IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

ENERGY ASSESSMENT FOR TRANSFORMERS *AT GRASIM INDUSTRIES LIMITED, NAGDA (M.P)*

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ABSTRACT

This paper emphasis on an energy assessment approach for transformers installed at Grasim Industries Limited, Nagda (M.P) India. The energy as well as cost saving was evaluated from the standard analyzed process. This saved energy is very useful in the absence of existing source. The various data which was required for evaluation are collected by means of plant visit, inspection and analysis of various energy flow pattern in the plant. The factors considered under this assessment are behavior of user, climatic condition and energy demand pattern. This paper proposes the results of energy assessment at Energy Centre # 4 of Grasim Industries Limited, Nagda and recommends the ways of sorting problems arises from energy required at end use. Needful studies are required to quantify and evaluate the parameters affecting energy efficient measures.

Keywords: Energy, efficiency, energy audit, savings.

I. INTRODUCTION

Energy is always crucial to economic development of developing nation and it should be considered as a valuable resource required in governing a business. It has environmental and ecological impact. There is need to manage it, in order to increase the business profits and compatibility in the market. The process towards reducing energy consumption in various energy consuming sectors is considered one of the most easiest, quick and feasible measure to minimize the problem of energy and environmental imbalance. Individual industries and business have different demands, which are met by various combinations of on-site heat and power generation from delivered fuels, electricity and coal consumption from the main supplies. This paper highlights the importance and need for energy assessment in the plant through implementing energy saving opportunities in transformers and motors in order to minimize energy consumption and result in the form of monetary saving could be utilize for the advancement of plant. The main idea of this paper is to present an energy assessment for transformer and motor based on energy audit.

II. METHODOLOGY

During the field visit, a number of on-site measurements were taken. A range of portable electrical instruments as well as online instruments are used for collecting the required data. Data collection for equipment/ auxiliaries of EC 4 unit was done when it was ensured that the unit load remained more or less constant. Subsequent to field visits, detailed analysis of data was carried out to identify specific options for energy savings in each of the

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

selected areas. Following are the basis for computing savings in energy consumption. Estimates are based on design/ rated operating parameter and energy consumption level. Payback period ≤ 3 years for cost benefit analysis.

Electrical systems

The energy audit of captive power generating unit, EC-4 was carried out to study, analyze and identify the potential for energy conservation. The operating parameters of electrical drives and power distribution transformers were measured using 3–phase portable power analyzer. The application of individual drives and associated loads were studied to identify possibilities of improvements.

Transformation system

Unit EC#4 has a 45 MVA transformer set and the power is generated at 11 kV level. The voltage is stepped up to 22 kV using 45–MVA transformer. The unit has two 10–MVA transformer connected at 11 kV buses which is used to supply power to the auxiliary load by stepping down to 6.6 kV level. The power is also fed to mechanical coal handling plant (MCHP) and staple fibre division. Table provides brief design specifications of transformers.

Table 1.Design specifications of Transformers

S.No	Transformer ID	Rated Capacity (MVA)	Nos.	Rated Voltage (kV)
1.	Export transformer	45	1	11/22
2.	AG-3	10	1	11/6.6
3.	AG-6	10	1	11/6.6

Transformer loading pattern

Electrical parameter measurements such as voltage, current, power factor, active and reactive power of distribution transformers were measured using three phase electrical power analyzer at 22 kV level. The unit exports power to the Chemical division. A tie link with EC-5 also provided to supply power during shut down. A summary of the active power and the loading pattern of transformers are given in table.

Table 2.Loading pattern of measured distribution transformers

S.No	Transformer ID	Rated capacity (MW)	Active power (MW)	Apparent power (MVA)	% Loading
1.	Generator Transformer	45	21.95	22.28	49.6
2.	AG-3	10	3.47	4.10	41.1
3.	AG-6	10	3.31	3.92	39.2

$$\%\ loading = \frac{Maximum\ demand\ /\ Active\ power}{Rated\ \ capacity\ \ of\ \ transformer} \times 100$$

The loading patterns of the three transformers are given in figures a to c. From the figures it can be deduced that the loading is uniform in these transformers.

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

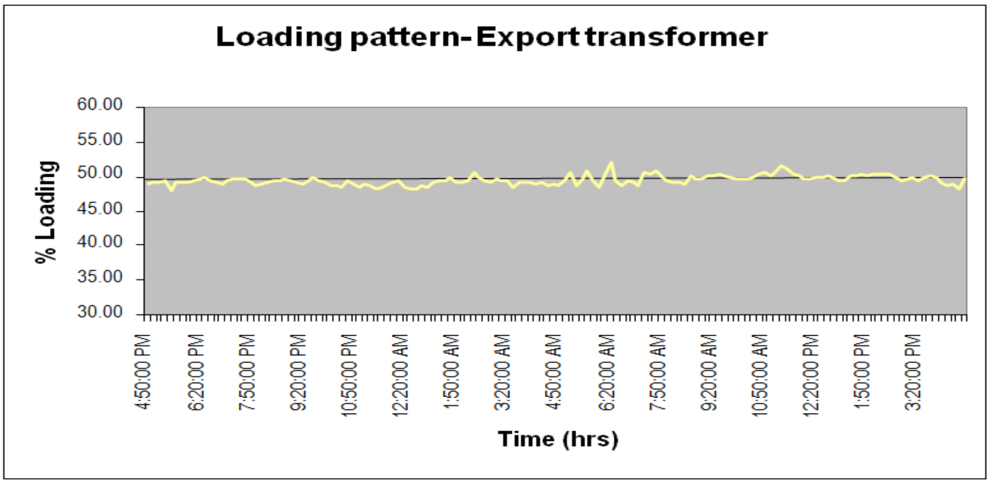

Figure a. Loading pattern of 45 MVA export transformer

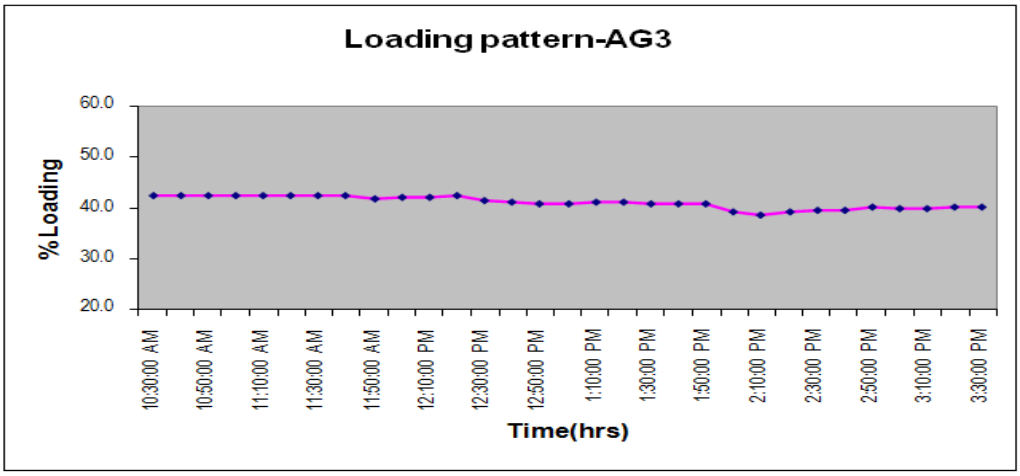

Figure b. Loading pattern of 10 MVA transformer AG-3

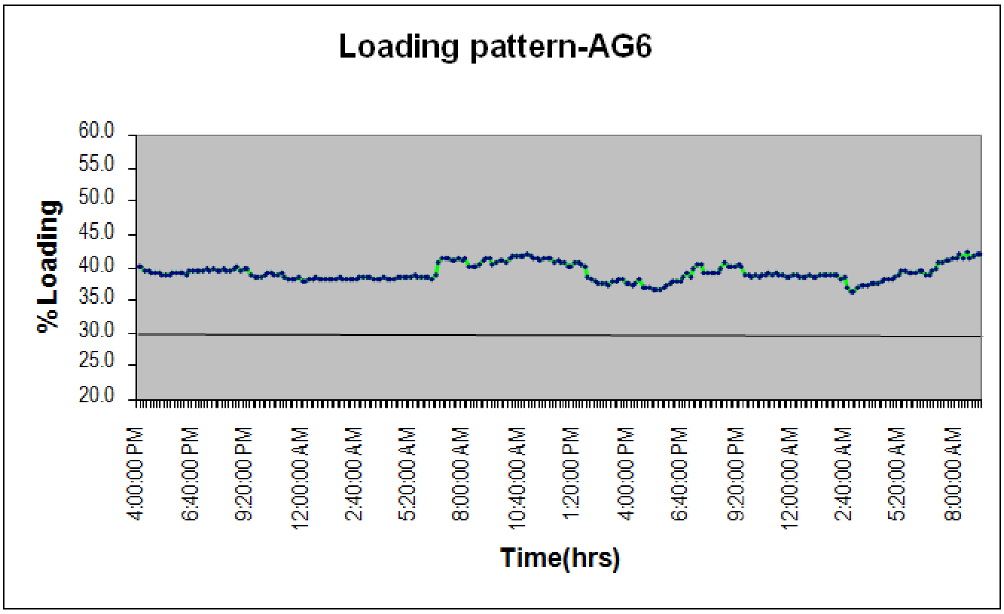

Figure c. Loading pattern of 10 MVA transformer AG-6

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

- It has been observed that all the above transformers are loaded closest to their best efficiency level. Best efficiency for export transformer will occur at 34.3% loading. Presently export transformer is loaded up to 49.5% on an average. The power factor is observed at 0.85.
- The 10 MVA transformers have their best efficiency at 38.84% loading. Presently AG-3 is loaded at 41.1 % at 0.84 power factor and AG-6 is loaded at 39.2% at 0.85 power factor on an average. The loading of these transformers are close to the best operating load of the transformer.

Table 3.The operating efficiencies of transformers

S.No	Transformer ID	Present load (%)	Operating efficiency (%)	% loading for best efficiency	Best efficiency (%)
1.	45 MVA	49.6	99.69	34.3	99.69
2.	AG-3	41.1	99.49	38.8	99.49
3.	AG-6	39.2	99.50	38.8	99.50

Table 4.Summary of the evaluated losses of transformers

S.No	Parameters	Unit	45 MVA	10 MVA	10 MVA
1.	Transformation Capacity	MVA	45	10	10
2.	Primary/ Secondary	Volt	11000/22000	11000/6600	11000/6600
3.	Active power	MVA	22	4.1	3.93
4.	% loading		49.53	41.10	39.30
5.	Load factor		0.95	0.96	0.93
6.	No-load loss	kW	23.76	8.32	8.32
7.	Full load loss	kW	201.604	55.196	55.196
8.	Load loss	kW	50.401	9.278	8.831
11.	Total losses/annum	kWh	649649	154162	150245
12.	Total transformation losses/annum	kWh	954056		

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ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

III. CALCULATION

45 MVA Transformer

$$Load\ factor = \frac{Average\ load}{Maximum\ demand\ during\ a\ given\ period}$$

$$= \frac{3923.7}{4232.5} \quad = 0.95$$

$$Load\ loss \quad = \left(\frac{\%\,loading}{100}\right)^2 \times full\ load\ loss$$

$$= \left(\frac{49.53}{100}\right)^2 \times 201.604 \ = 50.401\,kW$$

$$Total\ losses\,/\,annum\ = (no\,load\ loss + load\ loss) \times 8760$$

$$= (23.76 + 50.401) \times 8760 \quad = 649650\ kWh$$

$$\%\,Efficiency\ = \frac{P \times kVA\,rating \times p.f \times 1000 \times 100}{P \times kVA\,rating \times p.f \times 1000 + N.L + L.L \times \left(\frac{\%\,loading}{100}\right)^2}$$

$$= 99.69\ \%$$

10 MVA Transformer

$$Load\ factor = \frac{Average\ load}{Maximum\ demand\ during\ a\ given\ period}$$

$$= \frac{4105}{4251} \quad = 0.96$$

$$Load\ loss \quad = \left(\frac{\%\,loading}{100}\right)^2 \times full\ load\ loss$$

$$= \left(\frac{41.10}{100}\right)^2 \times 55.196 \ = 9.278\,kW$$

$$Total\ losses\,/\,annum\ = (no\,load\ loss + load\ loss) \times 8760$$

$$= (8.32 + 9.278) \times 8760 \quad = 154162\ kWh$$

$$\%\,Efficiency\ = \frac{P \times kVA\ rating \times p.f \times 1000 \times 100}{P \times kVA\ rating \times p.f \times 1000 + N.L + L.L \times \left(\frac{\%\ loading}{100}\right)^2}$$

$$= 99.49\ \%$$

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10 MVA Transformer

$$Load\ factor = \frac{Average\ load}{Maximum\ demand\ during\ a\ given\ period}$$

$$= \frac{3923}{4232} = 0.93$$

$$Load\ loss = \left(\frac{\%\,loading}{100}\right)^2 \times full\ load\ loss$$

$$= \left(\frac{39.30}{100}\right)^2 \times 55.196 = 8.8312\,kW$$

$$Total\ losses / annum = (no\,load\ loss + load\ loss) \times 8760$$

$$= (8.32 + 8.8312) \times 8760 = 150245\ kWh$$

$$\%\,Efficiency = \frac{P \times kVA\,rating \times p.f \times 1000 \times 100}{P \times kVA\,rating \times p.f \times 1000 + N.L + L.L \times \left(\frac{\%\ loading}{100}\right)^2}$$

$$= 99.50\ \%$$

$$Total\ transformation\ losses / annum = sum\ of\ all\ the\ total\ losses\ of\ three\ transformer$$

$$= 954056\ kWh$$

IV. RECOMMENDATION

Reduction in load losses due to improvement in power factor

As we know that transformer load losses vary as a square of current. For the particular kW load, current drawn is proportional to kW/p.f. If p.f is improved close to unity at load end, the saving in load losses can be done. Industrial p.f varies from 0.6 to 0.8. Thus the load draws 60% to 25% excess current due to poor p.f. Thus, if p.f is 0.85 and it is improved close to unity, the saving over existing level of load losses can be made. This is simple opportunity and must not be missed. It should also be kept in mind that correction of p.f saves cable losses, which will be almost twice in value compared to transformer losses.

Saving in load losses due to improvement in power factor from 0.85 to 0.95

45 MVA Transformer

$$saving\ in\,load\ losses = (per\ unit\ loading\ as\ per\ kW)^2 \times load\ loss\ at\ full\,load \times \left[\left(\frac{1}{p.f}\right)^2 - 1\right]$$

$$= 0.25 \times 201.604 \times 0.5 = 25.20\,kW$$

$$= 25.20 \times 24 \times 365 = 220756\ kWh / annum$$

$$Monetary\ saving\ @\,Rs.5.50 = 220756 \times 5.50 = Rs.1214158 / annum$$

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10 MVA Transformer

$$saving\ in\ load\ losses = (per\ unit\ loading\ as\ per\ kW)^2 \times load\ loss\ at\ full\ load \times \left[\left(\frac{1}{p.f}\right)^2 - 1\right]$$

$$= 0.168 \times 55.196 \times 0.5 \quad = 4.634\ kW$$

$$= 4.634 \times 24 \times 365 \quad = 40615\ kWh/annum$$

$$Monetary\ saving\ @\ Rs.5.50 \quad = 40615 \times 5.50 \quad = Rs.\ 223384/annum$$

10 MVA Transformer

$$saving\ in\ load\ losses = (per\ unit\ loading\ as\ per\ kW)^2 \times load\ loss\ at\ full\ load \times \left[\left(\frac{1}{p.f}\right)^2 - 1\right]$$

$$= 0.152 \times 55.196 \times 0.5 \quad = 4.194\ kW$$

$$= 4.196 \times 24 \times 365 \quad = 36747\ kWh/annum$$

$$Monetary\ saving\ @\ Rs.5.50 \quad = 36747 \times 5.50 \quad = Rs.\ 202110/annum$$

Proposed annual saving = 298118 kWh /annum

Proposed annual monetary saving = Rs. 1639652 /annum

V. CONCLUSION

Energy assessment should be viewed as a part of management activities which improves policy making by any organization. It provides information regarding the eradication of energy wastage; reduce losses and maximization of profits. Therefore, it should be given a good preference in all the levels of national development. Energy should not be taken as a right, but as a requirement with a price tag. Those who need it must pay for it; there comes the economies of energy should be upheld by everyone. Energy assessment should be supported which create a conductive environment for learning and research that will positively affect the development of particular organization and the nation.

REFERENCES

[1] Imad.H.Ibrik and Marwan M.Mahmoud, **"**Energy efficiency improvement procedures and audit results of electrical, thermal and solar applications", Palestine, 2003.

[2] D. Lindenmeyer, H.W. Dommel, A. Moshref, P. Kundur, "An induction motor parameter estimation method", Electrical Power and Energy Systems 23 (2001) 251-262

[3] R.M, Pai, Ion Boldea, S.A. Nasar, "A Complete Equivalent Circuit of a Linear Induction Motor with Sheet Secondary", IEEE Transaction on Magnetics, Vol. 24, No. 1, January 1988.

[4] D. Lindenmeyer, H.W. Dommel, A. Moshref, P. Kundurb, "An induction motor parameter estimation method", Department of Electrical and Computer Engineering, The University of British Columbia, August 2000

[5] T.Phumiphak, and C. Chat-uthai, [5] in their paper "Estimation of Induction Motor Parameters Based on Field Test Coupled with Genetic Algorithm", Department of Power Engineering, Faculty of Engineering, Mahanakorn University of Technology, Thailand.

[6] Rui Esteves Araujo, Americo Vicente Leite, Diamantino Silva Freitas, "Estimation of Physical Parameters of an Induction Motor Using an Indirect Method" Faculty of Engineering University of Porto.

[7] Marin Despalatovic, Martin Jadric, Bozo Terzic, "Identification of Induction Motor Parameters from Free Acceleration and Deceleration Tests", ISSN 0005–1144 ATKAAF 46(3–4), 123– 128 (2005)

[8] J.D.Kueck,P. Otaduy, J.Hsu, "Evaluation of Method for Estimating Motor Efficiency Without Removing Motor from service".

[9] Aníbal T. de Almeida, Fernando J. T. E. Ferreira, John F. Busch, Pierre Angers, "Comparative Analysis of IEEE 112-B and IEC 34- 2 Efficiency Testing Standards Using Stray Load Losses in Low-Voltage Three-Phase, Cage Induction Motors" IEEE Transaction on Industry Applications, Vol. 38, No. 2, March/April 2002

[10] Pichit Lumyong, Chaiwut Chat-uthai, "Power Minimization Technique for Induction Motor Load Test", Department of Electrical Engineering, Faculty of Engineering.

[11] J.D.Kueck,P. Otaduy, J.Hsu," Evaluation of Method for Estimating Motor Efficiency Without Removing Motor from service".

[12] Aníbal T. de Almeida,Fernando J. T. E. Ferreira, John F. Busch, and Pierre Angers, "Comparative Analysis of IEEE 112-B and IEC 34-2 Efficiency Testing Standards Using Stray Load Losses in Low Voltage Three-Phase, Cage Induction Motors" IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 38, NO. 2, MARCH/APRIL 2002

[13] P. C. Sen , Principles of Electric Machines & Power Electronics, Wiley 1999

[14] Stephan J. Chapman, Electric Machinery Fundamentals, 4/E McGraw-Hill, New York (2005).

[15] MA Khan, DPATI, HM Mzungu, "Comparison Of a 3KW Standards and high efficiency induction motor".

[16] Kent Davey, "Predicting Induction Motor Circuit Parameters", IEEE TRANSACTIONS ON MAGNETICS, VOL. 38, NO. 4, JULY 2002.

[17] A. B. Proca, A. Keyhani, "Induction Motor Parameter Identification from Operating Data for Electric Drive Application", 1999 IEEE.

[18] Anibal De Almeda, Fernando Ferreira, "Efficiency Testing Of Electric Induction Motors", ISR Dep. Eng. Electrotecnica, University of Coimbra, Portugal.

[19] F. Parasiliti, M. Villani, C. Paris, O. Walti, G. Songini, A. Novello, T. Rossi, "Three Phase Induction Motor Efficiency Improvements With Die-Cast Copper Rotor Cage and Premium Steel", SPEEDAM 2004 June 16th - 18th, CAPRI (Italy), Department of Electrical Engineering, University of L'Aquila, Italy.

[20] O. Bottauscio, M. Chiampi, C. Concari, C. Tassoni, M. Zucca, From the ideal to the real induction machine: Modelling approach and experimental validation" Parma, Italy, 15 April2008.

[21] "Transformers manual" by Devki Energy Consultancy Pvt. Ltd., Vadodara for Bureau of energy efficiency in 2006