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COMPARATIVE EFFICIENCY OF HEAT TRANSFER INTENSIFICATION METHODS IN HEAT-REMOVING CHANNELS OF SOLAR PANELS

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Abstract:
the article provides a brief comparative analysis of the effectiveness of various methods of heat transfer intensification in the heat-removing channels of solar panels, the expediency of using almost all passive methods of heat transfer intensification for a laminar flow regime is shown.

Key words: heat-receiving panel, intensification, intensifier, efficiency, convective, heat transfer, discrete roughness, hydrodynamic resistance.

At present, the intensification of convective heat transfer is one of the most promising and complex problems in the theory of heat transfer. The increase in the thermal efficiency of solar collectors is also largely determined by the intensity of heat transfer in its heat-removing channels. Therefore, special intensifiers are often used for this purpose.

To compare the thermal efficiency of intensifiers of different design based on experiments carried out by different authors at different average temperatures of the medium flow and in different ranges of Reynolds and Prandtl numbers, it is possible to use the ratio:

$$(Nu/Nu_0) = f(Re), \qquad (1)$$

where: index "0" means a smooth heat exchange surface. Dependence (1) characterizes the increase in the heat transfer coefficient in a pipe with an intensifier compared to the heat transfer coefficient in a smooth pipe.

Figure 1 shows the results of processing the experimental data of various authors [1, 2] as a dependence of Nu/Nu_0 on the Re number, while the Nusselt numbers were reduced to the Reynolds numbers corresponding to a smooth pipe. Such a comparative assessment of the experimental data of different authors allows us to conclude that, from the point of view of thermal effects, the most promising methods for intensifying convective heat transfer in viscous media that affect the near-wall area of application of heat transfer intensifiers

according to the Reynolds number. As can be seen from Fig. 1, the greatest effects of increasing heat transfer occur in the range of Re numbers up to 3000, i.e. in the laminar flow region and in the region of underdeveloped turbulence.

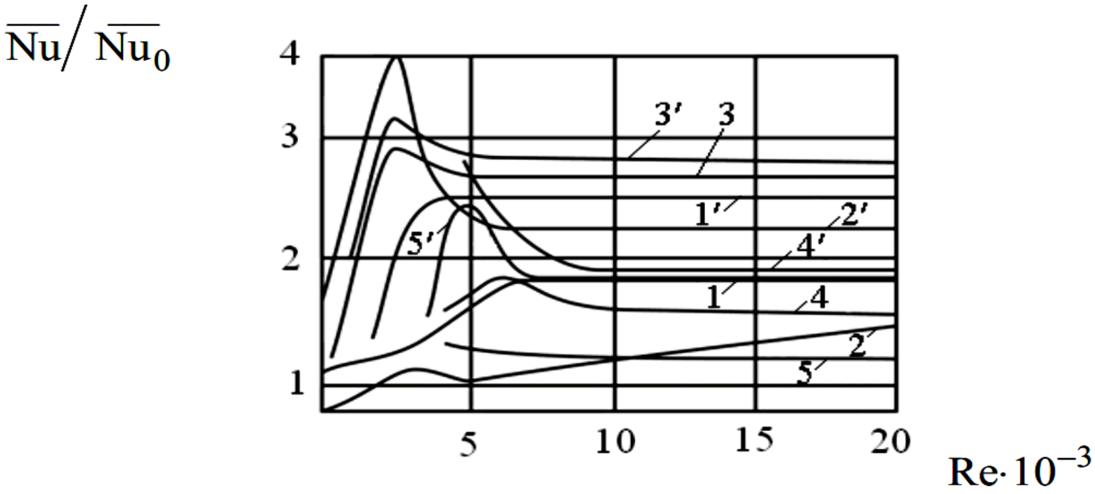


Fig. 1. Comparison of experimental data on heat transfer in pipes with heat transfer intensifiers

1, 1′ – screw swirler, $\varphi = 45^o$ and 75^o; 2, 2′ – transverse knurling, $d/D = 0,983$ and $0,875$; 3, 3′ – spiral knurling, $S/D = 3,25$ и 1; 4, 4′ – wire spiral swirler, $S/D = 2,17$ and $0,724$; 5, 5′ – band swirler, $S/D = 19$ and $3,16$ [4].

For methods based on the use of artificial periodic roughness, this is due to the emergence and development of vortices behind the protrusion element. With the gradual development of turbulence, the value of Nu/Nu_0 somewhat decreases, remaining, nevertheless, much higher than unity. At Re>8000, turbulence begins to have a predominant effect on heat transfer, while the role of vortices gradually decreases. As for intensifiers (tape, screw, etc.), their use, based on the available experimental data, will be more promising for media with higher viscosity. The use of any of the known methods is also accompanied by an increase in hydrodynamic resistance. Therefore, in order to compare the total thermohydrodynamic efficiency of intensifiers of different designs, it is often advisable to use the well-known relation: $(Nu / Nu_o) / (\xi / \xi_o) = f(Re)$ characterizing the relative increase in the intensity of heat transfer in a pipe with an intensifier per unit of additional energy expended. Comparison of the effectiveness of various methods of heat transfer intensification, also performed by V.K. Migay, shown in fig. 2. Here: $И = (Nu / Nu_o) / (\xi/\xi_o)$. The author points out that at low Reynolds numbers, tubes with annular protrusions have the best performance.

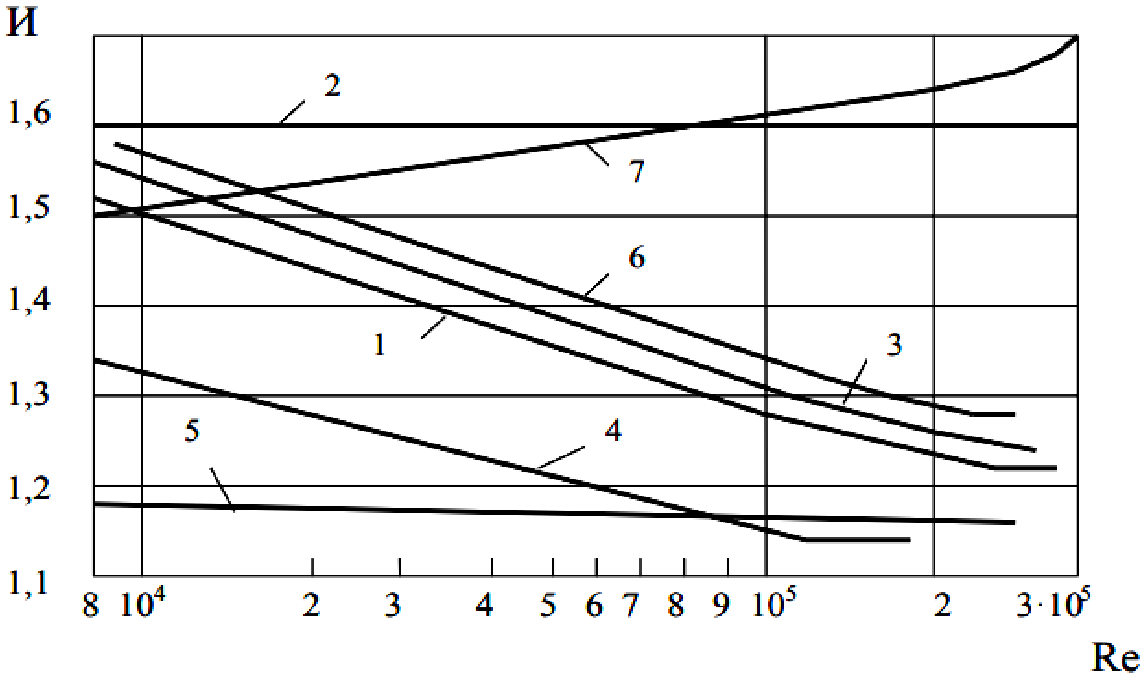
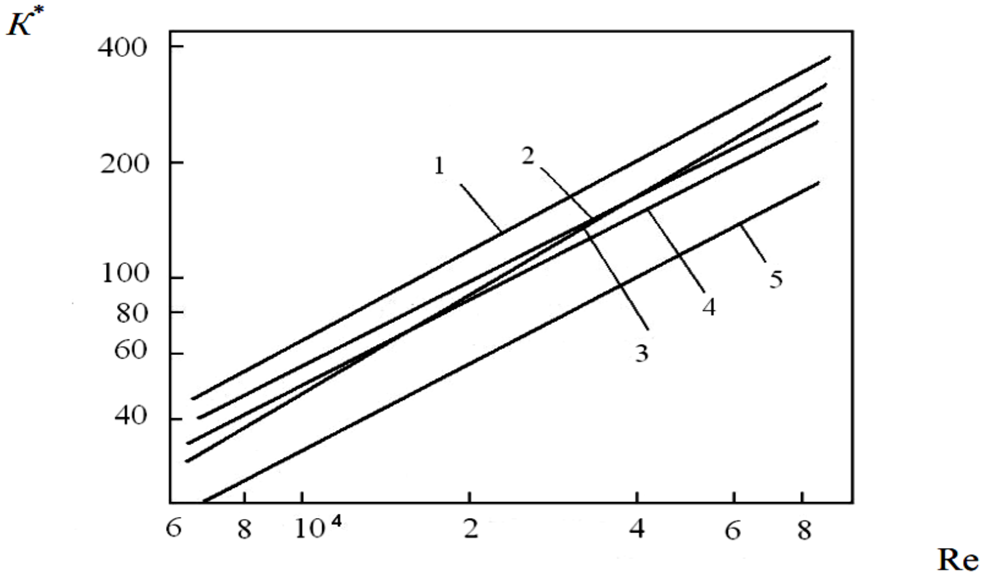


Fig. 2. Comparative efficiency of various methods of heat transfer intensification

1–7 – pipes, respectively: with annular protrusions, of the confuser-diffuser type, with spiral inserts, spirally profiled, with a wavy axis, with perforated inserts, with streamlined protrusions.

A comparative assessment of heat transfer for various types of intensifiers was carried out in [3] and presented in Fig. 3.

Here: K* - criterion equations for calculating the numbers Nu, corresponding to each experiment [3]. As can be seen from fig. 4, an effective method of intensification is the use of multi-start spiral grooves on the inner surface of pipes created by electrochemical processing.



Rice. 3. Heat transfer in pipes with various types of intensifiers

1 - spiral grooves; 2 - tape swirler; 3 - screw coil; 4 - bladed swirler; 5 - smooth pipe. The above brief comparative analysis of known works showed the feasibility of using almost all passive methods of heat transfer intensification in the laminar regime of fluid flow in the heat-removing channels of solar collectors to increase their thermal efficiency.

Literature

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