SHELL-AND-TUBE HEAT EXCHANGER DESIGN WITH INCREASED TURBULENCE OF THE HEATED LIQUID FLOW

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Abstract. *the article presents methods for calculating heat exchangers by design, size and surfaces.*

Keywords: *heat exchangers, shell-and-tube heat exchanger, geometry of the heat exchange surface, heat transfer coefficient, thermal and hydraulic calculations.*

КОНСТРУКЦИЯ КОРПУСНО-ТРУБНОГО ТЕПЛООБМЕННИКА С ПОВЫШЕННОЙ ТУРБУЛЕНТНОСТЬЮ ПОТОКА НАГРЕВАЕМОЙ ЖИДКОСТИ

Аннотация. *в статье представлены методы расчета теплообменников по конструкции, размерам и поверхностям.*

Ключевые слова: *теплообменники, кожухотрубный теплообменник, геометрия поверхности теплообмена, коэффициент теплопередачи, тепловые и гидравлические расчеты.*

INTRODUCTION

It should be noted that in the heat supply systems of housing and communal services and industrial enterprises, heat exchangers are used when heating water for:

- heating systems;
- hot water supply systems;
- various technological needs, where a coolant in the form of hot water is required.

At the same time, it should be noted that the temperatures at the inlet and outlet of the heated water for these systems are always different; the temperatures of the heating circuit coolant may coincide [1, 3-4]. Accordingly, the speed modes in the heating and heated circuits can also change, which affects the main characteristic of the heat exchanger – the heat transfer coefficient [5].

MATERIALS AND METHODS

The task of developing heat exchangers of an efficient design is to determine the geometric dimensions of the heat exchange surface for various speed modes of the coolant and the heated liquid. At the same time, an important condition is to achieve the required values of the heat transfer coefficient K, W / (mIC), and pressure losses H, M. It is under this condition that it is possible to design heat exchangers for various temperature and hydraulic modes and, accordingly, expand their use in heat supply [6 - 7].

It should be noted that the design development of shell-and-tube heat exchangers (Figure 1.3) it is conducted quite intensively. At the same time, both experimental and theoretical studies are actively carried out [8-9].

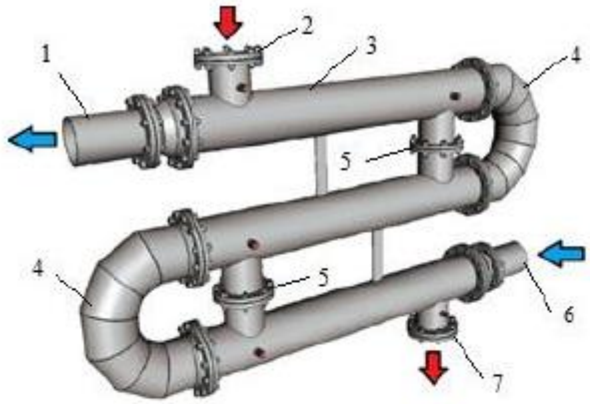

Figure 1.

Shell-and-tube heat exchanger GOST 27590: 1 – branch pipe for the discharge of cooled liquid (pipe space); 2 - branch pipe for the supply of heated liquid; 3 – housing; 4 – connecting roll; 5 - branch pipes for the connection of the inter-tube space; 6 – branch pipe for the supply of hot (heating) liquid; 7 - branch pipe for the discharge of heated liquid.

Intensification of thermal processes of shell-and-tube heat exchangers is an important problem. It is the intensity of thermal processes that determines the dimensions of heat exchangers, the number of sections, and, ultimately, the cost of the device for a specific heat supply facility (heat source, TTP or consumer etc.).

RESULTS

The heat exchanger in the heat supply system must ensure the transfer of the necessary amount of heat energy from one heat carrier to another at a given temperature and hydraulic conditions and with the greatest possible intensity of heat exchange, be sufficiently reliable and easy to operate, have a sufficient margin of safety, be sealed (i.e. one heat carrier should not fall into another, and also flow out). The heat exchange surface and other elements of the heat exchanger, streamlined by aggressive heat carriers, must have sufficient chemical resistance. When designing heat exchangers, it should be ensured that they are as small as possible and have the lowest specific metal consumption. Also, the costs of their manufacture, operation and repair should be minimal. It is especially necessary to take into account the cost of energy for the circulation of heat carriers and the costs of the corresponding pumping equipment.

Thus, the requirements for heat exchangers are very diverse, and sometimes contradictory. Usually, one or more possible designs of the device are selected to solve a production problem, and the flow patterns of heat carriers are determined. Based on the expected operating conditions, heat carriers are selected. Thermal and hydraulic calculations of the selected heat exchangers are necessarily performed. A strength calculation can also be made. In the course of economic calculations, capital investments, operating costs, profitability and other indicators are compared.

It should be noted that there is no generally accepted classification of methods for improving the designs of shell-and-tube heat exchangers. Depending on the principle by which the modernization of the design of the apparatus for the intensification of heat exchange processes is carried out, the following directions can be conditionally distinguished:

- organization of the movement of the coolant in the heat exchanger housing;
- use of external physical fields;
- addition of chemicals to the coolant;

- changing the geometry of the heat exchange surface.

Let's consider the designs of heat exchangers in which the method of changing the geometry of the heat exchange surface was used.

Currently, shell-and-tube heat exchangers with smooth tubes are the most common in heat supply systems [10]. This heat exchanger has proven itself for use in heat supply systems according to many positive technical characteristics. But such a device has one drawback – a relatively low heat transfer coefficient, which leads to large overall dimensions.

Currently, developments are actively underway to improve the operation of shell-and-tube apparatuses. For the most part, constructive changes are being made. However, theoretical research is not carried out enough [11].

To intensify heat exchange, we have proposed an original design of a shell-and-tube heat exchanger with increased turbulence of the heated liquid flow (Appendix A), with a modified geometry of the heat exchange surface [12].

- remove the partitions in the heat exchanger housing, place the hot and cold liquid supply pipes on the opposite end walls of the heat exchanger, place the heated liquid outlet pipe on the side surface of the housing from the side of the hot liquid supply pipe and, mainly,

- additionally equip the fin plates with cylindrical ribs (Figure 2).

In the technological process, a hot liquid is fed into the nozzle 2 (for example, from a boiler room), which then enters the heat exchange tubes 8, heating them along their entire length. Passing through the tubes, the liquid is cooled and at the end of the process is discharged through the nozzle 3.

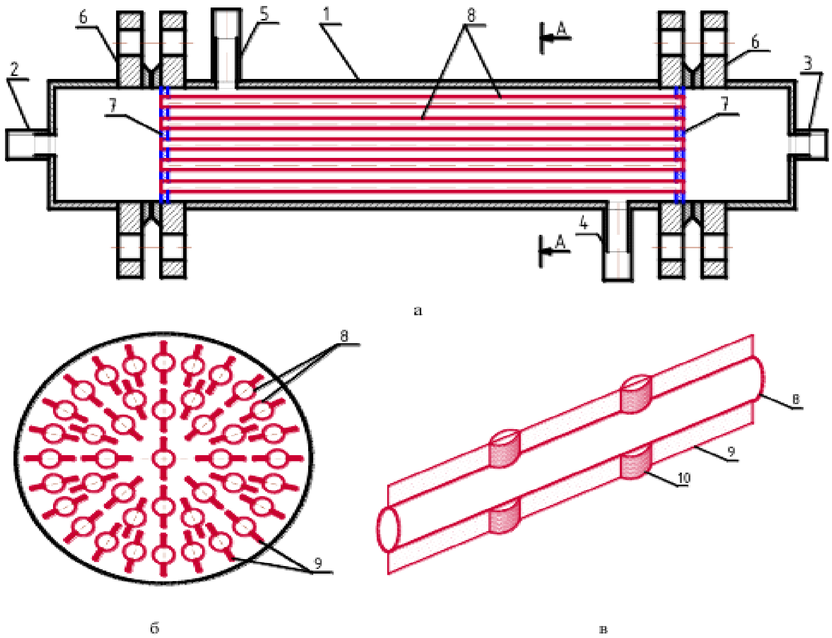

Figure 2.

Shell–and–tube heat exchanger with increased turbulence of the heated liquid flow and a modified geometry of the heat exchange surface: a - longitudinal section; b – section A-A; c - general view of the heat exchange tube; 1 – housing; 2 – hot liquid supply pipe; 3 – cooling liquid discharge pipe; 4 – supply pipe heated liquid; 5 – outlet pipe of heated liquid; 6 – flange connection; 7 – transverse partitions; 8 – heat exchange tubes; 9 – plates; 10 – cylindrical ribs

The heated liquid enters the body of the heat exchanger 1 through the nozzle 4, passes, evenly distributed, in the inter–tube space located between the transverse partitions 7, flowing longitudinally around the heat exchange tubes 8 with plates 9, as well as in the transverse direction - the ribs 10. Then the heated liquid is discharged through the nozzle 5 and supplied to the consumer of thermal energy for further use in engineering systems [12].

DISCUSSION

Equipping plates 9 with cylindrical fins 10 allows to increase the heat exchange surface, as well as to create additional turbulence of the heated liquid flow when these fins flow around. In turn, the turbulence of the flow will contribute to the destruction of the wall laminar layer, which means an increase in the processes of heat transfer from the heat exchange surface to the heated liquid. Ultimately, this will lead to an increase in the performance of the heat exchanger for the target product – hot water.

Mathematical modeling

According to SP 41-01-95 "Design of heat points", the heat transfer coefficient K, W / (m2K), for heat exchangers with smooth tubes is calculated:

$$K = \frac{\Psi\beta}{\frac{1}{\alpha_1} + \frac{1}{\alpha_2} + \frac{\delta_{cm}}{\lambda_{cm}}}. \quad (1.1)$$

where Ψ is the heat transfer efficiency coefficient, β is the coefficient that takes into account the contamination of the pipe surface [13], is the heat transfer coefficient from the hot liquid flowing in the tube to the inner surface of this tube, W/(m2 K), is the wall thickness of the heat exchange tube, m, λst is the thermal conductivity coefficient of the tube material, W/(m•K), - the coefficient of heat transfer from the outer surface of the heated heat exchange tube to the heated liquid of the inter-tube space, W /(m2 K).

CONCLUSION

Since in our case the geometry of the heat exchange surface of only the outer surface of the tube has been changed, it is necessary to determine the coefficient. To do this, it is necessary to consider the nature of the flow around the new heat exchange surface.

REFERENCES

1. Usmonova, N. A., & Khudaykulov, S. I. (2021, April). SPATIAL CAVERNS IN FLOWS WITH THEIR PERTURBATIONS IMPACT ON THE SAFETY OF THE KARKIDON RESERVOIR. In E-Conference Globe (pp. 126-130
2. Nosirov A.A., Nasirov I.A. Simulation of Spatial Own of Vibrations of Axisymmetric Structures EUROPEAN MULTIDISCIPLINARY JOURNAL OF MODERN SCIENCE https://emjms.academicjournal.io
3. Shavkatjon o'g'li, T. B. (2022). SOME INTEGRAL EQUATIONS FOR A MULTIVARIABLE FUNCTION. Web of Scientist: International Scientific Research Journal, 3(4), 160-163.
4. Рашидов, Ю. К., Орзиматов, Ж. Т., Эсонов, О. О. Ў., & Зайнабидинова, М. И. К. (2022). СОЛНЕЧНЫЙ ВОЗДУХОНАГРЕВАТЕЛЬ С ВОЗДУХОПРОНИЦАЕМЫМ МАТРИЧНЫМ АБСОРБЕРОМ. Scientific progress, 3(4), 1237-1244.

5. Рашидов, Ю. К., Орзиматов, Ж. Т., & Исмоилов, М. М. (2019). Воздушные солнечные коллекторы: перспективы применения в условиях Узбекистана. *ББК 20.1 я43 Э 40*.
6. Abobakirovich, A. B., Sodikovich, A. Y., & Ogli, M. I. I. (2019). Optimization of operating parameters of flat solar air heaters. Вестник науки и образования, (19-2 (73)), 6-9.
7. Abbasov, Y. S., & ugli Usmonov, M. A. (2022). Design of an Effective Heating System for Residential and Public Buildings. *CENTRAL ASIAN JOURNAL OF THEORETICAL & APPLIED SCIENCES*, *3*(5), 341-346.
8. Usmonova, N. A. (2021). Structural Characteristics of the Cavern at a Fine Bubbled Stage of Cavitation. Middle European Scientific Bulletin, 18, 95-101.
9. Nasirov Ismail Azizovich. On The Accuracy of the Finite Element Method on the Example of Problems about Natural Oscillations. EUROPEAN MULTIDISCIPLINARY JOURNAL OF MODERN SCIENCE https://emjms.academicjournal.io
10. Nosirov A.A., Nasirov I.A. Simulation of Spatial Own of Vibrations of Axisymmetric Structures EUROPEAN MULTIDISCIPLINARY JOURNAL OF MODERN SCIENCE https://emjms.academicjournal.io
11. Xamdamaliyevich, S. A., & Rahmankulov, S. A. (2021, July). Investigation of heat transfer processes of solar water, air contact collector. In E-Conference Globe (pp. 161-165).
12. Madaliev, M. E. U., Rakhmankulov, S. A., & Tursunaliev, M. M. U. (2021). Comparison of Finite-Difference Schemes for the Burgers Problem. Middle European Scientific Bulletin, 18, 76-83
13. Abdullayev, B. X., & Rahmankulov, S. A. (2021). Modeling Aeration in High Pressure Hydraulic Circulation. CENTRAL ASIAN JOURNAL OF THEORETICAL & APPLIED SCIENCES, 2(12), 127-136.
14. Abdukarimov, B. A., O’tbosarov, S. R., & Tursunaliyev, M. M. (2014). Increasing Performance Efficiency by Investigating the Surface of the Solar Air Heater Collector. NM Safarov and A. Alinazarov. Use of environmentally friendly energy sources.
15. Rashidov, Y. K., & Ramankulov, S. A. (2021). Improving the Efficiency of Flat Solar Collectors in Heat Supply Systems. CENTRAL ASIAN JOURNAL OF THEORETICAL & APPLIED SCIENCES, 2(12), 152-159
16. Madraximov, M. M., Nurmuxammad, X., & Abdulkhaev, Z. E. (2021, November). Hydraulic Calculation Of Jet Pump Performance Improvement. In International Conference On Multidisciplinary Research And Innovative Technologies (Vol. 2, pp. 20-24).
17. Akramov, A. A. U., & Nomonov, M. B. U. (2022). Improving the Efficiency Account Hydraulic of Water Supply Sprinklers. Central Asian Journal of Theoretical and Applied Science, 3(6), 364-370.
18. Умурзакова, М. А., Усмонов, М. А., & Рахимов, М. Н. (2021). АНАЛОГИЯ РЕЙНОЛЬДСА ПРИ ТЕЧЕНИЯХ В ДИФФУЗОРНО-КОНФУЗОРНЫХ КАНАЛАХ. *Экономика и социум*, (3-2), 479-486.
19. Сатторов, А. Х., Акрамов, А. А. У., & Абдуразаков, А. М. (2020). Повышение эффективности калорифера, используемого в системе вентиляции. Достижения науки и образования, (5 (59)), 9-12.
20. Усаров, М. К., and Г. И. Маматисаев. "Вынужденные колебания коробчатой конструкции панельных зданий при динамических воздействиях." Проблемы

механики 2 (2010): 23-25. Shavkatjon o‘g‘li, T. B. (2022). Proving The Inequalities Using a Definite Integral and Series. Texas Journal of Engineering and Technology, 13, 64-68.

21. Madaliev, M. E. U., Maksudov, R. I., Mullaev, I. I., Abdullaev, B. K., & Haidarov, A. R. (2021). Investigation of the Influence of the Computational Grid for Turbulent Flow. Middle European Scientific Bulletin, 18, 111-118.
22. Hamdamalievich S. A. Determination of the deposition of particles contained in the water passing through the sump well //Central asian journal of theoretical & applied sciences. – 2022. – Т. 3. – №. 6. – С. 244-251.
23. Hamdamalievich S. A., Nurmuhammad H. Analysis of Heat Transfer of Solar Water Collectors //Middle European Scientific Bulletin. – 2021. – Т. 18. – С. 60-65.
24. ugli Mo‘minov, O. A., Maqsudov, R. I., & qizi Abdukhalilova, S. B. (2021). Analysis of Convective Finns to Increase the Efficiency of Radiators used in Heating Systems. Middle European Scientific Bulletin, 18, 84-89.
25. Maqsudov, R. I., & qizi Abdukhalilova, S. B. (2021). Improving Support for the Process of the Thermal Convection Process by Installing. Middle European Scientific Bulletin, 18, 56-59.
26. Усаров, Махаматали Корабоевич, and Гиёсиддин Илхомидинович Маматисаев. "КОЛЕБАНИЯ КОРОБЧАТОЙ КОНСТРУКЦИИ КРУПНОПАНЕЛЬНЫХ ЗДАНИЙ ПРИ ДИНАМИЧЕСКИХ ВОЗДЕЙСТВИЯХ." Научный форум: технические и физико-математические науки. 2019.
27. Madaliev, E. U., & qizi Abdukhalilova, S. B. (2022). Repair of Water Networks. CENTRAL ASIAN JOURNAL OF THEORETICAL & APPLIED SCIENCES, 3(5), 389-394.
28. . Malikov, Z. M., & Madaliev, E. U. (2019). Mathematical simulation of the speeds of ideally newtonovsky, incompressible, viscous liquid on a curvilinearly smoothed pipe site. Scientific-technical journal, 22(3), 64-73.
29. Мадхадимов, М. М., Абдулхаев, З. Э., & Сатторов, А. Х. (2018). Регулирования работы центробежных насосов с изменением частота вращения. Актуальные научные исследования в современном мире, (12-1), 83-88.
30. Mo‘minov, O. A. O‘tbosarov Sh. R.“Theoretical analysis of the ventilation emitters used in low-temperature heat supply systems, and heat production of these emitters” Eurasian journal of academic research, 495-497.