Energy conservation in process industries

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Abstract—

Energy is necessary for running of all processes plants in a country like India where per capita energy availability and consumption is very low compared to developed countries the optimum utilization of energy in each sphere of activity resumes tremendous importance per capita energy consumption is considered to be an indicator of economic development of any country and in this respect India ranks very low in the international community a large capital is required for creation of installed capacity for generation of electricity e and availability of this capital is also Limited by social economical factor in India on one hand utilization of installed capacity is low and on the other hand losses in Transmission and distribution are very high in this background it is imperative to use each unit of energy as optimally and efficiently as possible to cope up with short term and long term energy demand in the country in energy conservation and management is increasingly as human importance this paper discusses various methods of energy recovery energy conservation and Energy Management which can be employed in process plants in general and desalination of plants in particular various methodologies that can be adopted for conservation of energy during early design stage are discussed in details with respect to individual components and the Technologies that can be used to conserve energy in an existing system as a retrofitting scheme are discussed monitoring analysis and control of energy as a part of integrated Energy Management System is explode finally energy audit to identify potential areas of energy conservation is explained.

Keywords— Energy, Economic, Motors, Monitoring, Audit.

1. Introductions

As we look forward in the future years to come the host of our millions are for a higher standards of Living and is ever increasing the development and growth potential of any country's economy is now more closely linked to its availability of energy the future Era will be the one where energy and related Technologies shall be of utmost priority.

India's first shifting from an agricultural economy to an industrial power there are a lot of challenges and augmenting and improvement of Energy efficiency so as to cater the country's ever-increasing energy demands.

The solution to the problem lies in efficient Energy Management which covers generation augmentation optimum utilization and efficient use of available energy. This energy management is of both technical and managerial nature utilizing concept from engineering science economics and Management and information technology too.

In this paper we will discuss various aspects of energy conservation it starts with energy conservation right from design stage and speaks about the energy saving equipments available then it explains various methods of energy conservation in pumps then the concept of energy recovery is touched in the specific reference to sea water reverse Osmosis plant. The modern tools available for Energy Management are described finally the importance and practice of energy audit is discussed.

2. Energy Conservation In Design Stage

The old saying goes prevention is better than cure. The same is true with energy conservation also. The aspects of energy conservation are to be incorporated at the design stage itself so as to ensure energy efficiency right from the Inception of the plant.

2.1 Methodology

This can be achieved giving you attention to the following:

- Selection of Technology
- Selection of equipments
- System design

It is always desirable to go in for energy efficient technology is right at the design stage. It involves only marginal additional investment. It can result in Quantum jumps in energy savings. Example for this technology is process integration from the energy point of view and installation of energy recovery/ heat recovery systems. If these in corporations are to be done as a retrofit to the existing system, we have to face lot of difficulties such as production loss, shutdown/ startup cost loss and resistance from personal towards change.

The efficiency of individual equipment can be improved tremendously by installing energy saving devices like energy efficient Motors, variable speed drives. Hence such devices shall be plant at the initial stages of design itself.

The system shall be designed to ensure maximum flexibility. The flexibility of the system gives better runability/ operation through which Energy Efficiency is increased indirectly. It is required to arrive at an optimal white between standardizing the system and the actual

reality. Similarly design may be as per the actual requirement and may not be an over design. These aspects are to be resolved at the design stage and the most suitable economic option is to be adopted. The design cell emphasizes more on the overall life cycle cost rather than on initial investment alone.

In order to achieve the above efficiently, any new project proposal shall be viewed from the energy prospective at the design stage. It is better to involve an expert in energy conservation field in the design team and get the proposals scrutinized. Though, this may involve some additional cost, the benefits we can reap out of this over a long run will sure it be more than the incremental expenditures. Thus adoption of energy conservation at design stage is the best approach for an energy efficient design.

3. Energy Efficient Motors

Motors are the workhorses of an industry. About 70% of the energy consumed is used for driving electric motors. And implementation of Energy Efficiency in Motors gain considerable importance as it has a huge potential for energy savings. Thus use of energy efficient Motors assumes high-priority.

3.1 Principle of energy efficient Motors

The high efficiencies are achieved in Motors by

- Iron loss reduction
- Copper loss reduction

The iron losses are reduced by way of switching over to beta material which has low magnetic losses. The operating flux density of the material is reduced.

The copper losses are reduced by increasing the cross-sectional area of the copper. This could lead to subsequent increase in slot area.

The above modifications lead to increase in the stator yoke. Hence the rotor diameter reduces the torque output and hence the core length has to be proportionately increased to maintain the required torque.

3.2 Efficiency characteristics

The efficiency characteristics of a motor are essentially the variation of efficiency at various loads.

The characteristics are very important from energy conservation point of view considering the following facts:

- Motors are selected for the maximum possible load conditions.
- In practice motor operate on an average load of around 75%.

Thus the energy efficiency of motor operation largely depends upon the actual load that is being operated.

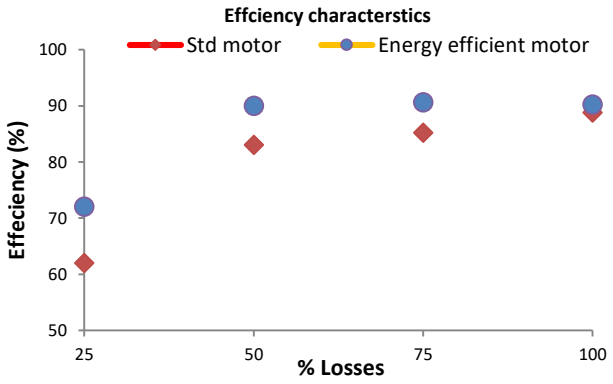

Fig.1 shows typical efficiency characteristics of a standard motor and an energy efficiency motor.
From the efficiency characteristics it can be seen that for a standard motor the efficiency is lowest at lower loads. Up to 50% load there is a steep increase in efficiency. From 50 % to 100% load the efficiency increases at a lower slope.

Since most of the motors operate at an average rate of 75% the standard motors are seldom operated at its maximum efficiency resulting in poor energy efficiency.

On the contrary the efficiency of energy efficiency motor is a flat one. This implies that the efficiency is almost the same from 50% load to 100% load and is higher than the standard motor at any point of load. Thus there is a considerable energy saving while using energy efficient motors.

3.3 Economics of energy efficient Motors

The energy efficient motors requires more copper more lamination for longer code length high grade laminations for low loss and sometimes maybe of higher frame size when compared with the standard motor. So there is a definite increase in cost of these motors. These Motors are generally price at 15% higher than standard Motors.

Case studies reveal that going for an energy efficient motor is economical when

- The motor operates at partial load most of the time.
- The running hours of the motor are more than 1500 hours per annum.

Typical payback period for employing energy efficient motor ranges from 4 months to 1 year depending upon the average load of operation and running hours 1500 to 5000 hours per annum.

4. Energy conservation in pumps

Pumps are one among the very are few essential machines that serve us every facet of our daily life. It is also one of the major energy consuming activities in the process industry. There is a huge potential of energy saving by study of pumping systems. Thus pumping of fluids deserves your attention from energy point of view.

4.1 Pump characteristics

The most common type of pump used in industries is the centrifugal pump. The important characteristics are:

(i) Head versus floor
(ii) Power versus flow
(iii) Efficiency versus flow

The characteristics is as shown in fig. 2

From the characteristics we can direct the following conclusions:

- With increase in flow the pump head decreases.
- Pumping power required does not drop significantly when operating at lower loads.
- Energy efficiency of the pump initially increases with increase in flow reaches a maximum value and then decreases again.

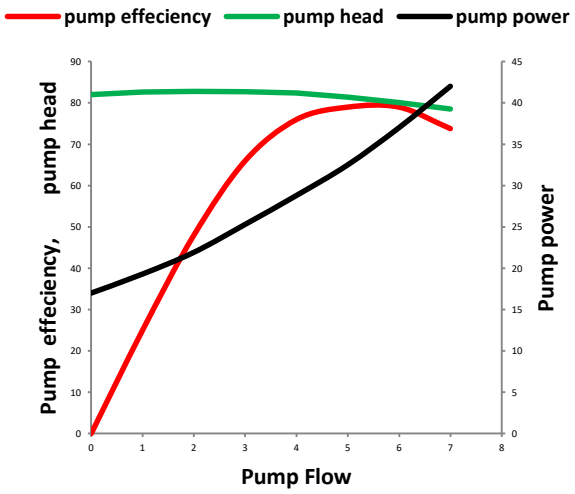

Fig.2 Centrifugal pumps performance characteristics.

4.2 Avenues of energy conservation

It is normally observed that pump operator point far away from the maximum efficiency. This is because the characteristics of the system are not properly matched to be the characteristics of the pump. Open the system characteristics cannot be accurately determined during design stage and pumps are selected with a large factor of safety leading to an over design and hence energy loss.

If the actual requirement is less than the pumping the flow is reduced by throttling the pump. This shifts the operating point of the pump to a higher head. As we can fight from the pump characteristics there is no significant reduction in the input power requirement. Also the operating point is shifted to a lower efficiency region.
The pump characteristics can be altered by the following methods to reduce the input power requirement.

4.2.1 Providing smaller impeller

This method can be adopted if there is a significant scope of reducing the output flow. Also the proposed impeller size matches the existing pump casing. Most number of matching impellers is available from the manufacturer. This will alter the pump characteristics and shift it down to achieve required flow at the required head.

4.2.2 Trimming of impeller

If the flow has to be reduced in marginal quantity is up to 10% the next smaller impeller may not suit the required system characteristics. In these cases the outer diameter of the existing impeller can be reduced by trimming.

The following is the relationship of flow head and power with impeller diameter.

Flow α Dia,
Head α $(Dia)^2$,
Power α $(Dia)^3$

As the relationship of impeller diameter with power is Cubic there is a significant power reduction.

4.2.3 Speed reduction

All the above techniques speak about alteration of pump characteristics without changing its speed. But change in pump speed drastically alters the characteristics. This total shifts the curve to any point.

The following is the relationship of low head and power with pump speed

Flow α speed,
Head α $(speed)^2$,
Power α $(speed)^3$

Again there will be a drastic power reduction because of cubic relationship.

Speed reduction can be a permanent nature like changing of pulley, gear-box ratio etc or by replacing a prime mover of suitable lower speed. A variable speed drive may also be employed.

5. Variable speed drives

AC variable speeds drives make it possible to measure the motor speed to the load requirements and avoid all the

losses that otherwise occur. The most effective applications of AC variable frequency drive which can results in a considerable energy savings is centrifugal pumps and fans. All the mechanical ways of achieving flow control adds resistance to the fluid path with respect to power wastage in the form of heat and fiction resulting in poor overall energy efficiency.

The variable speed AC drives alters this speed of the motor in a continuous manner and moreover it this itself to the load requirement. Thus it controls the output flow without adding resistance to the fluid path.

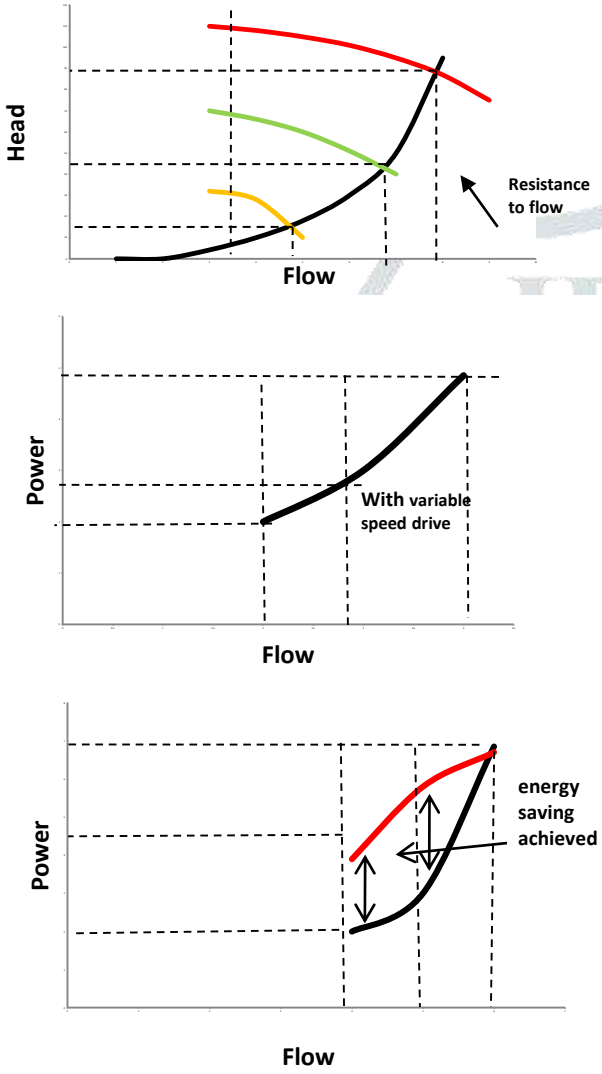

Fig. 3 Pump characteristics

Fig. 3 shows the variation of power input with respect to floor and without variable speed drive. At any given point the gap between the two curves is the energy saving due to implementation of variable speed drives.

5.1 Flow control using speed variation

Variable speed motor drive the pump and the flow reductions are achieved by reducing the speed from in normal speed to the required speed. The pump characteristics shift to a new position for various speeds. Thus operating point of teacher speed forms and you pump characteristic curves with variable speed motor.

5.2 AC drive products

AC drives are the sophisticated power converters and most widely used product for variable speed drives. A modern AC drive as an IGBT (insulated Gate bipolar transistor) inverter selection which is pulse width modulated (PWW). There are also enabled with microprocessor and other facilities to be integrated into an automated environment.

6. Energy recovery

Energy recovery is one area which is normally untouched. But this has a huge potential of energy savings. Energy recovery in a system often involves some modification in the process. This can be best explained with the help of the following examples.

6.1 Energy recovery in sea water Reverses Osmosis System

The sea water reverse osmosis desalination system would serve as a typical example energy recovery can be best employed. The major portion of the energy required what the system is the energy utilized in pressurizing the sea water to the required level.

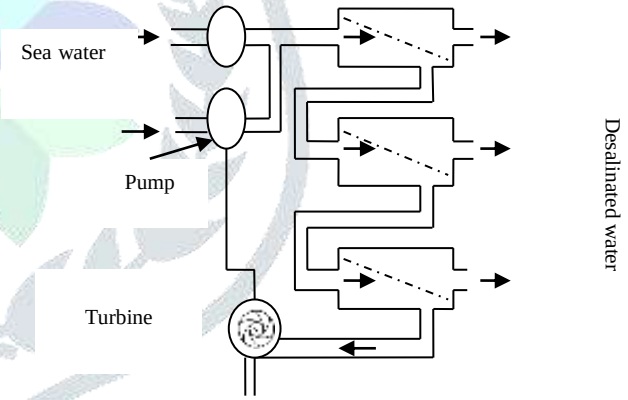

Fig. 4 Energy recovery using turbine

The mechanical energy consumed by the high pressure pump is transformed into heat within the desalination system. Part of the heat is dissipating in water flow through the membrane and part by the water flow through the pressure control valve. Remaining part of the free energy is accumulated busy in the concentrated salt water that leaves system. If this water is let out the system as such, the corresponding among off energy is lost. This energy and principal can be utilized, return back to the system and improves its efficiency.

The above figure presents of system where the pressurized salt water, that leaves the membrane modules, drive an auxiliary high pressure pump that supplies sea water to the membrane modules and reduces the water supply and energy consumption of the first pump. Alternatively the turbine can be mounted on

the same shaft of the high pressure pump and reduce its energy consumption.

As water is practically incompressible it cannot accumulate energy. This property is the basis of a class of devices that exchange pressurized concentrated salt water with the modules with outside sea water. There are many specific designs available but they all operate on the same rotating door principle.

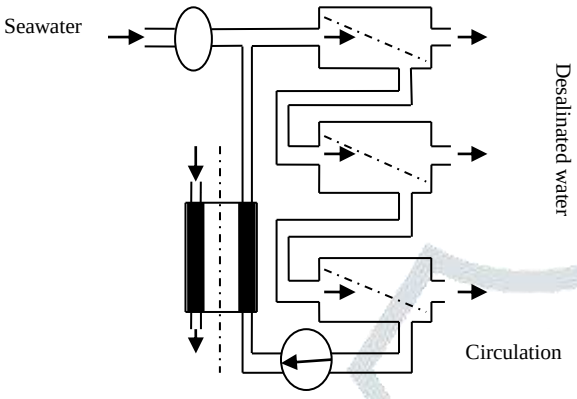

Fig. 5 Pressure Exchange- Schematic

The rotating door has two compartments, one filled with pressurized concentrated salt water and one filled with sea water. The door rotates 180 degrees and exchanges the positions of the two compartments. By that it introduces sea water to the high pressure line of the modules and relieves pressurized concentrated sea water to the sea water line. The seawater in the right compartment now flows towards the membranes and is replaced by another dose of concentrated salt water. The concentrated salt water in the left compartment flows away and is replaced by the fresh sea water. The door then rotates 180 degrees again. The operation involves pressurizing sea water and depressurizing concentrated salt water.

Thus energy recovery system can be efficiently incorporated in the process to make the system highly energy efficient.

7. Energy management systems

The concept of energy management is more or less similar to money management. After all, energy has its direct implication on money. To manage electrical energy efficiently and effectively, it is the primary necessity to have a good energy accounting system. These data are then processed, analyzed and presented in formats that can be readily used for evaluation and decision making.

The energy accounting system is a powerful tool that brings into focus the effectiveness of various operations, indicate if they are in the right direction, point out the areas that need attention and bring to surface the lapses, wastages etc. It helps us to come at the decisions on what to be done for the correction of the above.

7.1 Monitoring

The starting point of energy management is monitoring. Each operation is to be optimized from the energy efficiency point of view. The specific energy consumption, the energy input to a particular system with respect to the unit quantity of output from that system is a good indicator of Energy Efficiency.

The electrical parameters to be monitored all those aspects that contribute to the cost of electrical energy:

- Power
- Power factor
- Energy
- Demand

In addition to the above keeping in mind, the monitoring of electrical systems, voltage, current and frequency shall also be recorded. Each monitoring point will be a note which collects information in its vicinity.

7.2 Control

The basic purpose of collection and Analysis of data disk to optimize energy and envisage savings. Most of the control measures for Optimization have to be implemented online. The central system that requires all the data online is used for decision making based on the data. This provides excellent support for implementing control measures.

A typical control station generally has a personal computer system with all nodes connected to it. A software package controls all the functions like Collection of data, storing of dada, analyzing them and controlling output. Actual control output is generally close to the point of control and monitors the respective operations.

8. Energy audit

Energy audit is a vital link in the entire process of Energy Management. While processing various courses of action and evaluating their consequences, energy audit attempts to balance the total energy inputs with its use and service to identify all the energies streams in the system and quantifies energy usage according to its discrete function.

Energy audit is an effective tool in defining and pursuing comprehensive energy management program. It is positive approach at continuous improvement in energy utilization in contrast to financial audit which stresses to maintain regularity. Energy audit provides answer to the questions- what to do, where to start, at what cost and for what benefits.

8.1 Objectives of energy audit

Energy audit provides vital information based for overall energy conservation program covering essentially energy utilization analysis and evaluation of energy conservation measures. It aims at:

- Identify the quality and cost of various energy inputs
- Assessing present pattern of energy consumption and different cost centre of operations
- Relating energy inputs and production output
- Identifying potential area of thermal and electrical energy economy
- Highlighting wastage in major areas
- Fixing of energy saving potential targets for individual cost centers
- Implementation of measures of energy conservation and realization of savings

8.2 Approach

The overall objective of the energy audit is accomplished by;

- Identifying areas of improvement and formulation of energy conservation measures requiring no investment or marginal investment for system improvement and optimization of operations.
- Identifying areas requiring major investment by incorporating of modern energy efficient equipment and up gradation of existing equipments.

It is evident that for a proper energy audit, it should be looked from a different point of view, rather than as energy conservation. Energy audit is a tool for energy conservation; it is not energy conservation itself. Instead it gives as an energy balance for long term usage.

9. Conclusion

Finally, energy conservation is to be seen not only from the point of cost savings but its impact of environment also. Whatever be the amount of energy be waste, a proportionate quantity of pollution we are creating to the environment some way or the other. The several of energy conservation activities are poor awareness, in correct attitude, insufficient technical know-how, big governmental policies and capital shortages. Hence to overcome the above, we have to have educational and promotional activities, improved legislation, technical assistance, training energy audit and financial assistance for energy conservation proposals.

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