Paradigm reference-global.com Ovidius University Annals Series: Civil Engineering, Year 27, 2025
DOI: 10.2478/ouacsce-2025-0007

Indicator for the energy transferred by a heat exchanger

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Abstract – **This paper presents aspects related to optimizing the use of heat exchangers in heating plant. Thus, we will determine the indicator for the transferred energy of a heat exchanger in the heating system defined as the ratio between the sum of the energy incorporated in the manufacture of the exchanger end the energy consumed for the circulation of thermal agents during the use of the exchanger and the energy transferred during the same period of time by the exchanger.**

Keywords – energy, exchanger, thermal agent.

1. INTRODUCTION

The heat exchangers are equipment that ensure the transfer of heat from one fluid to another, a very important phenomenon in heating, cooling, boiling or condensation processes, but also in other thermal processes in which two or more fluids with different temperatures are involved. The heat exchanger is an important part in thermal plants, central heating, refrigeration installations because based on this principle (presented above), heat exchange take place from the thermal water or refrigerant to the thermal agent water or air. Numerous studies have done on the topic of heat exchangers.

Iordache F. in [1], presented the operational relationships that underlie the establishment of the functional constructive state of heat exchangers. He started from the thermal balance in the stationary regime of these equipment and continue with the simulation of current operating regimes. The heat exchangers in buildings services are the thermal networks that supply the central heating systems and the heat exchangers in solar energy loops [2]. In [2] is presented the method of calculus of thermal characteristics for heat exchangers.

Lavric D., ed al [3] present a review about the finned heat exchangers modelling and simulations. Finned heat exchangers are used in cryogenic industry, nuclear industry, food industry etc. The aspects concerning the air circulations through the heat exchanger components tubes are studied, as well as those involved in the thermal transfer from technological fluid to wall or from fin to air. A particular attention in [3] is given to the physical and mathematical complete models of finned heat exchangers.

Baran A. I., in [4] conducted a study in order to capitalize on the results for the realization of modular geothermal heat exchangers with variable geometry. The modular concept consists in increasing the energy efficiency and a uniform distribution of the heat flow by sizing the heat exchange surface inversely proportional to temperature difference between the fluid and solid.

Hera D., ed al in [5] presents a analysis of heat exchangers from refrigerant plants (evaporator, condenser, sub cooler or super heater) with stand out the increasing of heat transfer phenomena using the turbulence shapes. A particular case of heat exchanger is the heat pipe [6]. The thermal tube is a device that achieves an efficient heat transfer by combining in a closed cycle the phenomena of vaporization, transport vapor, condensation and condensation return, of a working fluid.

In the paper presented below we make a technical analysis about using heat exchangers in heating plant.

2. EXPERIMENT DESCRIPTION

We will consider a heat exchanger in heating system for which we propose to present the method for calculus the indicator for transferred energy [7].

The power transferred by the thermal agent at temperature T_1/T_2 .T_1 temperature at entry in primary circuit, T_2 temperature at output in primary circuit, is given by the calculation formula:

$$E_1 = m_1 c_{p1} (T_1 - T_2) \quad [J] \tag{1}$$

The thermal power taken over by the secondary agent from the secondary circuit of exchangers with temperature t_1/t_2. t_1 temperature at entry in secondary circuit, t_2 temperature at output in secondary circuit, is given by the calculation formula:

$$E_2 = m_2 c_{p2}(t_2 - t_1) \quad [J] \tag{2}$$

Transferred thermal power is:

$$E_{trams} = 3600\, A_1 v_1 \rho_1 c_{p1}(T_1 - T_2) \quad [W] \tag{3}$$

$$E_{trans} = 3600 A_2 (v_2 \rho_2) c_{p2}(t_2 - t_1) \quad [W] \tag{4}$$

$A_1 =$ cross section area on primary circuit [m^2];
$A_2 =$ cross section area on secondary circuit [m^2];
v_1 = circulation speed in primary circuit[m/s];
v_2 = circulation speed in secondary circuit [m/s];
c_p = specific heat at constant pressure [j/Kg ºC];
T_1 = temperature at entry in primary circuit [ºC];
T_2 = temperature at output in primary circuit [ºC];
t_1 = temperature at entry in secondary circuit [ºC];
t_2 = temperature at output in secondary circuit [ºC];
ρ_1 = density primary agent [Kg/m^3];
ρ_2 = density secondary agent [Kg/m^3];

On the other side thermal power given by heat exchanger according with transfer surface is:

$$E_{trans} = \text{k S } \Delta_{tm} \qquad \text{[W]} \qquad (5)$$

k= global coefficient for heat transfer (thermal transmittance) [W/m^3ºC];
S= surface for heat exchanger [m^3];
Δ_{tm}= average temperature difference [ºC].

$$\Delta_{tm} = \frac{T_1+T_2}{2} + \frac{t_1+t_2}{c} \qquad \text{[ºC].} \qquad (6)$$

For global coefficient for heat transfer we choose the equation:

$$\text{k=p } (v_2\rho_2)^q \; {v_1}^r \qquad (7)$$

From equations (3) si (4), the speed v_1 is:

$$v_1 = \frac{A_2(v_2\rho_2)c_{p2}(t_2-t_1)}{A_1\rho_1 c_{p1}(T_1-T_2)} \qquad \text{[m/s]} \qquad (8)$$

The heat exchanger surface is :

$$\text{S}= \frac{E_{trans}}{\text{p } (v_2\rho_2)^q \; {v_1}^r \, \Delta_{tm}} \qquad [m^2] \qquad (9)$$

Next, we going on to write S as a relation between masic flow(($v_2\rho_2$) and temperature of agents:

$$\text{S} = \frac{3600 \, A_2(v_2\rho_2)c_{p2}(t_2-t_1) \, [A_1\rho_1 c_{p1}(T_1-T_2)^r}{p(v_2\rho_2)^{q+r}[A_2 v_2\rho_2 c_{p2}(t_2-t_1) \, {}^r \Delta_{tm}} \qquad [m^2] \qquad (10)$$

The energy incorporated in manufacturer heat exchanger is:

$$E_{\ exchange} = \frac{3600 \, {A_2}^{(1-r)} C_{p1}(t_2-t_1)[A_1\rho_1 c_{p1}(T_1-T_2)]^r}{p[c_{p1}(t_2-t_1)]^r \, \Delta_{tm} \, {(v_2\rho_2)}^{q+r-1}} \qquad [\text{ kWh}/m^2] \qquad (11)$$

To calculus the energy consumed for the circulation of thermal agents during the use of the exchanger we must consider follows:

- The rated life time of heat exchanger
- The variation law of lost pressure low Δ_{h1}, Δ_{h2} for primary agent and secondary agent

The electric power consumed to circutation the primary agent and secondary agent is:

$$P_1 = \frac{A_1 v_1 \rho_1 g \Delta_{h1}}{10^3 \eta_{p1}} \qquad \text{[kW]} \qquad (12)$$

$$P_2 = \frac{A_2 \rho_2 v_2 g \Delta_{h2}}{10^3 \eta_{p2}} \qquad \text{[kW]} \qquad (13)$$

η_{p1} = pump efficiency for circulation of primary agent;
η_{p2}= pump efficiency for circulation of secondary agent

The service life D of exchanger represents the operating time during the normalized service life. Total energy used for the circulation of the agents :

$$E_{Durata-transport} = \mathrm{D}(P_1 + P_2) \quad \text{[kWh]} \tag{14}$$

The energy transffered on the service life of exchanger is:

$$E_{Transfer\ D} = 3600\ A_2(v_2\rho_2)c_{p2}(t_2 - t_1)\mathrm{D} \quad \text{[kWh]} \tag{15}$$

The indicator for transfer energy to heat exchanger:

$$I_{transfer\ HE} = \frac{E_{exchanger}}{E_{TransferD}} + \frac{E_{Durat-Transport}}{E_{transfer\ D}} \tag{16}$$

$$I_{transfer\ HE} = \frac{\dfrac{3600\ A_2{}^{(1-r)}C_{p1}(t_2-t_1)[A_1\rho_1 c_{p1}(T_1-T_2)]^r}{p[c_{p1}(t_2-t_1)]^r\ \Delta_{tm}\ (v_2\rho_2)^{q+r-1}}}{3600\ A_2(v_2\rho_2)c_{p2}(t_2-t_1)} + \frac{D}{3600\ A_2(v_2\rho_2)c_{p2}(t_2-t_1)}\left(\frac{A_1 v_1\rho_1 g\Delta_{h1}}{10^3\eta_{p1}} + \frac{A_2\rho_2 v_2 g\Delta_{h2}}{10^3\eta_{p2}}\right) \tag{17}$$

3. CONCLUSIONS

The indicator for transffered energy is dimensionless and represent the energy consumed by the heat exchanger to transffer the unit of thermal energy. This indicator depend by the masic flow of second agent. This is related in graphic Fig 1 below.

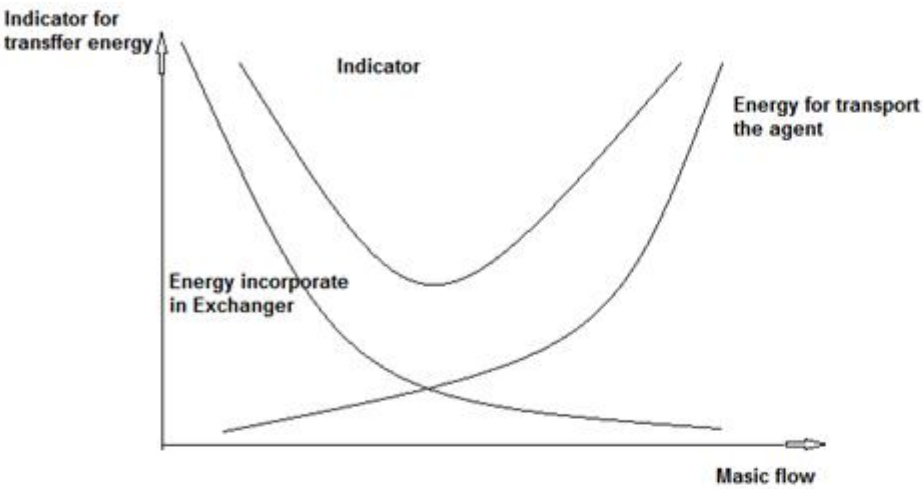

Fig. 1 Variation of Indicator for heat transffered of heat exchanger with masic flow

In heating system the temperatures in primary circuit and secondary circuit are established by the designer of heating plant and all this data will determine the size of heat exchanger.

Informations about areas for exploatation of heat exchangers must be presented by the manufacturer of heat exchangers in technical informations for the standard parameters.

4. REFERENCES

[1] Iordache F. „*Schimbatoare de căldură –regimuri de exploatare. Aspecte termice şi energetice*, Romanian journal of Civil Engineering/ Revista Romǎna de Inginerie Civilă 2017,Vol 8, Issue 3, p243. ISSN -3987

[2] Iordache F., Draghici A., *Two types of heat exchangers specific to construction instalations,* Revista Romǎna de Inginerie Civilă 2017, Volumul 11(2020), Numarul 2

[3] Lavric D., Soare G., Lavric V., Muntean O., Danciu E., *Finned heat exchangers.Ia.General and basic aspectsşSchimbatoare de caldura cu aripioare.Ia.Aspecte generale şi fundamentale*, Revista de chimie; Journal Volume 46;Journal Issue:3,1995.

[4] Baran A., I., *Analiza variaţiei regimului termo- conductiv în schimbătoare de căldură tubulare funcţionând cu nano fluid,* "Creaţii universitare 2017" , Al X-lea Simpozion Naţional Iaşi, România, 2 iunie 2017.

[5] Hera D., Drughean L., Girip A., Ilie A., *Solutions pour accroître l'efficacite energetique des installations frigorifiques pour la climatisation,* COFRET 08,11-13 juin 2008,Nantes Franţa.

[6] Ungureanu V., B., *Heat Pipe for Heat recovery Systems,* Bulletin of Transilvania University of Braşov, Series 1Engineering Sciences, Vol 12, No2,2019.

[7] Terzi P., *Aspecte privind stabilirea unor indicatori de calitate si eficienta economica a bateriilor de încălzireă şi răcire a aerului.*Conferinta de Instalatii Sinaia 1988.