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DISTRICT HEATING FROM CHP WITH LARGE HEAT PUMPS

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ABSTRACT
The overall objective of this CHP project was to deliver fuel efficiency in an integrated way through a fuel efficient energy technology that, unlike conventional forms of separate electricity and heat production, uses the by-product heat from Power Plant Kosovo B that is normally wasted by being rejected into the environment. With prices for primary energy resources increasing, the recovery of waste energy was getting into the focus of attention as feasible solution. Also the global climate change reminded us to limit the use of primary energy resources to a minimum, thus exploiting waste energy potentials wherever feasible. The process of upgrading low grade waste heat is especially interesting where large amounts of such energy are available at one point. In order to use the thermal potential of cooling water potential feasible in large quantities in Power Plant Kosovo B, it is proposed to use thermal heat pumps to increase the return temperature from local DH Company from 70 °C to 90 °C. To reach an acceptable operational supply temperature of the water returning to DH Company during peak load conditions, additional temperature raise are needed so that the water temperature will be increased from 90 °C to 120 °C.
Results shows significant improvement of overall thermal efficiency, lower heat cost price (consumer price), cooling feed water savings, less use of fossil fuel and emission reductions (CO2).
Keywords: CHP, waste energy, Heat Pumps

1. COGENERATION CONCEPT

1.1. Introduction
New technical solution is developed on the idea to use different sources of waste heat available in TPP Kosovo B. First of all huge amount of cooling water required for reducing of condensate temperature gives one of opportunities to generate energy for heating purposes.

Having in mind that this source is energy with the low temperature and low enthalpy it was necessary to investigate further technical solutions. Enormous quantity of exhaust gases from the coal fired boilers, with high outlet temperature, came across as first opportunity to increase the water temperature, but proved not to be sufficient for additional heat transfer.
Instead, smaller steam/water heat exchangers are proposed to boost the temperature to operational level.

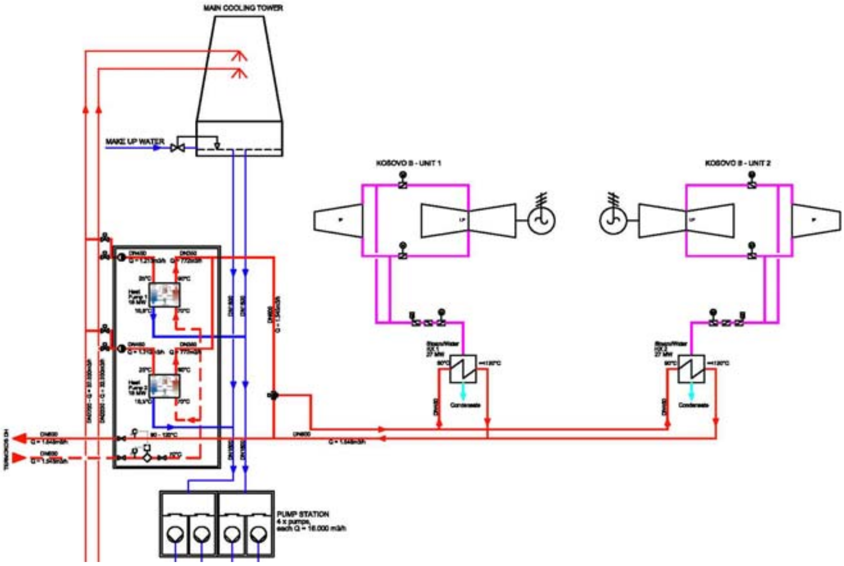

Figure 1. A conceptual diagram of cogeneration

Comparing the data derived from both solutions, we can conclude that the new concept of cogeneration is high-efficiency cogeneration using less primary energy. This concept is in a line with cogeneration Directive 2004/8/EC (the CHP Directive).

2. HEAT EXCHANGE STATION AT KOSOVO B

2.1. Thermal Pumps (Heat Pumps)

In order to use the thermal potential of cooling water it's proposed to use thermal pumps to increase the return temperature from DH Termokos j.s.c. from 70 °C to 90 °C.

According to the main design and measurements from the table of analyses (source Kosovo B1), the cooling system in average circulate G_{mcw} = 32,000 m3/h, supplied by 2 main pumps 2 x 16,000 m3/h which have electrical consumption P_{pumps} = 1.2 MW. This quantity depends from the condensers requirement and pumps power.

Reduction of condensing temperature to 24 ^{o}C reduce the pressure to 0.03 bar which cause increase of steam extraction from LP turbine and reduction of electrical production. This is the situation during winter time.

New concept of cogeneration and use of cooling water enable controlling of optimal parameters for cooling water, condensation temperature inside condenser, significant reduce of make up water and increasing flexibility of cooling system.(water savings-benefit)

MAN "Abnahmeversuche 1 Kosova B" defines for different working regimes an "optimal" temperature of supply cooling water between 15-23 °C

Actual technical parameters in condenser

- Quantity of condensate 600-700 m3/h
- Condensing temperature 31°C- on the coldest days

Optimal (for capacity 252 MW) - real capacity 300 MW, but not 339 MW (never reached)

- MCW- supply 16.5 °C

- MCW- discharge 25 °C
- Δt = 8.5 °C

Actual parameters

- t_s = 18.2 °C
- t_d = 28.2 °C, maximum ts = 32.0 °C
- Δt = 10 °C

Best parameters

- t_s = 15-23 °C
- t_d = 25 °C, maximum ts = 42.0 °C
- Δt = 10 °C (designed 12 °C)

where

t_s = supply temperature
t_d = discharge temperature
MCW = Main Cooling Water

Designed temperature difference between condensation and discharge temperature is Δt = 2.5 °C, but measured difference reaches values up to Δt = 8 °C. It gives great opportunities to control the condensation parameters, temperature 36.4 °C and vacuum 61 mbar.

Through the new technical solution vacuum disorder can be avoided, keeping optimal conditions in the condenser.

The benefits are:

- Design temperature MCW - supply 15.0 °C or 16.5 °C
- Control of water quantity through MCW piping. – pumps now works either with full or half capacity
- Decreasing MCW - discharge temperature (t_{dmin} = 28.2 °C or t_{dmax} = 30.0 °C (wintertime)) will “relax” the cooling system and ease up cooling in the cooling tower. Instead sending water through MCW-discharge piping to the top of the tower it can be passed through the basin bottom.
- Significant quantity reduction of make up water for the cooling system. The make-up water reaches values up to 2.5 t/h per MW produced in TPP, added during production process.

The cooling water with parameters 25 °C / 16.5 °C (cooling water in/outlet) will be extracted through pipes DN 450 from both main cooling pipes DN 2,200, Q = 16,000 m3/h for blocks B1 and B2 or alternatively, in total quantity of 674 kg/s, which generates in evaporator total cooling capacity up to Q = 24 MW.

In the thermal pumps condenser and sub cooler, with steel tubes, there will be generated 18 MW heating capacity at 70 °C / 90 °C (heating water in-/outlet), 772.5 m3/h or 215 kg/s heating water flow approx. This means that with two heat pumps and total water flow 430 kg/s it is expected to generate capacity of 36 MW hot water, with temperature regime 70 °C / 90°C.

Having in mind that the impact on the net generated electricity from Kosovo B is an important indicator for the numbers of installed Heat Pumps 15 different scenarios have been investigated.

To , technically, determine the optimal number of HP, so that the impact on the net generated electricity do not exceed the impact derived from steam extraction only, it can be verified that the scenarios SC9, SC10, SC13 and SC14 results in a higher impact on the net generated electricity than the option without any HP.

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To reach an acceptable operational supply temperature of the water going back to DH Termokos j.s.c. additional temperature raise are needed.

This will be achieved in steam/water heat exchangers, extracting steam from the IP steam turbine. The steam/water heat exchangers will only have to cover around 22% of the annual heat demand. Hence steam extraction will be much less than predicted in the FS2005.
The steam extraction has of course an impact on the generated electricity from Kosovo B, but using HP will decrease the impact significantly. The water temperature will be increased from 90 °C to 120 °C.

Extracting steam from the exhaust from the IP steam turbines will be proposed to increase the hot water temperature up to an acceptable operational temperature.

In these heat exchangers with primary side steam/condensate, temperature regime 260 °C (4 bar) / 90 °C and secondary side-hot water 120 °C / 90 °C generation of additional 54 MW of heating energy will be provided.

This will result with total heating capacity toward DH Termokos j.s.c. at 90 MW of hot water 120 °C / 90 °C, which covers assessed actual heat demand for Prishtina.

3. FINAL CONCLUSIONS

Based on the analyses in the all technical analyses the most feasible option SC2 comprises of:

- Two (2) thermal Heat Pumps (18 MW each) and steam extraction equipment (heat exchangers), 2 x 54 MW tube type heat exchangers at KEK Kosovo B
- A new SS 220/6,3 kV at KEK Kosovo B for power supply to the Heat Pumps
- A pre-insulated pipeline, 2 x DN 600, from KEK Kosovo B to Termokos DH Company including a booster pump station
- A Heat Exchanger station at Termokos DH Company, 4 x 30 MW plate type heat exchangers
- Main circulation Pumps at Termokos DH Company for the transmission system, 3 x 1.030 m3/h at 4,2 bar, frequency controlled.
- A complete Water Treatment Plant for the transmission system, capacity 20 m3/h
- A complete Expansion and Pressure Holding System for the transmission system
- A complete SCADA system (control and monitoring) for the transmission system

The conclusion of the technical and financial assessment reports is further that it is technical and financial viable to install additional 2 Heat Pumps at KEK Kosovo B, if the development in the heat market is at least according to the “low growth” scenario.

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