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Heat transfer characteristics and pressure drop in concentric tube type Using CuO and TiO_2 with ethylene glycol and H_2O as Nanofluid.

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Abstract

It has been a great challenge in heat transfer to provide efficient thermal fluids for cooling purposes especially in engineering practice. The concerns on various operating temperatures become the main concern in the present study to investigate the heat transfer and friction factor of titanium oxide (TiO_2) and copper oxide (CuO) under flow in a tube. The nanofluids were prepared using the with the mechanical stirrer and sonication process for volume concentrations of .5% 1%,1.5% in a mixture of water (W) and ethylene glycol (EG) at a volume ratio of 70:30 (W:EG). The convective heat transfer investigations were conducted at a constant heat flux boundary condition and operating temperatures of 30, 50 and 70 °C. The enhancement of thermal conductivity was studied for Reynolds number 4000 to 18000. The enhancement of thermal conductivity and viscosity of CuO was found to be influenced by the temperature while the enhancement of the TiO_2 nanofluid properties was observed to be independent of temperature. Both CuO and TiO_2 nanofluids were observed to have almost the same values of heat transfer coefficients for 1.0% concentration at 50 and 70 °C with an average enhancement of 18%. However, the heat transfer coefficients of CuO nanofluids were found to be higher than TiO_2 nanofluids at the operating temperature of 30 °C. The heat transfer concentrations increased with volume concentration and observed for both types of nanofluids at all operating temperatures. The friction factors for both CuO and TiO_2 nanofluids slightly increased with volume concentration.
Keywords:*heat transfer, pressure drop, volume concentration, nanofluid, and enhancement.*

1. Introduction

This study is about flows of nanofluids having a mixture of Copper oxide; Titanium oxide nanoparticles with Ethylene Glycol and water in a horizontal concentric pipe type of heat exchanger with fluid water at different temperature are investigated. The horizontal pipe test section is modeled and solved using a CFD program. Palm et al.'s correlations are used to determine the nanofluid properties. A single-phase model having two-dimensional equations is employed with either constant or temperature dependent properties to study the hydrodynamics and thermal behaviors of the nanofluid flow. The study of enhancement of heat transfer rate and pressure drop is performed for a same particle size of Copper oxide, Titanium oxide nanoparticles. The pressure and temperature vectors are presented in the entrance and fully developed region. The changes of the fluid temperature, heat transfer coefficient and pressure drop along tube length are shown in the study. Effects of nano particles for different concentration and Reynolds number on heat transfer coefficient and pressure drop are presented. Numerical results show the heat transfer enhancement due to presence of the nanoparticles in the fluid in accordance with the results of the experimental study used for the validation process of the numerical model

Thermal conductivity is an important parameter in improve the heat transfer performance of a heat transfer fluid.100 years ago, Maxwells published some theory related with heat transfer. Convectional heat transfer can be depends on flow of geometry, boundary conditions or thermal conductivity of liquid. Thermal conductivity can be enhancing by reducing crystalline size of particles. Below 50nm crystalline size result improved shown by Choi in 1995.He shows that nano particles with nano fluids have enhanced result as compared to conventional pure suspensions. Nano fluid refers as two phase mixture continuous liquid phase and dispersed solid phase. Metallic nanoparticles, non-metallic nanoparticles and Carbon nanotubes are used to improve results reported by Eastman, Xie.

2. Methodology

2.1 Sample Preparation

In the present study, two types of nano materials copper oxide (CuO) and titanium oxide (TiO_2) were received from Fume Chemicals, Kolhapur. The oxides were suspended in Ethylene glycol 30%and remaining was H_2O. The average size of nanomaterial is 50nm.

Nanofluid as a mixture of ethylene glycol and H_2O were used for the present experiment. To maintain the stability and homogeneity of nanofluid using mechanical stirrer for 60 minutes and sonication process for 75 minutes. The thermal conductivity, dynamic viscosity, specific heat and density was measured with the given relations

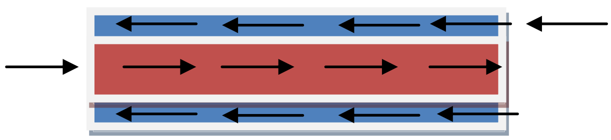

Fig.1 heat exchanger

2. Experimental Investigation

The experimental setup is a two concentric pipe type heat exchanger of length 1500mm. The inner tube material with outer diameter 10 mm and inner diameter is 8 mm. The outer tube is made up of Poly Vinyl Chloride an outer diameter of 34 mm and 28 mm. The nanofluid is passed through outer tube and hot fluid is circulated to inner tube by two pumps. The outer tube is wound with asbestos rope insulation to minimizing the loss of heat to the atmosphere. The inside and outside temperature of nanofluid and hot fluid are measured with K-Type thermocouple.

Nanofluids with different concentration are prepared with adding required quantity of nano materials with ethylene glycol and H_2O as base fluid. The solution was mixed with mechanical stirrer for 60 minutes. The solution was going under sonication process for 75 minutes to get stability and homogeneous mixture. A U-tube manometer is employed to measure the pressure drop of nanofluid along the length of the testsection. Initial experiments on heat transfer and friction factor are conducted with basefluid which is a mixture of ethylene glycol and water in the ratio of 30:70% by weight as a working fluid.

Measurement of heat transfer coefficient:-

Rate of heat flow from hot fluid to the cold fluid is estimated based on the measurements of inlet and outlet temperatures along with the mass flow rates of hot and cold fluids using the following set of equations:

$$Q_h = m_h \times C_h \times (T_{hi} - T_{ho})$$

$$Q_c = m_c \times C_c \times (T_{co} - T_{ci})$$

$$Q_{average} = \frac{Q_h + Q_c}{2}$$

3. Data Processing

The Heat Transfer Coefficient of Nano-Fluid (HTCNF) can be calculated by pursuing the following procedure. From (1), the HT rate qNF is determined by means of collecting the experimental data and using physical properties of NF including the mass flow rate; mNF, fluid heat capacity; Cp,NF, and changes in the temperature of hot nanofluid passing through test chamber TNF,OUT and TNF,IN

$$qNF = m\text{NF}C_{P,\text{NF}} (T_{\text{NF,OUT}} - T_{\text{NF,IN}}) \quad (1)$$

$$q\text{ColdWater} = m\text{ColdWater}C_{P,\text{ColdWater}} (T_{\text{CW,IN}} - T_{\text{CW,OUT}}) \quad (2)$$

$$\frac{q\text{CW} + q\text{NF}}{2} \quad (3)$$

The overall heat transfer coefficient of nanofluid; U, is determined from(4), where HT surface area, A, andHTrate, q, are obtained experimentally

$U = qA\cdot \Delta T$LMTD

$= m\text{NF}C_{P,\text{NF}} (T_{\text{NF,OUT}} - T_{\text{NF,IN}})A\cdot \Delta T$LMTD. (4)

Equation (5) addresses the use of mean logarithmic changes in temperatures and LMTD of the inlet and outlet streams, that is, Hot NF and cooling water calculated from the experimental data.

$$\Delta T\text{LMTD} = \frac{(T_{\text{NF,OUT}} - T_{\text{COLD,IN}}) - (T_{\text{NF,IN}} - T_{\text{COLD,OUT}})}{\ln ((T_{\text{NF,OUT}} - T_{\text{COLD,IN}}) / (T_{\text{NF,IN}} - T_{\text{COLD,OUT}}))} \quad (5)$$

Figure 4:The TEM image of Al2O3 nanoparticles.

From (6), the overall heat transfer coefficient of the heat exchanger is determined from the fluid inlet and outlet convective heat transfer coefficients $hi$and ho, respectively, the inner tube wall conductive heat transfer coefficient, kw, and inner tube wall thickness, δw

$$\frac{1}{U} = \frac{1}{hi} + \frac{1}{\delta w} + \frac{1}{ho} \quad (6)$$

Equation (7) refers to the substituted values in (6), where tube diameter and surface area, D and A, respectively, are derived from design values, the subscripts i, and o assigned for the inner and outer tubes

$$\frac{1}{U} = \frac{1}{hi(Ai/Ao)} + \quad + \text{In} + \frac{1}{2kDiho} \quad (7)$$

OBSERVATIONS.

1 Parallel Flow Configuration :-

1.1.1 Mass Flow Rate of Nanofluid

Sr. No.	Volume (L)	Time (Sec)	Mass Flow (Kg/sec)
1.	15	31	0.0058
2.	15	56	0.0065
3.	15	86	0.0064
4.	15	116	0.0063
5.	15	146	0.00625

1.2 Mass Flow Rate of Water

Sr. No.	Volume (mL)	Time (Sec)	Mass Flow (Kg/sec)
1.	70	16	0.0125
2.	70	29	0.013
3.	70	44	0.0136
4.	70	60	0.0133
5.	70	70	0.0142

1.3 Temperature reading

Sr. No.	Nanofluid Inlet Temp. (Tci)	Nanofluid Outlet Temp. (Tco)	ΔT WATER	Hot Water Inlet Temp. (Thi)	Hot Water Outlet Temp. (The)
1.	28	36	8	90	53
2.	28	38	10	89	51
3.	28	35	7	90	49
4.	28	38	10	88	50
5.	28	39	11	92	52

1. **Counter Flow Configuration** : -

2.1 Mass Flow rate of Hot Water

2.2 Mass Flow Rate OfNano Fluid

Sr. No.	Volume (L)	Time (Sec)	Mass Flow (Kg/sec)
1.	70	35	0.005
2.	70	76	0.0048
3.	70	114	0.0048
4.	70	156	0.0047
5.	70	190	0.0048

Sr. No.	Volume (L)	Time (Sec)	Mass Flow (Kg/sec)
1.	15	18	0.01
2.	15	34	0.012
3.	15	55	0.011
4.	15	76	0.0105
5.	15	93	0.0107

2.3 Temperature Reading

Sr.No.	Nanofluid Inlet Temp. (Tci)	Nanofluid Outlet Temp. (Tco)	ΔT WATER	Hot Water Inlet Temp. (Thi)	Hot Water Outlet Temp. (The)
1.	28	34	6	90	61
2.	28	35	8	89	60
3.	28	36	8	90	58
4.	28	36	9	91	57
5.	28	37	10	90	55

Conclusions

The authors can write the conclusion as a whole in a paragraph or by making points. An example is given as under.

1) The thermal conductivity enhancement of CuO is higher than TiO2 nanofluids.
2) The behavior of thermal conductivity enhancement was increasing with increasing the volume concentrations.
3) The maximum enhancement was observed in the study.
4) The friction factor for both CuO and TiO_2 nanofluids increases with volume concentration.

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