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INCREASE OF EFFICIENCY OF SHELL-AND-TUBE HEAT EXCHANGERS BY IMPROVEMENT OF STRUCTURAL DESIGN OF INTERTUBE SPACE

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Abstract

This article investigates the intricacies of shell and tube heat exchangers (CTA) commonly used in the chemical and oil and gas industries. It delves into the complexities arising from the implementation of flat transverse baffles within these heat exchangers, impacting coolant flow and heat transfer efficiency. The study aims to evaluate the influence of radial clearances between these baffles and the casing on thermal and hydraulic characteristics. Additionally, it addresses the formation of stagnant zones due to flow direction changes, which can lead to overheating and surface deposits, subsequently affecting heat transfer efficiency. By focusing on these factors, the research aims to enhance the understanding of design complexities and challenges to optimize the efficiency of heat exchange processes in shell and tube heat exchangers. This article encapsulates the focus and objectives of the research, emphasizing the investigation into the impact of baffles, radial clearances, and flow dynamics on heat transfer efficiency in shell and tube heat exchangers. Adjustments can be made to include specific methodologies or additional focal points of the study if needed.

Keywords: Shell and Tube Heat Exchangers (CTA), Transverse Baffles, Thermal Efficiency, Hydraulic Characteristics, Radial Clearances, Coolant Flow Dynamics, Stagnant Zones, Heat Transfer Efficiency, Overheating, Surface Deposits, Flow Direction Changes, Oil and Gas Industry, Chemical Industry, Rheological Properties.

Introduction

In practice, the unaccounted influence of bypass currents is compensated by the reserve of heat transfer surface area. Such an approach leads to an increase in metal intensity of CTA. Modern development of computer technology allows to increase significantly the efficiency of solving scientific and engineering problems. Analysis of the results of numerical modelling allows solving a number of questions aimed at increasing the efficiency of heat transfer, which remains one of the most important in the design of CTAs [1-4]. Therefore, taking into account the influence of bypass flows and stagnant zones as factors reducing the efficiency and intensity of heat transfer in CTA, selection of optimal values of cutout height and distance between segmental transverse baffles, providing maximum energy efficiency of heat transfer, is an urgent task.

Shell and tube heat exchangers are important devices in engineering and chemical industry used to transfer heat between two media. They consist of an outer shell and inner tubes within which heat transfer takes place. Improving their efficiency is important for energy saving and process optimization [5-9].

Methods to improve the efficiency of shell and tube heat exchangers include:

1. Improving the geometry of the intertube space: Optimising the shape of the tubes and shells can increase the heat transfer surface, resulting in improved efficiency.
2. Use of advanced materials: The use of high-strength and thermally conductive materials can improve heat transfer and reduce losses.
3. Flow control: Controlling the speed and direction of flow of fluids within the apparatus can optimise heat transfer.
4. Cleaning and Maintenance: Regular cleaning and maintenance of the apparatus can help prevent the accumulation of deposits and increase its efficiency.
5. Application of innovation: Adopting innovative technologies such as micro- and nanotechnology can significantly improve the performance of heat exchangers.

The importance of improving the efficiency of shell and tube heat exchangers is related to reducing energy costs, increasing productivity and reducing the negative environmental impact. This is an urgent task in various industries including chemical, power, and manufacturing [10-19].

Improving the efficiency of shell and tube heat exchangers requires a collaborative effort between engineers and researchers to find new methods and solutions to help optimise these devices [18-26].

The importance of improving the efficiency of shell and tube heat exchangers is related to reducing energy costs, increasing productivity and reducing the negative impact on the environment. This is an urgent task in various industries, including chemical industry, power engineering, and manufacturing [27-38]. Improving the efficiency of shell and tube heat exchangers requires a collaborative effort between engineers and researchers to find new methods and solutions to help optimise these devices. Intensification of heat transfer and reduction of hydraulic resistance in shell-and-tube heat exchangers with single-segment transverse baffles through the use of additional structural elements in the intertube space.In order to achieve the above goal the following tasks were solved:1 To develop finite element models for calculation of hydrodynamics and heat transfer in shell-and-tube heat-exchange apparatuses with diameters D = 147, 400, 500, 600 mm and to carry out verification of the developed models; 2 To establish the shares of bypass flows passing through the structural gaps in the intertube space of the shell-and-tube heat-exchange apparatus, to estimate their influence on the heat transfer coefficient and hydraulic resistance of the flow space; 3 To investigate the influence of geometrical dimensions and parameters of placement of single-segment transverse baffles; 3 To investigate the influence of geometrical dimensions and parameters of placement of single-segment transverse baffles in the flow space of the shell-and-tube heat-exchange apparatuses with single-segment transverse baffles [39-47].

Scientific novelty

1. Dependences of heat transfer coefficient, pressure drop and shares of bypass flows in the intertube space of shell-and-tube heat exchangers on the value of structural gaps are established.It is shown that at the maximum permissible value of gaps between transverse partitions and the shell the coefficient of energy efficiency decreases by 35%, at the maximum permissible value of gaps between holes in partitions and heat-exchange tubes the coefficient of energy efficiency decreases by 13% [48-51].
2. Dependences of the heat transfer efficiency in the intertube space on the ratio of the height of the cutout hw of the single-segment transverse 6 baffle and the distance Lb between the baffles are obtained. It is shown that the maximum energy efficiency is achieved at the ratio hw/Lb= 0.57.3 It is established that the placement of three additional partitions of 0.1D width at each step between single-segment transverse partitions allows increasing the step between transverse partitions by 60% and the energy efficiency coefficient of heat transfer M.V. Kirpichev by 22% at the same amount of transferred thermal energy [52-55]. Theoretical significance of the work consists in scientific substantiation of choice of optimum geometrical sizes and parameters of placing of transverse partitions in intertube space of KTA, proceeding from conditions of maintenance of energy efficiency of heat transfer.Practical significance of the thesis work consists in the following:1 Methodology of calculation of hydraulic and thermal characteristics of shell-and-tube heat-exchange apparatuses with one-segment transverse partitions is accepted for introduction on JSC "Ferganaazot". 2 Methodology of calculation of hydraulic and thermal characteristics of shell-and-tube heat exchangers is used in the educational process in Ferghanaazot JSC during training of bachelors in the direction 5320300 "Technological machines and equipment" In the course of research methods of computer finite element modelling (module of calculation of dynamics of liquids and gases of amyachnitrate), methods of mathematical statistics, experimental methods of heat exchange research were applied.Positions put forward for protection 1 The results of numerical experiments on the analysis of thermal-hydraulic characteristics (velocity and temperature fields) of the liquid flow in the intertube space of shell-and-tube heat-exchange apparatuses with single-segment 7 transverse partitions. 2 Regularities of influence of the value of structural gaps between baffles and shell, pipes and holes in baffles on the heat transfer coefficient and hydraulic resistance of the intertube space of shell-and-tube heat exchangers, established as a result of numerical experiment. 3 Design solutions to improve the efficiency of shell-and-tube heat exchangers due to more uniform flow distribution, reduction of stagnant zones and bypass currents in the intertube space.

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