IMPROVISING HEAT TRANSFER RATE IN COUNTER FLOW HEAT EXCHANGER BY USING FRAXINUS

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Abstract - *This article reports an experimental study on the free convective heat transfer and flow characteristics of a water and different volume concentrations of fraxinus (5 and 10) % flowing in a counter flow heat exchanger. The fraxinus nanoparticles of about 18 nm diameter are used in the present study. The experimental data carried out based on two time intervals of two volume concentrations at same mass flow rates. The results show that the heat transfer rate will be increased due to mixture concentrations of water and fraxinus with the base fluid at the same mass flow rate. However increasing the volume concentration causes increase in the capability of the heat conduction leading to increase in heat transfer rate. Due to this situation a maximum heat transfer rater was increased at a short time period. So, a locally available by product from the power plants is used. It is easily available, the cost is less and very effective too for increasing heat transfer rate.*

Key Words: counter flow heat exchanger, fraxinus.

1. INTRODUCTION

As the name implies industrial heat exchangers are pieces of industrial equipment which are designed to exchange or transfer heat from one medium to another. The heat exchange may be for the primary purpose of heating up elements or cooling it down.
Today for our energy needs, we mostly concentrate on effective usages of energy. Energy generation is mostly done by the power plant industries. In this power plant, huge amount of water is required to convert into steam. After the process, it will be converted into low pressure gas or water droplets. For safety purpose we need to maintain very low material temperature. So we need to reduce the temperature.

At this fracture, we need to use the heat exchanger. The advantage of heat exchanger is that, there is no need of purest form of water. So in this work we add fraxinus particles into normal water. Due to this activity the heat transfer rate will be reduced. Because of this, specific heat increases with the distilled water and fraxinus particles.

2. EXPERIMENTAL SETUP

To design a project that could be used to transfer heat from hot water in a heat exchanger to a mixture of fraxinus concentrations of cold fluid. For monitoring purpose two thermocouples are installed flow meters. And a stop watch is used to get experimental values of particular time intervals. This systems fully based on free convective heat transfer. So its function and handling is easy compared to the other.

Area of the tube: 0.0314 m^2

Specific heat of fraxinus mixed with water: 4.3671 kJ/kg^{0}C.

3. EXPERIMENTAL DATA AND CALCULATIONS

To investigate counter flow heat exchanger performance, the three conditions based experimental data is collected as tabulated below.

Table-1: Results of counter flow heat exchanger. (Normal water)

S.No	Hot water				Cold water		
	Time	Flow rate	Hot fluid temperature		Flow rate	Cold fluid temperature	
	Sec	L/Sec	T_i (^{0}C)	To (^{0}C)	L/Sec	t_i (^{0}C)	t_o (^{0}C)
1	300	0.35	60.1	56.7	0.37	31.7	36.8
2	600	0.35	61.2	53	0.37	31.8	36.5

Table-2: Experimental results of counter flow heat exchanger (Normal water + 5% of Fraxinus)

S.No	Hot water				Cold water contains 5% of Fraxinus		
	Time	Flow rate	Hot fluid temperature		Flow rate	Cold fluid temperature	
	Sec	L/Sec	T_i (^{0}C)	To (^{0}C)	L/Sec	t_i (^{0}C)	t_o (^{0}C)
1	300	0.35	60.1	52.7	0.37	32	38.7
2	600	0.35	61.2	53	0.37	32.5	39.2

Table-3: Experimental results of counter flow heat exchanger (Normal water + 10% of Fraxinus)

S.No	Hot water				Cold water contains 10% of Fraxinus		
	Time	Flow rate	Hot fluid temperature		Flow rate	Cold fluid temperature	
	Sec	L/Sec	T_i (⁰C)	T_o (⁰C)	L/Sec	t_i (⁰C)	t_o (⁰C)
1	300	0.35	60.1	52.7	0.37	31.2	41.6
2	600	0.35	61.2	53	0.37	32	42.9

Model Calculation for Table 1:

$$\theta_1 = 60.1 - 36.8 = 23.3$$

$$\theta_2 = 56.7 - 31.7 = 25$$

$$\Delta T_{lm} = \frac{\theta_2 - \theta_1}{\ln(\frac{\theta_2}{\theta_1})} = 24.140$$

$$Q = m_c \times C_{P_c} \times (t_{c2} - t_{c1})$$

$$= 0.37 \times 4.3671 \times (36.8 - 31.7)$$

$$Q = 7.888\ kJ/s$$

$$A = \pi \times d \times l = \pi \times 0.01 \times 1 = 0.0314\ m^2$$

$$U = \frac{Q}{A \times \Delta T_{lm}} = \frac{7.888}{0.0314 \times 24.140} = 10.406\ W/m^2{}^\circ C$$

Based on the above theoretical calculations can be followed for the Table reading values of 2 and 3.

4. RESULTS AND DISCUSSIONS

Evaluating the counter flow heat exchanger based on different concentrations of mixed fluid:

As per the fluid properties water has the ability to transfer heat from hot fluid into cold fluid. So we mixed certain quantities of Fraxinus ash with the base fluid of water. Due to this, the heat transfer rate increased based on additional heat carrying capacities of ash particles.

Heat transfer rate increased by increasing the quantities of Fraxinus particles. Comparison details of various operating conditions of cold fluids are shown below. This will a helpful for a better understanding about their concepts.
As per the results shown in Table 4, it is concluded that the heat transfer rate improved based on fraxinus particles mixed with the water.

Table -4: Comparison data for all operating conditions

Parameters	Water		Water + Ash (5%)		Water + Ash (10%)	
	Time = 300 Sec	Time = 600 Sec	Time = 300 Sec	Time = 600 Sec	Time = 300 Sec	Time = 600 Sec
LMTD	24.140	22.905	21.048	21.241	19.962	19.619
Q (kJ/s)	7.888	7.269	10.826	10.826	16.805	17.613
U ($W/m2$°C)	10.406	10.107	16.381	16.232	26.809	28.590

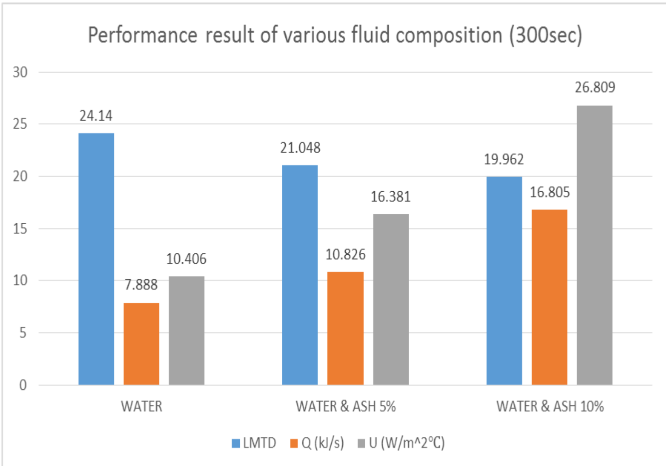

Chart -1: Graphical representation of experimental results (Time = 300sec)

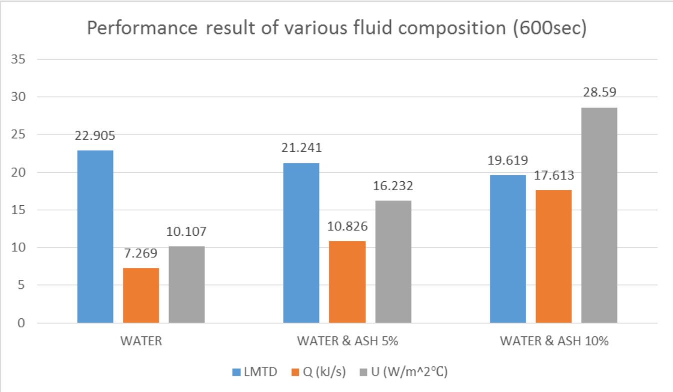

Chart -2: Graphical representation of experimental results (Time = 600sec)

5. CONCLUSIONS

The convective heat transfer performance and flow characteristics of Fraxinus ash particles flowing in a horizontal tube heat exchanger has been experimentally investigated. Experiments have been carried out under cooling fluid mixture variation conditions. Based on this study, it is understood that small size products achieve a maximum heat transfer rate. If used in an industry, definitely it will yield high heat transfer rate. It is applicable for power plants as well.

The effect of particles concentration on the heat transfer performance is determined. Important conclusions have been obtained and are summarized as follows:

1. Dispersion of the fraxinus particles in the distilled water increases the specific heat and viscosity of the fraxinus particles, this augmentation increases with the increase in particle concentrations.

2. At a particle volume concentration of 10%, the use of Fraxinus/water particles yield significantly higher heat transfer characteristics compared to 5%.
For example at the particle volume concentration of 10% (at 600sec) the overall heat transfer coefficient is 28.590 $W/m2$°C and for the water it is 10.107 $W/m2$°C for a mass flow rate of 0.37 L/s. so the amount of the overall heat transfer coefficient of the fraxinus particles is 64% greater than that of distilled water.

3. Friction factor increases with the increase in particle volume concentration. This is because of the increase in the viscosity of the fraxinus particles and it means that the fraxinus particles incur little penalty in pressure drop.

REFERENCES

[1] Choi SUS. Enhancing thermal conductivity of fluids with nanoparticle. ASME FED 1995;231:99.

[2] Abu-Nada E, Chamkha AJ. Effect of nanofluid variable properties on natural convection in enclosures filled with a CuO–EG–Water nanofluid. International Journal of Thermal Sciences 2010;49:2339.

[3] Chein R, Chuang J. Experimental microchannel heat sink performance studies using nanofluids. International Journal of Thermal Sciences 2007;46:57.

[4] Brinkman HC. The viscosity of concentrated suspensions and solution. Journal of Chemistry and Physics 1952;20:571.

[5] Xuan Y, Roetzel W. Conceptions for heat transfer correlation of nanofluids. International Journal of Heat and Mass Transfer 2000;43:3701–7.

[6] Hamilton RL, O.K. Crosser. Thermal conductivity of heterogeneous two component systems. Industrial and Engineering Chemistry Fundamentals 1962;1:187.

[7] Duangthongsuk W, Wongwises S. Effect of thermophysical properties models on the prediction of the convective heat transfer coefficient for low concentration nanofluid. International Communications in Heat and Mass Transfer 2008;35:1320.

[8] Duangthongsuk W,Wongwises S. An experimental study on the heat transfer performance and pressure drop of TiO_2–water nanofluids flowing under a turbulent flow regime. International Journal of Heat and Mass Transfer, 54; 334–44.

[9] Hwang KS, Jang SP, Choi SUS. Flow and convective heat transfer characteristics of water based Al2O3 nanofluids in fully developed laminar flow regime. International Journal of Heat and Mass Transfer 2009;52:193–9.

[10] Li Q, Xuan Y. Convective heat transfer and flow characteristics of Cu–water nanofluid. Science in China 2002;45:408.

[11] Xuan Y, Li Q. Investigation on convective heat transfer and flow features of nanofluids. ASME Journal of Heat Transfer 2003;125:151.

[12] Mapa LB, Mazhar S. Heat transfer in mini heat exchanger using nanofluid. In: Proceedings of the American Society for Engineering Education, Sectional Confrence; 2005.

[13] Mirmasoumi S, Behzadmehr A. Effect of nanoparticles mean diameter on mixed convection heat transfer of a

nanofluid in a horizontal tube. International Journal of Heat and Fluid Flow 2008;29:557–66.

[14] Pak BC, Cho YI. Hydrodynamic and heat transfer study of dispersed fluids with submicron metallic oxide particles. Experimental Heat Transfer 1998;11:151–70.

[15] Putra N, Roetzel W, Das SK. Heat and Mass Transfer 2003;39:775.

[16] Zamzamian A, Oskouie SN, Doosthoseini A, Joneidi A, Pazouki M. Experimental investigation of forced convective heat transfer coefficient in nanofluids of Al_2O_3/EG and CuO/EG in a double pipe and plate heat exchangers under turbulent flow. Experimental Thermal and Fluid Science 2011;35:495.

[17] Yu W, Choi SUS. The role of interfacial in the enhancemened thermal conductivity of nanofluid: a renovated Maxwell model. Journal of Nanoparticles Researches 2003;5:167.

[18] Drew DA, Passman SL. Theory of multi component fluids. Berlin: Springer; 1999.

[19] Gnielinski V. New equations for heat and mass transfer in turbulent pipe and channel flow. International Chemical Engineering 1976;16:359–68.

[20] Duangthongsuk W,Wongwises S. Heat transfer enhancement and pressure drop characteristics of TiO_2–water nanofluid in a double-tube counter flow heat exchanger. International Journal of Heat and Mass Transfer 2009;52:2059.

[21] Rott N. Note on the history of the Reynolds number. Annual Review of Fluid Mechanics 1990;22:1–11.

[22] White FM. Viscous fluid flow, 3rd ed. New York: McGraw-Hill; 69–91.

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