ID: 1078

The Impact of Alumina Nanofluid on the Heat Transfer and Hydraulic Performance in the Laminar Flow Conditions

Laichi Ammar[1]*, Bouhezza Aicha[2], Kholai Omar[3]

[1] Faculty of Sciences, University of 20th August 1955 Skikda, 21000, Algeria
[2] Faculty of Technology, University of 20th August 1955 Skikda, 21000, Algeria
[3] Faculty of Technology, University of Constantine 1, 21000, Algeria
*Corresponding author's email: a.laichi@univ-skikda.dz

ABSTRACT

Laminar forced convection heat transfer of nanofluid flow through a horizontal circular duct under an isothermal heat flux was studied numerically. The study was conducted in a volume concentration range not exceeding 3% for Al2O3 nanoparticles and the Reynolds number in the case of laminar flow conditions on the thermal and hydraulic fields and the system efficiency. ANSYS FLUENT is used to solve partial differential equations numerically based on the finite volume method and the SIMPLE algorithm. The findings show that the bulk and wall temperature decrease with increasing nanoparticle concentration and Reynolds number as well as the local heat transfer coefficient. The heat transfer performance factor of Nu number, the pressure drop of alumina nanofluids increases with increasing alumina concentration and Reynolds number while the best enhancement showed at 3% of concentration and Re = 2100 [-] about 2.5%, 62.4% and 2.49% compared with water. The friction factor of alumina nanofluids is the same as that of water, except, it has a slight increase that appeared at a low Reynolds number, which is a good indicator for the adoption of nanofluids in heat transfer applications.

Keywords: Laminar Forced convection, Nanofluid, Thermal efficiency, Boundary layer.

1. Introduction

The enhancement of heat transfer characteristics of base fluid using in industries such as, heat exchangers, electronics and energy storage, transportation is only of future important research. The use of ultra-fine particle such as Al_2O_3, TiO_2 and SiO_2 dispersed in water has been reported by H. Masuda [1]. The results showed that the thermal conductivity of Al_2O_3-Water and TiO_2-Water nanofluids increased with increasing of volume concentration and no change for SiO_2-Water nanofluid. Also, for the effective dynamic viscosity increased with increasing of volume concentration and decreased with increasing of temperature. Moreover, it observed that the suspension has a higher dispersion for spherical nanoparticle. A new class of fluid call Nanofluids contained a small size of nanoparticle less than 100 nm has been found by Choi [2]. It reported that the dispersion of Cu nanoparticle in water enhanced the heat transfer coefficient as the thermal conductivity and flow rate increased. Palm et al [3]studied the laminar forced convective heat transfer enhancement using Al_2O_3-Water nanofluids in radial flow cooling systems considering temperature-dependent properties. It found that the average heat transfer coefficient at 4% volume concentration increased with 25% than water base fluid. However, the modeling using temperature-dependent nanofluids properties gave a better heat transfer enhancement predictions as well as lower wall shear stresses than when considering constant properties throughout the domain. Many experimental studies have been reported for this reason, Kim et al [4]. It studied the effect of dispersion of Al_2O_3 in water on the convective heat transfer coefficient in laminar and turbulent flow condition and found that the maximum enhancement showed when used Al_2O_3 in turbulent flow condition. In the present study, we describe the effect of Al_2O_3 nanoparticles volume concentrations from 0 to 3%, Re number from 100 to 2100 on the local heat transfer coefficient, Nu number and pressure drop, friction factor and performance evaluation criteria factor. The 2D Laminar forced convective heat transfer in horizontal circular pipe under a constant heat flux is investigated.

2. Numerical model

Laminar forced convective heat transfer nanofluids flow using Al_2O_3-Water from 0 and 3% under a constant heat flux. ANSYS FLUENT Computational fluid dynamic language used in this study. The 2D steady state incompressible coupled non-linear partial differential equations have discretized using the finite volume method. A second order upwind scheme uses for pressure, momentum and energy for high accuracy while the SIMPLE algorithm applied for the velocity–pressure coupling. The present study showed a better

DOI: 10.21467/abstracts.169 ISBN: 978-81-970666-4-1 (eBook)

agreement compared with numerical result of Bayat and Nikseresht [5] with error less than 1.84%. While the present study coincide to classic theory at the fully developed region when Nu = 4.364 with average relative error 5.44 % but it's different at the developing region. Also, Shah and London equation [6] is given a good result compared with present study with average relative error less than 3.946%.

3. Results and discussion

Figure 1 shows the heat transfer performance factor η versus Reynolds number using 0 to 3% of alumina nanoparticles.

.

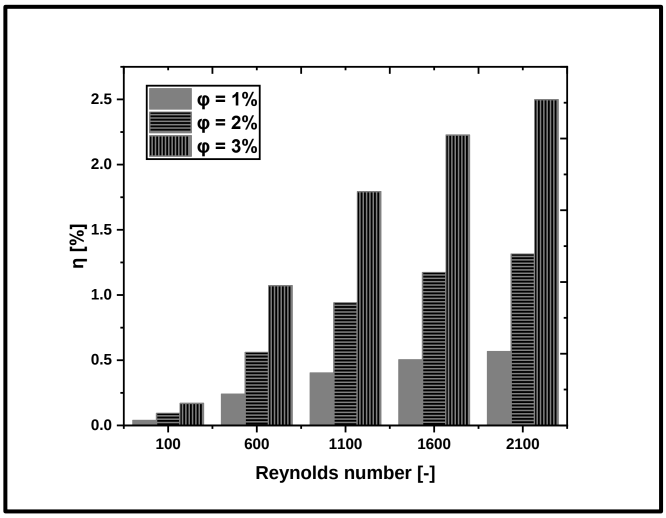

Figure 1: *Heat transfer performance factor*

4. Conclusion

The local and the average heat transfer coefficient, pressure drop and η increase with increasing volume concentration of nanoparticles and Reynolds number. The friction factor decrease with rising of Reynolds number and slightly decrease with increasing of volume concentrations. The heat transfer performance factor showed that the Al_2O_3-Water nanofluids is suitable for heat transfer applications compared with water.

References

[1] H. Masuda, A. Ebata, K. Teramae, and N. Hishinuma, "Alteration of Thermal Conductivity and Viscosity of Liquid by Dispersing Ultra-Fine Particles," *Netsu Bussei*, vol. 7, no. 4, pp. 227–233, 1993.

[2] S. U. S. Choi and J. A. Eastman, "ENHANCING THERMAL CONDUCTIVITY OF FLUIDS WITH NANOPARTICLES," *ASME Publications FED*, vol. 231/MD 66, pp. 99–105, 1995.

[3] S. J. Palm, G. Roy, and C. T. Nguyen, "Heat transfer enhancement with the use of nanofluids in radial flow cooling systems considering temperature-dependent properties," *Applied Thermal Engineering*, vol. 26, no. 17, pp. 2209–2218, Dec. 2006.

[4] D. Kim *et al.*, "Convective heat transfer characteristics of nanofluids under laminar and turbulent flow conditions," *Current Applied Physics*, vol. 9, no. 2, Supplement, pp. e119–e123, Mar. 2009.

[5] J. Bayat and A. H. Nikseresht, "Investigation of the different base fluid effects on the nanofluids heat transfer and pressure drop," *Heat Mass Transfer*, vol. 47, no. 9, pp. 1089–1099, Sep. 2011.

[6] R. K. Shah and A. L. London, *Laminar Flow Forced Convection in Ducts: A Source Book for Compact Heat Exchanger Analytical Data*. Academic Press, 1978.

ISBN: 978-81-970666-4-1

Series: AIJR Abstracts

DOI: 10.21467/abstracts.169