Optimizing Energy Use in Chemical Process Industry

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Cost reduction is a successful mantra used by Indian companies in the wake of global competition. Achieving energy efficiency by totally eliminating energy waste and enhancing process efficiency is a relevant and needed strategy to reduce manufacturing costs.

There are energy intensive areas in a plant and the very process itself that need to be revisited and reworked with gainful opportunes to reduce energy consumption. Indian companies have still a long way to go in this. And there is nothing more effective than learning from a successful company like Atul Ltd in energy conservation. Through their vast experience the author suggests a series of steps to achieve energy efficiencies in a chemical plant. Readers can use these steps and carry the process further.

During the last four decades the induction of energy efficient technologies has lead to dramatic reduction in energy usage in chemical process industries. Due to compulsions from global competition to be highly cost competitive and the awareness thereof, companies are on a drive to reduce costs. Energy consumption in Chemical Process Industries (CPI) is dependent on the products manufactured and process employed. Energy cost in caustic chlorine plant is around 60% of the manufacturing cost. But on an average the energy cost in CPI lies between 10-12 % of the total manufacturing cost. Therefore, energy cost reduction can play a significant role in increasing the profitability of any CPI. On an average the net profit of a company is around 3% of revenue. For companies having utility cost as 10% of revenue, a saving of 20% in utility consumption can result in an increase of profit by 66%!

Energy conservation is many times understood as a cut in energy consumption but actually it is a cut in the misuse/waste of energy. Successful firms concentrate on efficiency first, products second, and then on marketing and sales. Revenue expansion based on efficient operations results in severe operating losses. Successful companies reduce cost to watch existing revenue levels. Unsuccessful companies attempt to increase revenue to cover existing costs.

Methodology of Optimizing Energy Use

1. Measure and benchmark consumption. Compare with globally accepted norms.
2. Carryout energy audit and energy balance.
3. Examine availability of more energy efficient processes and equipment with higher efficiencies. Implement new technologies bringing in a reduction in energy & raw material consumptions.
4. Reduce cycle time by eliminating non-value adding activities.
5. Identify areas of losses and plan methods to reduce losses.
6. Reuse waste, harness waste streams.
7. Replace higher form of energy use by low grade / low cost / renewable energy.
8. Minimize transmission losses.
9. Measure and control.

Areas of energy Optimization in CPI

Boilers & Steam Usage

a. For Solid fuel fired boilers: Convert stoker fired boilers to FBC
b. Optimize excess air. Provide continuous monitoring with auto adjustment of oxygen trim in large boilers and periodical checking in smaller boilers.
c. Preheat combustion air with waste heat
d. Install variable frequency drives (VFD) on large boiler combustion air fans having variable loads.
e. Burn waste stream if permitted, use bio waste like coconut kernel, rice husk, instead of conventional fuels.
f. Recycle condensate.
g. Recover flash steam from higher pressure condensate.
h. Pass steam through back pressure steam turbine rather than through pressure reducing station for low pressure steam.

i. Attend steam leakages and repair damaged insulation.
j. Examine possibility of installation of cogeneration systems (combined electricity and steam generation) / trigeneration system (combined electricity, steam & refrigeration generation)

Pumps

a. Select the right pump to match head and flow requirements.
b. Make maximum use of gravity flow. Avoid intermediate storages to avoid pumping. For circulation system use siphon effect; avoid free fall (gravity) return.
c. Avoid throttling / bypass; to control flow, prefer speed controls or sequenced operation of pumps.
d. In pumping to systems having a number of non-continuous users, auto ON-OFF valves / control valves need to be provided on users and VFD on pumps.
e. Check if pumps are operating near best efficiency points (BEP).
f. Segregate high head and low head loads and install separate pumps.
g. Operate booster pumps for small loads requiring higher heads, in place of operating complete system at higher head.
h. Operator cooling/chilling system with higher fluid differential temperature to decrease flow and hence save pumping energy.
i. Replace old pumps by high efficiency pumps.
j. Trim impellers wherever pumps are over designed.
k. Valve throttling indicates pump over design; replace pump with correct size pump or install lower size impeller
l. Coat hydraulic passages of pumps with resins having better surface finish to reduce internal friction and increase efficiency.
m. Minimize pressure drop in piping by rerouting of pipeline, removing valves, which never need to be operated, and resizing of pipeline.

Process

Process is defined as a systematic sequence of chemical, physical or biological activities for conversion of raw materials into products.

a. Eliminate non-value adding activities.
b. Attempt to reduce cycle time.
c. Increase batch size to get higher throughput with minimal increase in utility consumption.
d. Reduce reflux in distillation by redesigned of column height / replacement by more efficient packings.
e. Reexamine the usage of utilities. Attempt switching over from chilled brine to chilled water and chilled water to cooling water.
f. Examine the possibility of intermittent stirring. Control operation of stirrers by interlocking, providing timers.
g. Examine possibility of speed reduction.
h. Examine switching over from batch to continuous process.
i. Examine correction stages if any. Attempt getting it right the first time so that corrections are avoided. This will reduce utility consumption.
j. Remove redundant piping / equipment from the plant to make all leakages visible and easy to attend to.
k. Find alternatives to electrical heating systems.

Compressed air

a. Clean suction filter regularly
b. Check / Clean intercooler / aftercooler regularly.
c. Attend to suction & discharge valves of reciprocating compressors.
d. Reduce air compressor discharge pressure to lowest allowable setting.
e. Replace compressed air usage by air blowers wherever possible. Use hydraulic system rather than pneumatic cylinders. Use electronic controls in place of pneumatic controls.
f. Check for leakages regularly and attend to them immediately.

g. Install VFD for single compressor operation or control system for coordinating multiple compressor operation.
h. For small compressors (<25 HP) convert from load / unload operation to ON / OFF operation.
i. For compressed air dryers use highest allowable dew point settings. Use refrigerated air dryer if within the operating range or else if desiccant dryer is required used heat of compression (HOC) dryer.
j. Check pressure drops in piping systems, and optimize pipe size / provide ring main system.
k. Check actual free air delivered (FAD) regularly, calculate specific power consumption and rectify / replace inefficient compressors.

Cooling Towers

a. Control CT fans based on cold well temperature; use two speed or VFD if fans are few and on-off stage control if cells are many.
b. Select CT with low pressure drop, high efficiency PVC cellular fills in place of splash bars.
c. Periodically clean, water distribution nozzles. Ensure that no channeling of water flow is taking place. Uniform flow distribution will improve performance of cooling tower.
d. Optimise cooling water chemical treatment.
e. Replace aluminum fans by aerodynamic FRP fans.

Refrigeration Systems

a. Challenge the need of refrigeration system, particularly, for old batch processes. Optimise the temperature requirement.
b. Examine the possibility of vapour absorption system operating with waste heat streams in place of vapour compression systems.
c. Check regularly for correct refrigerant charge levels.
d. Check for damaged insulation / sweating.
e. Select multistage compressors with inter cooling for low temperature applications.
f. Operate chillers with lowest possible condensing temperature and highest possible chiller (evaporator) temperature.
g. Carryout regular cleaning of condenser to ensure proper heat transfer.

Lighting

a. Select high efficiency lighting luminaries having highest lumens / watt output. eg. Compact fluorescent lamp (CFL), low pressure sodium vapour lamp.
b. Provide lighting transformer to reduce the voltage of lighting loads.
c. Make use of task lighting.
d. Make most use of day lighting by providing skylight.
e. Paint walls and ceiling with light colors.
f. Lower height of light fixtures.
g. Control lighting with clock timers, occupancy sensors, photocells and master switch.
h. Select ballast with high efficiency and high power factors.
i. Use LED lamps for indicating purpose.

Fans & Blowers

a. Select fans with aerofoil fan blades; replace old inefficient fans by modern high efficincy fans / blowers.
b. Ensure that design of fans / blowers are matching with operating conditions if not replace with correct size fan / blower.
c. Replace throttle / bypass control by speed control.
d. Minimize speed to minimum possible.
e. Reduce pressure drops in system by proper design / sizing of ducting. Minimize bends in ductings.
f. Eliminate leakages.
g. Clean screen, filters, fan blades regularly.
h. Avoid idle running of fans by interlocking with main equipments.

Motors

a. Properly size the motor for the optimum efficiency.
b. Use energy efficient motors for continuous operating loads.
c. Balance three phase loads. An imbalanced voltage can reduce efficiency of motor by 3-5%.
d. Connect motors remaining under loaded (< 40%) continuously, in star.
e. Rewound motors should be checked for efficiency.
f. Provides capacitor banks at MMC to correct PF.
g. Use soft starters / VFD instead of fluid coupling for loads having high starting torque or loads prone to jamming.

By following the above proven approach that is simple and easy to implement any organization can save substantial energy and tap the potential for improving profit margins, which the entire chemical process industry is striving hard to achieve. It is mandatory for all registered companies to include, as a part of the director's report, the energy conservation measures taken and the additional measures being implemented.

Many readers working in chemical process industries would certainly be aware of some or all of these steps; many may be aware but not attempting to put this into effect and many others may not be aware of how much these measures can be really help in reducing energy costs. The authors fell that readers can use these as clues to further work on these areas and attempt for higher energy efficiencies.

The author will be very happy to share their experience on the subject for mutual benefit.

Editor's Note

Atul Ltd, a member of 2500 crores Lalbhai Group, setup in 1947 on the banks of River Par in Valsad District of Gujarat State, 200 kms north of Mumbai, has received seven awards for energy conservation, from different institutions like the Government of India, Federation of Gujarat industries, ICMA, International Greenland Society.

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Reference Book:

Chemical Industry Digest
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