

Investing in Industrial Heat Recovery

FLUE GAS COOLING



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INVESTING IN INDUSTRIAL HEAT RECOVERY ?

Considerations on how to get better economy through better utilization of the waste heat in the flue gas from heaters and boilers

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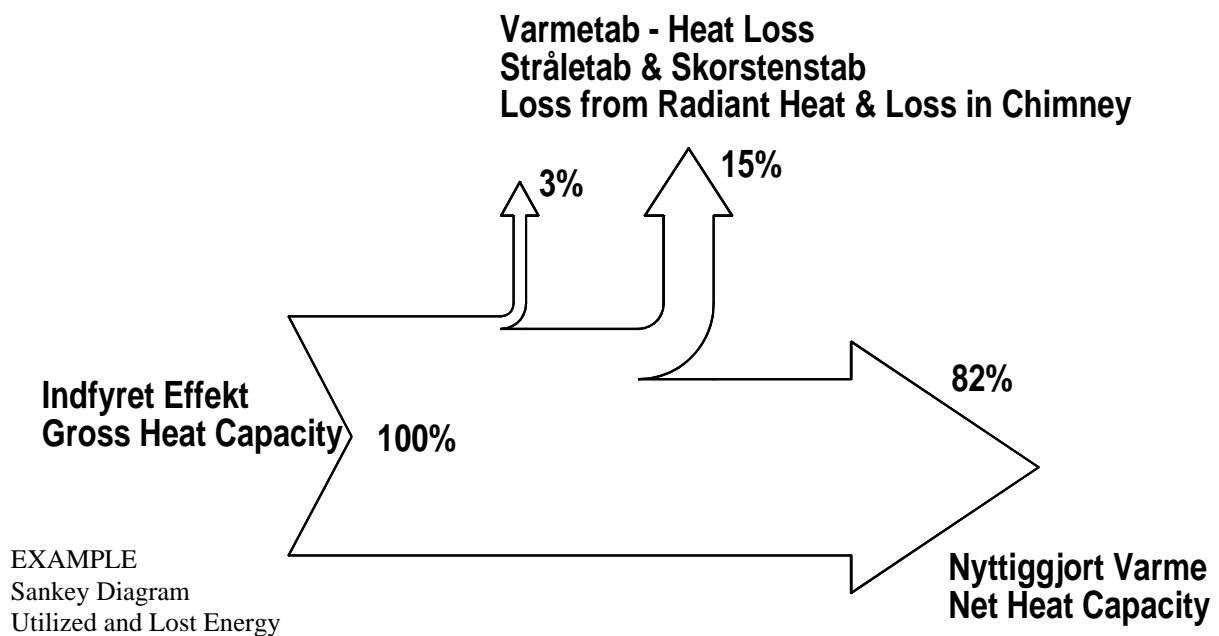
1. Is the waste heat dissipation from the plant too large ?

In thermal processes there are always a heat loss - processes without waste heat dissipations are purely theoretical, and do not exist the real world. Energy arises from thermal processes and it always proceed while it seems to vanish in other thermal or thermodynamic processes - whether it might be in conventional heat transfer, engines, tubines or refrigeration plants (just to mensions some examples). But although the heat loss always exists, it is important to evaluate the size of this loss, in relations to what is considered as being reasonable from an economical and/or enviromental point of view - thus to consider investing in heat recovery.

The task in good heat recovery is to create maximum cut in the operation expenses with a minimum of investment.

Modern boilers, heaters and heating systems are developed with only modest heat loss. They

have what you call a high efficiency. The efficiency tells how much of the total amount of potential energy is being utilized for the main purpose. A modern e.g. boilers can for instance have an efficiency of 0,8 - 0,9 (or 80 - 90%), meaning that the boilers has got a loss - mainly due to the chimney loss - of 10 - 20%. An older boiler might however have an efficiency of only 0,6 - 0,7 (or 60 - 70%) equal to a heat loss of 30 - 40%.



Still heat losses can be very large even in modern boilers, both considering the amount in it self, as well as relatively to the potential total energy (the efficiency). There are many reasons for this, but common for all existing industrial heating systems are, that they originally were determined and adapted to the demands at the time when they were erected. For instance an enlargement of the production plant might result in a demand for other larger amount and/or other types of process heating. New lines requiring high temperature processes, insufficient heat supply, or a surplus of low temperature process heat leading to a low utilization of capacity of the old old boiler, price increase on electricity, possibility of using new fuel (e.g. natural gas). All these circumstances might result in a situation which is not optimal for the old heating system, thus the overall efficiency might drop significantly.

2. The Advantages of Heat Recovery for an Industrial Production Plant

The heat loss from a fired boiler/heater is primarily dissipated through the chimney i.e. it comes from the hot flue gas. The amount of flue gas and the temperature of this, is proportional to the heat loss. Often a considerable economical advantage can be achieved by cooling the flue gas, and thereby utilizing the energy amount, which under normal circumstances would have been let out as heat loss.

In industrial production plants, large amount of energy for process heating are often used, and it is characterized by quite high temperatures. The heating media (the carrier of the process heating) can be steam, thermal fluid (hot circulating oil), pressurized/unpressurized hot water or air/gas - as well as more sophisticated heating media for special tasks, and used maybe locally in the production plants.

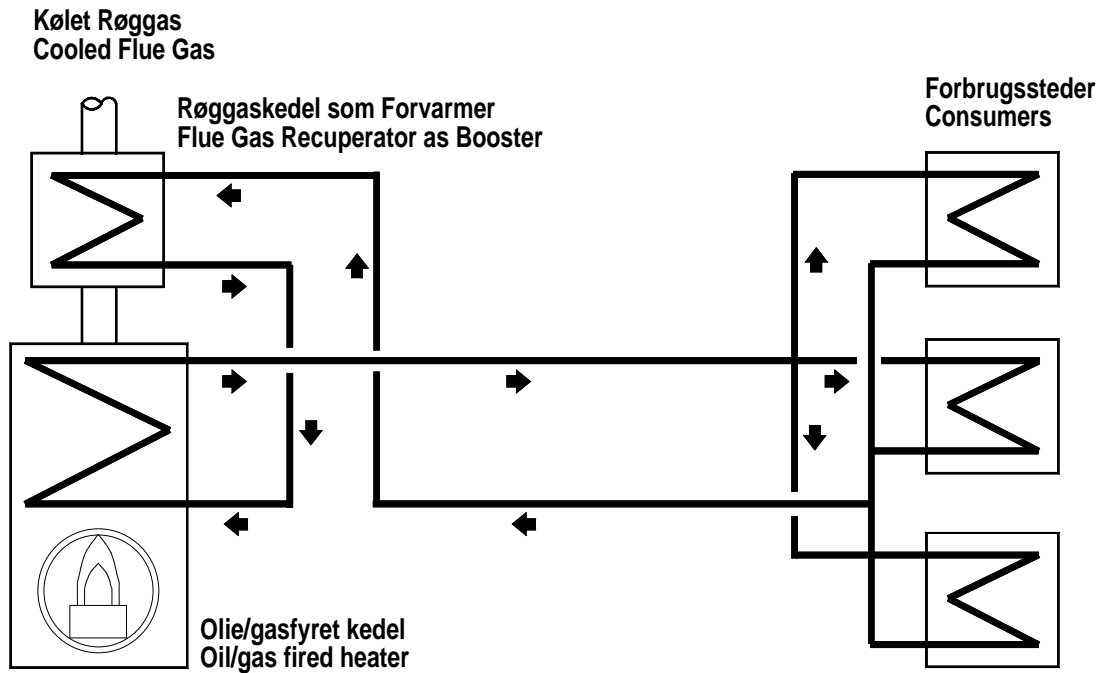
Generally a high temperature level on the heating media often means a high chimney temperature (flue gas temperature). Consequently large oil or gas fired industrial boiler/heaters very often makes efficient and thus economical attractive solutions possible. By inserting a heat exchanger in the flue gas flow - just before the chimney - process heat can be generated at almost no costs.

Heat produced in a flue gas recuperator (exhaust gas boiler) will in many new installations be of a lower temperature level than the existing boiler/heater can provide - simply because the boiler/heater already has utilized most of the the energy developed, by combustion of fuel. The smaller heat loss through the chimney can be seen by the lower flue gas temperature, which thereby gives some restriction i.e. limitation for the temperature level of the produced/recovered heat.

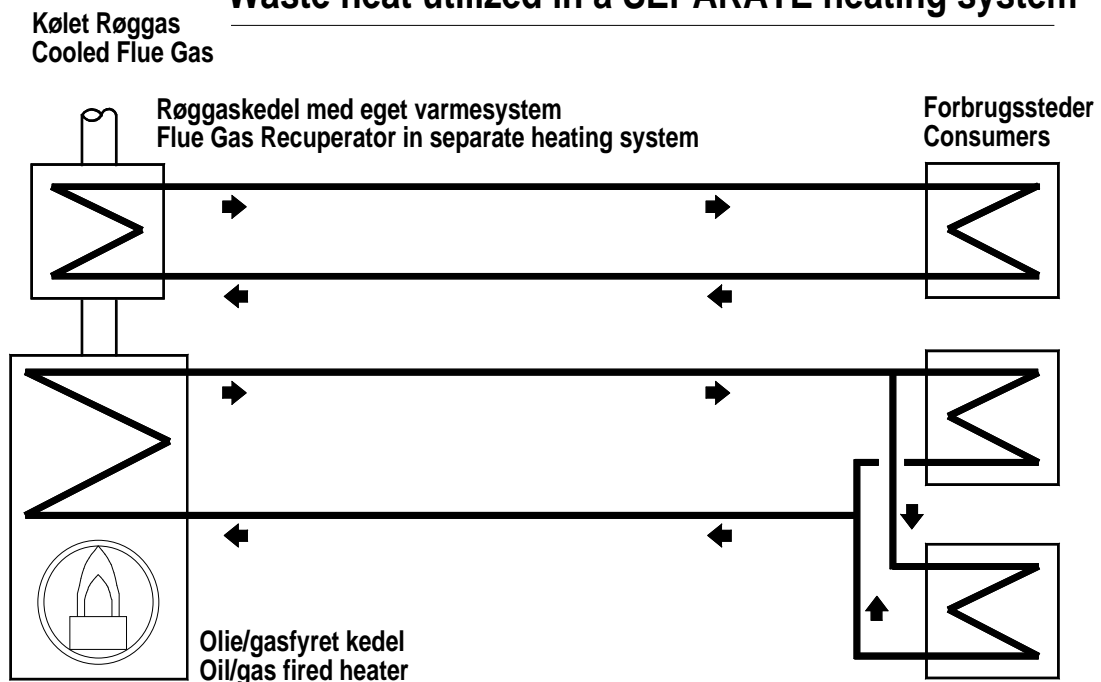
In most production plants and heat consuming factories it is often advantageous to establish a secondary heating system - for instance for production of low pressure steam for low temperature applications. Either indirectly such as preheating of air / liquid / oils - or directly such as injection of steam in tanks and reactors, or for cleaning/sterilization in general.

Nevertheless, still in many installations, the recovered heat can be used in the primary heating system. This means a better utilization of the fuel, which gives a higher overall efficiency - either by a higher amount of heat produced on the same amount of fuel - or by the same amount of heat produced by a smaller amount of fuel (see illustrations next page).

Spildvarme udnyttet på det EKSISTERENDE varmesystem Waste heat utilized on the EXISTING heating system



Spildvarme udnyttet på et SEPARAT varmesystem Waste heat utilized in a SEPARATE heating system



3. Investment & Benefit

Like any other kind of investments, the purpose of investing in heat recovery, is to get a net profit which is as large as possible compared to the total expenses related to the investment.

Technically likewise -

the task in heat recovery is to utilize as much of the energy bound in the fuel as possible by the most simple solution i.e. optimizing the size of the heat recovery system. For instance to take out as much heat from the flue gas as possible.

In other investment models, especially the purely financial models, the profit is often difficult to determine exactly. They often depends and rely on weak elements such as expectation on up or down going figures.

Investment in heat recovery is easier to survey by the following facts:

Heat cost money
Any amount of heat represents an amount of money
Not utilized heat is loss of money

Heat recovery investments is actually less risky. Only real uncertainty in determine the size of profit in heat recovery investments, is if the fuel prices drops significant. But is that likely to happen?

The art of heat recovery is to evaluate the system individually, and based on these investigations - to get the maximum amount of heat recovered by the smallest alteration of the system.

This also emphasizes the fact that there are an optimum for each system, and that requires to be determine in order to maximize profit compared to the investment (“price/earning”). This is best illustrated by the extreme cases, where the size of the investment in both cases are wrong (too large and too small respectively). The basic costs for heat recovery equipment make a too small investment insufficient, because the capacity of the heat exchanging part simply becomes insignificant and the costs for accessories becomes too high. In contradistinction to this is the too ambitious investment, which does not correspond at all what is actually possible to save in fuel.

It takes a infinite large heat exchanger part
- to recover all of the heat loss

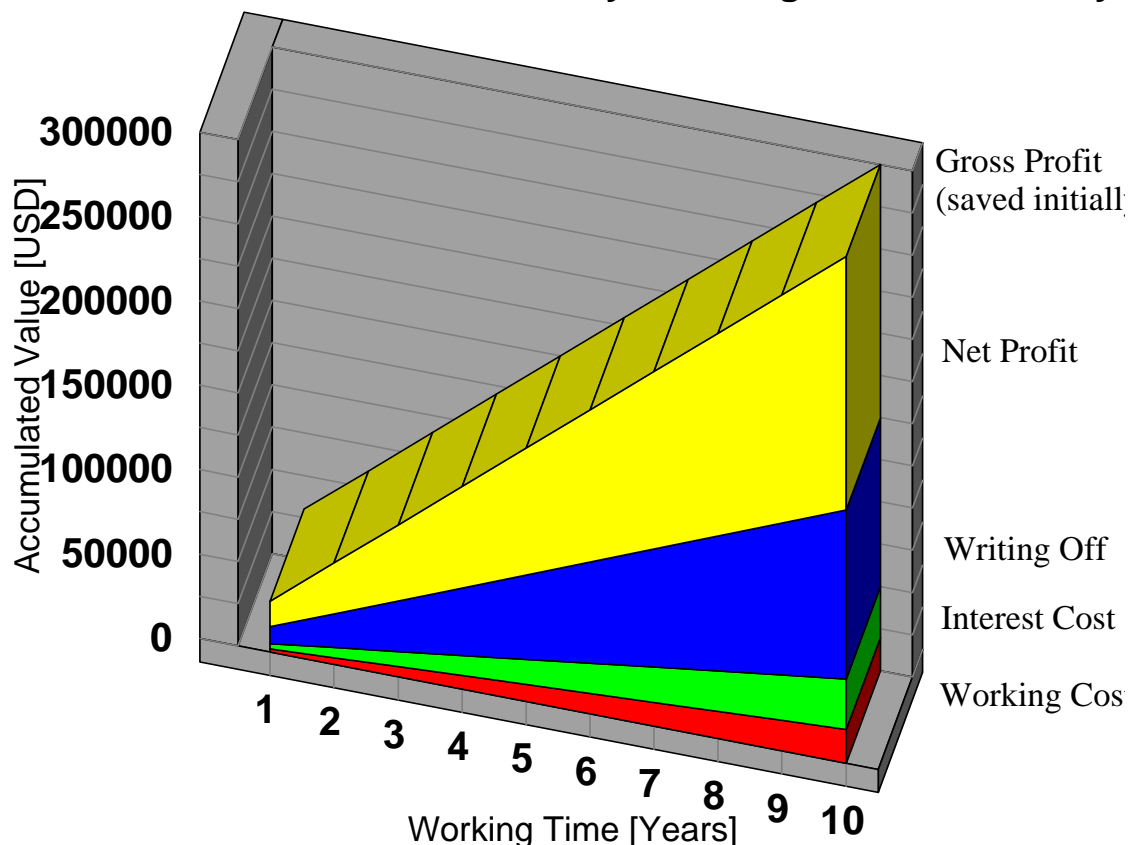
It takes an almost infinite large heat exchanger part
- to recover almost all of the heat loss

It means that the heat recovery amount practically represents a limited amount of heat, which is sometimes far less than the overall heat loss.

Therefore the optimum heat recovery is very often found by evaluating the annual gained (from saved fuel cost) per invested \$ - combined with what is totally gained during an estimated life time of the heat recovery plant.

When a non-optimum is chosen despite a serious and throughout evaluation, it is often due to a decision of limiting the investment anyhow - for different reasons. These could be e.g. uncertainty about the futuring use of the oil/gas fired heater, or to observe the feasibility in a small scale investment.

EXAMPLE Earned by Investing in Heat Recovery



P.S. Note the calculation in Cpt. 8

4. Heat Recovery Invest Indicators

<i>Positive indicators</i>	<i>Negative indicators</i>
<i>High Chimney Temperatures (temperature of the flue gas)</i>	<i>Frequent start and stop of oil/gas fired heater together with a demand for continuously supply of heat in a separate heating system.</i>
<i>Old oil/gas fired heaters and heating systems.</i>	<i>Low temperature of the flue gas.</i>
<i>Medium sized and large oil/gas fired heaters</i>	<i>Heaters for domestic heating</i>
<i>High temperature oil/gas fired heaters</i>	<i>Small and new heaters.</i>
<i>Additional need for live steam and for a secondary heating system.</i>	<i>Electrical heating, district heating (anything beside oil/gas fired heating)</i>
<i>High prices and taxes on oil and gas, including enviromental duties.</i>	<i>Already existing and efficient heat recovery systems.</i>
<i>Possibility of getting subsidies (economical support) from state or international funds.</i>	<i>General outdated production plants, which can be expected to be closed in a couple of years</i>

5. The Concept from AB&CO Ltd.

AXA Exhaust Gas Recuperators, produced by AB&CO Ltd. In Denmark, are based on a new and price attractive concept, where heat loss from older industrial heating systems are recovered simply and effectively, for the purpose of producing process heat - as steam, hot water, high temperature pressurized water, hot oil (thermal fluid), air/gas or as other heat carrying fluids.

Basicly the concept is that a heat exchanger are build-on the flue gas outlet of the gas/oil fired heater, engine or turbine. In the heat exchanger of the recuperator, a smaller or larger part of the heat loss is converted into accessable heat - due to the heating of the heat carrying fluid (like above mensioned) or production of low pressure steam.

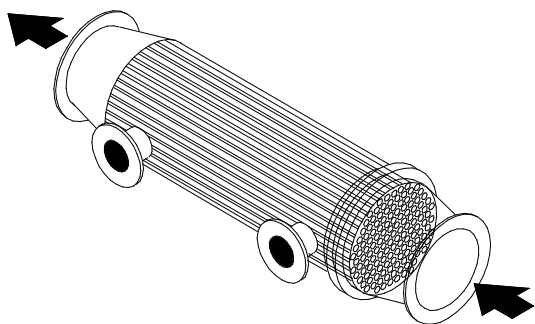
The news is firstly the heat exchanger part (module 1), which is adapted **individually** to the actual circumstances - not only in size and performance, but mainly in the design of the heat transferring surface. It means that the design of the basic heat exchanger part, are chosen from a broad program of heat exchanger principles (fin tubes vs. plain tubes, straight tubes vs. winded coils, sections w. rectangular face and cross flow vs. circular face and counter flow etc.).

A correct choice of heat exchanger principle for actual task and circumstances is essential in order to obtain the best technical solution for the smallest investment (see the illustrations on page 8 and 9).

The choice of heat exchanger principle is considered in relation to a.o. the nature of the flue gas, the heat carrying fluid, temperatures, pressures and the the capacity. For instance, a resuperator for heating of low temperature water, and cooling non-agressive flue gas, might be designed with a fin tube heat exchanger - while a heat exchanger for production of steam (exhaust gas boiler) most likely will be designed as coils.

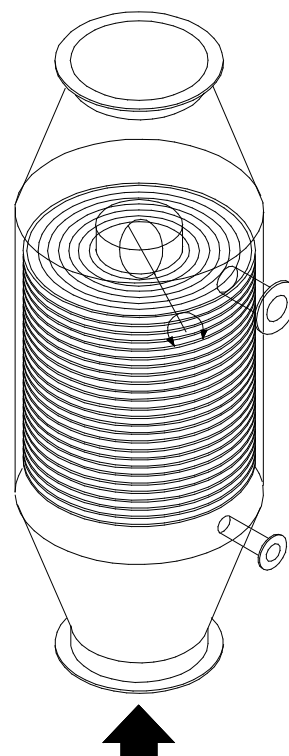
C. TUBE BUNDLE WITH STRAIGHT PASS

Flue Gas inside tubes. Strong construction for demanding tasks.



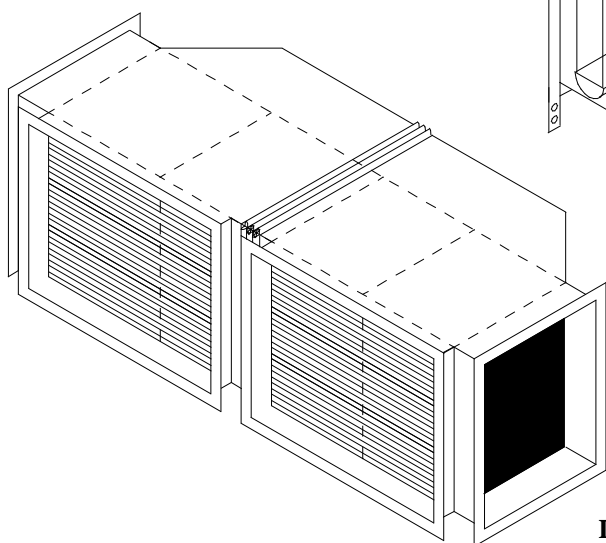
A. WINDED COIL

Flue Gas surrounding the tubes
Suitable for production of steam thermal fluid and other high temperature heating media.



B. MODULAR BUILD BATTERY

Flue Gas in cross flow around plain tubes, fin tubes or fin plates.
Compact and high performances.



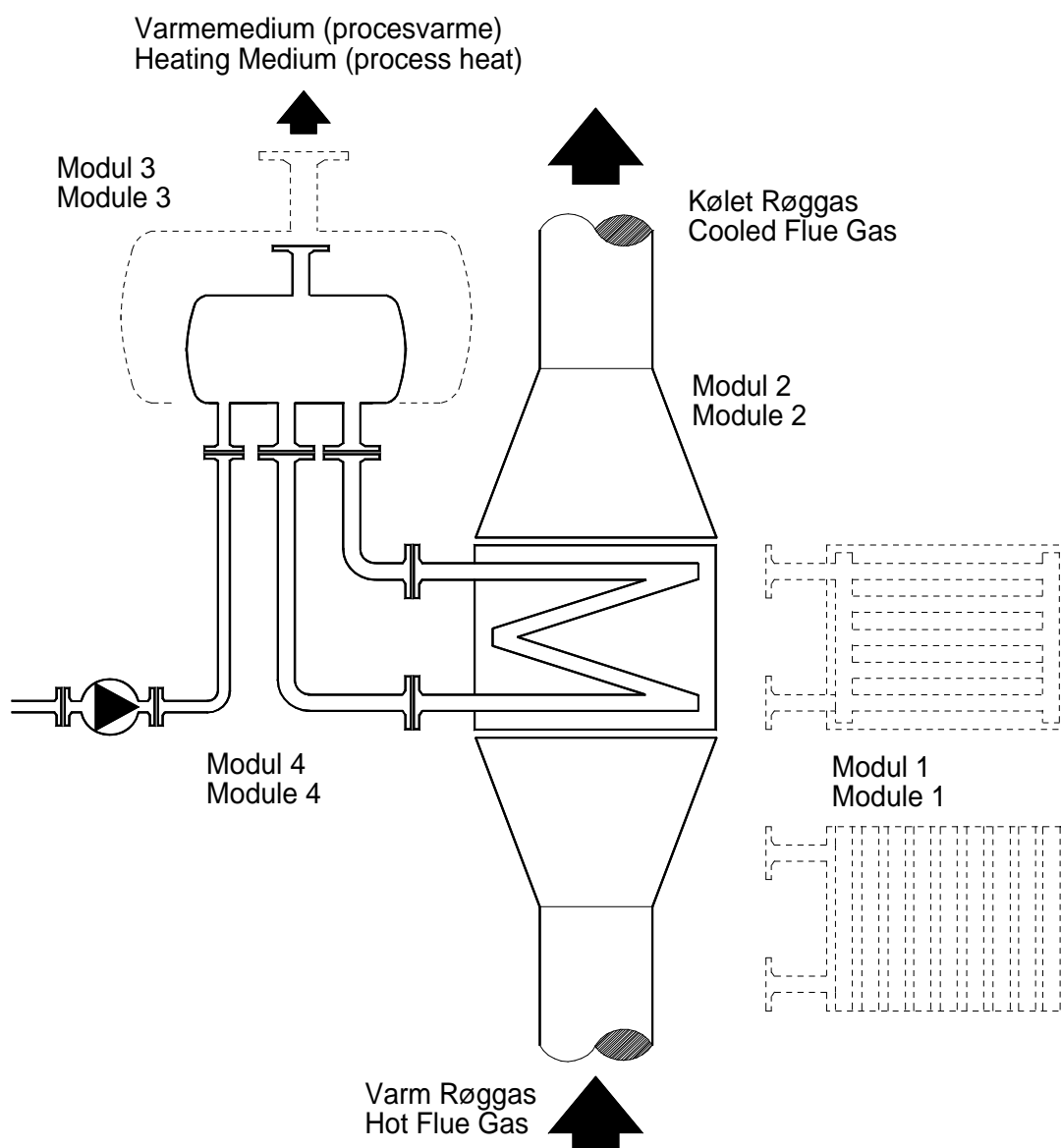
D. GAS-TO-GAS HEAT EXCHANGER

Flue Gas in cross flow with air or secondary gas. Build with tubes or plates. Steel with or without coating - or with glass tubes.

6. A Simple and Economical Solution

The other new topic is the **modular** concept, which makes the installation simple and significant more economical than common known recuperator solutions. Furthermore the modular design means that the installation can be build-out later within very reasonable economical means.

Due to the flexibility in the modular concept, a wide range of operating temperatures are optional within the limits of (i.e. below) the flue gas inlet temperature ofcourse.

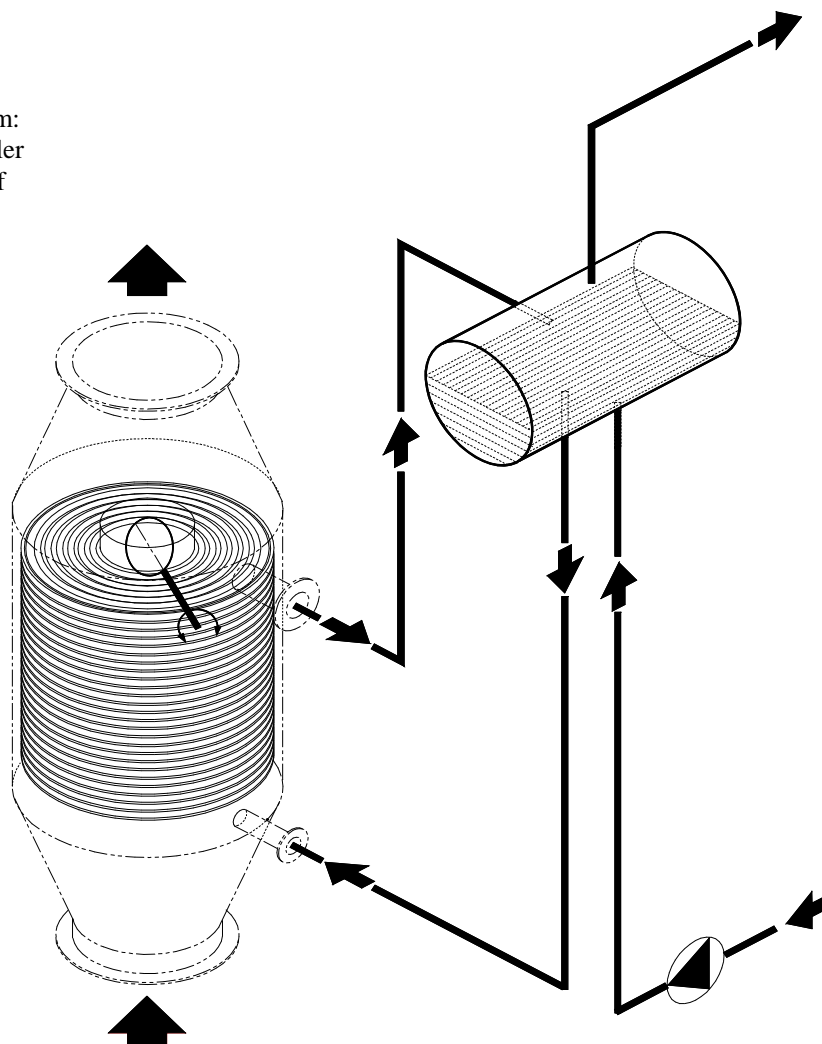


As heat recovery creates additional heat, it is also optional to either produce extra heat on the existing oil /gas fired heater - or to run reduced load on the oil /gas fired heater with the produced heat than before. Running on reduced load gives a better efficiency of the system, but also on the oil/gas fired heater itself, because the combustion chamber (the convection and radiant heat part) becomes larger *relatively* to the combusted amount of fuel. The recuperator forms an extension of the oil/gas fired heater - which utilize the heat in the flue gas to make up the reduced heat output from the combustion chamber of the oil/gas fired heater. Totally the oil/gas fired heater together with the recuperator give the same heat output - but with less fuel.

7. Heat Recovery delivered as a unit - or as a complete system / turn-key

AXA Exhaust Gas Recuperators™ & Heat Recovery Systems™ can be delivered optional either as units, as system solutions (packages) or just one or few heat exchanger “components”. Generally heat recovery requires tailormade solutions, thus not two recuperators are identical. However the modular concept from AB&CO Ltd. utilizes the similarity in the different kind of heat exchanger design and instrumentation as mentioned on page 8 and 9.

Principle Diagram:
Exhaust Gas Boiler
For production of saturated steam



The unit design offers a complete skidmounted heat recovery system with piping, tank, armatures, instrumentation and controls - ready to be connected to the existing heating system. This is a good alternative for uncomplicated small and medium size heat recovery.

The system solution are complete heat recovery system as well. But due to the size or because it might involve heat recovery in general of the whole heating systems, it is delivered as a package of separate components/item and complete instruction for building up the system on site. This alternative is recommended e.g. for erection of complete secondary heating systems and for large scale heat recovery.

The third alternative is just to use one or a few items for “self-made” heat recovery systems. Often this requires assistance from AB&CO Ltd. for lay-out, design, engineering and supervision. Sometimes only the AXA heat exchanger part - the heart of the recuperator - is required, whereas the rest of the system including the other items and the engineering are made without assistance from AB&CO Ltd.

8. Is this worth an investment

You often gain a lot when investing in heat recovery. Still it should be evaluated carefully to avoid unpleasant surprises. Special circumstances might disturb a nice picture of heat recovery.

To make a first step evaluation, the table on page 7 indicating the positive and negative indicators might give an idea. In the below simplified feasibility studies, the calculations might give a better impression.

Generally it is a good idea to make some considerations on how potential the present heat loss is related to the potential heat recovery. E.g. how much flue gas is available and how much higher the temperature of the flue gas is compared to the temperature of the existing or new heating system. Then go to the more detailed considerations as shown on the next page (8.1 and 8.2).

- 1. What heat carrying fluid is required in the recuperator, and what is preferred (steam, thermal fluid (oil), water or gas/air) ?***
- 2. What temperature level of above mentioned heat carrying fluid is possible and necessary related to the flue gas temperature ?***
- 3. Should the heat recovery aim towards a reduction of the fuel consumption with same heat output - or towards a larger heat output and maintaining the fuel consumption ?***
- 4. Is a new secondary system acceptable if it is economical (better utilization of recuperator) - or should only heat recovery within the limit of the existing heating system be considered (requires higher flue gas temperature) ?***

EXAMPLES OF PROFITABILITY CALCULATIONS FOR A HEAT RECOVERY INVESTMENT

8.1. Reduction of fuel consumption - Unchanged Heat Output

Simple
Consideration

*Investment \$ 100,000.- , annually saved net \$ 25,000.-
Working time 10 years =>after 4 years the heat recovery system is
paid and the makes \$ 25,000.- annually the remaining 6 years.
Total net profit \$ 150,000.-*

Sophisticated
consideration (liniary)

*Investment: \$ 100,000.-
Working time: 10 years, after which the equipment it written off.
Income: Saved fuel \$ 30,000.- annually
Expenses: Extra operation cost due to the heat recovery system
\$ 2,000.- annually.
Liniary write off over 10 years equals \$ 10,000.-
annually.
Loss of interest rate of the avarage value in 10 years
(\$ 50,000.-) by 6 % p.a. equals \$ 3,000.- annually.
Net Profit: \$ 15,000.- annually in 10 years.
Total net profit \$ 150,000.-*

P.S.: See illustration on page 6.

8.2. Increasing Heat Output - Unchanged Fuel Consumption

Calculation of the profitability is done not only by setting up values the classic way. Using the above exampel the annual total expenses of \$ 25,000.- (which including write off, interest rate and extra operational/maintenance cost) must be compare to what is gained by higher thermal performance in e.g. the production plant.

The calculation is in principle like above. If additional heat should be produced by upgrading the oil/gas fired heaters (without heat recovery) it would mean extra fuel expenses of \$ 30,000.- plus investing in the upgrading. Therefore the net profit will be way above the \$ 15,000.- .

The exact calculation is thus much more complicated, and it involves not only the figures related to the heat recovery system. Therefore it would not give a typically picture to make such an example. However if additional heat is needed and if this heat recovery system are capable of covering this need - the investigation will likely result in a decision about making the heat recovery.

9. Public economical support

Heat recovery is ofcourse healthy for the economy - sometimes even for the national economy (despite less fuel tax income). In enviromentally terms, the heat recovery contribute to less emmision, and that has made the public interested in heat recovery too.

In many countries or regions it is possible to get subsidies (economical support) for stimulating heat recovery initives. It does varies a lot - in some countries it is forced by law to keep the temperatures and the amount of flue gas (emmision) below a certain level. But the tendency is that public interest developes rapidly, thus also the possibility of public subsidies.

E.g. in Denmark, a large so called "CO₂ Fund" has through taxes on fuel, collected a large amount of money, which is now being allocated back to the industry as subsidies for public recognized (approved) heat recovery systems. Similar arrangement exist in other countries and region, and might very well make the feasibility calculations turn out even better.

10. Doing the first feasibility calculations

AB&CO Ltd. offers a preliminary and general evaluation free of charge. Based on a developed questionnaire the actual circumstances are enlightened. When it is filled out, it will give a hint on whether heat recovery it worth an investment. The result can be calculated directly by using formulars on the sheet, or it can be faxed, mailed or E-mailed directly to AB&CO - Project Dept. and the answer will be returned within two working days.

The result of this calculation might lead to inquiry for a heat recovery system, and/or a more detailed investigation on consultant basis.

11. AB&CO Ltd.

AB&CO Ltd. is a one of Europe's leading manufacturers of units for industrial heating, cooling and heat recovery. A wide range of heat exchangers and complete units for process heating and heat recovery can match almost any task. The solutions that is offered are customized to the actual circumstances, but still always economical as an investment, and considering the operation costs as well.

Products delivered from AB&CO A/S and in operation all over the world:

- Heat Exchangers (designed and customized for the task)
- Process Air Heaters (steam, thermal fluid, electrical)
- Process Air Coolers & Dehumidifiers
- Gas-to Gas Heat Exchangers (single and multi pass recuperators)
- Exhaust Gas Coolers (for e.g. steam production/heating of fluid and gas)
- Heater Units/Systems (complete skidmounted) for special tasks within industrial heating.
- Steam Boilers (Oil/Gas fired & Electrical)
- Thermal Fluid Heaters (Oil/Gas fired & Electrical)
- Gas Incinerators (high temperature combustion)

More informations at: www.abco.dk www.ttboilers.dk
