ENERGY CONSERVATION AT HOCL

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Abstract— Nowadays we all are aware that man's urban and modern life style requires huge amount of ever increasing energy. This is the energy required to run manufacturing units, factories, machines, automobiles, homes, etc. in terms of electricity for heating, lighting and many other purposes. As most of this energy comes from non-renewable sources, it is essential to conserve it. Energy conservation refers to efforts made to reduce energy consumption. This project deals with various methods adopted for the conservation of energy at HOCL. This study was conducted in the Cochin unit of HOCL where various energy saving techniques for energy conservation is adopted by the petrochemical industry. And suggestions for implementing new techniques are proposed. They are:

1) Energy efficient lighting involves use of energy efficient tube lights,
2) Variable Frequency Drives, employed for motors with variable load,
3) Trimming of pump impellers,
4) FRP blades for fans.

After implementing the suggested conditions it is anticipated to save 14,50,428 Units of energy annually. This will save ₹ 84,26,987 for the company annually. For implementing the suggested modifications, a capital investment of ₹ 15,76,750 is needed. This amount can be recovered by the company in just 3 months of simple payback period.

Keywords— Affinity Laws, Energy Conservation, Motors, Pumps, Fans, VFD, Pay Back Period.

INTRODUCTION

Energy conserved is energy generated. 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. Though our country has taken rapid strides towards self-reliance on energy over last few years, still on the energy supply side India is facing severe shortage. With growing demand for energy it has become essential to minimise energy losses. Energy conservation should be considered as the wise and efficient use of the available energy for achieving maximum activities with productive work and profitability. Thus conservation does not mean the curtailment in energy use at the expense of industrial and economic growth. It means the efficient utilisation of energy resources ensuring the same level of economic and industrial activity with less energy inputs of energy. Energy efficiency is achieved when energy intensity in a specific product, process or area of production or consumption is reduced without affecting output, consumption or comfort levels.

AREAS OF FOCUS

2.1 Motors

Electric motors in industry constitute the single largest component of the electrical load and account for about 72% of the total electrical energy consumed by the industrial sector. The 3-phase squirrel cage motor is the workhorse of industry; it is rugged and reliable, and is by far the most common motor type used in industry. These motors drive pumps, blowers and fans, compressors, conveyers and production lines.

HOCL has 10 HT motors and about 172 LT motors. The 66 kV supply is stepped down to 6.6 kV and fed to HT motors. The 6.6 kV supply is further stepped down to 433 V and supplied to loads at various locations.

2.1.1 Steps to Improve Electric Motor System Efficiency [4]

i. Use variable Frequency Drives (VFDs) or two-speed motors where appropriate.
ii. Convert delta to star connection for lightly loaded motors.
iii. Install soft start-cum-energy saver for lightly loaded motors.
iv. Avoid frequent rewinding of motors. Greater the number of rewind, lesser the efficiency.
v. Choose energy-efficient motors for new applications. Consider replacement V/s repair for older, inefficient motors.
vi. Match motor operating speeds, and size motors for overall system efficiency.

2.1.2 Present Condition

In HOCL, flameproof squirrel cage induction motors are the most widely used because of their low cost, reliability of operation and ruggedness.

It was found out that many of the maintenance practices are not done regularly and efficiently. A checklist of good maintenance practices to be undertaken in HOCL to ensure reliable and efficient motor operation are suggested.

2.2 Pumps
In the chemical industry, about 26% of all electricity use in motors is for pumps. This equals 16% of the total electrical energy in the chemical industry making pumps the one of the largest electricity users in the chemical industry together with compress air systems and material processing. Pumps are used throughout the industry to generate a pressure and move liquids. Studies have shown that on average in the manufacturing industry, 20% of the energy consumed by these systems could be saved through equipment or control system changes, roughly equally divided between speed reduction or control measures and other system efficiency measures. The potential for the chemical industry is with 21% close to the manufacturing industry average.

2.2.1 Present condition
In HOCL, during the study it was found out that all the pumps and associated motors are oversized. Thus lot of energy is wasted in pump operations. Reasons for oversized pumps are:
- to provide margin for design error
- to provide margin for equipment deterioration
- to provide margin for pump deterioration
- to provide surge capacity
- to provide margin for process upsets/errors
- to provide for process changes

For example, the DM water pump at the Boiler section is not sized optimally. The rating is 150 m^3/h and the actual requirement is between 10-40 m^3/h. The hot oil charge pump is another example for oversized pump. The rating of the pump is 413 m^3/h and the maximum required flow is only 300 m^3/h. The required flow is controlled by using valves and by-passing. By doing so, lots of energy is wasted because the energy consumption by the pump-motor will be the same.

2.3 Fans and Blowers
Fans are used in boilers, furnaces, cooling towers and many other applications. In the chemical industry, 12% of motor related energy use if for fans, corresponding to approximately 8% of the total electricity use in the chemical industry. As in other motor applications, considerable opportunities exist to upgrade the performance and improve the energy efficiency of fan systems. Efficiencies of fan systems vary considerably across impeller types. Overall energy saving potentials in these systems in the Manufacturing industry are estimated at 5.5% and for the chemical industry at 5.9%. However, the cost-effectiveness of energy efficiency opportunities depends strongly on the characteristics of the individual system.

2.3.1 Fan oversizing
Most of the fans are oversized for the particular application, which can result in efficiency losses of 1-5%. However, it may often be more cost-effective to control the speed than to replace the fan system. For example, ID and FD fans at the boiler was oversized to work at the worst condition. VFDs are installed in both fans to control the fan speed and thereby reducing the fan energy consumption.

2.3.2 Variable Frequency Drives (VFDs)
Significant energy savings can be achieved by installing variable frequency drives on fans. Savings may vary between 14 and 49% when retrofitting fans with VFDs [5].

2.3.3 Present Condition
The main fans working in HOCL are at Boiler section (four no.s), Tempered Cooling tower (two no.s), Cooling Towers (five no.s).
i. 55 kW ID fans (two no.s)
ii. 22 kW FD fans (two no.s)
iii. 30 kW Tempered cooling tower fan (two no.s)
iv. 55 kW Cooling tower fans (five no.s)

2.3.3.1 Cooling Tower Fans
Cooling towers are a very important part of many chemical plants. The primary task of a cooling tower is to reject heat into the atmosphere. They represent a relatively inexpensive and dependable means of removing low-grade heat from cooling water. The make-up water source is used to replenish water lost to evaporation. Hot water from heat exchangers is sent to the cooling tower. The water exits the cooling tower and is sent back to the exchangers or to other units for further cooling.

After detailed study, it was inferred that the area which could potentially contribute to considerable energy saving was cooling tower fans. This was mainly because the atmospheric temperature at the company varies with time. There is about 5-8⁰ C dip in the temperature during late night hours. So, demand for artificial cooling through fans is less because the lower atmospheric temperatures aid for significant natural cooling. Thus the desired temperature can be maintained even at lower fan speeds. Installing VFDs to the fans is the best way to maintain the desired cooling and in turn reducing the energy consumption of the fans. But it need accurate

readings of the temperature variations at day and night. Readings should be taken for many days and different seasons. A detailed VFD run readings also needed to calculate the potential energy savings so that the company can analyse the results and carryout the project.

2.3.3.2 FRP Fan Blades

The fan efficiency in turn is greatly dependent on the profile of the blade. An aerodynamic profile with optimum twist, taper and higher coefficient of lift to coefficient of drop ratio can provide the fan total efficiency as high as 85–92 %. However, this efficiency is drastically affected by the factors such as tip clearance, obstacles to airflow and inlet shape, etc. As the metallic fans are manufactured by adopting either extrusion or casting process it is always difficult to generate the ideal aerodynamic profiles. The FRP blades are normally hand moulded which facilitates the generation of optimum aerodynamic profile to meet specific duty condition more efficiently. Cases reported where replacement of metallic or Glass fibre reinforced plastic fan blades have been replaced by efficient hollow FRP blades, with resultant fan energy savings of the order of 20–30% and with simple payback period of 6 to 7 months. Also, due to lightweight, FRP fans need low starting torque resulting in use of lower HP motors. The lightweight of the fans also increases the life of the gear box, motor and bearing is and allows for easy handling and maintenance [10].

2.4 Power Factor Correction

Power factor correction is an important energy conservation method. HOCL has already installed capacitor banks to improve the power factor. The monthly average power factor is maintained between 0.98 and unity. HOC gets incentive from KSEB for maintaining a good power factor.

2.5 Lighting System

Energy conservation techniques applied to lighting installations can result in significant saving in energy without reducing lighting standards. Although new lighting installations are designed to incorporate energy savings, many existing schemes are lacking in terms of energy efficiency. A lot of opportunities exist to improve lighting standards by using modern equipment and techniques with the added benefit of lower energy consumption. Artificial lighting is provided to permit people to carry out tasks safely and with relative ease where insufficient or no natural lighting is available.

Artificial lighting from electrical sources is provided by three types of lamps: Incandescent lamps, Fluorescent lamps, Discharge lamps.

2.5.1 Present Condition

No. of tubes which glow for 8 hours/day & 25 days/month = 400
No. of tubes which glow all the time = 250
No. of 200 W GLS lamps (12 hours) = 80
No. of 125 W HPMV = 140
No. of 250 W HPMV = 220
No. of 400 W HPMV = 123
HOCL has already implemented many energy conservation measures in lighting system like:
i. Replacement of HPMV lamps with HPSV lamps
ii. Replacement of GLS lamps with LED lamps
iii. Providing Lighting Transformers at MRS, Utility Substation, H_2O_2 Auxiliary Substation and Propylene Recovery Unit.

The identified potential area in lighting system was the replacement of old 40W tube lights with 36W energy efficient tube lights.

2.5.2 Energy Efficient Tube Lights

Energy efficient tube light E+ consumes 36 W compared to a 40 W for a conventional tube light. There would be direct saving of 4 W per tube light. It also gives a lamp output more than 20 % compared to a conventional 40 W tube light. By installing a 36 W tube light in place of 40 W lamps, annual energy saving of 10 % per lamp can be achieved [7].

METHODOLOGY

3.1 Affinity laws

The affinity laws for pumps/fans are used in hydraulics/HVAC to express the relationship between variables involved in pump or fan performance (such as head, flow rate, shaft speed and power). They apply to pumps, fans, and hydraulic turbines. In these rotary implements, the affinity laws apply both to centrifugal and axial flows.

The affinity laws are useful as they follow prediction of the head discharge characteristic of a pump or fan from a known characteristic measured at a different speed or impeller diameter. The only requirement is that the two pumps or fans are dynamically similar, that is the ratios of the fluid forced are the same.

Law 1. With impeller diameter (D) held constant:

Law 1a. Flow is proportional to shaft speed;
$Q1/Q2 = (N1/N2)^1$
Law 1b. Pressure or head is proportional to the square of shaft speed;
$H1/H2 = (N1/N2)^2$
Law 1c. Power is proportional to the cube of shaft speed
$P1/P2 = (N1/N2)^3$

Law 2. With shaft speed (N) held constant:

Law 2a. Flow is proportional to the cube of the impeller diameter:
$Q1/Q2 = (D1/D2)^3$
Law 2b. Pressure or Head is proportional to the square of impeller diameter:
$H1/H2 = (D1/D2)^2$

SUGGESTED MEASURES

4.1 Installation of VFD in Hydrogenation Feed Pump
Rated Power, KW   = 45 KW
Rated Voltage, V   = 415 V
Rated Current, I   = 80 A max
Rated Speed, N   = 2960 RPM
Rated Frequency, f   = 50 Hz
Power Factor   = 0.87
Power Consumption without VFD   = 33.5 KW
Avg Motor speed reduction using VFD   = 25 %
Power consumed is proportional to cube of speed.
$P \propto N^3$
Motor speed   = 75 % of normal.
Power consumed with VFD= $(0.75)^3$ x 33.5 KW = 14 kW
Annual energy savings= (19.5)×24×330 = 1,54,440 kWh
Avg cost of energy   = ₹ 5.81
Annual savings in Energy charges = (33.5-14) x24x330x5.81 = ₹ 8,97,296
Investment cost   = ₹ 3.5 lakhs
Simple payback period   = 5 months

4.2 Installation of VFD in Oxidiser feed pump.
Rated Power, KW   = 75 KW
Rated Voltage, V   = 415 V
Rated Current, I   = 128 A
Rated Speed, N   = 3000 RPM
Rated Frequency, f   = 50 Hz
Power Factor   = 0.87
Power Consumption without VFD   = 55.2 KW
Avg Motor speed reduction using VFD   = 25 %
Power consumed is proportional to cube of speed.
$P \propto N^3$
Avg Motor speed   = 75 % of normal.
Avg Power consumed with VFD = $(0.75)^3$ x 55.2 KW   = 23.3 kW
Annual Energy savings [(55.2-23.3) x24x330]   = 2,52,648 kWh
Average energy cost   = ₹ 5.81
Annual savings in Energy charges   = ₹ 2,52,648×5.81= ₹ 14,67,885
Investment cost   = ₹ 5 Lakhs
Simple Payback period   = 5 Months

4.3 Installation of VFD in DM water pump.
Rated Power, KW   = 22 KW
Rated Voltage, V   = 415 V
Rated Current, I   = 41 A
Rated Speed, N   = 2920 RPM

Rated Frequency, f   = 50 Hz
Power Factor   = 0.87
Avg Power Consumption without VFD   = 18 kW
Avg Motor speed reduction using VFD   = 35 %
Power consumed is proportional to cube of speed.
$P \propto N^3$
Avg Motor speed   = 65 % of normal.
Avg Power consumed with VFD = $(0.65)^3$ x 18 KW
                = 5 kW
Annual Energy savings [(18-5) x24x330] = 1,02,960 kWh
Annual savings in Energy charges   = ₹ 1,02,960×5.81= ₹ 5,98,198
Investment cost   = ₹ 1.5 Lakhs
Simple Payback period   = 4 Months

4.4 Replace Aluminium blades with FRP blades in Cooling Tower Fans.
No. of fans   = 3 Nos
Rated Power   = 55 kW
Rated voltage   = 415 V
Rated Current   = 96 A
Rated Speed   = 1480 RPM
Avg Power consumption with Aluminium blades= 47 kW
Anticipated Energy Savings   = 25%
Avg Power consumption with FRP blades = 35.25 kW
Avg Power Savings   = 11.75 kW
Annual Energy Savings (11.75×24×330) = 93,060 kWh
Average cost of Energy   = ₹ 5.81/kWh
Annual savings in energy charges (93,060×5.81) = ₹ 5,40,679
Annual savings for 3 fans (5,98,198×3)   = ₹ 16,22,037
Cost of implementation for 3 FRP blade sets   = ₹ 1,80,000×3 = ₹ 5,40,000
Simple Payback period   = 4 months

4.5 Impeller Trimming of Hot Oil Charge Pump.
Rated Power, kW   = 450 kW
Diameter of impeller, D_1 = 510 mm
Power consumption, P_1 = 200.3 kW
Discharge, Q_1 = 413 m^3/h
Required max flow, Q_2 = 300 m^3/h
By Affinity law,
$$\frac{Q_1}{Q_2} = \left(\frac{D_1}{D_2}\right)^3$$
Diameter of impeller for 300 m^3/h flow, $D_2^3 = D_1^3 \times (Q_2 \div Q_1)$
                       $=(510)^3 \times (300 \div 413)$, D_2 = 459 mm
By Affinity law,
$$\frac{P_1}{P_2} = \left(\frac{D_1}{D_2}\right)^5$$
Power consumption at reduced impeller diameter, $P_2 = P_1 \div (D_1 \div D_2)^5$
                      $= 200.3 \div (510 \div 459)^5$
                      = 118.3 kW
Reduction in power consumption= 200.3-118.3= 82 kW
Annual Energy savings (82×24×330) = 6,49,440 kWh
Average energy cost   = ₹ 5.81
Annual savings in Energy charges   = ₹ 37,73,246
Investment cost   = ₹ 7500
Simple Payback Period = 1 day

4.6 Replacement of 40W tube light with Philips (With BEE mark) made Energy Efficient 36W tube lights [7].
No. of tubes to be replaced   = 650
Power savings   = 4W per Tube
No. of tubes which glow for 8 hrs/day and 25 days/month =400
Annual Energy savings for 400 tubes = (400×4)×(8×25×12)
                        = 3,840 kWh

No. of tubes which glow all the time = 250
Energy savings for 250 tubes   = (250×4)×24×330
                                 = 7,920 kWh
Total annual energy savings   = 3,840 + 7,920
                                 = 11,760 kWh
Avg energy cost   = ₹ 5.81
Annual savings in Energy charges = 11,760 × 5.81
                                 = ₹ 68,326
Investment cost   = ₹ 29,250
Simple Payback period = 6 months

RESULT AND DISCUSSION

We can summarize the results of the energy conservation measures suggested in HOCL as follows:

5.1 Potential Energy Savings in Motors

i. Anticipated annual saving in energy charges after the installation of VFD

   a) In Hydrogenation feed water pump = ₹ 8,97,296
   b) In Oxidiser feed pump = ₹ 14,67,885
   c) In DM water pump = ₹ 5,98,198

ii. Anticipated annual saving in energy charges after installation of FRP blades in CT fans = ₹ 16,22,036
iii. Anticipated annual Saving in energy charges after impeller trimming of Hot oil charge pump = ₹ 37,73,246
Total Potential Energy Savings in Motors = ₹ 83,58,661

5.2 Potential Energy Saving In Lighting
By replacement of 40 W tube light with Philips made 36 W tube light.
Anticipated annual savings in Energy charges = ₹ 68,326
Total Potential Energy Savings in Lighting = ₹ 68,326

5.3 Total Potential Energy savings
Total potential energy savings considering both motors and lighting = ₹ 84,26,987
Total investment needed = ₹ 15,76,750
Simple Payback Period = 3 months

CONCLUSION

This project work discusses about the Energy Conservation measures to be adopted in the petrochemical industry, HOCL, from this we can infer that a large amount of energy can be conserved by adopting conservation measures. Studies were conducted on the Energy Conservation activities implemented in some of the electrical systems at HOCL. Large reduction in energy cost is obtained by implementing the conservation measures.

Implementation of energy conservation activity can result in harmonics in supply but it can be got rid of by making use of proper filters [8]. In spite of these harmonics, energy conservation activities can increase energy saving compared to which effect of harmonics can be neglected.

This project focussed only on the Electrical Department of HOCL. After studying the present condition of the Electrical system, possible conservative measures were identified and suggested. By implementing the suggested measures the company can save 14,50,428 Units of energy annually. This will save ₹ 84,26,987 for the company annually. The capital investment needed was calculated and found out to be ₹ 15,76,750. The company will be able to recover the invested capital by 3 months after implementing the suggested measures. There is more scope of energy conservation in the Mechanical and also in the Electrical department of the company.

Like in those of electrical sector, if sufficient technological innovations are brought about in every sector, a substantial monitory benefits could be achieved. It not only benefit the company but instead becomes an asset to the entire mankind.

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