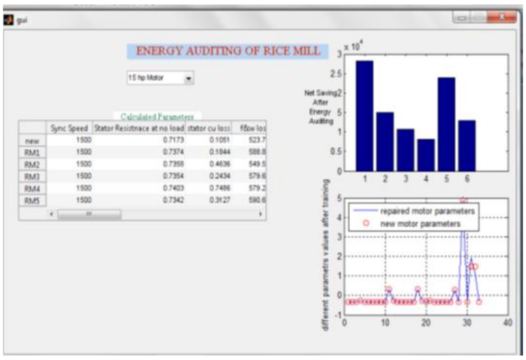

Figure1: GUI for 15 hp motor

The calculated parameters for 15 hp motor are tabulated in previous chapter. All calculated parameters of new motor and repaired motor are trained with neural network and a graph in figure 2 shows the output of both after training.

The bar graph representing net saving and payback period for all types of motors is shown in figure 3 and figure 4.

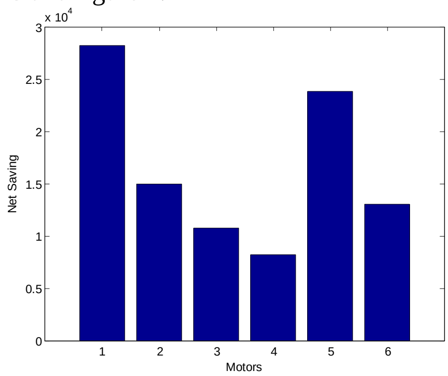

Figure 2: Bar Graph representing net saving in 15 hp motor

First bar represents new motor and net saving in this is highest but payback period is average. Training of new motor with R.M 1is shown in figure 5.

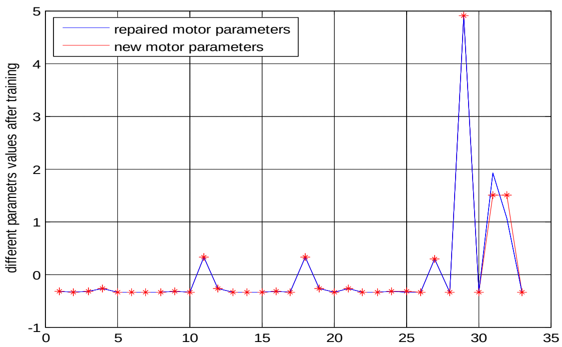

Figure 3: Graph after neural network training

After training expected output of new motor is matched with R.M 1. This is proved by following neural network graphs shown in figure 6.

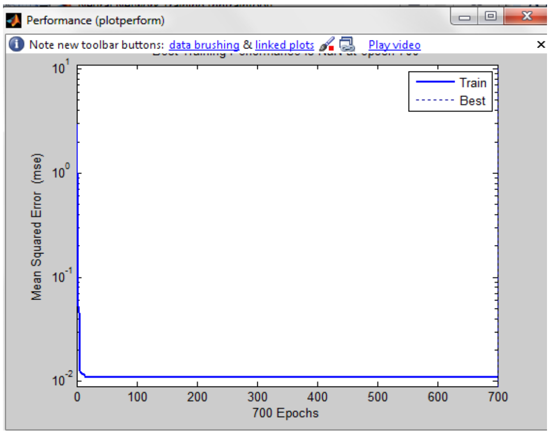

Figure 4: Mean square error during training

Performance of neural network is decided by mean square error. It should be decreasing to a minimum error. For 15 hp motor value of MSE is 10^{-2}. Results for 20 hp motors.

3.1 Standard Formulae's for calculated parameters Synchronous speed:

It can be calculated as:
Sync. Speed = 120f/p
Here f=supply frequency
P=no. of poles

Stator resistance:
It can be calculated as:
Stator resistance of N.L and F.L motor=R2/R1= (235+T2)/(235+T1)
Here R2 = unknown resistance at temp. T2
R1= resistance at temp. T1
F.L = Full Load
N.L = No Load

Stator Cu. loss:
It can be calculated as:
Stator Cu. loss at N.L and F.L = I2R
Here I= N.L/F.L current
R= N.L/F.L resistance

Iron and friction and windage losses:
It can be calculated as:
Iron and friction and windage losses= Pin- stator Cu. loss at N.L
Here Pin = input power

F.L rotor losses:
It can be calculated as:
F.L rotor losses = I2R
HereI= current at full load
R = rotor resistance

Stray losses:
It can be calculated as:
Stray losses = 1.5% of F.L input power for 1-125 HP motor
1.3% of F.L input power for 126-500 HP motor
1.2% of F.L input power for 501-2499 HP motor
0.9% of F.L input power for 2500 and above HPM

F.L output power:
It can be calculated as:
F.L output power= Pin (F.L)-stator Cu. loss at F.L-F&W losses- rotor Cu. loss- stray losses
Percentage loading:
It can be calculated as:
Percentage loading= (F.L. output power/rated power) ×100
Efficiency:
It can be calculated as:
Actual efficiency= (actual output power/actual input power) ×100
Rated efficiency= (rated output power/rated input power) ×100
Net saving:
It can be calculated as:
Net saving= benefits - (running cost + electrical expenses)

Simple Payback Period

The simple payback period can be defined as „the length of time required for running total of net savings before depreciation to equal the capital cost of the project . In theory, once the payback period has ended, all the project capital cost will have been couped and any additional cost savings achieved can be seen as clear „profit . Obviously, shorter the payback period more attractive the project becomes. The length of the maximum permissible payback period generally varies with the business culture concerned [10]

Generally, Simple Payback Period is, the time (number of years) required to recover the initial investment (First Cost), considering only the Net Annual Saving [13]. In some companies, payback periods in excess of 3 years are considered acceptable. The Simple Payback is usually calculated as follows:

Simple payback period (years) = Capital cost of the project (in Rs.)
Net Annual savings (in Rs.)
Here, Net Annual savings = benefits – costs
PB = CC
AS
Where, PB = payback period (years), CC = Capital cost of project (Rs.)
AS = Annual net cost saving achieved (Rs.)

IV. CONCLUSION & FUTURE SCOPE

4.1 Conclusion

Electrical energy is the most flexible type of energy since it can be converted to any form and can be transferred with equal ease. With every passing year the demand of electrical energy rises much higher than its supply and therefore the only way to plug this gap is to identify the place where it can be conserved. The preliminary study of rice plant has explored the possible energy saving areas such as induction motor, power factor improvement and optimized parallel loading of transformer. Analysis of some has been done to save energy. It has been seen in this study that a huge chunk of energy can be saved by replacing in- house rewound induction motor by new motor. After doing a thorough analysis on the rewound induction motor for its efficiency, it is found that rewound motor, if replaced by new ones, have a payback period in the range of 2 years to as less as 6 months. It is therefore recommended that the rewound motor should be analyzed for its efficiency and if the efficiency has found inadequate, these could be replaced by the new motors. In second method, energy auditing also has been done after power factor improvement by installing capacitor bank to the different motors for energy saving purpose. After doing this analysis, it is found that the total capital cost and benefits increased but the payback period is decreased as compared to first analysis. It is also noticed that the efficiency improves.

4.2 Future Scope

Present work reflects upon the preliminary study done on a typical rice plant with regard to a conservation of electrical energy only. The scope for further study exists in doing a detailed energy audit covering energy efficient motors. For the second analysis, the scope for further study can be to implement the power factor improvement of capacitor bank for the delta connection of motor.

V. ACKNOWLEDGEMENTS

We thank the department of electrical engineering, university institute of engineering and technology, kurukshetra university , kurukshetra for rendering the support and providing the facilities to setup the hardware circuit for the work proposed in this paper.

REFERENCES

[1] O.C. Agustin ,"Automatic milled rice quality analysis" *Future Generation Communication and Networking*, vol.2., pp.112-115, Issue13-15, 2008.
[2] M. D. Ahiduzzaman, A.K.M. Sadrul Islam , "Assessment of rice husk energy use for green electricity generation in Bangladesh", *Developments in Renewable Energy Technology*, pp.1, 2012.
[3] J. Armstrong, "Quality system implementation in a pulp and paper mills", *E&I maintenance group*, pp. 194-202, 1994.
[4] Ashrae , "Driftmier energy audit report", *University of Georgia Athens, Georgea,* 2006.

[5] A. Boysen, H.B. Hidemark Danielson, Sweden, "Energy conservation in building and community system*",* 1987.
[6] Bureau of energy efficiency , "Energy performance assessment for equipment & guide book 1st", pp. 57-80,2005.
[7] Bureau of energy efficiency, "Energy performance assessment for equipment & guide book 2nd", pp. 33-43, 2005.
[8] Bureau of energy efficiency, "Energy performance assessment for equipment & guide book IIIrd", pp. 37-63, 2005.
[9] Bureau of energy efficiency ,"Energy performance assessment for equipmnt & guide book 1Vth", pp. 73-85, 2005.
[10] Bureau of energy efficiency, "Energy conservation measures in rice mills- Vellore manual" pp. 163, 2011.
[11] Bureau of energy efficiency, "Energy conservation measures in rice mills- Warrangal manual" pp. 1-86, 2011.
[12] Bureau of energy efficiency, "Energy conservation measures in rice mills- Warrangal summary" pp. 1-6, 2011.
[13] Bureau of energy efficiency, "Energy conservation measures in rice mills – Ganjam summary" pp. 1-4, 2011.
[14] Kamalapur G.D.,Udaykumar R.Y., "Electrical energy conservation in India- challenges and Achievment", *Control, Automation communication and energy conservation*, pp.1-5, 2009.
[15] Z.K. Morvay, Gvozdenac, "Applied industrial energy and environmental management", *John Wiley & sons ltd. UK*, 2008.
[16] L.I.A. Pabamalie, H.L.P. Premaratne, "A grain quality classification system" ,*Information Society*, pp.56-61, 2010.