Invited paper

ENERGY MANAGEMENT IN SMALL AND MEDIUM SCALE INDUSTRIES: HOW TO SAVE FUEL AND ELECTRICITY

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Abstract:- This paper is aimed at showing how to save money through Energy conservation. It has been shown that an effective Energy conservation programme could reduce a factory's Energy bill by 30 -40 % with very good return on investment -- often less than 4 months. It has also been shown that for many industries in developing countries, the value of the savings are equal to the total cost of salaries of all employees.

INTRODUCTION

An Energy conservation program should comprise of the following points:

* A company conservation policy- that is: it is required that the company management understands that Energy conservation is aimed at saving money, and they should make it known that Energy saving is company policy.
* The entire Energy conservation program should be made a responsibility of one capable person with access to a budget and with sufficient authority.
* An Energy conservation audit should be conducted to establish a base from which future savings can be measured.
* A plan of action should be produced and the Energy conservation work begun.
* The program should be regularly reported, the results and the program updated.

THE ENERGY AUDIT AND YOUR COMPANY

An audit of any kind needs to be expressed in measurements, and since Energy costs money, the final form of an Energy audit will normally be expressed in Energy and money units.

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This proposal should therefore be aimed not only at the managing director but also at the management accountant and the engineer who ideally should work together to produce the audit for presentation to top management.

WHY HAVE AN ENERGY AUDIT

Energy can be a significant cost in your company and it is essential that it is used efficiently. An Energy audit will help you to understand more about the way Energy and fuel are used in your factory and help identify areas where waste can occur and where there is scope for improvement. It is a normal practice in a company to carry out financial audits- for example, budgetary control, cash - flow data and annual accounts. An audit should include an attempt to balance the total input of Energy with the use.

WHAT IS AN ENERGY AUDIT

An Energy audit is a critical examination of an Energy consuming facility. Typical objectives of conducting an audit are to set Energy conservation goals, develop Energy standards, identify and analyse Energy saving opportunities and to establish an accounting and reporting system.

HOW TO CONDUCT AN ENERGY AUDIT

PHASE 1 - An Audit of Historical Data

Collect and analyse company records of Energy use to determine :

* The cost and physical quantities of Energy inputs used.
* Annual and seasonal trends in Energy use and cost.
* The Energy use per unit of output.

PHASE 2 - The screening survey

Undertake a screening study of Energy use in the operation. This will be a fairly quick, low cost preliminary investigation of an operation using existing data to indicate,

* Major Energy consuming plant and processes
* Obvious Energy waste and inefficiencies.
* Gaps in the metering and reporting of Energy use.
* Priority areas for further investigation of inefficient or inappropriate Energy system.

PHASE 3 - Detailed Investigation and Analysis

Processes or plant identified by the screening survey as justifying further investigation, will have to be examined in order to determine the size of avoidable Energy losses and the cost of reducing this waste. Detailed surveys may incur considerable cost and/or time. Therefore, it is vital to select only those processes, areas or plant, which are more likely to yield significant cost savings for a reasonable effort. A check-list of information required to undertake an Energy audit is listed below:

* Energy consumption and cost details for the past twelve months (or last financial year etc.)
* Requirements in physical units i.e. liters of Oil, MJ of gas, kWh of electricity etc.
* Requirements for each month or quarter to show variation and for each metered area, if available.
* If Energy consumption details are not available, purchases of Energy will suffice (effect of stockpiles and storage can cause differences)
* A copy of accounts of past twelve months showing consumption, tariffs and calculations of costs. This enables tariffs and contracts to be critically examined to ensure the most favorable conditions.

Energy consumptions, costs and output levels for past years enable trends to be noted in total Energy use and costs as well as the trends in the Energy use (and cost) to produce audit of output.

* Energy system details- Layouts of buildings and Energy systems (site plans) showing location of buildings, names, functions, orientation and distances.
* Materials of construction of buildings (eg. double brick) insulated areas, approximate floor areas, air conditioned and evapourativelyoled building areas.
* Recirculation systems (pipe work layouts) for steam, hot water (space heating) chilled water, compressed air, condensate return, electricity, water (it is a good idea to use separate overlays for each system)
* Location of plant rooms, switchboards and meters.
* Location of major items of equipment, e.g. boilers compressors, air conditioning plant, transformers, ovens.

List Of Energy Equipment

* For each major item of plant give type of equipment, name of equipment, capacity, location, usual hours of operation, usual output and usual consumption.
* This equipment should include the large electric motors, fuel burning equipment, air conditioning plant (including reverse cycle units), standby generators, waste disposal equipment and computers..

If 35% of the Energy bill is saved by implementing an Energy conservation program, then the housekeeping improvements will comprise 30% of the total savings, process improvements 40% and waste heat recovery and new plant the final 30%. The earliest and cheapest to achieve is the housekeeping improvement. Pay back periods for housekeeping improvements are very short (often less than 4 months).

HOUSEKEEPING

Housekeeping improvements are easy;in many cases, the plant engineer or maintenance supervisor is aware of the problems but unaware of how much Energy, therefore money, is lost because of them. Also the pressure of production problems and breakdown repairs which are usually immediate, puts the other problems into the background. However, efforts must be made to ensure recognition that Energy is also a contribution to company profit.

A selection of some of the most commonly encountered housekeeping areas are given overleaf:

STEAM SYSTEMS

Steam is used in a large number of industries, but has also been found to be very wastefully used. In many steam systems, 20% of purchased fuel is wasted because steam is not used correctly.

A survey in Asian countries covering food, textile, wood, paper, chemical and metal industries has shown that the amount of Energy lost was between 10% and 24% of the cost of the fuel purchased. Corrections to the system had been easy and low in cost, returning the investment, in most cases, within six months.

Steam system losses

BY NOT RETURNING CONDENSATE	UP TO	20
FAULTY STEAM TRAPS	UP TO	15
PIPE LOSES	UP TO	10
LEAKS	UP TO	5
BOILER COMBUSTION EFFICIENCY	AVERAGE	3

The above table shows the groups that have been found to be the major areas of loss and indicates the amount of that loss as a percentage of total fuel.

To gain the quickest money saving however, it is always better to take action in the reverse order. That is, start by ensuring that the boiler air fuel ratio is properly adjusted.

Boiler house

Improved efficiency in boiler operation and savings in fuel will result from:

* improved combustion efficiency
* improved heat transfer on both water and fire side
* correct blowdown procedure
* burner maintenance
* minimising casing losses.

Improved Combustion Efficiency

If more air or fuel than is required for complete combustion is allowed in the boiler, fuel is wasted. Maintain combustion efficiency for each boiler, about 83% for oil firing and 79-81% for gas.

Improved Heat Transfer on both Water and Fire Side

Over a period of time, especially with heavier fuels, there will be a build up of sooty deposits on fire side heat transfer surfaces. This will cause a high fuel side temperature. Every 15 deg C rise in fuel temperature results in about 1% decrease in combustion efficiency.

Boiler feedwater must be chemically treated to prevent the build-up of solid (scale) deposits on waterside surfaces. The effect, however, is not as drastic as fireside build up and tube failure will occur due to overheating of tubes before efficiency is badly affected.

If waste treatment is poor, the result is poor efficiency and reduced system life. Remember that the cheapest water treatment is to returning condensate to the boiler. You have already paid for it.

Correct blowdown control

Blowdown (the purging of hot water from the boiler) removes sludge which, if not removed, will lead to the carry over of solids and many other problems. Remember that blowdown means waste of valuable Energy (hot water). A correct blowdown procedure should be adopted to avoid unnecessary wastage of Energy. Return as much condensate as possible - it is pure distilled water. If all the condensate is returned, the need for blowdown is drastically reduced and so are the losses.

Burner Maintenance

Poorly tuned and maintained burners and fans will result in a flame that will not suit your boiler, and cause fuel wastage.

Casing Losses

A fire tube boiler will waste around 4% of its maximum fuel input from its hot outside surface. If the boiler insulation is allowed to deteriorate or has been damaged, losses will be higher. Losses of about 4% of maximum boiler capacity may occur.

STEAM DISTRIBUTION SYSTEMS

Fuel cost savings can be achieved by correct design and maintenance of your steam distribution system.

* Steam/fuel metering
* Measure your fuel input and steam consumption by your factory regularly and keep a record. This will enable you to find out actual efficiency of your boiler and to monitor the performance of steam -using equipment and processes.

Steam quality

It is important that steam is free of liquid water when it is delivered to the process. Poor steam quality causes decreased process efficiency. Correct quality of steam could be obtained by having pressure reducing valves installed in proper places.

Layout and drain points

Make sure your steam pipes are correctly sized. Larger than necessary pipes cost and waste more. However, under-sized pipes can cause excessive pressure losses in the system. A correctly installed system should slope away from the boiler to adequately sized drain pockets.

Insulation

Poor insulation is a very common cause of waste. For example, a bare 2 inch steam pipe at 150 deg C will waste about Rs. 700/- per meter per year. (at 3000 hrs operations annually and at Rs. 19/50 per gallon of fuel).

Leaks

Repair all leaks as soon as possible. Even small leaks are costly.

STEAM UTILIZATION

You have gone through a lot of trouble to deliver good quality steam to the process. Don't stop there. Ensure it is used in the process as efficiently as possible. There are several areas where improvements can be made;

* Removal of air from the steam system
* Correct temperature control
* Correct operation of steam traps
* Insulation of process equipment
* Flash steam recovery where possible

Programmed plant usage will minimize peak steam loading and enable the minimum numbers of boilers to be used. Don't start all your processes at the same time, as this also contributes to peak demands.

CONDENSATE RETURN SYSTEM

Return of condensate

Wherever possible, return steam condensate to the boiler house. If there is a danger of contamination, install conductivity sensing equipment which will act to dump contaminated water to the sewer until the source of contamination is located.

Returning condensate is potentially the source of greatest saving as it is often the area of greatest abuse. Not only does condensate at 100 deg C contains, 25% of the Energy needed to make steam at 700 kPa but is also pure distilled water.

An efficient condensate return system saves on water costs. This adds up to big money savings.

Every 7 deg C increase in feedwater temperature saves 1% of boiler fuel costs.

COMPRESSED AIR SYSTEMS

On average, 10% of the electricity consumed in industry is used to compress air. Air leaks and abuse of compressed air can easily go unnoticed. These can, however, combine to waste up to 40% of all compressed air produced.

If you have a fluctuating load, check the compressor efficiency at low loads. If a screw compressor is installed, it should be used at full load to supply the base load with a reciprocating unit handling load fluctuations. Note however that the full load efficiency of reciprocating compressors is greater than that of the screw compressors.

Ensure that the compressor is not drawing hot air. Reducing inlet temperature by 15 deg C increase the mass of air delivered by 5% for the same electrical input.

Adequately sized receivers (1 to 15 litres for every 10 litres/sec air delivered) are important in reducing peak demands on the compressor. A large receiver will enable a smaller compressor to deal with higher peak demands.

Fixing air leaks reduces the Energy consumption of the compressor plant to save money. It may also mean you don't have to buy a new compressor plant to meet an increased demand if new equipment is installed.

LIGHTING SYSTEMS

In industrial plants, lighting may be only a small part of the Energy load. Checks should be carried out to see if improvements can be made for Energy efficient lighting. Decide first what lighting levels and quality are required for the job. Good lighting should be adequate in quality and quantity for the job but not excessive. Many areas have too much of light.

A good lighting design depends on three main points:

* Selection of the most efficient lamp suited for the job.
* Environmental factors such as interior wall colour, window, reflection,glare etc.
* The ability to switch off lights when not in use, or when not required.

ENERGY SAVINGS IN ELECTRIC MOTORS

Savings can be made by improving the efficiency of electric motors. Even though the Energy savings may be relatively small due to the high efficiency of electric motors, the high cost of electricity turns small Energy savings into big money.

As a first step in Energy cost saving, carry out a motor survey, listing all motors, their name plate rated power use, actual or estimated power use, drive type and annual operating hours.

FURNACES AND KILNS

Determine optimum operating temperatures, loading characteristics and cycle times.

* Upgrade furnace structure and insulation
* Improve sealing of doors and openings
* Investigate most suitable burner types
* improve air/fuel ratio control
* Improve temperature control

OVENS AND DRYERS

* Optimum loading characteristics and operating temperatures
* Reduce exhaust rates
* Improve insulation
* Consider direct heating
* Investigate mechanical drying methods

WASTE HEAT RECOVERY

Although the potential savings from waste heat recovery are high, they are often subject to large capital investment with pay back periods of between 2 to 5 years.

The methods of evaluating the potential savings for waste heat are identical to those for process efficiency. That is, detailed Energy balances should be carried out on the equipment to determine the heat available.

Potential areas of waste heat recovery are very dependent on the nature of the industry and the way that Energy is used in the plant.

ELECTRICAL SYSTEMS

Electrical Energy is the most expensive form of purchased Energy. For this reason, its use must be confined to the minimum for efficient operation.

Conservation opportunities

* Demand control through load shedding
* Correcting power factor
* Turning off unnecessary equipment

Demand control through load shedding

Maximum demand control requires knowledge of when electrical load demand occurs and how equipment is operated. Some of this information can be determined from load factors, and some from the inventory.

Savings from shedding electrical loads are calculated from the actual kilowatt load shed. For example, if a 10 horse power motor with an efficiency of 85% is shut off, the savings would be approximately 8 kilowatts.

The pay back period will depend on the amount of demand that can be cut during the peak period.

Correcting power factor

Power factor is a term that relates to AC electrical systems only. In a system of alternating voltages and currents, power factor is defined as the cosine of the phase angle that exists between the voltage applied to a circuit and the current that flows through the circuit. Hence power factor is a number whose value ranges from zero to plus or minus one. A large proportion of the electrical machinery used in industry has an inherently low power factor. This means that the utilities have to generate more current than is theoretically required. In addition, transformers and cables have to carry this extra current. When the overall power factor of a generating station's load is low, the system is inefficient and the cost of electricity is correspondingly high. Machinery or equipment with a low power factor include:

* Induction motors of all types
* Power transformers and voltage regulators

For inductive loads, the power factor is corrected towards unity by placing capacitors across the input lines feedings the electrical equipment. The capacitors can either be of fixed-value commercially available capacitors, or three phase synchronous motors with their fields appropriately excited to achieve the desired power factor.

Power factor correction should always be regarded as an investment with two main objectives;

* Reducing electrical costs.
* Freeing transformer, cable and switch gear capacity.

Mr. Newton Samarakoon obtained his BSc in Engineering from University of Ceylon and MAppSc in Fuel Engineering from University of New South Wales, Australia. Since graduation, he has received training on Energy Management in South Korea, Japan, Finland and Australia. He has undergone the EDMAC Energy Training Course of the Ministry of Power and Energy, Sri Lanka in 1983 and has subsequently involved in organising and conducting this course under the auspices of SLEMA.

Mr. Samarakoon has worked in the steel industry for 15 years and recently resigned as Chief Mechanical Engineer and Energy Manager of the Ceylon Steel Corporation, Sri Lanka. Presently he is a Senior Consultant/ partner of Erandi Engineering Services, Colombo, Sri Lanka, an Energy Management and Engineering Company. His specialised areas are in Energy Auditing, steam generation/distribution and furnace design/operation. He has designed, installed and commissioned steam distribution systems and condensate recovery systems in several major industrial plants. He is also the Energy Management and Engineering consultant to many major industries in Sri Lanka. He has several publications to his credit in the field of Energy Management. He has also undertaken the installation and commissioning of both solid fuel and oil fired boilers in many industries. His research interests are in the area of combustion of low calorific value fuels.

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