ScienceDirect

Materials Today: Proceedings

Volume 21, Part 1, 2020, Pages 934-939

Heat transfer augmentation by nano-fluids and circular fin insert in double tube heat exchanger – A numerical exploration

C. Gnanavel [a], R. Saravanan [b], M. Chandrasekaran [a]

Show more

https://doi.org/10.1016/j.matpr.2019.08.236

Get rights and content

Abstract

The heat transfer augmentation primary demand in industries like power plant, automobile and process industries for either heating or cooling or evaporation, in particularly in air conditioning, radiators, refrigerators, condensers etc. Such augmentation of heat transfer can either be achieved by passive and active techniques. In this paper the passive approach employed for heat transfer augmentation in double pipe heat exchanger. The four different nano-fluids are considered for the investigation like titanium dioxide nano-fluid, Beryllium oxide or beryllia nano-fluid, zinc oxide nano- fluid and copper oxide nanofluid. The role of nano-fluid is increasing the thermal conductivity of the fluid medium. The circular fin insert used for offering the flow resistance and spread the fluid to surface to enhance the heat transfer. The numerical study is investigating the thermal and flow fields utilizing various types of nano-fluids with circular fin insert in the double pipe heat exchanger. The Finite volume method employed for solve the continuity, momentum and energy equations the ANSYS 15.0 employed for conducting the numerical analysis.

Introduction

The heat transfer coefficients in forced convection are governed by thermal conductivity of the fluid as well as by factors representing turbulence and the operating condition. These fluids, including oil, water, and ethylene glycol mixture, are rather poor heat transfer media. Their thermal conductivity plays an important role in the heat transfer between the working fluid and the heated surface. An innovative way to improve the thermal conductivity of a fluid is to suspend nano-sized particles on the order of 1~100 nm with high thermal conductivity in the base fluid with low thermal conductivity [2], [3], [4], [5]. Generally, the thermal conductivity of the particles, metallic or nonmetallic, is typically an order of magnitude higher than that of the base fluids even at low concentrations resulting in significant increases in heat transfer Nanofluids thus lend themselves to potential candidates for next generation heat transfer media. In this paper the effect of trapezoidal cut twisted tape is inserted in the inner section of the annulus tube. The heat transfer rate is studied for the trapezoidal cut twisted tape using CFD simulation and the thermal performance factor is evaluated. Literature exists [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16] on the single-phase nanofluids forced convection flow in such various geometries as flat plates, circular tubes, noncircular channels, annuli, and cross flow over circular tubes. The previous results have underscored the enhancement of heat transfer due to the presence of nanoparticles in the fluids. In particular, the heat transfer coefficient increases appear to go beyond the mere thermal conductivity effect and cannot be predicted by such traditional pure fluid correlations as Dittus-Boelter's [4], [5], [6], [7], [8], [9]. Pak and Cho [1] experimentally investigated the convective heat transfer behavior of the γ-alumina (Al_2O_3) and titanium dioxide (T_iO_2) water-based nanofluids heated in a circular tube with constant heat flux. The Reynolds number Re and Prandtl number Pr varied in the ranges 104–105 and 6.5–12.3, respectively. They observed that the Nusselt number Nu of the dispersed fluids for fully developed turbulent flow increased with increasing volume concentration as well as Re [1]. They showed that the Darcy friction factors for dilute dispersion fluids used in their study coincided well with the values predicted from Kays' correlation for turbulent flow of a single- phase fluid. Due to the increase in the viscosity of dispersed fluids, there is an additional pumping penalty of approximately 30% at a volume concentration of 3%. The nano particle concentration increases the pumping loss [17], [18]. So this experimentation considers less concentration as 0.004 g for 1000 g. But this paper numerically analyzing the effect of using twisted tape with rectangular cut on its rib, insert placed in a circular double pipe heat exchanger on the thermal and flow fields utilizing various types of nano fluids.

Section snippets

Preparation of nano fluids

The prescription of the nano-fluid preparation is assumed that Nano fluids are to be prepared by using the Sonication process. The other things are the Sodium dodecyl sulphate surfactant, water is base fluid. The nano-powder and others are to be thoroughly mixed by using magnetic stirrer for 8 to 10 h for blending of nano particles with base fluid. The recommended ratio of the water to the nano powder for this preparation 4 mg nano powder is mixed with the 1 L water. The recommended particle

Results and discussions

The velocity, temperature, pressure and the turbulence kinetic energy profiles are observed and presented in the Fig. 5, Fig. 6, Fig. 7 and Fig. 8 respectively for the double tape heat exchanger with twisted tape insert. The Fig. 9 shows the thermal performance of various fluid medium in the DTHE with the Circular Fin insert at various flow conditions. The plain water, TiO_2 Nanofluid, BeO Nanofluid, ZnO.

Nanofluid and CuO nanofluid considered in which the increase of Reynolds Number increases

Conclusion

The heat transfer analysis of the twisted tape heat exchanger is carried out by the various Reynolds number regions of 1000, 2000, 3000, 5000 and 10,000 the pressure drop is increased in the twisted tape heat exchanger with increase in Reynolds number, as well as heat transfer rate. Fig. 9 and Fig. 13 presents the variation of Nusselt number with Reynolds number for the tube equipped with Circular Fin inserts. For all cases, the Nusselt number increases with increasing Reynolds number. This is

Special issue articles Recommended articles

References (18)

V. Bianco *et al.*

Numerical investigation of nanofluids forced convection in circular tubes
Appl. Therm. Eng. (2009)

V. Bianco *et al.*
Numerical investigation on nanofluids turbulent convection heat transfer inside a circular tube
Int. J. Therm. Sci. (2011)

Y. Xuan *et al.*
Conceptions for heat transfer correlation of nanofluids
Int. J. Heat Mass Transf. (2000)

V. Bianco *et al.*
Numerical investigation on nanofluids turbulent convection heat transfer inside a circular tube
Int. J. Therm. Sci. (2011)

Y. He *et al.*
Numerical investigation into the convective heat transfer of TiO2 nanofluids flowing through a straight tube under the laminar flow conditions
Appl. Therm. Eng. (2009)

S. Lee *et al.*
Measuring thermal conductivity of fluids containing oxide nanoparticles
J. Heat Transfer (1999)

H. Masuda *et al.*
Alternation of thermal conductivity and viscosity of liquid by dispersing ultra-fine particles (dispersion of Al2O3, SiO2 and TiO2 ultra- fine particles)
Netsu Bussei (Japan) (1993)

H. Aminfar *et al.*
Investigation of the velocity field and nanoparticle concentration distribution of nanofluid using Lagrangian-Eulerian approach
J. Dispers. Sci. Technol. (2012)

S. Lee *et al.*
Application of metallic nanoparticle suspensions in advanced cooling systems

There are more references available in the full text version of this article.

Cited by (11)

A review on nanofluids coupled with extended surfaces for heat transfer enhancement

2023, Results in Engineering

Show abstract

A comprehensive review of heat transfer enhancement and flow characteristics in the concentric pipe heat exchanger

2022, Powder Technology

Show abstract

Flow and heat transfer in obstacled twisted tubes

2021, Case Studies in Thermal Engineering

> *Citation Excerpt :*
>
> …Or even attaching twisted fins to the tube constructed in different configurations. It can be concluded that all types of assembled fins lead to higher thermal performance and rising friction factor penalty, see for example [23–30]. Some of these works used fins whether twisted or not inserted in the twisted tubes.…

Show abstract

Second law efficiency analysis of air injection into inner tube of double tube heat exchanger

2021, Alexandria Engineering Journal

> *Citation Excerpt :*
>
> …Bashtani et al. [25] numerically investigated the effect of wall corrugation on the performance of double tube heat exchanger. Gnanavel et al. [26] reported up to %70 augmentation at the performance of double tube heat exchanger due to the simultaneous usage of nano particles and circular fin inserts. Dizaji and Jafarmadar [27] studied the effect of air injection into the double tube heat exchanger.…

Show abstract

Nanofluid as the working fluid of an ultrasonic-assisted double-pipe counter-flow heat exchanger ↗

2023, Journal of Thermal Analysis and Calorimetry

Heat and fluid flow analysis and ann-based prediction of a novel spring corrugated tape ↗

2021, Sustainability (Switzerland)

View all citing articles on Scopus ↗

View full text