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ANALYSIS OF THERMODYNAMIC LOSSES IN REGENERATION SYSTEMS OF THE EXTRACTION BACK-PRESSURE POWER UNIT IN A COMBINED HEAT AND POWER PLANT

SUMMARY

An algorithm is developed for computing thermodynamic losses in the regeneration systems of the back-pressure power unit in a combined heat and power plant. Thermal measurements taken under the typical working loads were utilised to compute and analyse variability of the thermodynamic losses in heat exchangers of the high-pressure and low-pressure regeneration systems in the heating and pseudo-condensing modes of operation.

Keywords: *combined heat and power plant, extraction back-pressure power unit, regeneration system, thermodynamic losses, exergy analysis*

ANALIZA STRAT TERMODYNAMICZNYCH W UKŁADACH REGENERACJI BLOKU UPUSTOWO-PRZECIWPRĘŻNEGO ELEKTROCIEPŁOWNI

W artykule opisano algorytm obliczania strat termodynamicznych w układach regeneracji bloku upustowo-przeciwprężnego elektrociepłowni. Następnie na podstawie wyników pomiarów cieplnych dla typowego zakresu obciążeń eksploatacyjnych bloku wyznaczono wartości tych strat w wymiennikach ciepła układów regeneracji: wysokoprężnej i niskoprężnej oraz dokonano analizy przebiegu ich zmienności zarówno dla ciepłowniczego, jak i pseudokondensacyjnego trybu pracy bloku.

Słowa kluczowe: *elektrociepłownia, blok upustowo-przeciwprężny, układ regeneracji, straty termodynamiczne, analiza egzergetyczna*

1. INTRODUCTION

Bled-type regeneration always leads to a higher thermal efficiency of the cycle and by so doing improves the performance of a power unit in a steam plant. Effectiveness of regeneration systems in the extraction condensing unit was addressed in [1], and in an extraction back-pressure power unit will be in [2].

Effectiveness of regeneration systems in combined heat and power plant units is often deteriorated due to thermodynamic losses in heat exchangers caused by the finite difference in temperatures between the heat-exchanging media. In the consequence of a loss of exergy, i.e. the medium's ability to perform work with respect to its surroundings, energy supplied to the process has to be consumed or the final effect is deteriorated – electric power generation is reduced.

The effects of thermodynamic losses in the regeneration systems on the performance of the extraction condensing unit in a heat and power plant are addressed in [3].

This study focuses on thermodynamic losses in regeneration systems of the back-pressure power unit. Research data were obtained for a power unit BC-100 in the combined heat and power plant "Elektrociepłownia Kraków S.A". Measurements were taken over a wide range of working loads, both for the heating and pseudo-condensing modes of operation. Detailed results supported by qualitative and quantitative evaluation of the effects of thermodynamic losses on BC-100 unit performance are summarised in [4].

2. CONTROL PLANT

The control plant is the extraction back-pressure power unit BC-100 type no 4, one of the two extraction back-pressure power units in the combined heat and power plant "Elektrociepłownia Kraków S.A.". These are typical heating units operated in the conditions of the peak demand for district heating. Schematic diagram of the power unit is shown in the Figure 1.

Installations of the power unit BC-100 no 4 include:

- Radiant, two-pass, single-drum, natural circulation steam boiler OP-430 type, fired with pulverised coal.
  Nominal parameters of the boiler:
  - fresh steam pressure – 13.53 MPa,
  - fresh steam temperature – 813 K (540°C).
- Turbine 13UP-110 type – axial, tandem-compound back-pressure type impulse steam turbine; the turbine has a high-pressure section HP and low-pressure section LP, with two district heating bleeds, bleed control on the outlet of turbine cylinder, five bleeds for regenerative heating of the feed water.

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Nominal parameters of the turbine:
  - turbine speed – 3000 rpm,
  - fresh steam pressure – 12.75 MPa,
  - fresh steam temperature ratings – 808 K (535°C),
  - potential thermal power – 191 MW,
  - flow rate of network water – 1305 kg/s.
- Synchronous generator TGH-120 type with hydrogen cooling:
  - power ratings – 120 MW,
  - voltage ratings – 13.8 kV.
- Regeneration system with heat exchangers: low-pressure exchanger XN1 and high-pressure exchangers: XW1, XW2, XW3.
- Degasifier DG with a supply tank.
- Feed pump PZ and condensate pump PK.
- Heating exchangers system: XA, XB.
- Water coolers WW1, WW2.

BC-100 unit can be used for cogeneration of electricity and heat.

Two operating modes are available:

1) heating mode,
2) pseudo-condensing mode.

In the **heating mode of operation** (see Fig. 1) a stream of superheated steam leaving the boiler {I} is fed to the blades of the high-pressure turbine section HP, where it expands to the pressure and temperature {II}. A portion of steam, after expanding to the value at the point {1} is supplied to the high-pressure heat exchanger XW3 at the point {4}, where it condenses and by so doing transfers heat to the maim stream of condensate fed to the boiler. On leaving the HP turbine, steam passes then to the LP turbine where it is further expanded to reach the parameters given in the point {2}, whilst some portion of it is supplied to the heat exchanger XW2 at the point {5}. A portion of this stream of steam is collected via process bleeding and supplied to municipal customers {u}, the remaining portion is used for generation of heat and electricity.

In the low-pressure section steam is further expanded to the parameters at points {2} and {3}. In the turbine enthalpy of steam is converted into mechanical energy and then converted into electric energy in the generator. In the low pressure section there are three bleeds: a bleed port to high- pressure regeneration heat exchanger XW1 and to a low-pressure exchanger XW2 – where steam performs the same task as in XW3 and XW2; there is also a bleed port to the degasifier, which is mixer preheater the stream from the supply tank. The main stream of steam (points {2}, {3}) is condensed in the heating exchangers XA, XB transferring its heat to network water used for district heating.

In the **pseudo-condensing mode** the flow of network water for district heating is arranged such that thermal power contained in water leaving the heating exchangers XA, XB is not absorbed by municipal customers but transferred to cooling water in coolers WW1-WW2 (water-water exchangers). Water cooling the exchangers WW transfers its thermal power in the cooling tower. Under these conditions the power unit operates as a conventional power plant with a lesser vacuum and an extended cooling system.

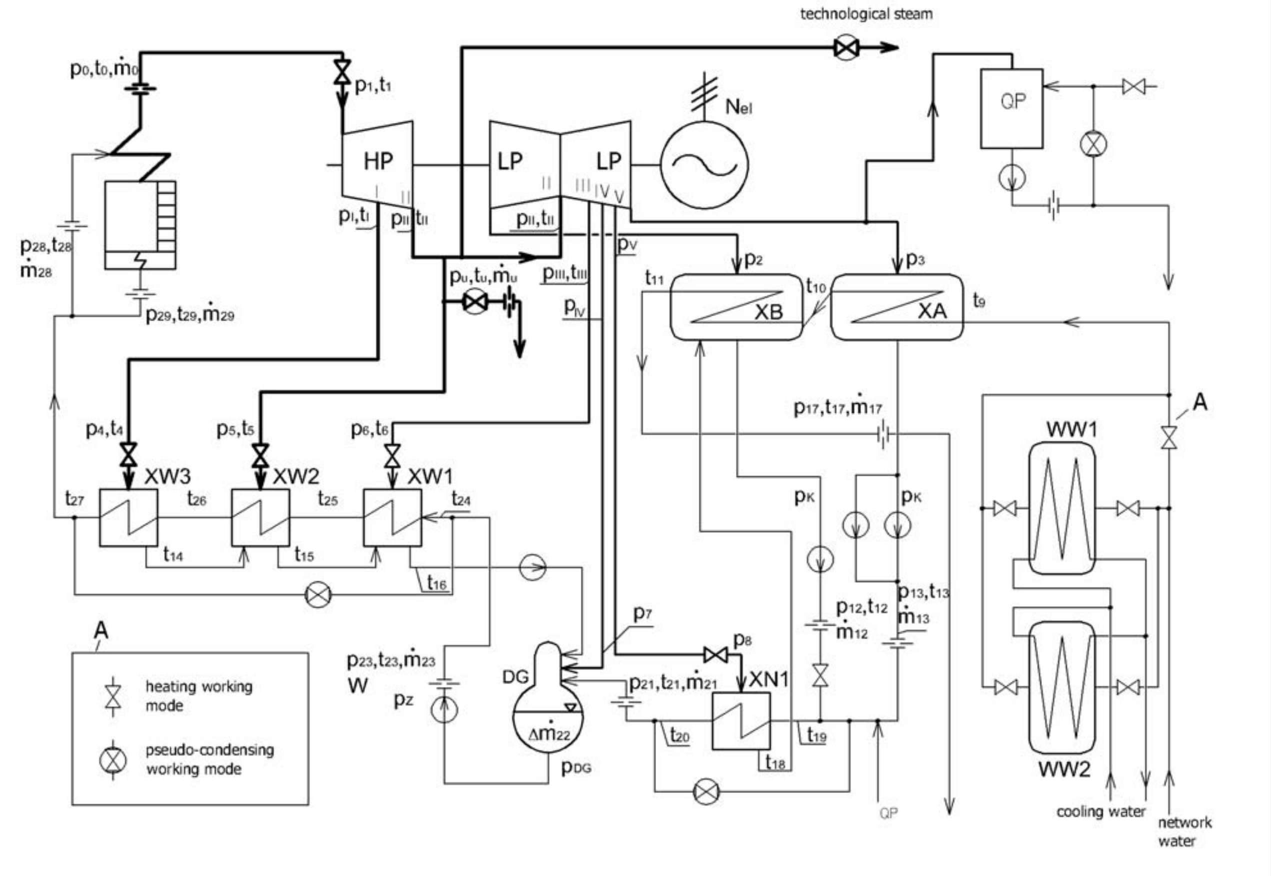

Fig. 1. Schematic diagram of the back-pressure power unit BC-100 in the combined heat and power plant "Elektrociepłownia Kraków S.A."

This study focuses on the high-pressure regeneration system: heat exchangers XW1, XW2, XW3 and a low-pressure exchanger XN1 in the regeneration system of the BC-100 power unit. These are steam-water exchangers supplied by steam from bleed ports in the turbine. The low-pressure regenerative preheater XN1 is supplied by wet steam whilst high-pressure exchangers are supplied by superheated steam. Condensate from heating exchangers XA, XB supplemented by water from a vacuum degasifier QP flows through the low-pressure heater XN1 and into a degasifier DG. Stream of water from the degasfier DG plus the stream of condensed steam from the bleed port {IV} and the stream of condensate drip {16} flows subsequently through the exchangers system XW1-XW3, at the same time its temperature rises by about 30°C. Condensate drips from the heat exchanger XW3 cascade down from XW3 to XW2 and next to XW1, where they impart their heat to the condensate by mixing with the streams of steam from bleed port {5} (in XW2) and {8} (in XW1). The design of the power unit allows the low-pressure and high- -pressure regeneration systems to be switched off (in the case of failures or repairs). In this situation water will flow to the boiler circumventing the regeneration systems.

Technical specification and nominal parameters of heat exchangers:

- High-pressure regenerative preheater XW1 – PWU-550 type:
  - water-end pressure (max) – 22.66 MPa,
  - steam-end pressure (max) – 0.981 MPa,
  - mass flow rate of extracted steam – 6.35 kg/s,
  - water temperature at the inlet to XW1 – 401 K (128°C),
  - water temperature at the outlet from XW1 – 430 K (157°C).
- High-pressure regenerative preheater XW2 – PWU-460 type:
  - water-end pressure (max) – 22.66 MPa,
  - steam-end pressure (max) – 1.57 MPa,
  - mass flow rate of extracted steam – 12.22 kg/s,
  - water temperature at the inlet to XW1 – 430 K (157°C),
  - water temperature at the outlet from XW1 – 455 K (182°C).
- High-pressure regenerative preheater XW3 – PWU-460 type:
  - water-end pressure (max) – 22.66 MPa,
  - steam-end pressure (max) – 2.55 MPa,
  - mass flow rate of extracted steam – 6.75 kg/s,
  - water temperature at the inlet to XW1 – 455 K (182°C),
  - water temperature at the outlet from XW1 – 485 K (212°C).
- Low-pressure regenerative preheater XN1 (vertical surface configuration):
  - water-end working pressure (max) – 1.667 MPa,
  - steam-end working pressure (max) – 0.294 MPa,
  - heating surface – 300 m^2,
  - mass flow rate of extracted steam – 5.93 kg/s,
  - temperature of incoming steam – 368.5 K (95.5°C),
  - condensate temperature at the inlet – 341.2 K (68.2°C),
  - condensate temperature at the outlet – 372.4 K (99.4°C).

3. METHODOLOGY

Performance parameters of heat exchangers are obtained by computing the loss of exergy flux in the investigated exchanger and the resulting loss of electric power in the generator. An exergy loss flux in a heat exchanger associated with irreversibility of processes inside the control volume is derived from the Gouy-Stodola law

$$\delta_q = T_{ot} \sum_i \Delta S_i \tag{1}$$

where:

$\sum_i \Delta S_i$ – sum of entropy flux increments of all i bodies involved in the process,

T_{ot} – absolute ambient temperature.

According to [5, 9, 10] exergy loss flux for k heat exchanger – with steam and water as heat-exchanging media – is obtained from the formula

$$\delta_{qk} = T_{ot} \left(\frac{\dot{Q}_W}{T_W} - \frac{\dot{Q}_P}{T_P} \right) \tag{2}$$

where:

$\dot{Q}_W = q_W \cdot \dot{m}_W$ – thermal power of feed water in the exchanger,

$q_W = i_2 - i_1$ – feed water enthalpy encrement,

$\dot{m}_W$ – mass flow rate of feed water,

$T_W = \frac{T_1 + T_2}{2}$ – mean value of absolute temperature of feed water,

$\dot{Q}_P = q_P \cdot \dot{m}_P$ – thermal power of steam supplying the exchanger,

$q_p = i_a - i_b$ – enthalpy encrement of steam,

$\dot{m}_P$ – mass flow rate of steam,

$T_P = \frac{i_a - i_b}{s_a - s_b}$ – mean value of absolute temperature of steam,

$s_a - s_b$ – steam entropy increment.

Explanation refering on the principle of energy loss flux determination and used above symbols for the double section exchanger abstracting superheating steam are shown graphically in Figure 2.

Assuming that internal efficiency of the turbine should remain unchanged [5, 6], electric power loss associated with thermodynamic loss in the given heat exchanger k, if it takes into consideration the mechanical efficiency η_m and the generator efficiency η_g, is given as

$$\Delta N_{elk} = \eta_g \cdot \eta_m \cdot \delta_{qk} \tag{3}$$

Total power loss in the generator due to exergy loss in the regeneration system can calcutate from

$$\Delta N_{el} = \sum_{k=1}^{k} \Delta N_{elk} \tag{4}$$

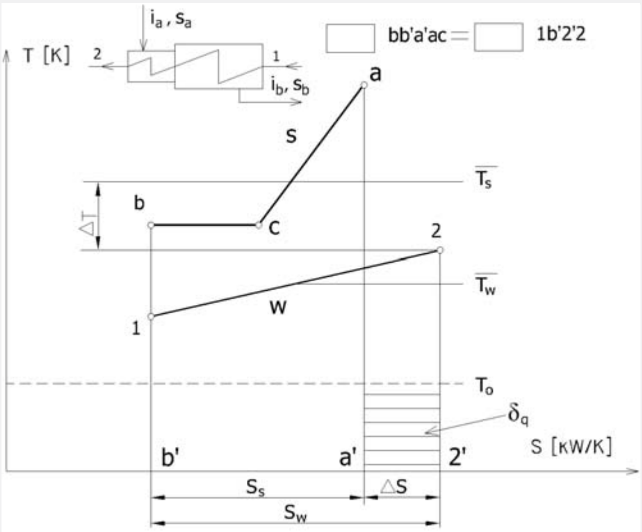

Fig. 2. Thermodynamic losses in a double-section exchanger abstracting superheated steam

Contribution of electric power loss ΔN_{el} associated with thermodynamic loss δ_q in the regeneration system of the back-pressure power unit in relation to the generated electric power N_{el} is a relative electric power drop ε and is equal to

$$\varepsilon = \frac{\Delta N_{el}}{N_{el}} \cdot 100\% \tag{5}$$

Equation (2) was applied to the evaluation of heat exchange processes in regenerative exchangers. Accordingly, the fluxes of exergy loss are:

– for preheater XN1

$$\delta_{qXN1} = T_{ot} \cdot \left(\frac{2(i_{20} - i_{19})\dot{m}_{21}}{T_{19} + T_{20}} - \dot{m}_8 (s_8 - s_{18}) \right) \tag{6}$$

– for preheater XW1

$$\delta_{qXW1} = \\ = T_{ot} \cdot \left(\frac{2(i_{25} - i_{24})\dot{m}_{23}}{T_{24} + T_{25}} - \dot{m}_6 (s_6 - s_{16}) - (\dot{m}_4 + \dot{m}_5)(s_{15} - s_{16}) \right) \tag{7}$$

– for preheater XW2

$$\delta_{qXW2} = \\ = T_{ot} \cdot \left(\frac{2(i_{26} - i_{25})\dot{m}_{23}}{T_{25} + T_{26}} - \dot{m}_5 (s_5 - s_{25}) - \dot{m}_4 (s_{14} - s_{15}) \right) \tag{8}$$

– for preheater XW3

$$\delta_{qXW3} = T_{ot} \cdot \left(\frac{2(i_{27} - i_{26})\dot{m}_{23}}{T_{26} + T_{27}} - \dot{m}_4 (s_4 - s_{14}) \right) \tag{9}$$

4. THERMAL MEASUREMENT PROCEDURE

Measurements of the power unit BC-100 were taken in the heating and pseudo-condensing mode of operation. The range of working loads, parameters of steam and heating water are summarised below.

- Heating mode of operation
  - generator loading: from 79.1 to 100.2 MW,
  - steam pressure ahead of the turbine: from 13403 to 13667 kPa,
  - steam temperature ahead of the turbine: from 783 to 792 K (from 510 to 519°C),
  - water temperature ahead of XA: from 322.1 to 305.0 K (from 49.1 to 62.0°C),
  - flow rate of network water: from 1410.2 to 1552.64 kg/s.
- Pseudo-condensing mode of operation
  - generator loading: from 76.9 to 96.1 MW,
  - steam pressure ahead of the turbine: from 13339 to 13767 kPa,
  - steam temperature ahead of the turbine: from 795 to 801 K (from 522 to 528°C),
  - water temperature ahead of heating exchanger XA: from 337.9 to 344.1 K (from 64.9 to 71.1°C),
  - flow rate of network water: from 1759.4 to 1792.4 kg/s.

Measurements in the pseudo-condensing and heating mode were taken for eight levels of working loads. Each measurement was taken twice to improve their reliability.

During measurements steam pressure at the inlet to the turbine was higher than the nominal value, though the admissible level p_{dop} = 12 750 ±1275 kPa was not exceeded. Steam temperature was considerably below the nominal level and the admissible value was exceeded t_{dop} = 535°C (–8°C) (+15°C).

The fluxes of steam and condensate were obtained using measurements in reducers (at the points designated on the diagram), the remaining streams of extracted steam were obtained from the energy and mass balance formulas for the whole power unit.

5. COMPUTED DATA

Computations of exergy flux losses in particular regenerative exchangers and of the associated electric power drop were performed for eight levels of working load, for the heating and pseudo-condensing modes of operation. Results are summarised in Tables 1 and 2 and displayed in graphic form in the Figures 3–16.

6. CONCLUSIONS

Because of specificity of BC-100 power unit operation in the two available operating modes, the evaluation of thermodynamic losses in the regeneration systems has to be performed separately for the heating and pseudo-condensing mode. It is worthwhile to mention that computed results are obtained on the basis of experimental measurement data, which might involve certain errors inherent in the applied measurement method or due to inadequate precision of measuring instruments.

Heating mode

Research data (Tab. 1) reveal that the largest thermodynamic losses are generated in the low-pressure preheater XN1 and next come the losses in the heat exchangers XW1, XW2, XW3, accompanied by electric power drop.

Generated exergy losses that control heat exchange in the selected operating point of heating mode for working load N_{el} = 96.0 MWare shown graphically in the Figures 3–6.

This correlation is borne out by the size of areas representing exergy flux losses in particular heat exchangers and by the electric power drop distribution (Figs 8 and 9). Certain doubts can be raised, however, as to the profile of temperature difference (ΔT) between heat exchanging media in the function of working load for the heat exchanger XN1 (Fig. 7). It appears that its plot should be that shown by last point omission.

The total decrease of generated electric power due to thermodynamic losses in regeneration systems tends to grow in proportion to the working load (Fig. 9) and reaches its highest value $\Delta N_{el} \approx 1.7$ MW under the load N_{el} = 100 MW.

During the 6 months' heating season where power unit operates in the heating mode, the financial loss ΔKc due to thermodynamic losses in regeneration systems of the back-pressure power unit is equal to:

$$\Delta Kc = 6 \text{ months} \times 30 \text{ days a month} \times 24 \text{ hours a day} \times \times 1.6 \text{ MW} \times 27.9 \text{ euro/MWh} = 205\ 300 \text{ euro/season.}$$

Table 1

Computed thermodynamic losses in the high-pressure and low-pressure regeneration systems of the power unit BC-100 in the heating mode of operation

No.	Description			Symbol	Unit	Operating load							
						1	2	3	4	5	6	7	8
1	Heating mode of operation	Electric power		N_{el}	MW	79.06	79.12	90.31	90.51	95.06	96.02	100.21	100.27
2		XN1	Exergy loss flux	δ_{qXN1}	kW	457.2	375.1	403.8	623.56	434.9	438.8	430.75	494.21
3			Electric power drop	ΔN_{elXN1}	kW	439.1	360.2	387.8	593.7	417.7	421.4	413.7	474.6
4		XW1	Exergy loss flux	δ_{qXW1}	kW	291.5	241.4	336.1	333.7	323.1	369.4	488.7	485.7
5			Electric power drop	ΔN_{elXW1}	kW	280.0	231.8	322.8	320.5	310.3	354.8	469.3	466.5
6		XW2	Exergy loss flux	δ_{qXW2}	kW	309.1	275.8	292.6	294.7	356.2	321.9	372.8	362.4
7			Electric power drop	ΔN_{elXW2}	kW	296.9	264.9	281.0	283.0	342.1	309.2	358.0	348.0
8		XW3	Exergy loss flux	δ_{qXW3}	kW	291.0	298.1	295.8	304.6	330.7	341.2	369.3	359.6
9			Electric power drop	ΔN_{elXW3}	kW	279.5	286.3	284.1	292.5	317.6	327.7	354.7	345.4
10		Total	Exergy loss flux	δ_q	kW	1348.7	1190.4	1328.3	1556.56	1444.9	1471.3	1661.6	1701.9
11			Electric power drop	ΔN_{el}	kW	1295.3	1143.3	1275.7	1489.8	1387.7	1413.0	1595.7	1634.5
12			Relative electric power drop	ε	%	1.63	1.44	1.41	1.64	1.47	1.46	1.72	1.64

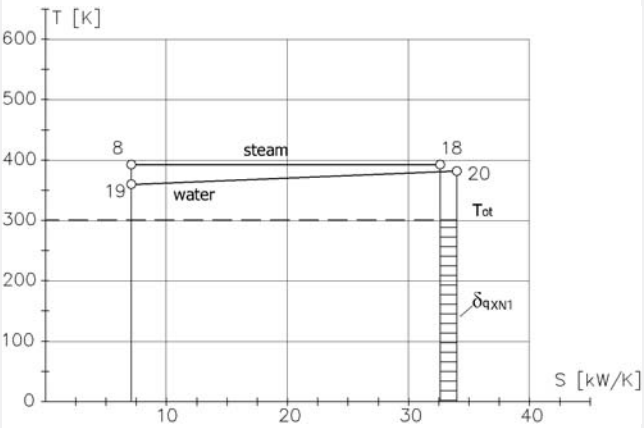

Fig. 3. Exergy loss flux δ_{qXN1} in the heat exchanger XN1 in the heating mode of operation, for the working load N_{el} = 96.0 MW

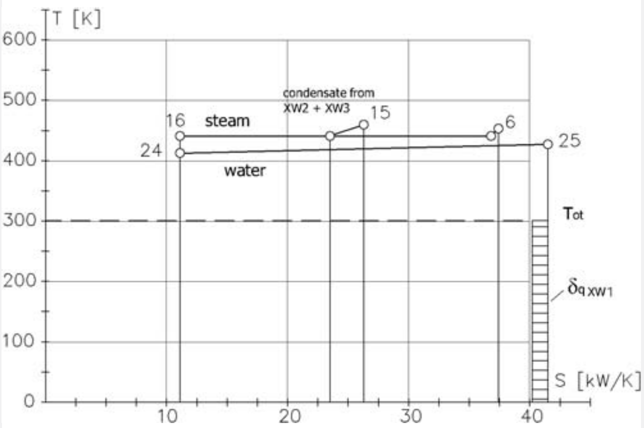

Fig. 4. Exergy loss flux δ_{qXW1} in the heat exchanger XW1 in the heating mode of operation, for the working load N_{el} = 96.0 MW

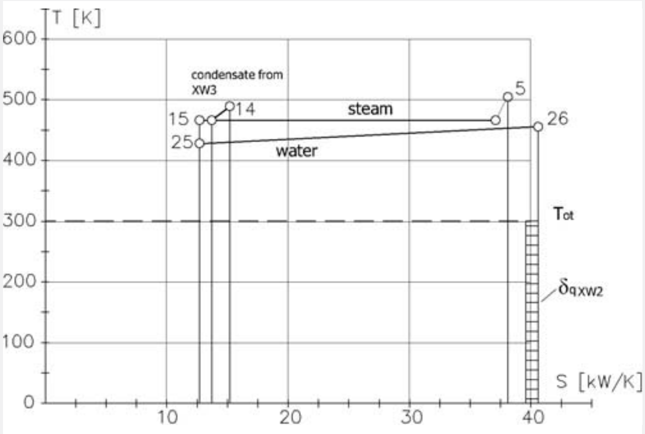

Fig. 5. Exergy loss flux δ_{qXW2} in the heat exchanger XW2 in the heating mode of operation, for the working load N_{el} = 96.0 MW

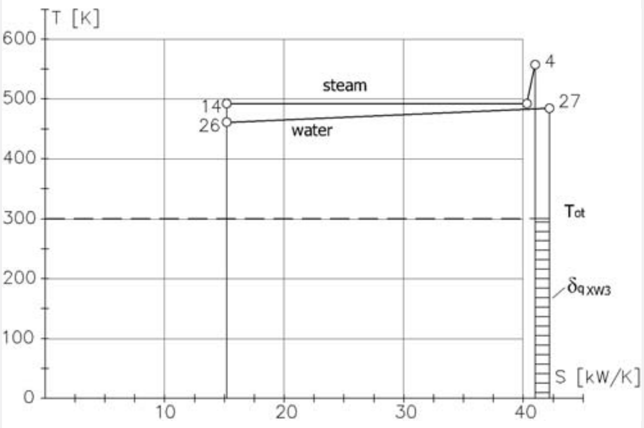

Fig. 6. Exergy loss fluxin δ_{qXW3} the heat exchanger XW3 in the heating mode of operation, for the working load N_{el} = 96.0 MW

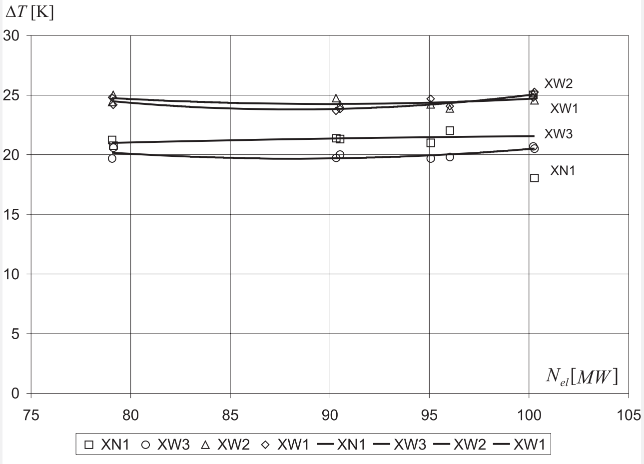

Fig. 7. Temperature difference ΔT between heat-exchanging media in the range of working loads for heat exchangers XN1, XW1, XW2, XW3 for heating mode of operation

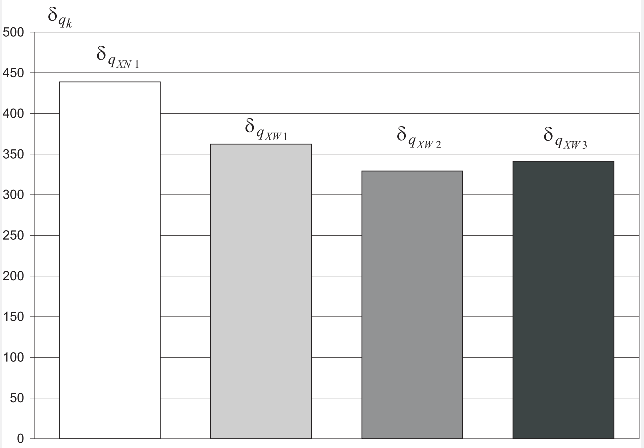

Fig. 8. Distribution of exergy losses fluxes δ_{qk} in regenerative exchangers for N_{el} = 96.0 MW for heating mode of operation

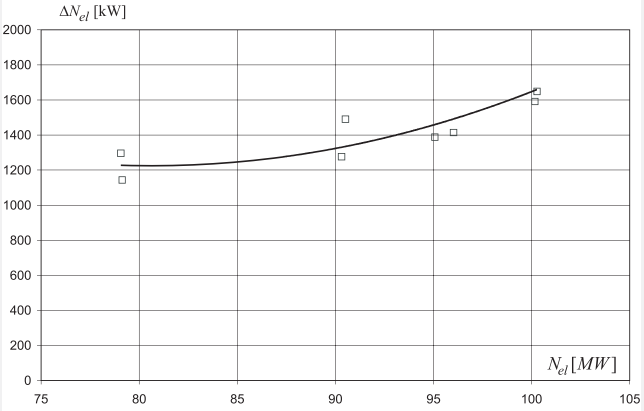

Fig. 9. Electric power drop ΔN_{el} due to thermodynamic losses in the function of working loads N_{el} for heating mode of operation

Pseudo-condensing mode

Research data (see Tab. 2) indicate that the smallest thermodynamic losses in the pseudo-condensing mode occur in the heat exchanger XN1, much higher thermodynamic losses are reported in XW1, XW2, XW3, which is illustrated by plotted areas in the Figures 10–13 and 15. One has to bear in mind that in the pseudo-condensing mode the values of thermodynamic losses in XN1 and XW1 were much lower in relation to the heating mode.

The plot of electric power drop due to thermodynamic losses in the function of working load in the pseudo-condensing mode (Fig. 16) is analogous to that for the heating mode (Fig. 9). The total drop of electric power tends to grow in proportion to working load, up to the value $\Delta N_{el} \approx 1.6$ MW.

When the extraction back-pressure power unit operates in the pseudo-condensing mode, outside the heating season, the financial loss ΔKp due to generated thermodynamic losses in the regeneration systems will be:

$$\Delta Kp = 6 \text{ months} \times 30 \text{ days a month} \times 24 \text{ hours a day} \times 1.3 \text{ MW} \times 27.9 \text{ euro/ MWh} = 166\,800 \text{ euro/season.}$$

Table 2
Computed thermodynamic losses in the high-pressure and low-pressure regeneration systems of the power unit BC-100 in the pseudo-condensing mode of operation

No.	Description			Symbol	Unit	Operating load							
						1	2	3	4	5	6	7	8
1	Pseudo-condensing mode of operation	Electric power		N_{el}	MW	76.90	76.93	83.12	83.34	89.27	89.54	96.13	96.13
2		XN1	Exergy loss flux	δ_{qXN1}	kW	170.0	203.8	241.9	236.0	153.6	150.8	242.9	228.4
3			Electric power drop	ΔN_{elXN1}	kW	163.3	195.7	232.3	226.7	147.5	144.8	233.3	219.4
4		XW1	Exergy loss flux	δ_{qXW1}	kW	242.0	251.7	266.4	271.5	316.7	298.5	334.2	368.6
5			Electric power drop	ΔN_{elXW1}	kW	232.4	241.7	255.9	260.7	304.2	286.7	321.0	354.0
6		XW2	Exergy loss flux	δ_{qXW2}	kW	267.7	269.0	288.5	276.5	320.0	284.2	377.0	372.9
7			Electric power drop	ΔN_{elXW2}	kW	257.1	258.3	277.1	265.6	307.3	272.9	362.1	358.1
8		XW3	Exergy loss flux	δ_{qXW3}	kW	263.0	238.0	265.8	279.3	343.7	337.0	369.2	377.8
9			Electric power drop	ΔN_{elXW3}	kW	252.6	228.6	255.3	268.2	330.1	323.7	354.6	362.8
10		Total	Exergy loss flux	δ_q	kW	942.8	962.5	1062.6	1063.3	1134.1	1070.6	1323.3	1347.8
11			Electric power drop	ΔN_{el}	kW	905.5	924.4	1020.5	1021.2	1089.2	1028.2	1270.9	1294.4
12			Relative electric power drop	ε	%	1.18	1.20	1.23	1.23	1.22	1.15	1.32	1.35

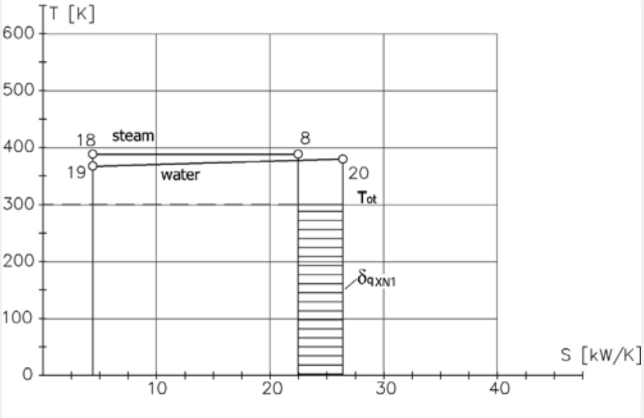

Fig. 10. Exergy loss flux δ_{qXN1} in the heat exchanger XN1 in the pseudo-condensing mode of operation, for the working load $N_{el} = 96.1$ MW

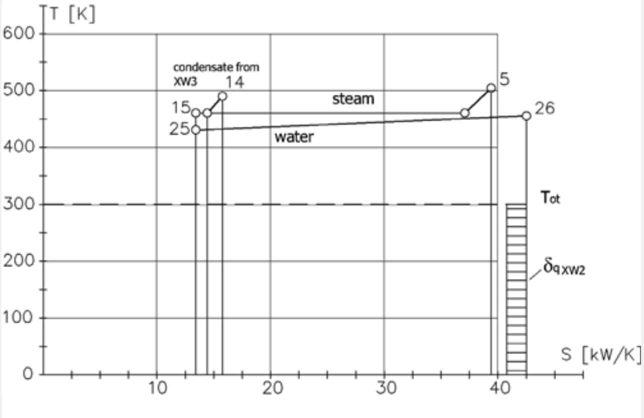

Fig. 12. Exergy loss flux δ_{qXW2} in the heat exchanger XW2 in the pseudo-condensing mode of operation, for the working load $N_{el} = 96.1$ MW

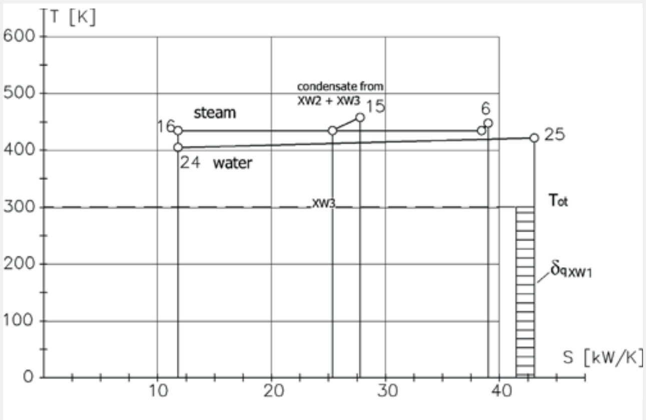

Fig. 11. Exergy loss flux δ_{qXW1} in the heat exchanger XW1 in the pseudo-condensing mode of operation, for the working load $N_{el} = 96.1$ MW

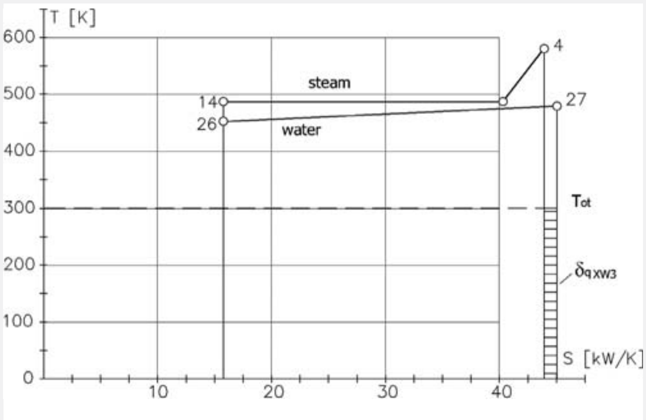

Fig. 13. Exergy loss flux δ_{qXW3} in the heat exchanger XW3 in the pseudo-condensing mode of operation, for the working load $N_{el} = 96.1$ MW

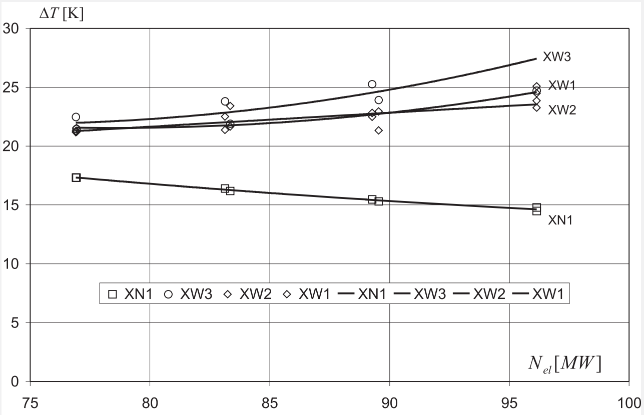

Fig. 14. Temperature difference ΔT between heat-exchanging media in the range of working loads for heat exchangers XN1, XW1, XW2, XW3 for pseudo-condensing mode of operation

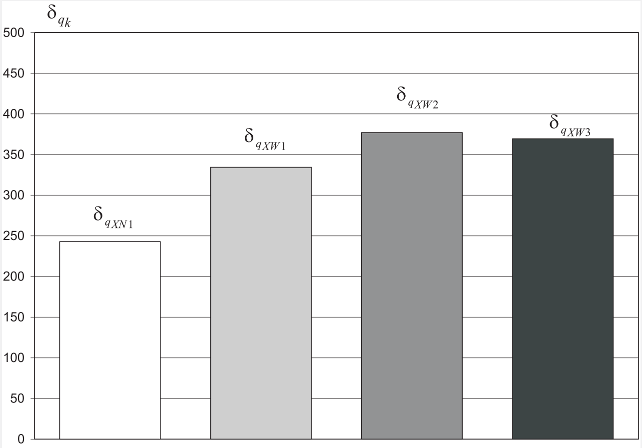

Fig. 15. Distribution of exergy losses fluxes δ_{qk} in regenerative exchangers for N_{el} = 96.1 MW for pseudo-condensing mode of operation

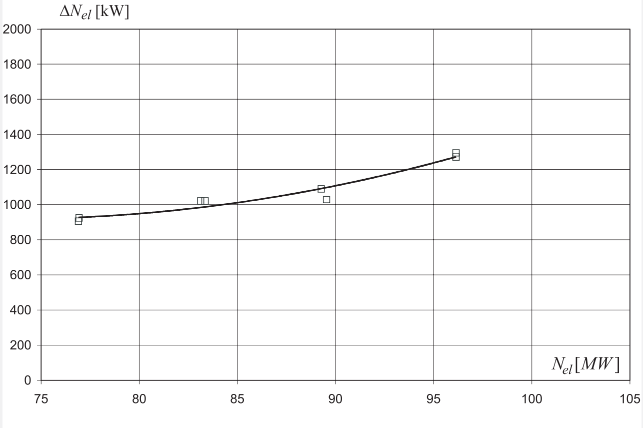

Fig. 16. Electric power drop ΔN_{el} due to thermodynamic losses in the function of working load for pseudo-condensing mode of operation

Evaluation of thermodynamic losses in the extraction back-pressure power unit

It is reasonable to suppose that thermodynamic losses generated during a yearly operation of the back-pressure power unit BC-100 lead to the following financial loss

$$\Delta K = \Delta Kc + \Delta Kp = 372\ 100 \text{ euro.}$$

The economic evaluation of thermodynamic losses generated in regeneration systems of the back-pressure power unit shows the importance of such studies, at the same time prompting power engineers to modernise the existing regeneration systems in the power unit BC-100 in order to reduce thermodynamic losses.

Actually the level of thermodynamic losses in regeneration systems is determined by the design of installations and the parameters of the working medium. It is a well-established fact that plant design is more important than finding the optimal temperature difference.

A widely applied approach to reduce thermodynamic losses in regeneration exchangers consists in reducing the difference between the mean temperatures of heat-exchanging media.

This effect can be achieved by [6, 8]:

- reducing the level of steam superheating in relation to the saturation temperature in the given exchanger,
- employing an additional front turbine whose branch taps supply the regeneration system
- supercooling of steam drips.

It has to be emphasised that a rational choice of the optimal solution requires that financial and energy-related aspects of the heat regeneration installation operation be thoroughly examined, taking into account the reliability criteria. Reducing the electric power losses due to exergy loss in regenerative exchangers and potential financial benefits after modernisation are will produce results in the form of reduced investment costs and payoff period. A review of methods of thermodynamic losses reduction in regeneration systems in the context of modernisation of the back-pressure power unit might shall be provided in the next papers.

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