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Heat Transfer Coefficient from Light-Absorbing Heat-Exchanging Panel to the Heat Transfer in Flat-Plate Solar Collectors and Absorbers for Heating of the Heat Transfer Fluid

Nilufar Rabbanakulovna Avezova

***Abstract*— In this work a new approach for improvement of existing methods of thermal calculation and testing of flat-plate solar collectors and absorbers for heating the heat transfer fluid [1] is presented. The authors proposed the introduction to the practice of their thermal calculation of heat transfer coefficient from their light-absorbing heat-exchanging panel to the coolant in its heat-removing channels. The mechanism of formation of heat transfer coefficient is studied and proposed formula for its calculation. The insignificant dependence of heat transfer coefficient value on designation of light-absorbing heat-exchanging panel is established.**

***Index Terms*— Flat-plate solar collectors, absorbers, sheet-piped light-absorbing heat-exchanging panel, heat transfer coefficient.**

I. Introduction

Steady growth of world production and in consumption of flat-plate solar water collectors in recent years puts on the agenda the task of designing their certification documents in a single form, which are necessary for designers and manufacturers work on their further improvement, and the consumers should focus on the nomenclature-produced collectors compare them together and choose the most suitable design to meet their needs.

II. Calculations

Based on calculation method to determine the specific heat output of flat-plate solar water collectors and absorbers for heating the heat transfer fluid the following expression is proposed

$$q_{us} = K_{ref_{p-f}}(\overline{t_p} - \overline{t_f}). \qquad (1)$$

where in ($K_{ref_{p-f}}$) – given unite area of frontal surface of the collector frame the heat transfer coefficient from their light-absorbing heat-exchanging panel to coolant in its heat-removing channels; $\overline{t_p}$ – working temperature of the light-absorbing heat-exchanging panels; $\overline{t_f}$ - mass mean temperature of the coolant, circulating in the heat-removing channels of considered heat-exchange panel.

The value of $K_{ref_{p-f}}$ is determined from the formula

$$K_{ref_{p-f}} = \frac{\eta_{hp} K_{ref_{p-a}}}{1-\eta_{np}}, \qquad (2)$$

where η_{hp} - coefficient of thermal efficiency of the light-absorbing heat-exchanging panel; $K_{ref_{p-a}}$ - the total coefficient of thermal losses of a collector provided to unit of area of a frontal surface of the case in environment.

Results of computational studies to determine the value of $K_{ref_{p-f}}$ depending on the η_{hp} and formula (2) are show that, ceteris paribus (meaning structural dimensions and thermal properties of manufacturing material of light-absorbing heat-exchanging panel) the value $K_{ref_{p-f}}$ mainly depends on the coefficient of convective heat exchange of inner wall surface of the heat removing channel ($\alpha_{k_{in}}$) and very little on the $K_{ref_{p-a}}$.

Approximate expressions to determine the value $K_{ref_{p-f}}$ for the sheet-pipe light-absorbing heat- exchanging panels made of copper and having a 0,11 *m* intertubular distance, thickness light-absorbing plate and wall heat removing channels of 0,25 *mm* and 0,50 *mm*, respectively. The results obtained on the basis of processing the data of computational studies have following view

$$K_{ref_{p-f}} = 52{,}3 + 0{,}115(\eta_{hp} K_{ref_{p-a}}), W/m^2 \cdot {}^oC. \qquad (3)$$

The maximum relative error of calculations by the expression (3) is 0.2%.

The results of calculations to determine the dependence of $K_{ref_{p-f}}$ on the $\alpha_{c_{in}}$ at $K_{ref_{p-a}} = 7{,}5$ and 25,0 $W/m^2 \cdot {}^oC$ are given in Table 1.

Table 1

$K_{ref_{p-a}}$, $W/m^2 \cdot {}^oC$	$\alpha_{c_{in}}$, $W/m^2 \cdot {}^oC$					
	200	400	600	800	1000	1200
7,5	35,1379	53,0816	63,9967	71,3644	76,5807	80,5282
25	35,6942	54,3934	65,8792	73,6923	79,2987	83,5549

The analysis of results shows, that:

- dependence of the $K_{ref_{p-f}}$ on the $K_{ref_{p-a}}$ insignificant. So, with a growth of the values $K_{ref_{p-a}}$ from 3,5 $W/m^2 \cdot {}^oC$ (for high-quality collectors with single layer translucent and selective light-absorbing coating on the surface of the heat-exchanging panel) to 25,0 $W/m^2 \cdot {}^oC$ (for flat-plate solar absorbers with insignificant bottom heat insulation), i.e. with the growth of value $K_{ref_{p-a}}$ in 7,14 times, rise of $K_{ref_{p-f}}$ is only 3,1%.

- dependence of $K_{ref_{p-f}}$ on the $\alpha_{c_{in}}$ more significant, than its dependence from $K_{ref_{p-a}}$. At possible range of changes of values $\alpha_{c_{in}}$ from 200 to 1200 $W/m^2 \cdot {}^oC$, i.e. in 6 times, the values of $K_{ref_{p-f}}$ grow in 2,29 times at $K_{ref_{p-a}} = 7{,}5 W/m^2 \cdot {}^oC$ and in 2,34 times at $K_{ref_{p-a}} = 25{,}0 W/m^2 \cdot {}^oC$.

Insignificant dependence of value $K_{ref_{p-f}}$ on changes of $K_{ref_{p-a}}$ primarily explained by the mechanism of its formation, i.e. from the picture of thermal processes occurring in the internal elements light-absorbing exchanger panel.

III. CONCLUSION

A new approach for improvement of existing methods of thermal calculation and testing of flat-plate solar collectors and absorbers for heating the heat transfer fluid is presented. The authors proposed the introduction to the practice of their thermal calculation of heat transfer coefficient from their light-absorbing heat-exchanging panel to the coolant in its heat-removing channels. Insignificant dependence of this parameter of light-absorbing heat-exchanging panels on their designation at a specified (or desired) coolant flow through them allows making the appropriate marking in their certification documents.

REFERENCES

[1] Duffie J.A., Beckman W.A., *Solar Engineering of Thermal Processes.* New York: A Wiley-Interscience Publication, 1991. – 919 p.

Nilufar Rabbanakulovna Avezova is a scientist in the field of solar power, the leading researcher and the head of the laboratory "Low-potential solar and thermal installations", also is the head of fundamental, scientific-technical and innovative projects at the Physical-Technical Institute of SPA "Physics-Sun" of Academy of Sciences of the Republic of Uzbekistan. In the same time, she is the head of department "Solar Heat Supply" of the International Solar Energy Institute. Besides, she is the executive secretary of the international scientific journal "Applied Solar Energy".