

Intensification of Oil and Oil Product Heaters by Means of Auger Inserts

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Abstract. This paper discusses the approach of how to intensify the heat exchange processes under laminar flows of high-viscosity non-Newtonian fluids with the use of auger inserts. This approach of intensification refers to the methods of swirling the flow, which creates a rotational motion of the fluid throughout the entire duct cross-section being most relevant to the high-viscosity fluids.

One of the most important challenges that the companies of the country's energy sector face is the search for new ways of rational use of energy resources. The most promising way to reduce the weights and overall dimensions of heat exchange equipment is the heat exchange intensification. A description of the various types of intensifiers is given, in particular, in the works of Yu. G. Nazmeyer, A. Ye. Bergls, O. V. Mitrofanova, G. A. Dreitzer and other authors [1-3].

With regard to the flow of single-phase coolants, rough and developed surfaces are used, either by finning or creating cavities on the surface; swirling the flow with spiral fins; auger devices; swirlers installed at the duct inlet; mixing gas bubbles with the gas flow, and solids or liquid drops to the gas flow; rotation or vibration of the heat exchange surface; pulsation of the coolant flow; electrostatic fields influencing the flow; suction of the flow from the boundary layer; jet systems. The performance of these methods varies usually having an increase of heat transfer up to 2-3 times, while the energy costs are significantly different for various methods of intensification [1].

The laminar-flow region is a promising scope where the design and analysis of methods for increasing the performance of heat exchange equipment is quite a challenge of the day. Laminar flows are characterized by low heat transfer coefficients. The flow velocity and the temperature of the coolant vary over the entire duct height so that the thermal resistance occurs in the entire boundary layer, which can take the entire cross-section of the pipe or duct. Therefore, the small roughness on the heat exchange surface does not work for intensifying heat transfer in laminar flows [2]. Taking these features into account, it is possible to identify the approach of convective heat exchange intensification with swirling the flow by auger inserts [3]. Swirling the flow by means of a pipe-inserted auger considerably increases the energy efficiency of heat exchange versus the non-swirling flow.



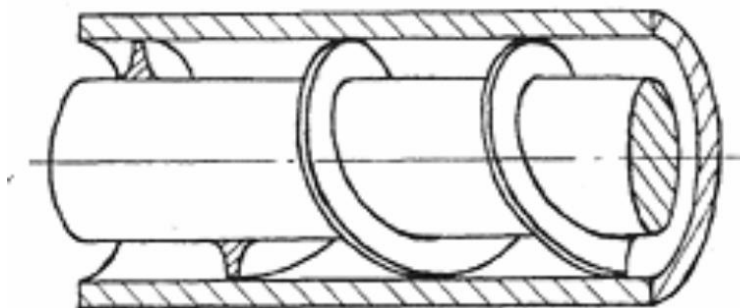


Fig. 1 Swirler - the auger insert in a round tube

In recent years, the rapid development of numerical methods and computer technology has made it possible to perform calculations for the swirling flow analysis to a high degree of detailing and a comparative performance analysis of various intensifier designs.

The auger inserts with multiple screw augmentation are expected to increase the intensification effect due to a strongest impact on the flow. The study of this effect requires the development of adequate full-scale mathematical models and methods of thermal hydraulics calculation.

The study of heat exchange intensification during the flow of heavy oil and oil products using the multi-screw auger inserts sets the following challenges:

1. Designing a mathematical model of hydrodynamics and heat exchange in the non-isothermal flow of a non-Newtonian fluid in a three-screw auger insert duct.
2. Making the Comsol Multiphysics software fit for addressing the challenge.
3. Numerical and experimental studies of non-isothermal flow of heavy oil in auger insert ducts for various geometric and duty parameters.
4. Analysis of the vorticity fields, the temperature and velocity profile following the results of numerical studies.
5. Evaluation of how the the auger fin angle, the screw pitch and the annular space have an effect on the vorticity fields, the temperature and velocity profiles and the thermal and hydraulic efficiency of the heat exchange equipment.
6. Summarizing and analyzing the results of numerical and experimental studies.
7. Providing recommendations on the use of auger inserts for heating oil and oil products at pumping stations.

The main effect on the thermohydraulic characteristics of the intensified ducts [4] is a decrease in the ducts' resistance to flow (internal flow) and the power expended for the transportation of oil and oil products, all other things being equal.

References

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