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Effect of different nanoparticle shapes on shell and tube heat exchanger using different baffle angles and operated with nanofluid

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ABSTRACT

Nanofluid is a new engineering fluid which could improve the performance of heat exchanger. The aim of this paper is to study the effect of different particle shapes (cylindrical, bricks, blades, and platelets) on the overall heat transfer coefficient, heat transfer rate and entropy generation of shell and tube heat exchanger with different baffle angles and segmental baffle. Established correlations were used to determine the abovementioned parameters of the heat exchanger by using nanofluids. Cylindrical shape nanoparticles showed best performance in respect to overall heat transfer coefficient and heat transfer rate among the other shapes for different baffle angles along with segmental baffle. An enhancement of overall heat transfer coefficient for cylindrical shape particles with 20° baffle angle is found 12%, 19.9%, 28.23% and 17.85% higher than 30°, 40°, 50° baffle angles and segmental baffle, respectively in corresponding to 1 vol.% concentration of Boehmite alumina (γ-AlOOH). Heat transfer rate is also found higher for cylindrical shape at 20° baffle angle than other baffle angles as well as segmental baffle. However, entropy generation decreases with the increase of volume concentration for all baffle angles and segmental baffle.

1. Introduction

Global warming, changes of climate, greenhouse effect, fuel security, high prices of energy and energy losses are now very challenging issues all over the world. These problems are now motivating people to think about energy savings. Energy savings could be done by confirming the efficient use of energy. Eenergy conversion, conservation and recovery are some ways to save energy. To do these, different types of heat exchangers are generally used in all sectors. Different technologies are used to enhance the efficiency of the heat exchanger systems. Increasing of the heat transfer area by using fins and micro channels are ordinarily applied. But, these methods are the reason for bigger and bulky heat exchanger system. Conventional methods i.e.: usage of fins and micro channels have already prolonged to their boundaries [1]. For the higher thermal conductivity of solid particles, the uses of solid particles in conventional fluids are also applied to enhance the heat transfer performance of these fluids. But the problems are fouling, sedimentation and increased pressure drop. The novel invention of nanofluid has provided the possibilities to overcome these problems [2]. Suspension of nanometer size particles (usually below 100 nm) in conventional fluid is called nanofluid. After the discovery of nanofluid, research is going on tremendously on thermal conductivity, different modes of heat transfer and different fundamental properties of nanofluids [3].

Among the available literatures about nanofluids, thermal conductivity is being considered most important thermophysical property of any fluid for heat transfer application. Thermal conductivity is directly related to heat transfer performance of any system. Thermal conductivity of the nanofluid has been studied numerically and experimentally by many researchers. Researchers showed in their experiments that thermal conductivity increases with the increase of volume concentration and temperature [4–6]. The effect of different size and shape of nanoparticles on thermal conductivity of nanofluids is also available in the literature. Although, there are still debate on the effect of particle size of nanofluids thermal conductivity; however, most of the researchers are agreed upon that thermal conductivity decreases with the increase of particle sizes. However, overall performance of the heat exchanger depends on thermal conductivity, viscosity, density and specific heat of the working fluids [7,8].

Most of the research available in the literature about viscosity and density of nanofluids reported that, viscosity and density of nanofluids increases with the increase of volume fractions [9]. Based on existing experimental and theoretical results in the literatures, specific heat of nanofluids decreases with the increase of volume concentration of nanoparticle though there are also some

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