EUROPEAN UNION
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Operational Programme Research,
Development and Education

MINISTRY OF EDUCATION, YOUTH AND SPORTS

KEE/TTE - Thermal power plants technologies

Semester work

(Solved by each student individually)

ESF II project of the University of West Bohemia in Pilsen, reg. number: CZ.02.2.69/0.0/0.0/18_056/0013239



ETU II [Zdroj foto: https://www.cez.cz/cs/o-cez/vyrobni-zdroje/uhelne-elektrarny-a-teplarny/uhelneelektrarny-a-teplarny-cez-v-cr/elektrarny-tusimice-58175]

Necessary content of semester work

I) Theoretical part - min. 10 A4 pages

*1) **Thermal power station***

- **Description of the thermal scheme** of the power plant, connection of the power plant to the electricity system. Operational characteristics (provision of ancillary services and island operation of the power plant) - description and function of basic technological units

- **Desulphurisation** - possible methods (scheme, chemical equations, etc.)

- **Chemical water treatment and control of operating substances and fuel**

- Description of water treatment (where both treated water is used and why)
- Which substances are controlled and how (oil, fuel - calorific value, etc.)

- **Block control room** - description of the control and information systém

Of course there is a title page, text assignment, numerical assignment and a list of used literature at the end of the theoretical part of the work. In the theoretical part of the work, in addition to the description of all parts of the assignment, focus mainly on the points: - listing the main technological units and their brief description - thermal scheme of the power plant - steam parameters at the T input - power output generator, transformers, boilers - description of water demineralization, more detailed description of wet limestone leachate - calorific value of fuel and how calorific value is determined - desulphurisation methods and description of wet limestone leachate with chemical equation, etc.

II) Computational part

*1) **Thermal calculation of the 200 MW unit of the Tusimice II power plant***

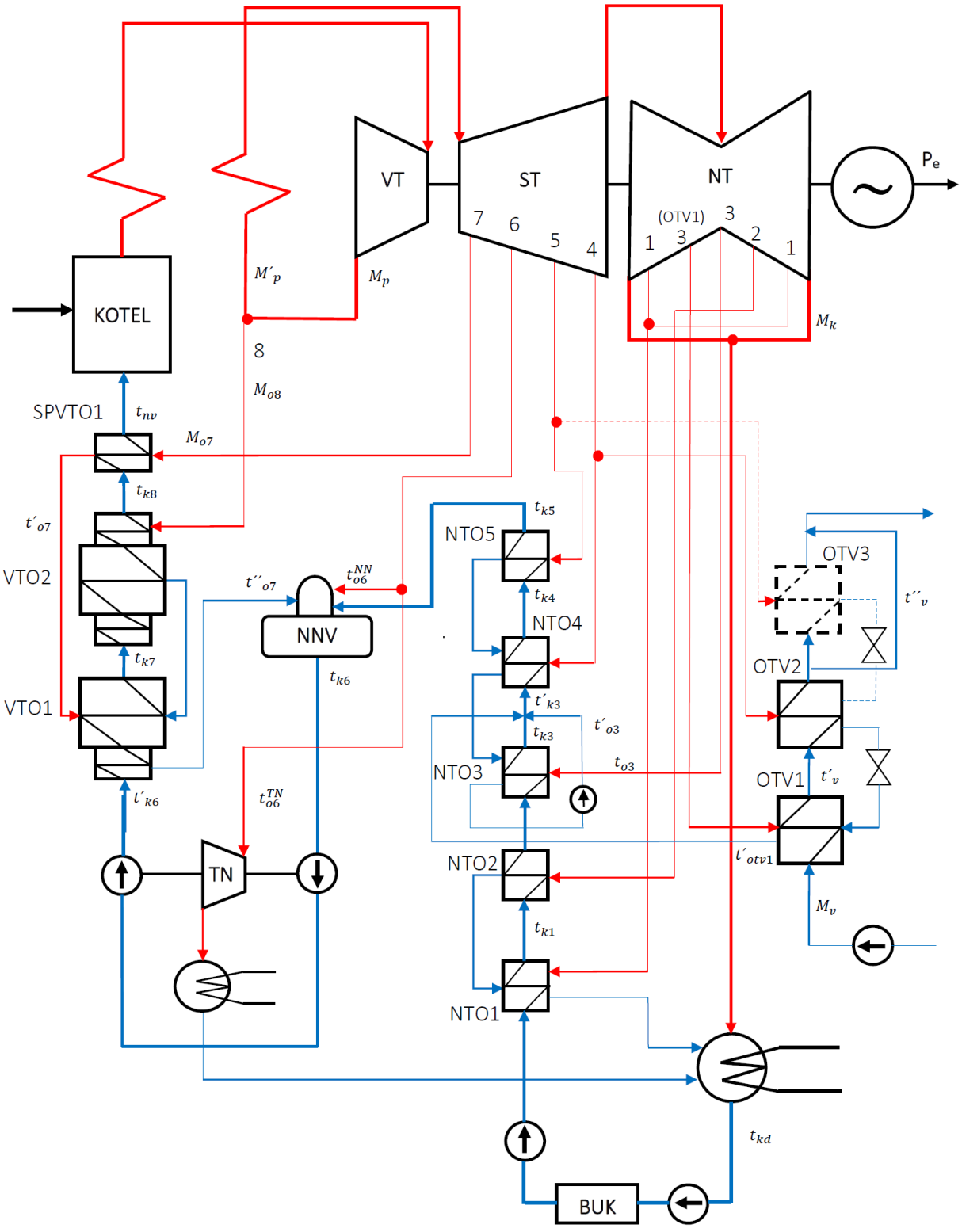
- **Task:**

  – determine by calculating the amount of steam M_p at the input to the turbine at a given power and compare with the measured value

  - own consumption of the block 11%, thermodynamic efficiency of the turbine 80%, non-fuel content in the slag 8.65%

The work must include:

- printed assignment
- simplified thermal diagram of the block manually described by all variables occurring in the calculation (marking must match)
- i-s diagram with plotted expansions in the turbine and with manual marking of the read parameters
- the balance equation of a specific turboset generally expressed using the variables given in the diagram, the numerical substitution for all variables and the minimum indicated calculation procedure
- extract of the necessary data from the system for the calculation of the thermal scheme


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NT
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(OTV1)
7
6
5
4
1
3
2
1
KOTEL
M'_p
M_p
M_k
8
M_{o8}
SPVTO1
t_{nv}
M_{o7}
t_{k8}
t'_{o7}
VTO2
t''_{o7}
t_{o6}^{NN}
NNV
t_{k7}
t_{k6}
VTO1
t'_{k6}
t_{o6}^{TN}
TN
NTO5
t_{k5}
t_{k4}
NTO4
t'_{k3}
t_{k3}
t'_{o3}
t_{o3}
NTO3
NTO2
t_{k1}
NTO1
OTV3
t''_v
OTV2
OTV1
t'_v
t'_{otv1}
M_v
t_{kd}
BUK

2) ***Correction of consumption characteristics of the 200 MW power plant unit***

- Use the prepared relationships, numerically install and manually calculate the values of all the coefficients needed to determine the basic and actual consumption characteristics for the selected power.
- From the entered values at variable power (from 130 to 200 MW in steps of 10 MW) calculate the courses of both characteristics and plot both resulting curves in the control range in the graph.
- Write the calculated all coefficients together with Qs and Qz for all outputs clearly in the table.

Correction of consumption characteristics of the power plant unit

Real basic consumption characteristics of the block:

$$\mathbf{Q_Z = 23.556 + 0.101\ P + 7.012 \cdot 10^{-4}\ P^2} \qquad \text{[tmp/h]}$$

Real consumption characteristics of the block:

$$Q_S = (S^{do}_{pals} + \sum_{i=1}^{10} k_i) \cdot \frac{P}{k_{eS}} (1 + k_{eS} - k_{eZ}) \qquad \text{[tmp/h]}$$

- the amount of heat consumed for the power supplied to the electricity system

$$S^{do}_{pals} = 0.61489 - 0.00246\ P + 6.3125.10^{-6} \cdot P^2 \qquad [-]$$

$\mathbf{k_{eS}}$ *- coefficient of own consumption - real*

$k_{eS} = 1 + p_{vs}$ (p_{vs} *- own consumption of the block*)

$\mathbf{k_{eZ}}$ *- coefficient of own consumption - basic*

$$k_{eZ} = 1.125 - 5{,}2286 \cdot 10^{-4}\ P + 1.083 \cdot 10^{-6} \cdot P^2$$

$\mathbf{k_i}$ *- correction factors having the greatest influence on the change in consumption characteristics*

1. $\mathbf{k_1}$ *- respects the effect of the change in steam pressure in the high-pressure part of the turbine*

$$k_1 = 0.000115 \cdot (16.18 - p_{1S})$$

$$p_{1S} = \frac{p_{1P} + p_{1L}}{2}$$

2. $\mathbf{k_2}$ *- respects the effect of changes in the temperature of the admission steam to the high-pressure part of the turbine*

$$k_2 = 0.00015 \cdot (540 - t_{1S})$$

$$t_{1S} = \frac{t_{1P} + t_{1L}}{2}$$

3. $\mathbf{k_3}$ - *respects the effect of a change in the temperature of the reheated steam*

$$k_3 = 0.0001 \cdot (540 - t_{2S})$$

$$t_{2S} = \frac{t_{2P} + t_{2L}}{2}$$

4. $\mathbf{k_4}$ - *respects the change in the amount of water injected into the reheated steam*

$$k_4 = q_Z \cdot (M_S - M_Z)$$

$$q_Z = 0.000371 - 0.0000013\ P$$

$$M_Z = - 19 + 0.15\ P$$

$\mathbf{q_Z}$ - *a factor indicating the amount of water injected per 1 t / h*

$\mathbf{M_S}$ - *amount of water injected into the steam - real*

$\mathbf{M_Z}$ - *amount of water injected into the steam – basic*

5. $\mathbf{k_5}$ - *respects the change in the temperature of the emission steam*

$$k_5 = - 1.283 \cdot 10^{-4} + 1.136 \cdot 10^{-3} (\Delta t_e) + 1.127 \cdot 10^{-5} (\Delta t_e)^2$$

$$\Delta t_e = t_{eS} - t_{eZ}$$

$$t_{eS} = \frac{t_{eP} + t_{eL}}{2}$$

$$t_{eZ} = 22.4676 + 0.06666\ P$$

6. $\mathbf{k_6}$ - *respects the change in feed water temperature*

$$k_6 = -5.857 \cdot 10^{-4} - 2 \cdot 10^{-4} (\Delta t_{nv}) – 6.31 \cdot 10^{-7} (\Delta t_{nv})^2$$

$$\Delta t_{nv} = t_{nvS} - t_{nvZ}$$

$$t_{nvZ} = 191.3 + 0.283\ P$$

7. $\mathbf{k_7}$ - *respects the change in intake air temperature*

$$k_7 = - 0.00025 \cdot (t_{vzS} - 20)$$

$$t_{vzS} = \frac{t_{vzP} + t_{vzL}}{2}$$

8. $\mathbf{k_8}$ - *respects the change in flue gas temperature*

$$k_8 = 0.00025 \cdot (t_{spS} - t_{spZ})$$

$$t_{spZ} = 177 - 0.336\ P + 0.00143\ P^2$$

$$t_{spS} = \frac{t_{spP} + t_{spL}}{2}$$

9. $\mathbf{k_9}$ - *respects the change in oxygen content in the flue gas*

$$k_9 = -1.9 \cdot 10^{-4} + 1.757 \cdot 10^{-3} (\Delta O_2) + 1.774 \cdot 10^{-4} (\Delta O_2)^2$$

$$\Delta O_2 = O_{2S} - O_{2Z}$$

$$O_{2Z} = 5.5\ \% = 0.055$$

10. $\mathbf{k_{10}}$ - *respects the change in the percentage of non-combustion in slag*

$$k_{10} = -4.021 \cdot 10^{-5} + 4.229 \cdot 10^{-4}\ \Delta S + 6.671 \cdot 10^{-6}\ \Delta S^2$$

$$\Delta S = S_S - S_Z$$

$$S_Z = 93.428 - 0.776\ P + 0.0019\ P^2$$

For the calculation we need the following measured values:

P	*- Power at the generator terminals*	[MW]
$\mathbf{p_{1L}}$, $\mathbf{p_{1P}}$	*- Admission steam pressure*	[MPa]
$\mathbf{t_{1L}}$, $\mathbf{t_{1P}}$	*- Temperature of the admission steam*	[^{o}C]
$\mathbf{t_{2L}}$, $\mathbf{t_{2P}}$	*- Reheated steam temperature*	[^{o}C]
$\mathbf{M_S}$	*- Amount of water injected into the steam - real*	[t/h]
$\mathbf{t_{eL}}$, $\mathbf{t_{eP}}$	*- Temperature of the emission steam*	[^{o}C]
$\mathbf{t_{nvS}}$	*- Water temperature in front of the boiler*	[^{o}C]
$\mathbf{t_{vzL}}$, $\mathbf{t_{vzP}}$	*- Air temperature in front of the air exchanger*	[^{o}C]
$\mathbf{t_{spL}}$, $\mathbf{t_{spP}}$	*- Flue gas temperature behind Ljungstroms*	[^{o}C]
$\mathbf{O_{2S}}$	*- Oxygen content in the flue gas*	[%]
$\mathbf{S_S}$	*- Percentage of non-combustible slag*	[%]
$\mathbf{P_{vs}}$	*- Own consumption of the block* (reading on electricity meters in the control room)	[MW]