Saving energy with

Steam Production and Distribution

Maxi Brochure 13

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CENTRE FOR THE ANALYSIS AND DISSEMINATION OF DEMONSTRATED ENERGY TECHNOLOGIES

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CADDET Energy Efficiency
PO Box 17, 6130 AA Sittard
The Netherlands
Tel.: +31-46-4202224, Fax: +31-46-4510389
E-mail: caddet@caddet-ee.org
Internet: http://www.caddet-ee.org

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Summary

Providing steam for process and space heating applications is one of the main energy costs at industrial sites and factories. Steam costs are also a major contributor to energy bills in building complexes in other sectors. Steam is used for heating and process work as it is an ideal carrier of heat. Its three main advantages as a heat transfer medium are as follows:

- it transfers heat at a constant temperature – extremely useful when dealing with heat sensitive materials;
- the temperature of steam is dependent upon the steam pressure – resulting in a simple method of temperature control;
- it is compact in terms of heat content per unit volume – this means that heat can be conveyed in simple piping systems.

The boiler has tended to be ignored as long as it produces hot water and steam reliably and safely. Additionally, steam is often used carelessly, resulting in systems becoming poorly maintained and thus inefficient. Even in the best regulated establishments there is bound to be some unavoidable wastage of heat, but allowing for this comparatively small loss, the rest of the heat should be properly utilised. A 10% energy saving could be achieved by improvements in the design and operation of boilers and their distribution systems [1].

This Maxi Brochure examines ways of improving the efficiency of steam heating systems. It includes an investigation into:

- when steam can be used in place of oil or hot water systems;
- the treatment of feedwater;
- improving boiler efficiencies;
- optimising the lay out and elements of a distribution network;
- a list of energy-saving measures.

The target audience for this Maxi Brochure is any organisation who wishes to make best use of their existing steam generation and distribution system. The efficiency of the entire system can be significantly increased by the introduction of a selection of the measures discussed below.

Potential for energy savings

USING STEAM INSTEAD OF OIL OR HOT WATER SYSTEMS

Steam is used generally for large industrial process heating. It is traditionally utilised as the distribution medium for space heating only on larger sites, in which there are long pipework lengths. Often a site has both steam and hot water for space heating via non-storage heating calorifiers.

The main attraction of steam for industrial users with a diversity of heat requirements is its versatility. This is particularly true for sites where the release of heat at constant temperature or the advantage of direct injection of steam into a process is a major benefit.

Steam has various advantages in that it is produced from water, which means that it is clean, colourless and tasteless which makes it a relatively cheap and plentiful heating medium. Steam has a very high heat content, which results in smaller diameter pipework carrying a greater amount of heat relative to water at the same pressure. Its ability to release its heat at constant temperature is particularly advantageous in critical process operations where it can simplify plant designs. It can be readily distributed and easily controlled, allowing it to be made available to new users simply by extending the steam distribution system without having to consider pumping and flow balancing. It is sterile, making it the first choice for sterilisation and humidification duties, this also means that it can often be used over and over again. However, not all of these advantages are relevant when comparing a steam system with pressurised water systems.

The disadvantage of steam is that it is distributed under pressure which means that leaks in the system can prove to be very costly if not attended to. This is also true of equipment failure such as steam traps in which if failed open, steam will vent freely but if failed closed will not provide the heating requirements and there will be additional concerns over safety.

There is a need for a high standard of maintenance and good operating procedures to be implemented and adhered to in instances where steam is generated, distributed and used. If there is no such commitment, expensive equipment will have to be installed to automatically control steam production and distribution. In many cases, even with good procedures in place, the installation of additional control equipment is becoming standard.

Efficient and effective use of the by-products of a steam system can greatly increase overall performance. In operations that require the use of steam as an integral part of a process, every effort should be made to make good use of the energy still remaining in the relatively high temperature steam and water.

Hot water systems

A hot water system uses a pump to circulate water around a closed pipe circuit. For overall efficiency, simplicity and costs, the use of hot water at a variety of pressures makes it the best choice when steam is not a necessity due to process considerations.

Low pressure hot water (LPHW) systems

With LPHW systems, a high level feed tank (or pressurisation vessel) allows for thermal expansion while a boiler provides heat.

LPHW systems have various advantages. The surface temperature of the heat exchangers is low (<85°C) and therefore there are minimal safety concerns as regards personnel contact with the heat transfer media. The use of liquid at low pressure means that hot water leaks are rare, more obvious and more easily dealt with than steam leaks. With limited or no losses, water treatment is minimal. Apart from heat losses from distribution pipework, all the unused heat is returned to the boiler house. The lower operating temperatures and pressures combine to give a low-cost easily maintained system.

The disadvantage of LPHW systems is that at atmospheric pressure, 90°C is the practical flow temperature limit without the risk of local boiling in the boiler heat exchanger.

High temperature hot water (HTHW) systems
To utilise the advantages of hot water, systems can be designed to operate at higher pressures and temperatures. In larger systems, pressurisation is most simply achieved with gas bottles feeding a pressurisation/expansion vessel, e.g. hot water at 10.5 bar gauge (barg) can flow at 170°C around a heating circuit.

Pipework sizes for supplying comparable amounts of heat at the same temperatures favour the use of steam. However, this is not the only consideration when comparing the pipework costs of the two heating media.

The advantage of HTHW systems is the lower capital costs in the boiler house and in the distribution system. The disadvantages include operating costs, for example, the electrical running costs associated with pumping the water around the circuit are higher than feed pump requirements for steam. In a large water system, pumping costs can be substantial, whereas steam in well-insulated pipes can travel unaided for several kilometres.

Demineralisation is recommended for high-pressure, hot water systems. This can be expensive for large system fills. There is a need to balance flows in parallel hot water circuits, as water flows through parallel circuits, it always finds the path of least resistance. Hence some circuits can find themselves with too low a flow and insufficient heat delivery. Hot water systems are generally simpler both in design and operation; they are therefore the usual choice for most space heating systems for domestic and much larger requirements.

Hot oil systems

These are occasionally selected as the heat-carrying medium, mineral oil being a typical choice. The application of thermal fluid systems is limited to compact process heating arrangements where higher temperatures (200-400°C) are required. Their use for space heating, or other duties where hot water or medium pressure steam can be used, cannot normally be justified.

Their advantage is the high operational temperatures that can be achieved without the high pressures required by steam systems.

The disadvantage of oil is that it is considerably more expensive than water to purchase and is

	Steam	**HTHW**	**Hot Oil**
Heat content	High (approx. 2,100 kJ/Kg)	Moderate (Specific heat = 4.2 kJ/kg°C)	Low (Specific heat = 1.6 kJ/kg°C)
Source cost	Cheap, but some water treatment	Cheap (only occasional dosing)	Expensive
Heat transfer coeficient	Good (Relative = 1)	Moderate (Relative = 0.6)	Relatively poor (Relative = 0.3)
Circulating pump required	No	Yes	Yes
Pipework size	Small	Large	Large
Pressure needed for high temperature	High	High	Low
Flash loss problems	Yes	No	No
Corrosion problems	Possible	Less Likely	Unlikely

Table 1: Important features of different heating media.

Figure 1: Checking water treatment control system.

potentially more dangerous to personnel and damaging to the product or the environment if a leak occurs.

Good design, through fully-welded pipework systems and safety systems such as inventory monitoring, will mitigate these risks. Unless heat recovery equipment is installed, fired heater efficiencies can also be low since the flue gas temperatures are high. **Table 1** compares and summarises the features of the three heating media [2].

FEEDWATER TREATMENT

Good water treatment practice is essential for the energy efficient operation of boilers and hot water heaters. The impurities present in natural water lead to corrosion, deposition and steam contamination. A good water treatment programme involves setting target values for operating parameters such as pH, alkalinity, total dissolved solids (TDS), hardness and monitoring to ensure these targets are achieved. In addition to energy savings, a good water treatment regime will reduce water, chemical and maintenance costs [3].

There are two types of water treatment – external and internal. External treatment involves using engineering plant to modify or remove problem impurities from the raw water before it enters the boiler system. Techniques include ion exchange, reverse osmosis and de-aeration. Internal treatment involves adding chemicals directly to the boiler water to modify the water chemistry and thus prevent scale formation and corrosion. Some water supplies may require the combination of both external and internal treatment to produce the optimum boiler water chemistry for energy efficient operation [3 & 4].

IMPROVING BOILER EFFICIENCY

Boilers should have an operating efficiency above 75% (Gross Calorific Value), if they do not then action should be taken to improve this. The efficiency of steam generation is defined as the proportion of the calorific value in the fuel that is converted into steam output [1].

Efficiency (%) =
heat in steam/heat added as fuel

It is more relevant to determine the overall boiler house performance when assessing the operating cost. This can be influenced by many factors, including losses from boiler blowdown, use of standby boilers, low-load operation and energy losses within the boiler house itself. In addition to the methods already discussed, the following additional energy saving techniques have been identified.

Optimise combustion conditions

- Check combustion conditions regularly, or monitor and control them automatically.
- Aim to minimise flue gas oxygen without producing excessive levels of carbon monoxide or a smoky stack.

Improve operating procedures and sequential boiler controls

- Reduce standing losses and losses associated with operating at low loads.
- Use sequential switching on/off of boilers in response to load.
- Eliminate boilers on hot standby at full pressure.
- Minimise the number of boilers in service.

Install flue gas isolation dampers

- Reduce standing losses by preventing air being drawn through the boilers when it is not firing.
- Alternatively fit an isolation damper on the air inlet to the combustion air fan [5].

Optimise the lay out and elements of a distribution network

Providing steam for process and space heating applications is one of the main energy costs at industrial sites and factories throughout the UK. Steam costs are also a major contributor to energy bills in building complexes in other sectors.

The cost of steam distribution is determined by the energy losses in the steam system and the operating regime at the site. Average savings of 8% are possible by improving the efficiency of steam distribution.

The measures shown in **Table 2** are recommended as minimising steam generation and distribution costs. The measures are generally technically simple and relatively low-cost and should provide an attractive return on investment.

These measures could include: improving or extending insulation; returning more condensate; isolating unused piping; improvements to steam trapping; reducing steam leaks etc. It may even be advisable to decentralise the energy supply system if the energy utilisation is very low [2].

Technique/method	Energy saving potential (%)
Condensate recovery	2
Flash steam recovery	<3
Boiler blowdown heat recovery	<3.75
Feedwater treatment	2
Improving boiler efficiency	<5
Optimising the lay-out and elements of a distribution network	<8

Table 2: Opportunities for saving energy.

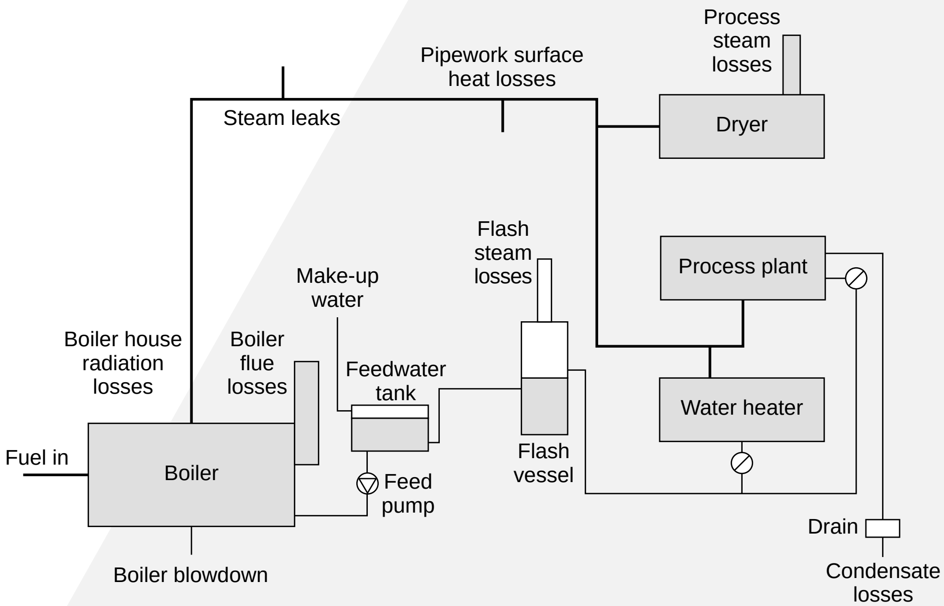

Figure 2: A simple steam system showing main areas for improving energy efficiency.

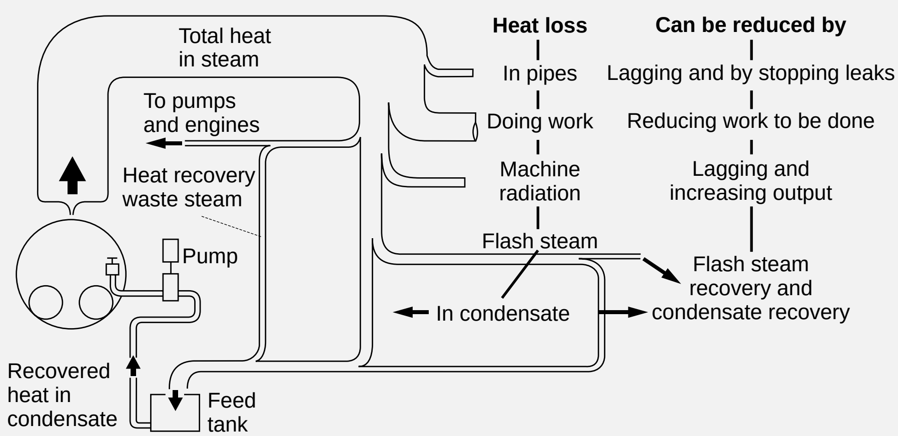

Figure 3: Where the heat goes and what can be done to reduce losses [15].

Energy saving measures

It is recommended that you consider the following questions when planning or changing a steam installation [16].

Monitoring

- Is the steam used by each department metered?
- Is a regular check being made on the amount of steam used by each department?

Good design

- Are steam mains properly sized, well laid out, adequately drained and correctly vented?
- Is the steam being used at the correct pressure?
- Is adequate provision made for expansion?
- Can separators be used to improve steam quality?
- Are there leaking joints and glands, or leaking valves and safety valves?

Preventing heat loss

- Are all steam pipes, flanges and valves insulated?
- Can bare process plant surfaces be insulated?
- Are draughts allowed to chill hot rooms or heated surfaces?
- Can redundant steam piping be blanked off or removed?

Good operation

- Is the mechanical removal of moisture being efficiently done before drying by heat?
- Is the material pre-heated by waste heat before processing, if this is practicable?
- Is the process plant loaded as much as possible and the idle time when hot cut to a minimum?
- In hot air dryers, is air recirculated to the maximum extent and excess cold air infiltration avoided?

Steam quality

- Are process temperatures controlled?
- Are process steam pressures higher than they need to be?
- When liquids are heated by direct steam injection, is the steam pressure as low as possible?
- Is the steam supplied to the process plant as dry as possible?
- Are peak loads inevitable and if so, is the boiler house given adequate warning?
- Can peak processes be staggered?

Effective trapping

- Is the correct type of steam trap used for each application?
- Are steam traps correctly installed and regularly maintained?
- Is each trap protected by a strainer and followed by a sight glass?
- Are by-passes fitted around steam traps only when essential and are they correctly used?
- Are traps which can be damaged by freezing insulated when fitted in exposed positions?
- Is each steam space properly air vented for maximum output and even heating?
- When condensate is lifted directly from steam traps, can output be improved by gravity drainage to a receiver from which a pump can lift the condensate?
- Are check valves fitted after the traps when necessary, especially if the condensate is lifted directly to an overhead return?

Flash Steam

- Is flash steam allowed to blow to waste?
- Can flash steam heat be used in a low pressure plant, for pre-heating cold material, for heating water or can it be returned to the boiler feed tank?

Condensate

- Is any condensate needlessly wasted?
- Are condensate return systems and feed tanks insulated?

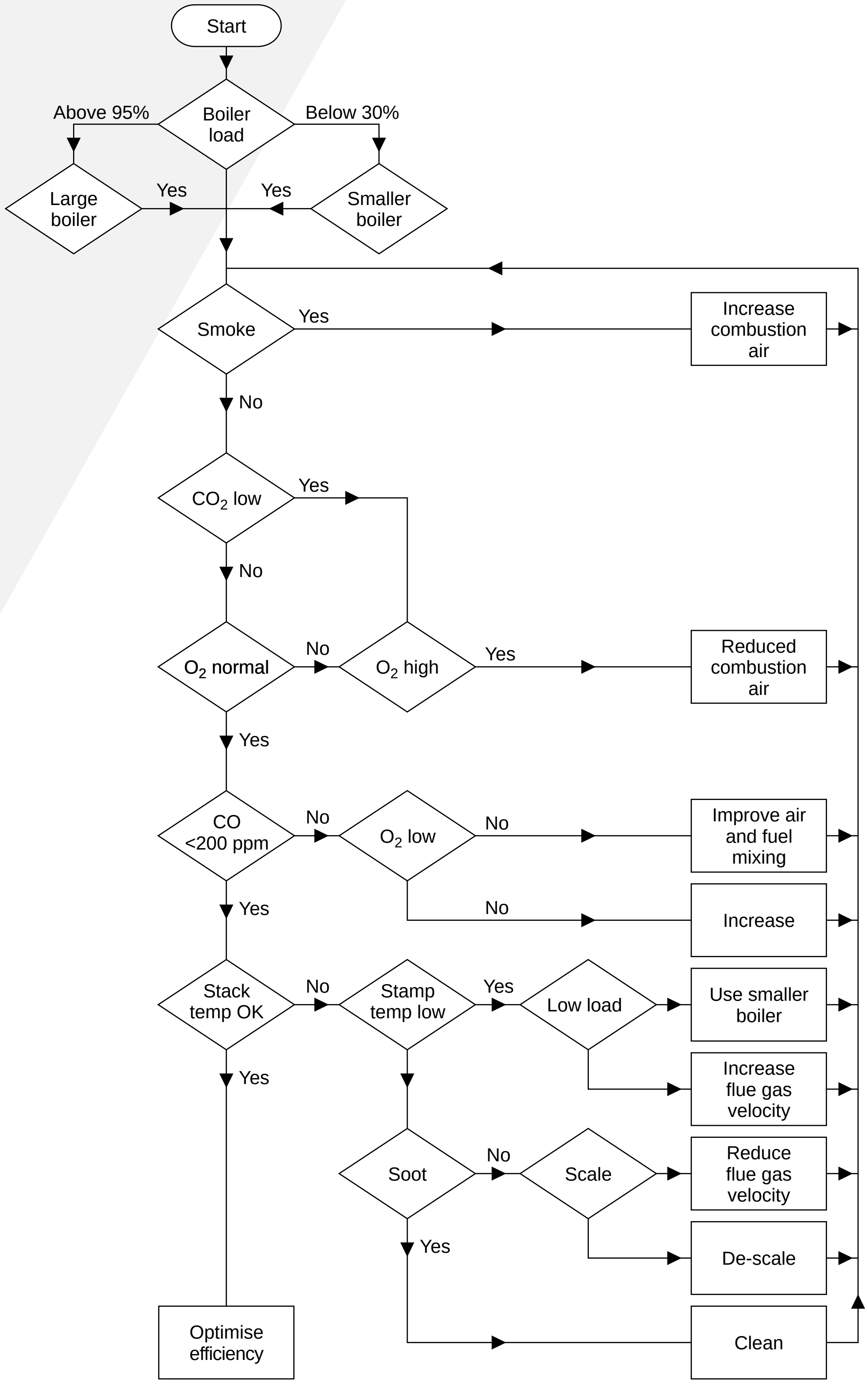

Figure 4: Flow diagram of efficient boiler operation [1].

Recent technological advances

Several countries have launched or are launching initiatives, which are changing the way energy efficient boiler technologies are viewed. A good example of this is in the UK, with the introduction of the Climate Change Levy and the Enhanced Capital Allowance Scheme [6]. Work is continuing on finalising the levy and allowance, but the principal issues will remain the same and are discussed below.

The climate change levy will be a tax on the use of energy in industry, commerce and the public sector in the UK, with offsetting cuts in employers' National Insurance Contributions and additional support for energy efficiency schemes and renewable sources of energy. It will entail no increase in the tax burden on industry as a whole and no net gain for the public finances. The reforms are intended to promote energy efficiency, encourage employment opportunities and stimulate investment in new technologies.

The introduction of the Enhanced Capital Allowances (ECAs) followed a number of representations from business proposing that the government should introduce tax incentives to encourage firms to make energy saving investments. Following consultation, it was announced that combined heat and power (CHP) systems, boilers, motors, variable speed drives, lighting, refrigeration, pipe insulation materials and thermal screens would be eligible for ECAs, providing that they met relevant energy efficiency criteria [1].

Under the conditions of the ECAs, the following technologies have been recognised as improving energy efficiency of a boiler plant.

BURNERS WITH DIGITAL COMBUSTION CONTROLS/BOILER MODULATION CONTROLS

The amount of fuel used in a burner is dependent upon the control of the air/fuel ratio. Traditionally, this critical ratio was controlled by the use of linkages or cables to position the air and fuel valves. These are subject to wear, repeatability difficulties and a limited amount of adjustment. A fine adjustment is necessary to position the valves to ensure the lowest practical air and fuel flows. The implementation of a digital system will result in greater control of the combustion process and will lead to an improvement in energy efficiency of 3-5%.

FLUE GAS ECONOMISERS

Flue gas economisers are used to recover the loss in efficiency when switching from oil fuels to natural gas. Economisers are essentially heat exchangers. The economiser reduces heat in the flue and transfers it to the feedwater. Economisers raise the efficiency of boilers by 3-5%.

CONDENSING ECONOMISERS

Condensing economisers work on the same principle as flue gas economisers but contain two heat exchangers to further reduce the flue gas temperature. This has the effect of doubling or trebling the efficiency compared to conventional boilers.

OXYGEN TRIM CONTROLS

Oxygen trim controls the fuel to air ratio within programmed limits. For example, as the air density changes as winter turns to summer or the fuel quantity reduces due to blocked filters, this ratio will change. The oxygen trim control system will correct the airflow so that the combustion efficiency remains as high as possible. Oxygen trim systems can improve the efficiency of a boiler by 1-2%.

SEQUENCE CONTROLS

A properly designed sequencing control can save fuel where more than one boiler is installed into a system. Boilers should where possible, operate at high outputs in order to maximise efficiency. The sequence control maximises efficiency by operating the fewest number of boilers at the highest firing rates. Sequence boilers are more suited to steam boilers rather than hot water boilers. Hot water boilers are quicker to start up and are not as susceptible to fluctuating temperatures as steam boilers and therefore have a smaller effect on the system.

AUTOMATIC FLOW VALVES

The efficiency of hot water boilers can improve through use of automatic flow valves. Automatic flow valves shut off the boilers that are not being fired, preventing the hot water from the fired boiler being cooled as it passes through the boilers in the system that are not being fired. Where valves are left open the average flow temperature is lower than designed for and more fuel is used.

HEAT RECOVERY FROM BOILER BLOWDOWN

To avoid boiler water foaming, the level of total dissolved solids (TDS) must be kept below the recommended level stated in the relevant British Standard for the type of boiler being used. As the steam leaves the boiler, the solids are left behind and feedwater containing more solids enters to make up for the evaporation. The TDS level then rises and when the limit is reached, the boiler water needs to be to drawn off. This discharged liquid is known as blowdown.

Up to 80% of the heat in the discharge is recoverable by using flash vessels and heat exchangers. Flashing off the high temperature water and directing this hot steam through a heat exchanger to add some heat to the cold water supply will increase the efficiency of the system.

AUTOMATIC TDS CONTROL

The correct TDS level is often maintained by manual control of the blowdown valve. This often causes erratic changes in the efficiency of the system. Automatic control of the TDS levels causes a regulated and continuous quantity of water to be discharged and optimises system efficiency.

CONDENSATE RETURN SYSTEMS

Steam condenses following release of its latent heat to the process. This condensate, in the form of hot water, carries about 20% of the original heat put into it by the burning of the fuel and can be kept within the system if returned for re-use as feedwater. Apart from pH adjustment little or no treatment is necessary. The more condensate returned, the lower the treatment costs due to less blowdown. It is not unusual to achieve a 6% reduction in blowdown, saving approximately 2% of the fuel.

FLUE SHUT-OFF DAMPERS

Where boilers are regularly shut down due to load changes, the heat lost to the chimney can be significant. A solution to stop this loss of hot air is to fit fully closing stack dampers, which only operate when the boiler is not required. Another alternative is to fit similar gas tight dampers to the fan intake.

Demonstration projects

Savings in steam distribution in the UK [7]

UK

A flash steam recovery system was installed and a steam trap inspection and maintenance programme was implemented at a tyre manufacturer in Colway Tyres, in the UK. This resulted in an increase in production targets without the need for a new boiler plant.

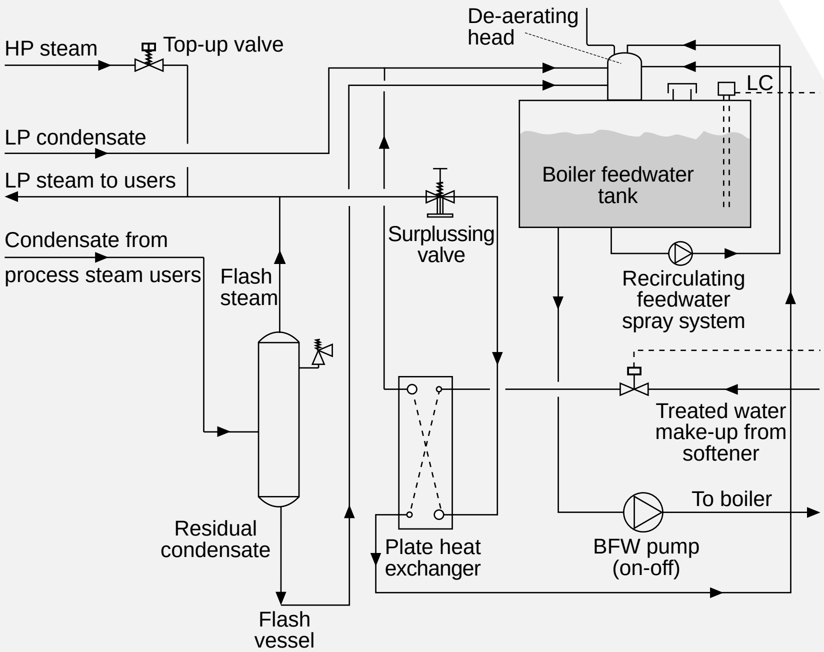

Figure 5: Flash steam recovery system and feedwater tank.

The decision to install the new system was based on:

- the need to meet increasing production demands;
- potential energy and cost savings;
- operational and environmental concerns. Steam was being condensed at relatively high pressure with a large proportion of condensate being returned to the feedwater tank. This was leading to over-heating of the feedwater tank, which in turn caused cavitation of the boiler feedwater pump and unsightly plumes of flash steam from the tank vent.

The new system contributed towards savings in fuel, make-up water and water treatment costs. Environmental benefits have included eliminating an unsightly steam plume and reducing the level of carbon dioxide and nitrogen oxides to 4% and 5% respectively. Payback period was only ten months.

Energy savings at a Swedish paper pulp plant [8]

SE

Vattenfall, a Swedish utility, is funding and carrying out an energy saving project at Utansj Bruk AB, a Rottneros Group paper pulp plant. The aim of the project was to save 50 GWh energy or 5,000 m³ oil/year. The new equipment came online between January and April 1999.

Prior to the implementation of the energy saving initiative, bark and sludge were burnt in a bark boiler. However, because the moisture content was too high, not all the material could be successfully burnt, resulting in additional oil burning. An installation of a new press lowered the moisture content considerably and this has eliminated the use of oil. Sludge and the bark are mixed and pressed to a dry solids content of 43% leading to a 25% increased fuel value and increasing the volume of bark and sludge which can be burnt. Oil consumption has been reduced by 20 GWh while steam production has increased by 5 GWh.

Heat recovery

Surplus heat from the bleeding process water and the process hot water are heat flows that previously went to waste. Although the heat had a low value, it had the potential to heat other process flows that use low-pressure steam. Measures have been taken that ensure surplus hot water is used for primary water and feedwater preparation. This saves 25 GWh steam annually and a further saving of 15 GWh/year has been identified.

Heating of drying air

The paper pulp manufactured at Utansjö Mill was previously flash dried with oil-heated hot air. The ambient air is heated with low-pressure steam to 115°C and process steam increases the temperature to 200°C. Oil is used to reach the temperature of 250°C. New measures include a system for heating the drying air with steam. This saves the equivalent of 30 GWh oil annually. The usage of 30 GWh steam is made available through the extra 5 GWh steam from the bark furnace and the 25 GWh savings from the heat recovery system.

Steam-condensate closed system in Canada [9]

CA

In 1987, the Quebec Cartier Mining Company (QCM – see back cover photo), Canada, began installation of a unique technology that enables the optimal use of steam. The steam-condensate closed system (SCCS), developed by Systhermique Canada in collaboration with QCM, allows condensate to return in a closed and pressurised loop to be subsequently reboiled.

Since its installation at QCM, the SCCS has reduced energy consumption by 18% compared with a conventional steam-condensate open system. Improved energy efficiency was achieved by eliminating vaporisation losses and returning 100% of the condensate to the deaerator. With the removal of all but one of the pumps and proper venting of the non-condensables, steam efficiency was increased, piping and equipment corrosion was better controlled, and maintenance costs were reduced. The installation of this system has led to a reduction in steam production, which equates to a 21% energy saving.

Industrial steam production with gas engine exhaust in Denmark [10]

DK

In April 1996, the Danish textile factory Brandtex inaugurated a small-scale industrial CHP application. The company has several textile factories, but the factory in Brandtex produces trousers, which require steam for pressing.

The factory used to be heated by a number of oil-fired boilers and the process steam was supplied from an oil-fired steam boiler. However, in 1994 the company was obliged to convert to natural gas. Conversion to CHP is voluntary in Denmark, but must be in accordance with the local authority's heating plan. In industrial plants with a high demand for process heat or steam it may be profitable to install a CHP unit to get the benefit of electricity and "low-temperature heat". Only half of the heat production can be utilised as steam, so it is important that all the low-temperature heat can be utilised for heating purposes.

The company decided to opt for an overall solution where steam, hot water and space heating are produced by a small 736 kWe Jenbacher gas engine. The electricity is sold to the public grid, the steam is used in the factory, and the heat is used as hot water and space heating in the buildings. Process steam is produced in an exhaust-gas steam boiler using the exhaust gas (500°C) from the gas engine, and is sent to the press at a temperature of 180°C and a pressure of 7.5 bar. If the steam cannot be utilised in the press it is condensed in a heat exchanger cooled by water from the central heating system and used as hot water for heating purposes. Primary fuel consumption is typically reduced by at least 30% when using CHP compared with the conventional separate production of electricity and heat. The electrical efficiency of the Brandtex plant is 39% and the thermal efficiency is 40%, giving a total efficiency of 79%.

NL

Hot standby for steam boiler in the Netherlands [11]

The steam requirements of Kemira BV's mineral fertiliser plant, the Netherlands, is almost entirely provided by the production processes. In addition, two auxiliary boilers (see front cover photo) are kept at minimum steam production levels. Each boiler produces 6 tonnes/h. Two auxiliary boilers are required so as to deliver steam rapidly in the event of disturbances in the production processes. Outside the winter season, part of this steam produced by the boilers was lost due to an over-capacity of process steam. One of the boilers, a 40 t/h water-pipe boiler with a superheater and economiser, was modified to combat these losses. This resulted in the boiler's minimum load being reduced to a standby situation of virtually zero steam production. The minimal remaining steam production of 1 t/h is used simply to cool the superheater. As a result of the modifications, savings of approx. 85% are achieved in the 'hot standby' condition. The payback period is approx. 1.3 years.

SE

Conversion of hot water boilers to produce steam and electricity in Sweden [12]

In recent years, a large number of district heating plants have built solid-fuel-fired hot-water boilers in Sweden. Since the boilers are relatively new and represent a considerable investment, consideration has been given to their conversion for electricity production. One solution is to convert a hot-water boiler into a low-pressure steam boiler with a steam turbine and gas turbine for superheating.

The technology involves converting a hot-water boiler to a 20-bar steam boiler, which is often possible without major modifications to the boiler other than changing the steel drum. The steam is superheated with the exhaust gases of a gas turbine powered by LPG or natural gas. This project in Sandviken, Sweden involves the conversion of two existing AFB-type (atmospheric fluidised bed) peat boilers. The two peat boilers are each rated at 15 MW (th). The purpose of the project was to demonstrate a cost-effective and environmentally benign conversion of a hot-water boiler to the production of electricity.

US

Increasing process and energy efficiency at a plywood plant in the US [13 & 14]

A plywood plant in Madison, Georgia, USA, is looking for ways to reduce the amount of fuel it must purchase to fuel its boilers. It was found that by improving process energy efficiency, it could virtually eliminate its purchase of fuel from external sources. The plant is owned by Georgia Pacific Corporation, who manufacture plywood using locally grown loblolly pine. The plant uses wood by-products, such as bark and trimmings, to fuel its boilers, which provide the steam needed for the plywood production process. At certain times of the year, not enough bark is available and the plant must purchase additional fuel.

To address the problem, Georgia Pacific formed a project team consisting of members from the plywood plant, from the North American Insulation Manufacturers Association (NAIMA), and from Rock Wood Manufacturing, Inc. The project team recommended insulating the steam lines from the boilers with mineral fibre and replacing 70 steam traps. The insulation and steam traps allowed the system to contain heat more effectively, thus reducing the amount of steam required and decreasing the steam boiler's fuel consumption. Payback is about six months.

Conclusions

Steam systems used widely in industry and commerce offer significant opportunities for energy savings. They are often overlooked and sometimes poorly maintained. Good management of steam systems and small investments in simple and easy-to-fit technical measures will provide short payback on investment.

Regular reviews of a steam system will identify where changes to the boiler, distribution system and final end use have occurred. These reviews often reveal unused pipework, missing lagging, etc., all of which reduce energy efficiency.

It should be the aim of every steam system user to operate at an overall efficiency close as possible to 80%. Losses in all parts of the system should be minimised. Where there are potential losses, then the opportunity to recover heat should be taken. Small energy saving improvements will come from maintenance items primarily to the distribution system.

Implementing one or more of the energy saving measures discussed in this Brochure will improve the energy efficiency of the system. The selection of the most appropriate measure(s) will vary greatly in each case, as no two boilers are the same. Careful analysis of the system will need to be carried out to ensure that the investment required will be recovered in an acceptable payback period. This will also vary with each company, but a general guide would be to aim for about a two-year payback.

Glossary

Blowdown

High pressure water at the steam saturation temperature released from a steam boiler to control sludge and total dissolved solids.

Boiling Point

The temperature at which water boils to form steam. This temperature increases as the pressure is increased.

Cavitation

Local boiling at pump inlets caused by pressure reduction. Resulting bubbles reduce pump efficiency, cause noise and damage the pump.

Check Valves

Non-return valves inserted into lines to prevent reverse flow.

Condensate

The liquid which is formed as steam condenses. Ideally pure water.

Demineralisation

Removal of inorganic contaminants found in water.

Desuperheater

A device where water is added to return steam to saturated conditions.

Flash Steam

The steam produced when the pressure of hot condensate is reduced.

Heat Content

The enthalpy of a system. Given by $H = U + PV$ where U is the internal energy, P is the pressure and V is the volume of the system.

Latent Heat

Heat that changes the state of a substance with no accompanying temperature rise. When water is changed into steam, the heat is also known as the Enthalpy of Evaporation.

Sensible Heat (Specific Enthalpy)

Heat that increases the temperature of the water or steam with no change of state.

Steam Separators or Dryers

Devices used to remove entrained water droplets from wet steam.

Steam Traps

Mechanical devices used to remove condensate (as it is formed) from pipes or plant.

Superheated Steam

Steam to which sensible heat has been added to increase its temperature to above its boiling point.

Thermal Fluids

Generally mineral oils with high heat capacities that can be used as alternatives to steam or hot water for process heating in the range 200-400℃.

Water Hammer

The result of condensate being pushed, by steam pressure, down pipes as solid slugs.

Wet Steam

A mixture of steam and water droplets.

References

This Maxi Brochure was compiled from information in the CADDET Energy Efficiency Register (R), and also from information published in Technical Brochures (T) and Newsletter articles (N). Further reference was made, with thanks, to other publications as indicated.

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The CADDET Energy Efficiency Maxi Brochure Series aims to raise awareness of key energy-saving technologies that not only save energy but make good financial sense. They draw on information compiled by CADDET Energy Efficiency through its world-wide network of National Teams and from other IEA sources.

Maxi Brochures are written for the benefit of energy managers, engineers or anyone with responsibility for energy efficiency. They are split into a number of short sections which lead the reader through the basics of the topic covered. The reasons why there is a need to make energy savings are examined, and the potential for savings is assessed. After a brief description of the main features of the technologies involved, recent technological advances within the relevant fields are discussed. A number of demonstration projects illustrate how such technologies have already been successfully applied in practice around the world.

When reading this Maxi Brochure, a basic technical knowledge on the part of the reader has been assumed. However, no specific background expertise is required.

Swentiboldstraat 21, 6137 AE Sittard
PO Box 17, 6130 AA Sittard
The Netherlands
Tel.: +31-46-4202224
Fax: +31-46-4510389
E-mail: caddet@caddet-ee.org
Internet: http://www.caddet-ee.org

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