Improving the Efficiency of Heat Exchangers and Water Suply Pipes when using the Resulting Heat Exchange Pipes

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Abstract: The main types of heat exchangers in domestic centralized heat and hot water supply systems are shell-and-tube heaters.

Keywords: heat exchangers, heat carriers, spherical wells, thermal efficiency.

Introduction: The designs were developed in the 50s of the last century and by the 90s were recognized as obsolete. In the last 15-20 years, this has been repeatedly noted in the periodical press, at conferences and symposiums [4-6]. Many thousands of units of this equipment, despite their structural imperfection and low thermal efficiency, not only remain in operation, but also continue to be produced by many manufacturers to this day.

Main body: By the mid-80s of the twentieth century, the problem of creating structurally more advanced and more efficient shell-and-tube type apparatuses for these systems had acquired a rather acute character. [1-3].

The technical analysis of the design and actual performance characteristics of the listed equipment showed the possibility of their significant improvement even if smooth-tube heat exchange surfaces are preserved in them. It also turned out to be possible to master the manufacture of shell-and-tube heaters of a new generation on existing equipment without making serious changes to the mastered technological processes [7-10]. However, the need to further improve their technical and economic characteristics requires a transition to surfaces that provide intensification of heat exchange in devices with single-phase (water-water) and two-phase (steam-water) heat carriers.

It is obvious that new types of surfaces must be technologically advanced in manufacturing, do not require new expensive equipment, have strength and mechanical properties that are not inferior to similar characteristics of smooth pipes and allow the same methods of fixing the ends in pipe boards that are used for smooth pipes and similar methods of cleaning internal surfaces. It is also essential to limit the increase in pressure losses by the amount of increase in thermal efficiency. The increase in the cost of such pipes in comparison with smooth ones should not exceed the level of 20%.

Taking into account these requirements, an assessment was made of the possibility of using various intensified surfaces in the equipment under consideration.

A number of organizations have been conducting studies of heat exchange intensification for a long time by applying spherical wells to the heat exchange surface of the system [11, 12]. An important feature of such pipes is that when they are manufactured using external pressure, an intensifying heat exchange relief also occurs on the inner surface of the pipes, the effectiveness of which, as has been shown in experiments, for turbulent convection is close to the "lunar" relief. This is especially important for convective heat exchangers, in which the thermal resistances of the sides are commensurate. With this method of intensification, a relatively small increase in pressure losses is also provided. Therefore, it was decided to use tinned pipes instead of smooth ones to solve the above problem.

Results: To realize this idea, it was necessary to create a pilot production of stacked pipes and test a pilot shell-and-tube heater with a heat exchange surface from such pipes.

The specialists of RENTA LLC, in cooperation with NPO CCTI, developed and manufactured an original installation for applying spherical wells to the surface of the initial smooth pipes (creating discrete regular roughness) and produced a trial batch of tinned brass pipes for an experimental steam-water heater, which was designed, manufactured and tested. The appearance of the tinned tube is shown in Fig. 1.

Fig.1.Olunennoy heat exchange pipe

The description of the experimental setup, experimental modes, and methods of processing experimental data related to the tests of an experimental steam-water heater with a heat exchange surface made of tinned pipes are described in detail in [13,17,18].

The test results showed the intensifying effect of the wells on the heat transfer from both the inner and outer sides of the pipes. The coefficient of heat transfer from the pipe wall to the water α2 increased most significantly, by 1.59 times. A certain intensification of heat transfer on the outer surface of the tinned pipes during the film condensation of steam on it also apparently took place, but it was neglected when processing the results of experiments.

The change in the heat transfer coefficient when using pipes with wells is shown in Fig. 2. As can be seen from the graph, the heat transfer coefficient when using such pipes (K) is 28% higher than its value for smooth pipes (Red). The value of the heat transfer coefficient for a steam-water heater turned out to be approximately 6.2 kW / (m2.K), which is twice the value for heaters of the PP brand according to [14,15,16]. The coefficient of hydraulic resistance by friction of the cooling water flow inside the tinned pipes λtr increased by 2.1 times.

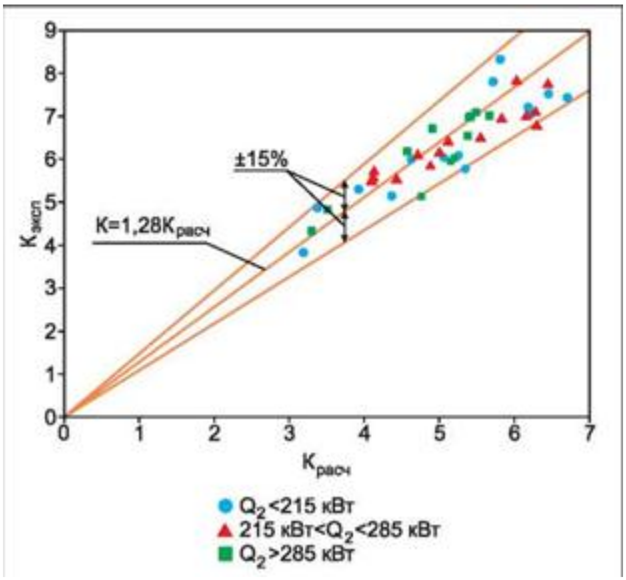

Fig.2. Comparison of experimental heat transfer values for the obtained pipes with calculated values for smooth pipes

Thus, the intensifying effect of wells on heat exchange in heaters used in heat supply systems has been confirmed experimentally. A 28% increase in the K value makes it possible to reduce the number of installed heaters of similar standard sizes by a quarter, while increasing the cost of one heater by only 10-12%. The achieved increase in the heat transfer coefficient made it possible to create a series of water-water heaters with heat exchange intensification, superior to plate-type devices in terms of thermal efficiency and operational characteristics.

Conclusion: It should be emphasized that the installation of tinned pipes instead of smooth ones in the tube bundles of heaters remaining in operation does not require special or expensive equipment, can be carried out during scheduled repairs during shutdowns by the own repair personnel of the facility, and thus allows to increase their thermal efficiency at minimal cost.

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