TOTAL UTILIZATION OF ENERGY IN BJERRINGBRO

New heat pump at the CPH plant in Bjerringbro utilizes the heat in the flue gas and thus increases the plant's heat effect without increased use of natural gas.

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EFFICIENCY IMPROVEMENT

If somebody believes that district heating is old technology without significant perspectives, they should turn their eyes to Bjerringbro heating plant. Here, they have succeeded in utilising the energy far more efficiently by using known technology in a completely new way. The result is that expensive natural gas is saved, and that at the same time CO_2 emissions are reduced by 1,350 tons per year. And the investment? It is expected to be paid back within two years!

It all started with Bjerringbro Varmeværk having to invest in new equipment. A gas boiler was ripe for replacement. However, with increasing prices of natural gas, there was an interest in finding something more efficient than just buying a new natural gas boiler.

One possibility was to condense the flue gas from the engine by means of electricity, but that was not interesting due to the electricity taxes. If, however, the flue gas could be used for powering a heat pump, that would be an interesting possibility.

0.9 MW EXTRA

During 2006 it was clear that Thermax could supply a suitable absorption heat pump, and it was decided to install a pump on one of the engines.

In November, 2007, Bjerringbro Varmeværk could demonstrate that reality surpassed the first calculations. By installing an absorption heat pump in one of Bjerringbro Varmeværk's four gas engines, there is now an extra heat effect of 0.9 MW at disposal - and that is without using more natural gas.

Previously, the flue gas from the engine was cooled from 428°C to 63°C in district heat exchangers before it was led out directly through the chimney. In a new flue gas exchanger connected to the heat pump evaporator, a further cooling to 27°C and condensing of the flue gas vapour take place. The heat pump absorber and condenser are cooled by district heating water, which is hereby heated from about 40°C to 80°C. That is above the operation temperatures in Bjerringbro's district heating network, and thus there is no need for cooling of heat from the heat pump, which is using the evaporation heat from the flue gas without losses. Condensing of flue gas has been considered before, but the network return temperature is not low enough.

HIGHER DEGREE OF EFFICIENCY

Before the renovation the heat efficiency was 48.4%. With the extra output of 0.9 MW, the heat efficiency has increased to 60.1% while the electricity efficiency remains unchanged 42.1%. The total efficiency of the plant has thus increased from 90.5% to 102.2%. In other words, an increase in effect from 3.7 MW to 4.6 MW has been obtained without causing additional consumption of natural gas. However, the condensed vapour from the flue gas must be discharged as waste water, implying a discharge duty.

A consequence of the conversion of so far one engine is that the district heating flow temperature has been reduced from max. 90°C to 80°C. This means that the capacity of the plant's heat storage tank is reduced correspondingly - to the extent that the heat is supplied from the reconstructed plant alone. Therefore, Bjerringbro Varmeværk is now considering establishment of another heat storage tank in order to maintain the full capacity.

THE ACTION PLAN IS CONTINUOUSLY REVISED

The first ideas of using a heat pump for increased utilisation of the heat in flue gas developed in connection with preparation of the Bjerringbro Varmeværk's action plan in October 2005. The plan has subsequently been revised several times.

For the time being, the extra heat storage tank is being considered, as this is the precondition for it being profitable installing flue gas cooling at another of the CPH plant's four 18-cylinder lean-burn engines from Rolls-Royce/Ullstein.

Because, even if the marginal price has decreased by 100 DKK (approx. 14 Euro) for the reconstructed engine, there must be capacity to store the heat produced when the electricity price is high.

Whether the third and the fourth engine are to be equipped with heat pumps some day is depending on Bjerringbro's future heat requirement and on the number of working hours expected for the individual engines.

In any case, an action plan is a good tool to estimate the future investments.

The test operation has demonstrated that the plant has the expected output. Therefore, the heat effect of the CPH plant can be increased by further 3 x 0.9 MW without increased consumption of natural gas.

In November 2007, the plant has definitively been taken over by Bjerringbro heating plant, which carried out the project in cooperation with Hollensen Energy A/S and COWI. Thermax has supplied the absorption cooling plant. The investment in heat pump, building and installation amounts to about 6 million DKK (approx. 0.8 million Euro).

POSSIBILITY OF DISTRICT COOLING

Another possibility of using absorption cooling plants at CHP plants is production of district cooling, which also is included in Bjerringbro Varmeværk's action plan.

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By district cooling, the distribution grid will be supplied from the evaporator with a supply temperature of 6°C and a return temperature of 14°C, while the flue gas is only cooled to 63°C. In that case, it will be necessary to cool some of the surplus heat in a cooling tower.

The COP of such a plant will be about 3 (Coefficient Of Performance is the cooling power and the supplied heat- or electricity power ratio).

For comparison, COP for an absorption cooling plant operated by hot water is about 0.7, whereas a traditional compressor plant has a COP of about 5. In the latter case, it must be taken into consideration that the driving energy is electricity, which involves conversion losses.

Seen in that light, the possibility of district cooling is promising.

Layout of the plant with the absorption heat pump causing an increase in the total efficiency from 90.5% to 102.2%.

	BEFORE	NOW
Flue gas temperature in chimney	63°C	27°C
Electricity efficiency	42.1%	42.1%
Heat efficiency	48.4 %	60.1%
Total efficiency	90.5%	102.2%
Thermal output	3.7 MW	4.6 MW

Overview of output and efficiency before and after installation of the absorption heat pump.

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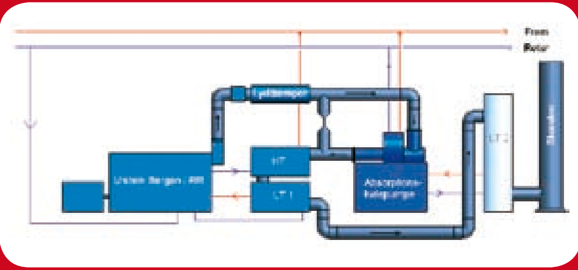

The hot exhaust gas is led through the engine's generator, which contains a mixture of water and lithium bromide (LiBr), approx. 58% LiBr. In the generator, enough heat is added from the exhaust gas to make the solution boil, and the water is led out as steam. The concentrated LiBr solution, ca. 62%, returns to the absorber of the engine via a counterflow heat exchanger.

The steam from the generator is condensed in a condenser and flows via a heat exchanger, which cools the 80°C hot condensate with the return water from the district heating, back to the evaporator.

From the evaporator, the water is pumped via trickle tubes out over the evaporator tubes. Thus the water evaporates, absorbing the necessary evaporation heat from the evaporator tubes, as the pressure in the evaporator corresponds to the desired evaporation temperature.

The evaporated water passes a tower with absorber tubes, which makes the steam condense again, and the evaporation heat is delivered as condensation heat. The condensate/water is then absorbed by the intense LiBr solution from the generator, which has flown to the absorber. The now diluted LiBr solution of approx. 58% is pumped back into the generator, and the process cycle is finished.

What is used for district heating is the cold water in the evaporator circle condensing a large amount of the steam in the engine's flue gas in a heat exchanger for the purpose. At the same time, the flue gas is cooled to about 27°C, and the heat thus absorbed by the evaporator circle is released in the absorption cooler via the absorber and a number of internal heat exchangers, which a.o. also reuse the condensing heat from the water in the circle.

The thermal output from an 18-cylinder Ullstein Bergen/Rolls Royce motor has thus increased by in total 888 kWh per operation hour, corresponding to the thermal efficiency having increased by 11.7%.