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Comparison of Value Thermal and Exergy Efficiency Power Plants "Kosova A5"

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Abstract: The turbine block A5 is a type K-200-130-5 LMZ, with installed capacity of 210 MW. The difference in relation to the turbine blocks A3 and A4 is in the fact that the supply of steam in the turbine following block A5is slightly higher. In the analysis of thermal power plants is of special significance energy and exergy analysis, comparative analysis and content blocks. In this sense, we define the qualitative and quantitative comparative indicators such as energy and exergy efficiency. It should be noted that the exergy analysis not only complement energy analysis, but also of special importance in terms of detection of the focal point of energy loss within a block of the power plant.

Keywords: Power plants, Energy analysis, Exergy analysis, Efficiency of the power plants

I. ENERGY AND EXERGY ANALYSIS THERMO BLOCS A5

Energy and exergy analysis can complement each other in terms of qualitative and quantified, if one bears in mind that the Exergy is a convertible part of the energy that can be transformed into other forms of useful energy.

In figure 1 presents the technological scheme of thermal power plants Kasova A5, while figure 2 presents a state diagram the mark (s, i) conditions.

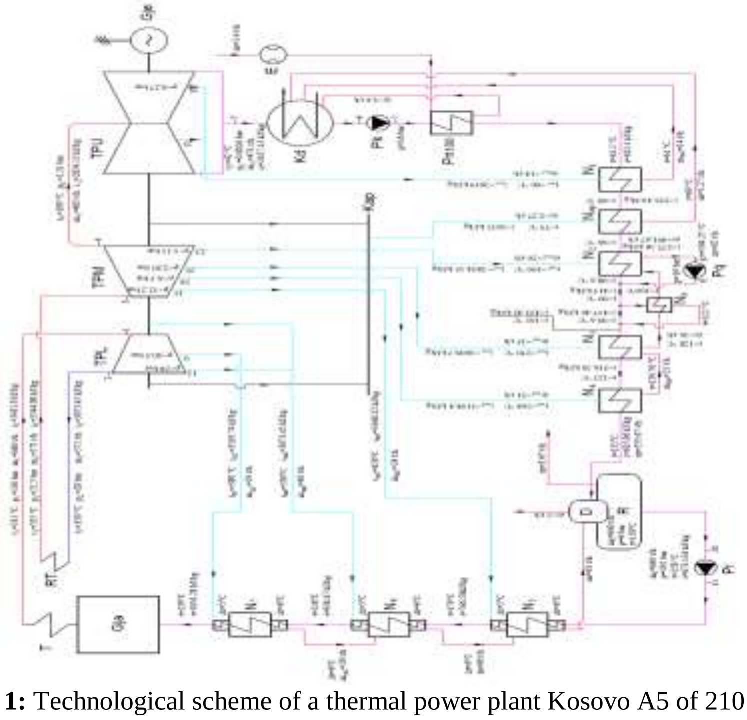

Figure 1: Technological scheme of a thermal power plant Kosovo A5 of 210 MW.

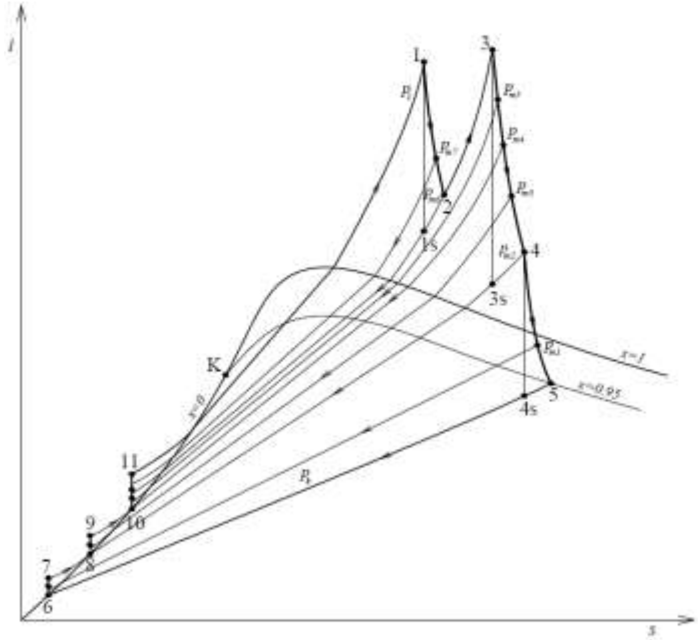

Figure 2: Thermodynamic state diagram (s, i) to Blocks A5.

Table 1 shows the parameters of steam turbine EPP Kosovo A5

HPT	At the entrance	At the outlet
Pressure, p, bar	$p_1 = 130$	$p_2 = 130$
Temperature, t , ^{0}C	$t_1 = 535$	$t_2 = 535$
Enthalpy, I , kJ/kg	$i_1 = 3431{,}8$	$i_2 = 3431{,}8$
Mass flow of steam , t/h	$m_1 = 640$	$m_2 = 640$
MPT	**At the entrance**	**At the outlet**
Pressure, p, bar	$p_3 = 21{,}5$	$p_4 = 130$
Temperature, t , ^{0}C	$t_3 = 535$	$t_4 = 535$
Enthalpy, I , kJ/kg	$i_3 = 3544{,}08$	$i_4 = 3431{,}8$
Mass flow of steam , t/h	$m_3 = 571$	$m_4 = 640$
LPT	**At the entrance**	**At the outlet**
Pressure, p, bar	$p_4 = 1{,}31$	$p_5 = 130$
Temperature, t , ^{0}C	$t_4 = 190$	$t_5 = 535$
Enthalpy, I , kJ/kg	$i_4 = 2854{,}15$	$i_5 = 3431{,}8$
Mass flow of steam , t/h	$m_4 = 485$	$m_5 = 640$

Table 2 shows the parameters of the water vapor with the seizure of regenerative steam for EPP Kosovo A5

Number regenerative seizure couples	**After the turbine degree**	**Pressure seizure**	**Temperature subtraction**	**Enthalpy**	**Steam flow in seizure**
7	9	p_{m7}=40,5 bar	$t_{m7}=380^0$C	i_{m7}=3165,74kJ/kg	m_{m7}=29 t/h
6	12	p_{m6}=28 bar	$t_{m6}=330^0$C	i_{m6}=3073,45kJ/kg	m_{m6}=40 t/h
5	15	p_{m5}=12,2 bar	$t_{m5}=450^0$C	i_{m5}=3368,32kJ/kg	m_{m5}=24 t/h
4	18	p_{m4}=6,5 bar	$t_{m4}=364^0$C	i_{m4}=3194,4kJ/kg	m_{m4}=21 t/h
3	21	p_{m3}=2,83 bar	$t_{m3}=270^0$C	i_{m3}=3009,7kJ/kg	m_{m3}=15 t/h
2	23	p_{m2}=1,31 bar	$t_{m2}=190^0$C	i_{m2}=2854,15kJ/kg	m_{m2}=246 t/h
1	25 and 29	p_{m1}=40,5 bar	$t_{m1}=66^0$C	i_{m1}=2619kJ/kg	m_{m1}=14 t/h

Markings according to Table 1: HPT-high-pressure turbine; MPT- medium-pressure turbine; LPT- low-pressure turbine; EPP- Electrical Power Plant.

The thermal efficiency of the turbine respectively determined by the following relationship:

$$L_T = m_1(i_1 - i_{m7}) + (m_1 - m_7)(i_{m7} - i_{m6}) + [m_1 - (m_{m7} + m_{m6})](i_3 - i_{m5}) +$$
$$+[m_1 - (m_{m7} + m_{m6} + m_{m5})](i_{m5} - i_{m4}) + [m_1 - (m_{m7} + m_{m6} + m_{m5} + m_{m4})](i_{m4} - i_{m3}) +$$
$$+[m_1 - (m_{m7} + m_{m6} + m_{m5} + m_{m4} + m_{m3})](i_{m3} - i_{m2}) +$$
$$+[m_1 - (m_{m7} + m_{m6} + m_{m5} + m_{m4} + m_{m3} + m_{m2})](i_{m2} - i_{m1}) +$$
$$+[m_1 - (m_{m7} + m_{m6} + m_{m5} + m_{m4} + m_{m3} + m_{m2} + m_{m1})](i_{m1} - i_5) =$$
$$= 640(3431.8 - 3165.74) + (640 - 29)(3165.74 - 3073.45) + [640 - (29 + 40)](3544.08 - 3368.32) +$$
$$+[640 - (29 + 40 + 24)](3368.32 - 3194.4) + [640 - (29 + 40 + 24 + 21)](3194.4 - 3009.7) + [640 -$$
$$-(29 + 40 + 24 + 21 + 15)[(3009.7 - 2854.15) + [640 - (29 + 40 + 24 + 21 + 15 + 26)](2854.15 - 2619) +$$
$$+[640 - (29 + 40 + 24 + 21 + 15 + 26 + 14)](2619 - 2457.13) = 219 \cdot 10^3 \ kW = 219 \ MW \quad .$$

In this respect, energy efficiency is a cycle:

$$\eta_t = \frac{L_T}{Q_{in}} = \frac{L_T}{m_1(i_1 - i_7^{out}) + m_2(i_3 - i_2)} =$$
$$= \frac{219 \cdot 10^3}{\frac{640}{3.6}(3431{,}8 - 1034.28) + \frac{571}{3.6}(3544.08 - 3073.45)} = 0{,}437 = 43{,}7(\%) \quad .$$

Exergy efficiency is a cycle (for T_0 = 293(K) and P_0 = 1(bar):

$$\eta_{ex} = \frac{L_T - L_P + EX_7^d + EX_{2,3}}{EX_1 + EX_3 + EX_4} = \frac{m_1 l_T - m l_P + m_7 ex_7^d + m_2(ex_3 - ex_2)}{m_1 ex_1 + m_3 ex_3 + m_4 ex_4} =$$
$$= \frac{219 - 1.49 + 44 + 214 - 180.7}{269 + 214 + 82} = 0{,}522 = 52.2\ (\%) .$$

Where :

L_P -the work of supplying pump;

EX_7^d -exergy of feed water;

$EX_{2,3}$ -the difference of exergy in reheater;

EX_1, EX_3, EX_4 -exergies of steam in the entrance of turbine.

In connection with the dynamic operation of the plant thermal block is important to give and how to modify the exergy efficiency as a function of ambient temperature (To).

For other conditions, T_0 = 288(K), p_0 = 1(bar), given: η_{ex} = 53,9 (%) .

Analyzing the change in exergy efficiency, according to the calculated values can be given diagram in **Figure 3:**

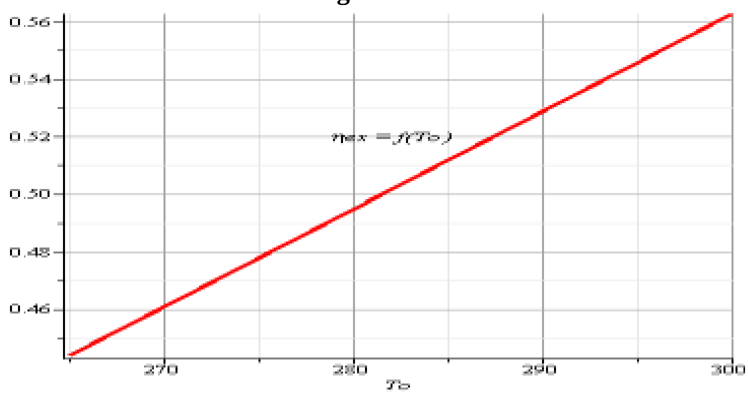

Figure 3: Change exergy efficiency as a function of ambient temperature To, K.

The heat is introduced into the cycle :

$$Q_G = m_1(i_1 - i_{11}) + m_2(i_3 - i_2) = 640\frac{10^3}{3600}(3431.8 - 673.134) +$$

$$+571\frac{10^3}{3600}(3544.08 - 3073.45) = 565077(kW) = 565.077(MW) \quad .$$

Relative heat consumption in the steam generator for 1 kg of fuel is [2]:

$$q_G = \frac{Q_G}{m_1} = \frac{565077 \cdot 3600}{640 \cdot 10^3} = 3178.558\ (kJ/kg) \quad .$$

The heat losses in the boiler are $\Delta q_G = (1-\eta_g)q_G = (1-0.85)\cdot 3178.558 = 476.784\ (kJ/kg)$.

In this way the relative losses in the boiler are:

$$\frac{\Delta q_G}{q_G} = \frac{476.784}{3178.558} = 0.15 = 15\ (\%) .$$

So analog set in the cycle relative distribution losses, in condenser, in turbine, in electric generator and the relative energy used. Control of the relative balance (RB) heat is:

$$RB = \frac{\Delta q_K}{q_K} + \frac{\Delta q_{tr}}{q_K} + \frac{\Delta q_C}{q_K} + \frac{\Delta q_m}{q_K} + \frac{\Delta q_{el}}{q_K} + \frac{\Delta q_{ut}}{q_K} \quad ,$$

respectively:

$$RB = 15(\%) + 0.85(\%) + 53.60(\%) + 0.31(\%) + 0.45(\%) + 25.60(\%) \cong 100(\%) \quad .$$

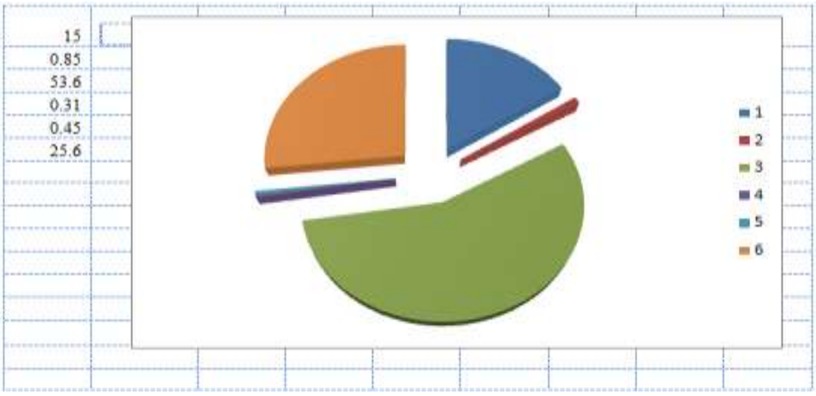

Figure 4: Graphic presentation of heat flux, mechanical and heat losses used.

Figure 4 is presented graphically chart the flow of heat, mechanical and heat losses used. The given series according to figures 4: 1 heat losses in boiler; 2- heat losses in the distribution network of steam; 3- heat losses in the condenser; 4- mechanical losses in the turbine; 5- heat losses in the electric generator; 6- heat used.
Relative balance of control over exergy analysis is shown in figure 5.

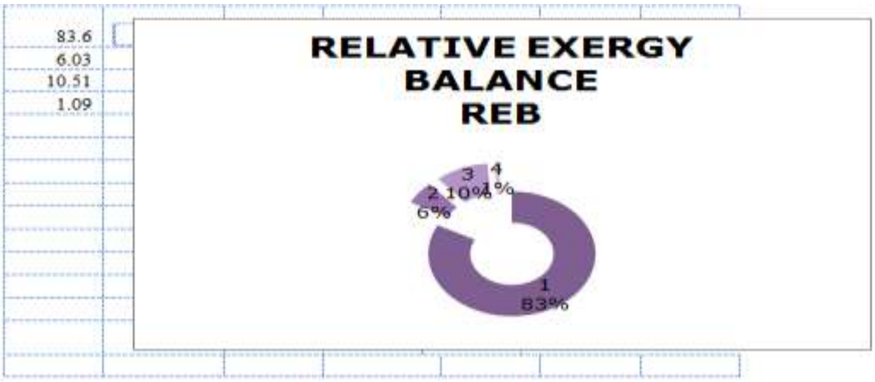

Figure 5: Balance control relative to exergy analysis.

In figure 5 are these data to the data analysis for the relative exergy balance: 1-exergy relative balance to the heat which enters the process; 2- relative exergy balance to losses in the turbine; 3- relative exergy balance to losses in the condenser; 4- relative exergy losses during pumping.

II. CONCLUSIONS

The paper is accompanied by Energy and Exergy analysis of thermal block EPP Kosovo A5. It may be noted that an energy and exergy analysis reciprocally complementary, and are very important in terms of determining the qualitative and quantitative energy indicators, such as energy and exergy efficiency.

The relative balance of control in relation to the flux of energy and exergy flux is of particular importance in defining efficiency EPP Kosovo A5. Relative control energy balance shows that the maximum energy loss in the condenser (53.6%), and the steam generator (15%), while the energy used around 25.6%. Clearly, efforts should be made to the energy losses in the condenser and the steam generator to reduce to a minimum.

The relative balance of control in relation to the flux-exergy shows that the maximum loss of exergy in the condenser (10%), and then in a turbine (6%), and was used as approximately 83% of exergy. It is noted that efforts should be made exergy losses in the condenser reduce to a minimum.

The attached paper is of importance in terms of the deepening of the issue concerned in professional and scientific sense.

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