III International Scientific Conference "**Sustainable and efficient use of energy, water and natural resources – SEWAN-2021**"

Title: «Using pinch analysis technology to assess energy efficiency in oil refining technology»

Authors: E.A. Yushkova[1], V.A. Lebedev[1], A.A. Nikitin[2]

Affiliations: [1]Saint Petersburg Mining University, [2]National Research University ITMO

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«Using pinch analysis technology to assess energy efficiency in oil refining technology»

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Keywords: exergy, increasing energy efficiency, energy, fuel

The relevance of research:

The fuel and energy complex in Russia consumes a significant part of the energy produced. Improving the energy efficiency of the fuel and energy complex is an important task for the state.

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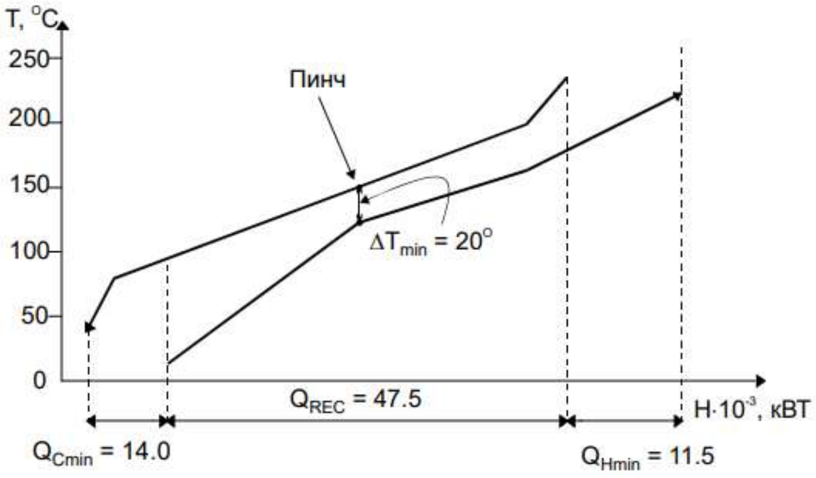

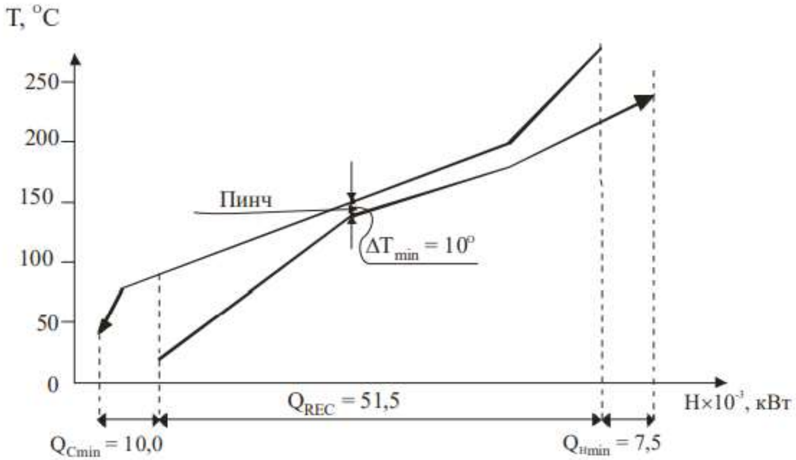

Pinch analysis is one of the most effective methods for assessing and improving the energy efficiency of heat and mass transfer processes. This method allows for structural and parametric optimization of heat exchange systems. This method is based on the enthalpy approach. Indeed, the enthalpy method is most often used to study power plants for energy efficiency. The enthalpy analysis method does not determine energy from the qualitative point of view.

A more complete and objective assessment of various types of energy allows us to give an exergy approach that takes into account the quality of energy.In connection with the above, it becomes necessary to develop such a method of thermodynamic analysis and improvement of systems (in particular, the oil refining industry), which would combine the advantages of the exergy method and the method of structural and parametric optimization of thermal processes based on Pinch analysis.

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The heat exchange system is optimal when exergy losses tend to be minimal. This expression is represented by the formula:

$$\sum \Delta E \rightarrow min\,, \qquad (1)$$

For this, it is necessary that the recuperation of the exergy of hot and cold streams is maximized, therefore, the difference in the exergy of hot and cold streams tends to a minimum. In most cases, external energy carriers are required for the heat exchange system to function. They, in turn, impose a financial burden on the enterprise. Thus, the sums of exergies of external hot and cold energy carriers (utilities) must be minimized. Taking into account the above, to optimize the heat exchange system, in addition to the convergence of the composite curves to ΔTmin, one should use the formula:

$$\begin{aligned} &\sum \Delta E = |e_h| - |e_c| + |E_{UH}| - | \\ &|e_h| - |e_c| \rightarrow \min, \\ &\sum E_{UH} \rightarrow \min, \\ &\sum E_{UC} \rightarrow \min, \end{aligned} \qquad (2)$$

Where e_h is the exergy of the hot compound curve,

e_c –exergy of a cold compound curve,

E_{UH} - exergy of external hot energy carriers,

E_{UC} - exergy of external cold energy carriers,

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$$E_H = \begin{vmatrix} T_{г.н.1} & T_{г.к.1} & T_{0г.1} & \ln\dfrac{T_{г.н.1}}{T_{г.к.1}} & CP_{г.1} \\ T_{г.н.2} & T_{г.к.2} & T_{0г.2} & \ln\dfrac{T_{г.н.2}}{T_{г.к.2}} & CP_{г.2} \\ \dots & \dots & \dots & \dots & \dots \\ T_{г.н.n-1} & T_{г.к.n-1} & T_{0г.n-1} & \ln\dfrac{T_{г.н.n-1}}{T_{г.к.n-1}} & CP_{г.n-1} \\ T_{г.н.n} & T_{г.к.n} & T_{0г.n} & \ln\dfrac{T_{г.н.n}}{T_{г.к.n}} & CP_{г.n} \end{vmatrix}. \quad (3)$$

$$E_C = \begin{vmatrix} T_{х.н.1} & T_{х.к.1} & T_{0х.1} & \ln\dfrac{T_{х.н.1}}{T_{гхк.1}} & CP_{х.1} \\ T_{х.н.2} & T_{х.к.2} & T_{0х.2} & \ln\dfrac{T_{х.н.2}}{T_{х.к.2}} & CP_{х.2} \\ \dots & \dots & \dots & \dots & \dots \\ T_{х.н.m-1} & T_{х.к.m-1} & T_{0х.m-1} & \ln\dfrac{T_{х.н.m-1}}{T_{х.к.m-1}} & CP_{х.m-1} \\ T_{х.н.m} & T_{х.к.m} & T_{0х.m} & \ln\dfrac{T_{х.н.m}}{T_{х.к.m}} & CP_{х.m} \end{vmatrix}. \quad (4)$$

$$T_H = \begin{vmatrix} T_{г1} \\ T_{г2} \\ \dots \\ T_{гk-1} \\ T_{гk} \end{vmatrix}. \quad (5)$$

$$T_C = \begin{vmatrix} T_{x1} \\ T_{x2} \\ \dots \\ T_{xk-1} \\ T_{xk} \end{vmatrix}. \quad (6)$$

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The functional dependences that form the composite curve of hot flows have the form (7):

for the first temperature range:

$$e_h=\left(T_{r2}-T_{r1}-T_o\ln\frac{T_{r2}}{T_{r1}}\right)\sum_{i=1}^{n}CP_{ri}\Big|_{T_{r1}}^{T_{r2}},T_{r1}<T_{r2};$$

for the first and second temperature ranges:

$$e_h=\left(T_{r2}-T_{r1}-T_o\ln\frac{T_{r2}}{T_{r1}}\right)\sum_{i=1}^{n}CP_{ri}\Big|_{T_{r1}}^{T_{r2}}+\left(T_{r3}-T_{r2}-T_o\ln\frac{T_{r3}}{T_{r2}}\right)\sum_{i=1}^{n}CP_{ri}\Big|_{T_{r2}}^{T_{r3}},T_{r1}<T_{r2}<T_{r3};$$

for (k-1) -th temperature intervals:

$$e_h=\sum_{j=1}^{j=k-1}\left[\left(T_{rj}-T_{r(j-1)}-T_o\ln\frac{T_{rj}}{T_{r(j-1)}}\right)\sum_{i=1}^{n}CP_{ri}\Big|_{T_{r(j-1)}}^{T_{rj}}\right]+\left(T_{rk}-T_{r(k-1)}-T_o\ln\frac{T_{rk}}{T_{r(k-1)}}\right)\sum_{i=1}^{n}CP_{ri}\Big|_{T_{r(k-1)}}^{T_{rk}},T_{r(k-2)}<T_{r(k-1)}<T_{rk};$$

for k-th temperature intervals:

$$e_h=\sum_{j=1}^{j=k}\left[\left(T_{rj}-T_{r(j-1)}-T_o\ln\frac{T_{rj}}{T_{r(j-1)}}\right)\sum_{i=1}^{n}CP_{ri}\Big|_{T_{r(j-1)}}^{T_{rj}}\right],T_{r(k-1)} \qquad (7)$$

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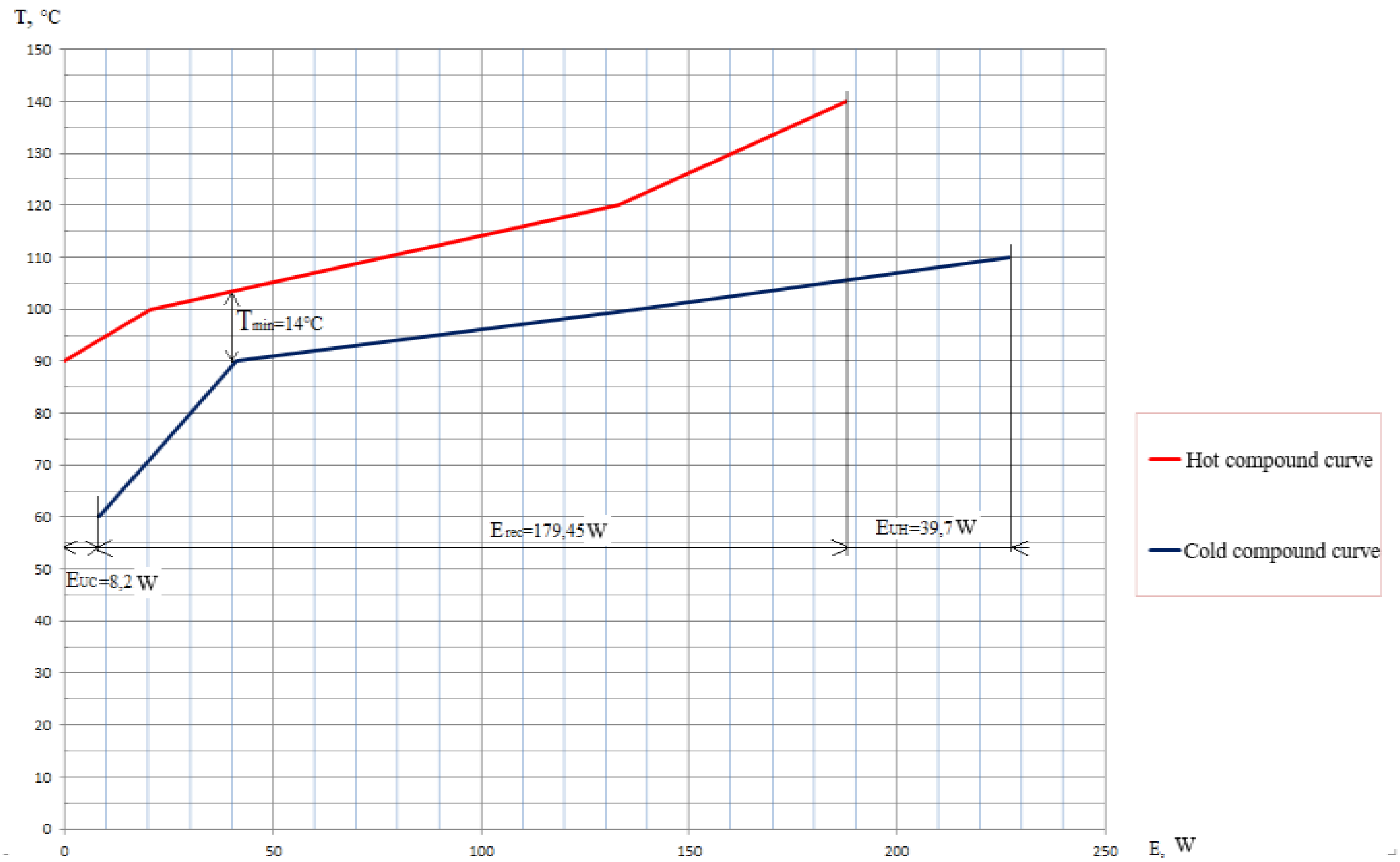

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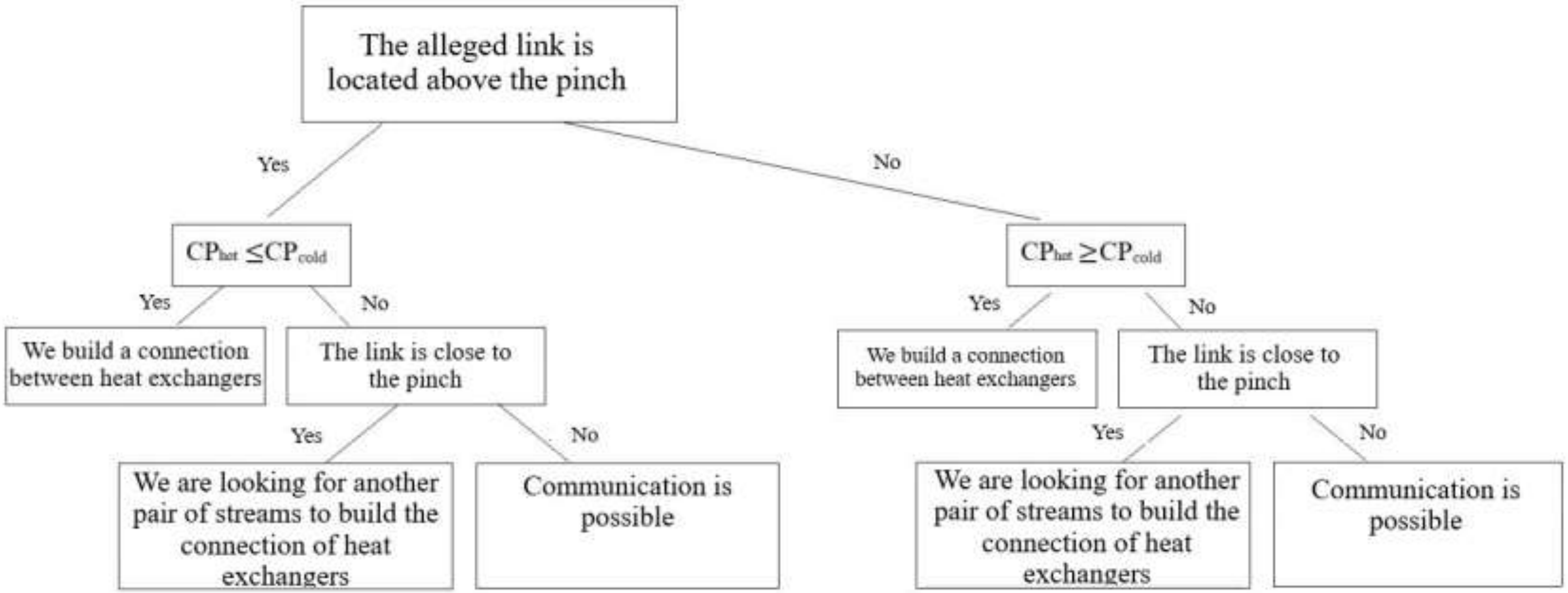
Algorithm for building a connection between heat exchangers



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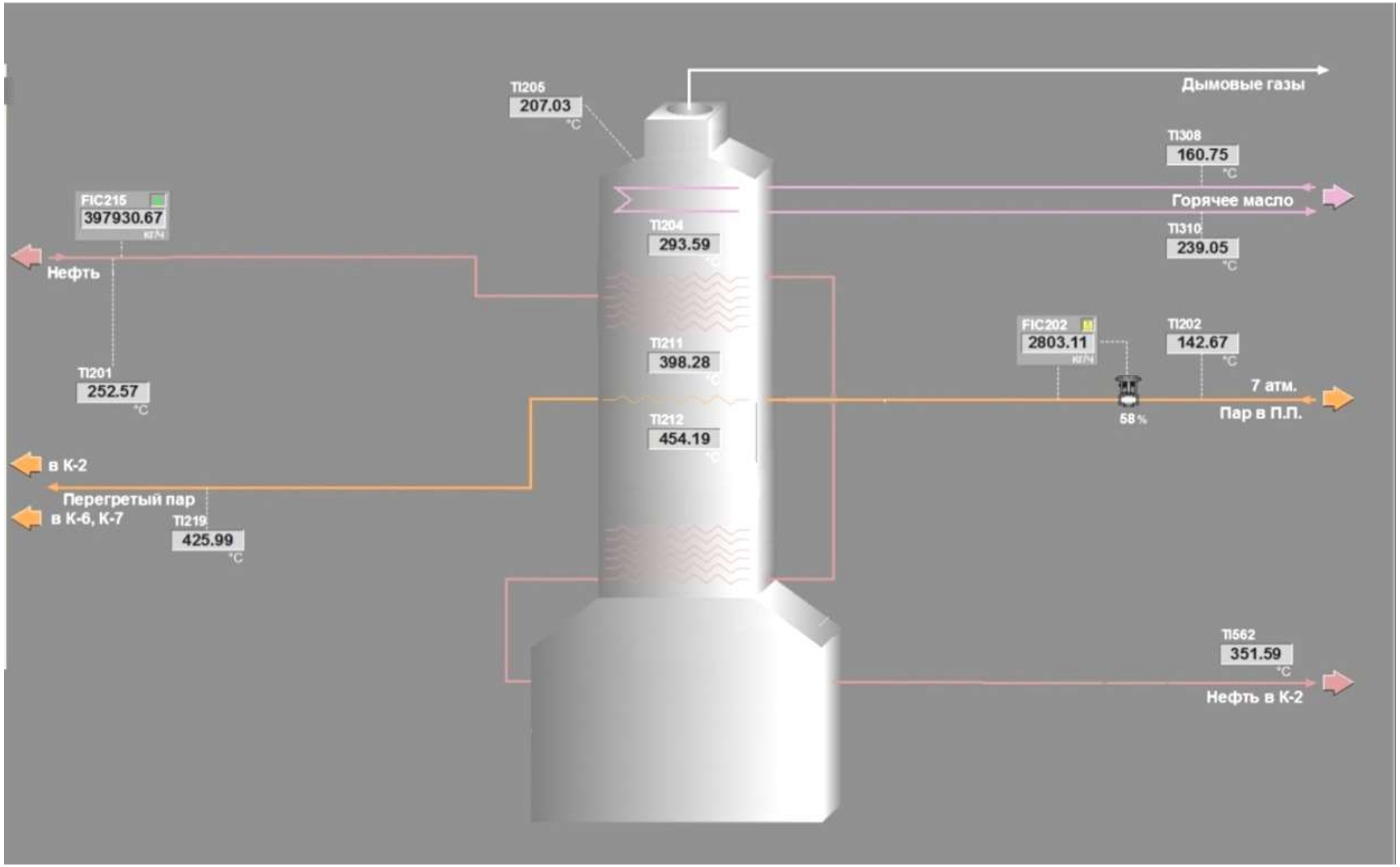
Object of study furnace of a primary distillation unit



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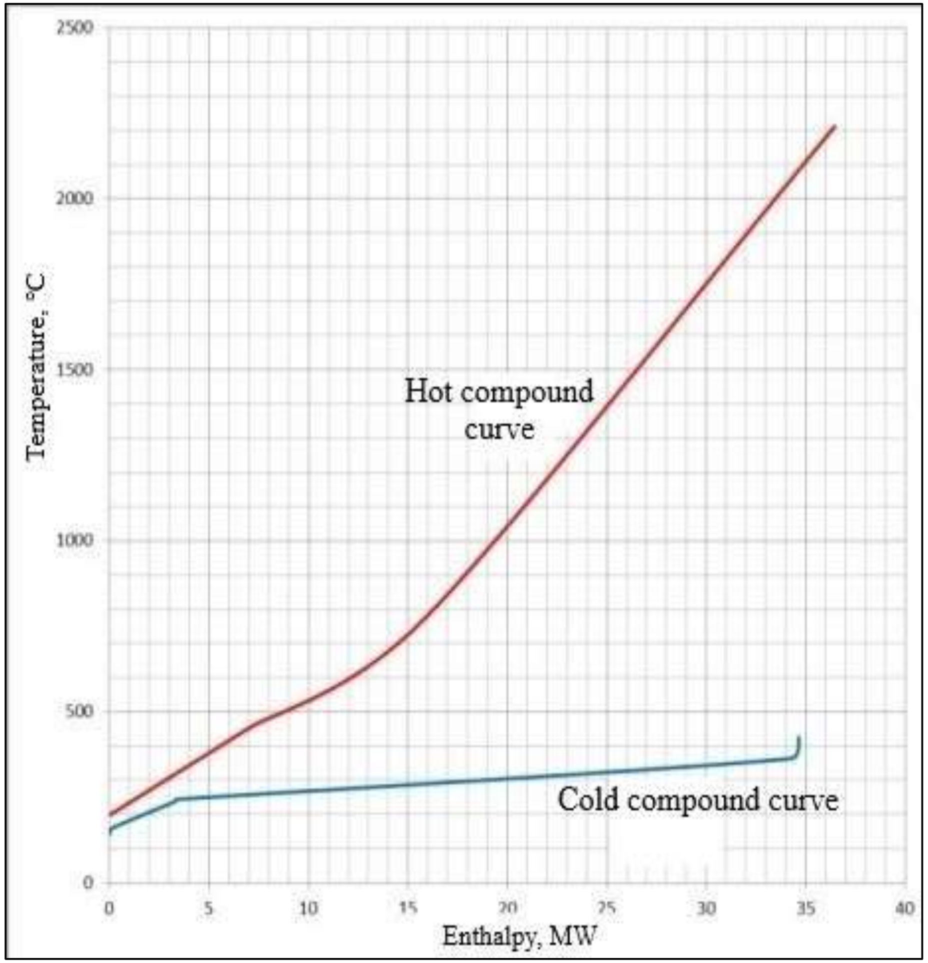
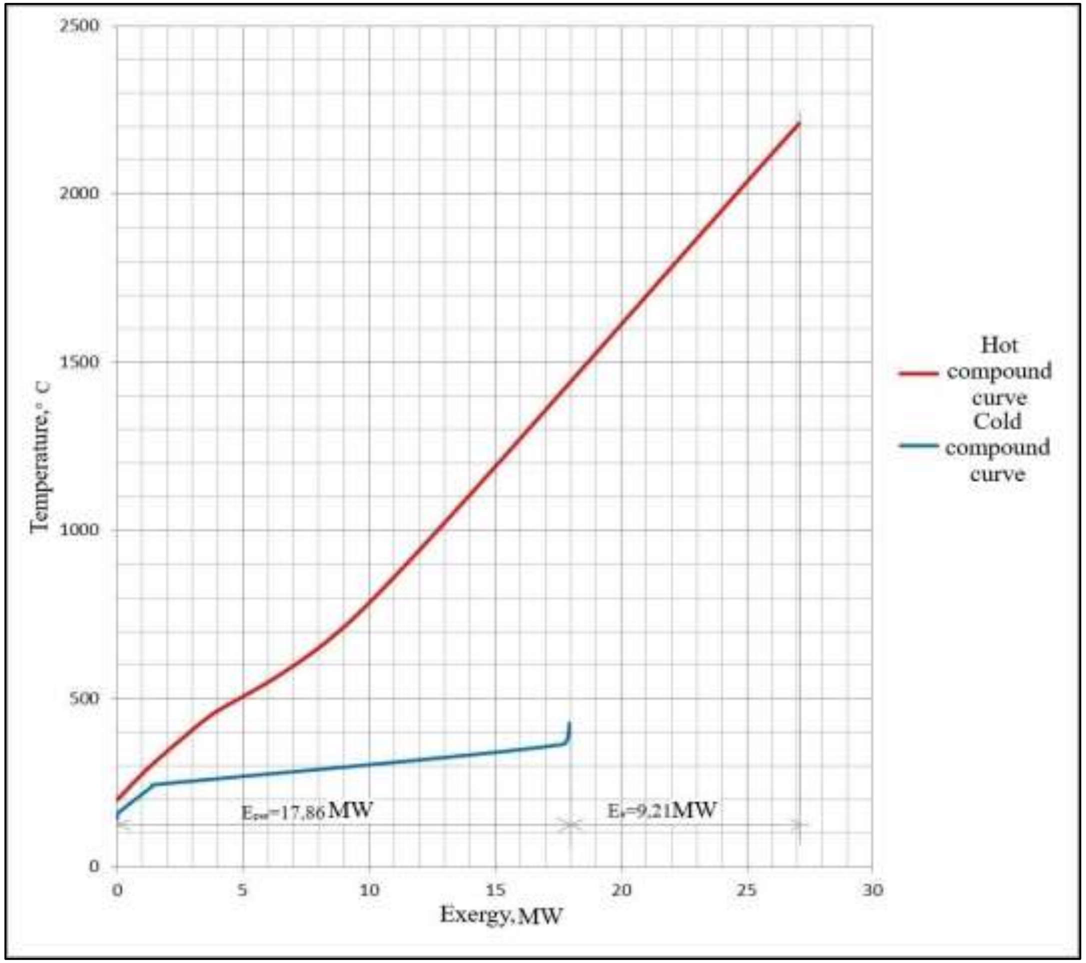
Converted heat fluxes of the furnace in the "enthalpy - temperature" coordinate system



Converted heat fluxes of the furnace in the "exergy - temperature" coordinate system



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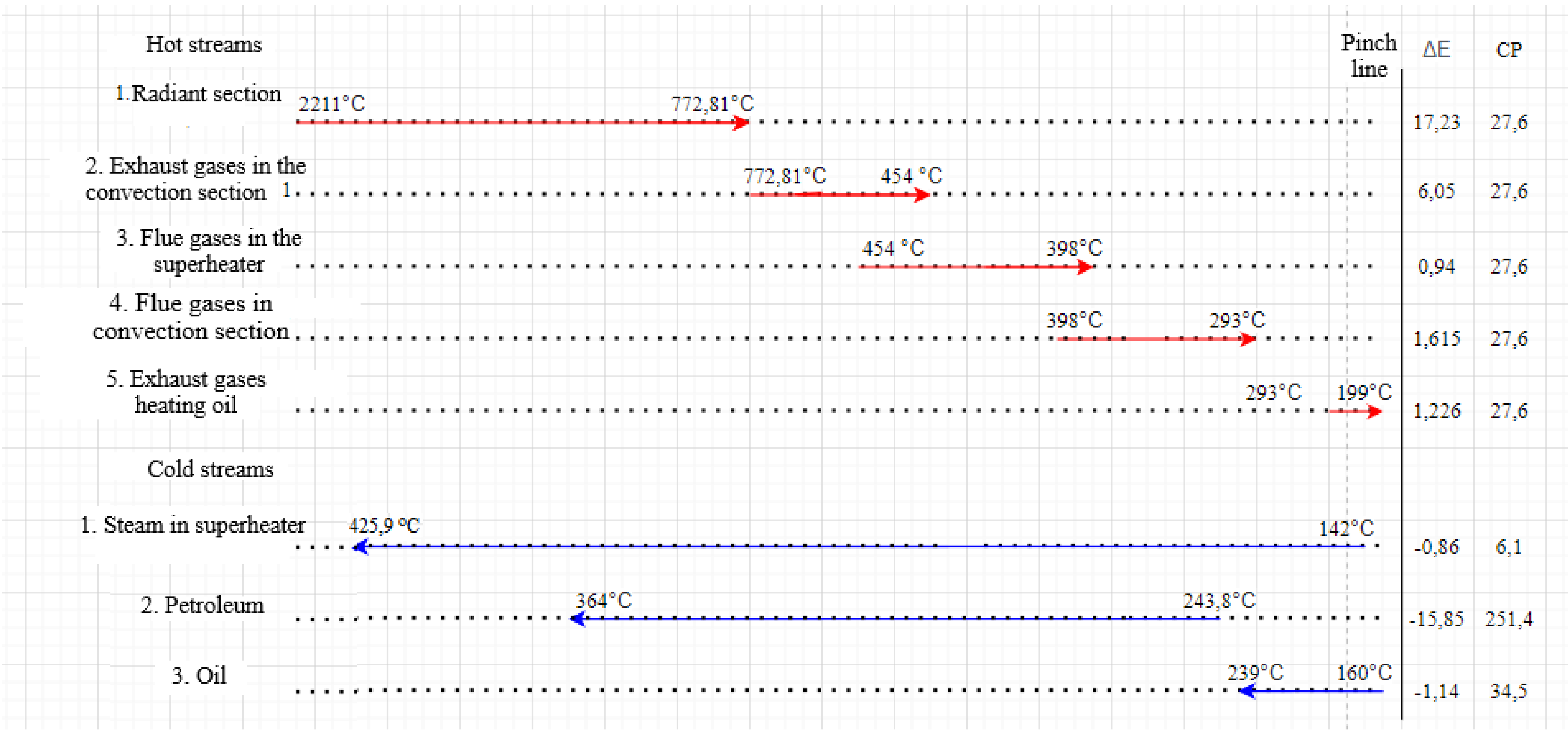
Hot and cold streams before building heat exchangers



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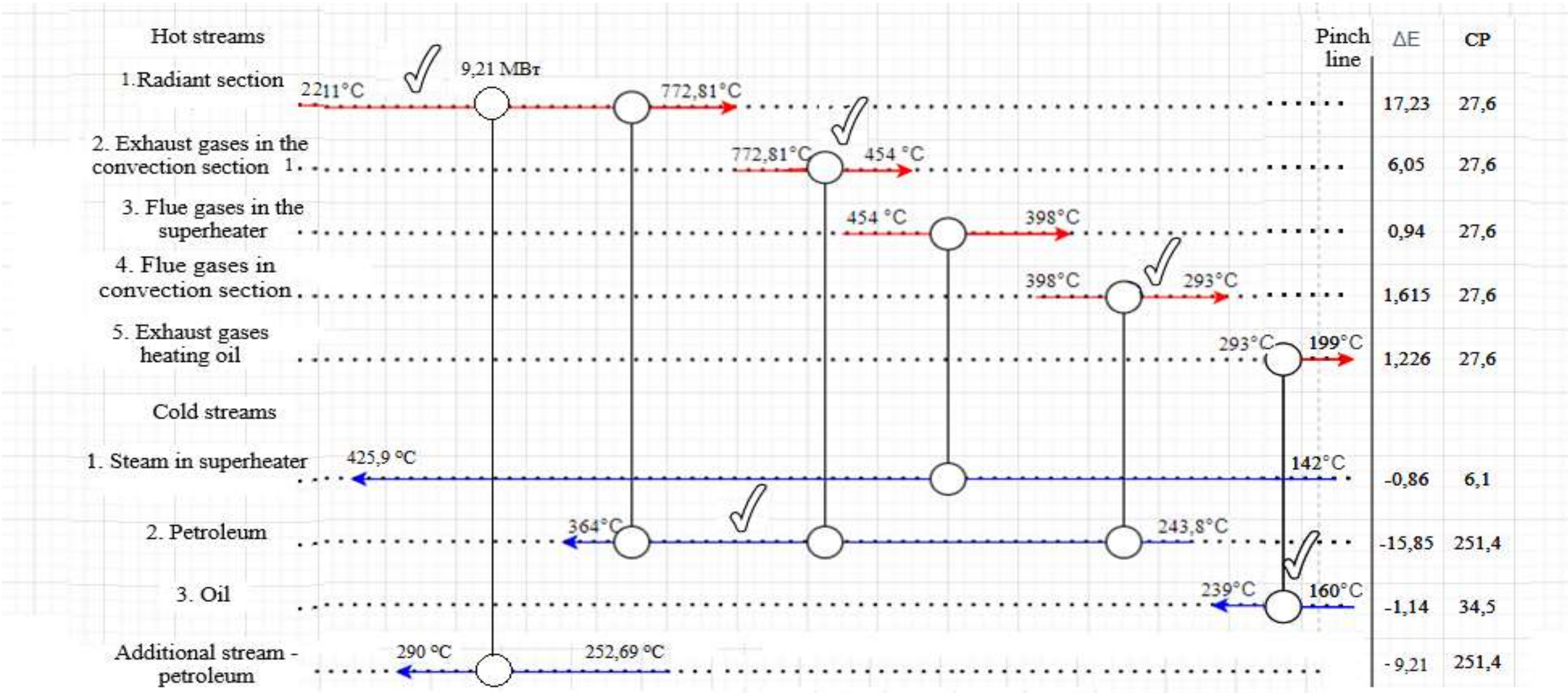
Results

The final heat exchanger system after optimization



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Conclusions

Thus, in the course of this study, we achieved that the loss of exergy became minimal. To rationally use the remaining exergy, we will bring another heat exchanger to hot stream 1, connecting it with an additional oil flow, thereby reducing the losses of the entire primary oil refining unit ELOU AT-6 to zero.

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Acknowledgement

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Thank you for your attention!

Authors: **E.A. Yushkova[1], V.A. Lebedev[1], A.A. Nikitin[2]**

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Contact details: atenoks@mail.ru, +79817126350