Енергозберігання з використанням технік аудитування енергії – на прикладі сталевої силової установки

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Промисловість – це головний комерційний сектор енергоспоживання в Індії, де найбільш поширеним видом енергії є саме електрична енергія. Оскільки попит і ціна електроенергії зростають з дня в день, питання збереження енергії турбує більшість користувачів, зокрема воно стосується промисловості. Енергія – один з обов'язкових чинників для розвитку будь-якої країни. Термін «енергія» переважно асоціюється з електричною енергією – найчастішим і найширше використовуваним видом енергії в світі. Найбільшим споживачем електричної енергії є індустріальний сектор, частка якого в електроспоживанні сягає 49%. Попит на електричну енергію постійно збільшується, разом зі стрімким розвитком промислових потреб. Незважаючи на це, що електрична є найдорожчим видом енергії (дороге виробництво), її недостача спричиняє користувачам значні проблеми. Тому, аудитування використання енергії, питання її збереження і управління нею – це кращі рішення для того, щоб задовольнити зростаючий індустріальний попит. Розумне використання енергії стає категоричним для країни третього світу, що розвивається у умовах енергетичної кризи. У будь-якій сталевій промисловості три головні експлуатаційні витрати підприємств це переважно енергія, праця і матеріали. Якщо інші фактори віднести до керування витратами або потенційним збереженням витрат, тоді енергія перебуває на першому місці і створює стратегічне поле для зменшення витрат. Тому, збереження та розумне використання електроенергії стає обов'язковим до виконання. Отже, аудитування, збереження і управління це три інструменти для просування ефективного і розумного використання електричної енергії. У даній роботі запропоновано деякі міри для збереження енергії, які можна рекомендувати для ліній прокатки сталевої промисловості. Описано верстат гарячого вальцювання на підприємстві JSL Stainless Ltd. в м. Гісар, як приклад збереження енергії. Загальне покращення використання електроенергії в світлі наведеної рекомендації представлено поряд з пропонованими методами утилізації і застосування. Збереження енергії можна досягнути у стандартному двигуні шляхом зміни або використання конвертора зірка/трикутник, зниження витрат в кабелях, зміни ламп розжарення на світлодіодах, заміна стандартного трансформатора та трансформатор з литтєвої смоли тощо. У роботі описано способи втілення системи управління енергією для збереження енергії та зменшення ціни за одиницю продукції.

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Energy Saving Using Energy Auditing Techniques – A Case Study for a Steel Power Plant

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An industry is the major commercial energy consuming sector in India, where electrical energy is the most common and widely used type of energy. As the demand and price of energy are increasing day by day. Therefore, the subject of energy conservation is a concern for most energy users particularly industry. Judicious use of energy becomes imperative for third world developing country being presence of energy crisis. This paper provides some measure for energy saving that can be commonly recommended for a rolling unit of steel industry. A case of hot rolling unit in JSL Stainless Ltd., Hisar for energy conservation is given. Overall improvement in energy consumption in light of the stated recommendation is illustrated along with the proposed utilization of the techniques and their applications. Energy conservation in conventional motor with replacement or use of star delta star converter, reduction in cable losses, replacement of filament of LED lamps, replacement of conventional transformer with cast resin dry type transformer and provision of energy management system for energy conservation and per unit production cost reduction are elaborated in this paper.

Keywords – Energy Cosnervation, Energy Audit, Energy Efficient Motors, LED Lamps

I. Introduction

Energy is one of the indispensable factors for development of any country. The term energy is broadly associated with electrical energy which is the most common and widely used type of energy in the world. The biggest consumer of electrical energy is industrial sector with an share in overall consumption as 49%. There is a continuous increase in demand for electrical energy to meet the rapid industrial needs. As well as the electrical energy is most expensive being costly production and always scarcity of electricity are serving problems for electricity consumer day by day. Therefore, energy audit, conservation and management are the best solutions to fulfill the growing industrial demand.

- Here energy audit is a measure to know how much energy is being used and should be used and to what extent can energy requirement be reduced by using specific techniques and energy efficient machines.
- Energy conservation is a program which includes load management. Losses and efficiency management and power factor management with the management of above stated factors energy conservation process can be performed as conservation of energy is production of energy. Energy management 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. Thus the optimized operation and efficient utilization of electrical energy is termed as energy management.

- Ø Energy audit, conservation and energy management discussed in this paper is carried out in aim of analyzing and identifying possible energy saving measures which can be implemented in hot rolling steel mill. This effort will help the organization to reduce their monthly electrical consumption and thus reducing the cost of production or we can say this effort is performed with two basic objectives.
  - o Saving in consumption unit (kWH).
  - o Saving in cost of energy.

The total energy consumption survey is conducted by means of onsite inspection measurements, questions and discussions with the maintenance staff. Energy consumption data have been recorded over a period of time at the main supply and in identified main equipments in the rolling mill of the factory. It is also stated that the use of efficient electric equipment in industry and energy conservation techniques may have great cost saving.

II. Electrical Energy Conservation For A Hot Rolling Mill In Steel Industry

In any steel industry the three top operating expenses are often found to be energy, labour and material. If one were to relate to the manageability of the cost or potential cost saving then energy would emerge as a top ranker and constitutes a strategic area for cost reduction. Therefore, it becomes imperative for us to save energy and use it judiciously. Here, energy audit, conservation and energy management are tool to promote efficient and judicious use of electrical energy.

In order to proceed with energy conservation, energy audit is an effective tool. A cold rolling steel mill was chosen for the purpose of demonstrating the principle of energy conservation using energy audit. The following steps were involved:

a) Determination of the energy inputs to the various stages in the process carried out in that particular unit. Then identification the process stages for which the large amounts of energy are needed.
b) Deciding where the most significant energy savings are possible.
c) Quantification of the derived saving and the cost of achieving them along with payback periods.
d) Elaboration the advantages that can be achieved through the implementation of energy saving measures and make strategic proposals for energy saving.

Following are the main components of rolling mill of a steel industry which bring a significant electrical energy conservation. A brief description about each as to how the saving can be achieved is also given:

a) Replace conventional motors with EEM.

The rolling unit of this steel industry has about 950 motors of various sizes. But all of these are conventional motors and some of these are rewounded. Such rewounded motors also loose efficiency about 3-7% of its original efficiency. But a reference point of 11 KW or 15 H.P. is considered for energy audit along with this reference pt only those motors are selected which has 12 or more than 12 working hours. As the average operating efficiency of these motors is very low and therefore replace these with EEM which improve the energy consumption scenario of that unit. The energy cost saving by replacing a conventional motor with an EEM is given by the following formula.

Saving in Rs./Annum:

= P x L x H x C (100/efficiency 1 (-) 100 efficiency 2)

Pay back period in years:

=Cost of EEM/Cost of Energy saved.

Where, P is Rating in KW, L is Load factor, H is working hours per annum & C is cost of electricity in Rupees per unit.

Table 1

Proposed motor parameters

Description	Existing Normal Motor	Proposed Energy Efficient Motor
Rated KW	15	15
RPM	1450	1450
Efficiency(As per manufacturer)	0.87	0.92
Year of make	1990	2011
% Loading	85	85
Actual Load (KW)	9.35	9.35
Energy consumed per day (24 hours per day)	258	244
Energy consumed per year (360 days per year)	92855	87809
Difference of Energy Consumed (KWH)	5046	
Energy Cost (@6.16 per unit)	31083	
Cost of new 15 KW motor (In Rs.) ABB Make	55000	
Payback period (In Year)	1.17	

Replace all these motors which has less than two years payback period and remaining motor whose payback period is less than five years but more than two years can be replaced by analyzing the result of previous replacement. The motors whose pay back period is more than five years do not require any replacement.

b) Use Star Delta Star Converter:

As it is obvious that power factor and efficiency varies with percentage of loading in conventional motors. In existing system some motors are found that whose %age loading varies with time. If loading is less than 40% iron losses will be more dominant that copper losses so because iron losses depend on voltage therefore, a less voltage about 58% is applied by connection again in star connection. Therefore, in the above stated situation an automatic star delta star device with built in load sensor can be used. This sensor continuously senses the load and if the loading goes beyond 40% it automatically changes over star reverting back to delta when load goes above 40%.

c) Keep Constant Voltage at Motor Terminal:

The effect of voltage variation on the performance of the motor is as below:-

Motor Specifications :- 3.7 kW, 4 Pole Motor (ABB Make)

Supply Volts:	300V	352V	415V	450V	
Effi.%:	72	85	100	108	
No-Load Performance:					
Current – A	2.10	2.60		3.10	5.4
Watts – W	224	295	400	600	
Full-Load Performance					
Current -A	9.5	8.0	7.3	7.8	
Effi. – %	81.0		82.5	83.6	80.9
PF – pu	0.93	0.92		0.85	0.81
Speed-rpm	**1380**	**1420**	**1450**	**1455**	

Therefore, the motors which are operated on full load during their duty cycle such as all ventilation pumps, pre heating furnace extractor WBF extractor etc. should be operated at constant voltage. Therefore with suitable means keep the voltage constant.

d) Reduction in Cable Losses

As the losses in the cable at specific load centre is high. with EEM which improve the energy consumption scenario of that unit. The energy cost saving by replacing a conventional motor with an EEM is given by the following formula.

Table 2

Calculation of losses

Sr No	Feeder Name	KWH consu. at Sub Station	KWH Consu. at Distribution End (AT PDB)	Diff. in KWH Consu. on (for 30 Min)	Diff. (Losess) in KWH Consu. on (For 1 Hour)	Losses per day (KW)	Losses per Year (KW)	Amt. in Rs. Equi. To losses @ 6.16 Rs. per KWH
1	Walking Beam Furnace	450	438	12.00	24	576	209088	1287982
2	Roughing Mill	332	323	9.00	18	432	156816	965987
3	Down Coiler	153	146	7.00	14	336	121968	751323
4	Twin Stand Unit	693	686	10.00	20	480	144240	1073318
5	Punching Mill	488	485	3.00	6	144	52272	321996
								4400606

Losses in cables must be reduced at walking beam furnace, twin stand and roughing mill by:

i) Replacing of lower size existing cable with higher size cable and keep the existing cable as standby cable.

ii) Laying another cable of same size in parallel to the existing cable.

e) Replace Filament Lamps installed in Panel on/off Indication with Energy Efficient LED lamps:

It is observed that 10w/15w filament lamps are used as on/off indicators; replace all these with (1w/2w) LED lamps. With this conversion there will be good potential of energy saving.

Pay back period for replacement of these filament lamps

Power consumption of filament lamp =10-14 watts/lamp

Power consumption of energy efficient LED lamp = 1.0-2.0 Watts/lamp

Saving/lamp = 08-12 Watts/lamp

Presently there are 96 filament lamps used for panel indication in different panels in plant.

It is recommended to replace the panel indication lamps with LED.

Saving per Lamp = 8-12 W(Average 09W)

Annual savings = {(96nos.x 0.009kW/lamp) x 8640hrs/year x Rs.6.16/unit

= Rs.45,984/-

Investment required= Rs.250/LEDx 96 nos

= Rs.24,000/-

Payback = 24000/45984x12

= 6.26 months

say 6.3 months

f) Replacement of Conventional indoor Distribution Transformer by a cast resin dry type energy efficient distribution transformer

Typical calculation for 1.6 MVA, 11/0.433 KV Transformer

1600 KVA Cast Resin Dry type

- No Load Loss in KW= 3.2 KW
  Full Load Loss in KW= 13.7 KW
  Total Loss in KW= 16.9 KW
- 1600 KVA Oil Filled Type
  No Load Loss in KW= 2.1 KW
  Full Load Loss in KW= 21 KW
  Total Loss in KW= 23.1 KW
- Saving in energy charges per year
  = Rs.[Diff. in losses x [24 x 360] x [6.16]
  = [(23.1-16.9) x 24 x 360 x 6.16
  = Rs.329979/-

– Cost of Cast Resin Dry type Transformer after Salvage deduction =Rs.6,30,000/-

- Pay back period in months = 630000/329979x12

As per the above calculation replace the conventional transformers by a cast resin dry type transformer only when the pay back period is small, otherwise on the basis of loading KVA sharing can be performed as the performance of a distribution transformer is good at 50% loading

g) Maintain Separate Lighting Feeder and Operate all lighting Circuit at 215 Volt.

It is obvious that in discharge of lighting the optimum voltage for lighting circuit is 215 Volt. A reduction in supply voltage by 15% result in:

a) Insignificant drop in illuminations level (2-3%).

b) Proportional drop in power consumption 15%.

Present operating voltage=235-240Volt (Average238V

Recommended operating voltage = 215 Volt

%age voltage reduction possible:

=238-215/238x100 = 9.6%,

say 9.5%

Approximate lighting load is = 90 KW

Thus, there is a good potential to save energy by installing voltage stabilizer and maintaining operating voltage at 215 volt and achieve saving to the tune of 9.5%. Therefore, a separate lighting feeder should be there and install a servo stabilizer of 150 KVA for lighting circuit and operate at 210-215 Volt.

h) Install Neutral Compensator:

Being single phase lighting load three phase system is unevenly loaded which result in voltage difference phase to neutral voltage and heavy returns current flow in the neutral line. This is shown in Table 3 below. Therefore, the best solution is to install a neutral compensator. Where, neutral compensator is a three phase specially wound transformer which is installed at the low voltage supply line between neutral and phase. Due to magnetic symmetry, it tries to establish neutral point symmetrical with respect to phase voltage, resulting in balanced voltage in all the three phases and hence reduced the neutral current.

Table 3

Various loading schemes

Lighting D.B.	Voltage (Single Phase)	Load Current (R,Y,B,) Amps)	KW	KVA
Street Lighting DB	234,237,231 (235 (Avg.)	20,15,23	3.0,2.5, 4.9 10.4 KW)	4.54,3.6,5.46
Main Plant Lighting DB	239,241,241 (240 V-Avg)	162,82,134	36.6,28 17.3 (80KW)	40,19.7,32

i) Energy Saving Recommendation in Installed Pumps:

A number of pumps out of pumps which are being used for cooling in that particular unit are of large capacity. Here for energy conservation use two or more smaller pumps instead of one larger pump so that excess pump capacity can be turned off. Two pumps can be operated in parallel during peak demand periods. Energy saving result from running each pump at a more efficient operating point and avoiding the need to throttle a large pump during low demand. An alternate is to use one variable speed pump and one constant speed pump.

The payback calculations are given below:-

- Power consumption without inverter = 14.69 KW
- Power consumption at 36 HZ = 6.43 KW
- Power saving = 8.256 KW
- Energy Saving = 8.256 x 08 x 360 x 6.16
- Total cost of energy saving = Rs.146448.00
- Cost of Inverter = Rs. 1.25 Lacs

Payback Period = 10.24 Months

say 11 Months

j) Provision of Energy Management System:

"An energy management system (EMS) is a system of computer-aided tools used by operator/consumer to monitor, control and optimize the performance of system and of utilization of electrical energy."

It provides a wide range of monitoring facilities including system manager equipment analysis and date recording. Due to energy management system power system component and equipment utilization and effectiveness can be assessed. Without energy management system implementation of effective monitoring is very critical. EMS improves production and reduces the cost per unit with the conservation of electrical energy. There should be provision of energy management system.

Conclusion

It is believed that energy audit, energy conservation technique and energy management are the comprehensive methods for the sake of national energy crisis. The analysis and calculation of electrical energy consumption of a steel rolling mill as well as the saving and payback period of energy conservation technique were carried out. The results reveals that by adopting and following the electrical energy conservation guidelines which are recommended in this paper for a hot rolling mill and steel industry and appreciated amount of electrical energy can be saved. These recommendation if applied any similar industry may also lead to a very reasonable cost saving. But the implementation of above energy saving measure is solely dependent upon the decision of the industry. Several energy conservation methods which are cost effective are not often implemented but even then the energy auditor should elaborate the advantage that can be achieved with the implementation of these techniques.

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