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Experimental Studies on Double Pipe Heat Exchanger for Heat Transfer Enhancement By Using Nanofluids

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***Abstract*—Heat transfer is one of the most important processes in many industries. Base heat transfer fluid like water normally is having low thermal conductivity. Since thermal conductivity is considered as important factor for rapid cooling and heating application, advanced heat transfer fluid called nano fluid is introduced. Nano particle is low concentration cooling agent which uniformly scattered in nano fluid Suspensions of Nano particles shows better enhancement of stability, heat transfer capabilities and reduction of particle clogging. All researchers tried to increase the heat transfer rate by controlling the parameters like shape, size, clustering, collision, porous layer, melting point of nano particle. Previously we were using only refrigerant as working fluid in heat exchanger for cooling purpose. The presence of fluorine and chlorine make the refrigerant non toxic. Hence the whole world attracted towards the Nano fluid. Finally this project is to be carried out through Concentric Double pipe Heat Exchanger with base fluid water and nano particles like MnO_2. Study is made to ascertain the effect of Nano fluids in enhancing the effectiveness of heat exchanger by varying the concentration of nano fluids.**

Keywords*— *Thermal Conductivity, Heat Transfer, Nano fluid, Double Pipe Heat exchanger, Nano particls.

I. INTRODUCTION

A heat exchanger is a device used to transfer heat between one or more fluids. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. The important heat transferring fluids are coolants and heat transfer oils. A coolant is a fluid which flows through or around a device to prevent its overheating, transferring the heat produced by the device to other devices that use or dissipate it. An emerging and new classes of coolants are nano fluids which consist of a carrier liquid, such as water, dispersed with tiny nano-scale particles known as nano particles. Nanoparticles such as MnO2, Graphite, Al2O3 are used in nano fluids.

Fig 1: Double pipe Heat exchanger

LITERATURE SURVEY

Madhushree Kole at all [1] [2] [3] [4] [5], investigated on the combinations of base fluid and nano particle such as Ethylene glycol-ZnO, Water-CuO, Gear oil-CuO, Ethylene glycol-ZnO(no surfactant), Ethylene glycol-Zinc Oxide.Then thy studied properties like Thermal Conductivity, Volume concentration, Pool Boiling, Viscosity and Thermal Resistance. It is found that there is an enhancement in thermal conductivity, viscosity, boiling heat transfer coefficient and total thermal resistance.

The Theoritical investigation is carried out by C. Yang et. al on combination of base fluid and nano particles and it is found that Nusselt number has optimal bulk mean nano particle volume fraction value for alumina water nano fluids, whereas it only increases monotonously with bulk mean nano particle volume fraction for titanium water nanofluids.

The numerical type of investigation is carried out by Adnan M. Hussein, Faris Mohammed Ali, A. Azari et. al and it is found that thermal conductivity and viscosity increase with increasing the volume concentration of nanofluids.

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A experimental type of investigation is carried out by Y. Raja Sekhar S. Zeinali Heris et. al and it is found that the Nusselt number and friction factor increases with increase of particle concentration. But, friction factor decreases with increase of Reynolds number of flow where as the Nusselt number increases and enhancement of heat transfer coefficient.

Both experimental and numerical investigation is carried out by A. Azari et. al results showed that the thermal performance of nanofluids is higher than that of the base fluid and the heat transfer enhancement increases with the particle volume concentration and Reynolds number.

II. PROBLEM DESCRIPTION

The objective of this work is to enhance heat transfer rate using nano fluids in place of pure working fluid in heat exchangers. In this study, Graphite, MnO_2 and Al_2O_3 nano particles are suspended in water with concentration upto 1.5% by volume has been selected as a coolant in a typical horizontal double-tube counter flow heat exchanger because of their reasonably good thermal properties and easy availability. Study on heat transfer investigation by changing the particle shape can be taken up as future work .Water has been chosen as heat transfer base fluid. The experiments are conducted in the heat exchanger for different concentrations of nano particles.

Fig 3: Experimental set up of Heat exchanger

CHARACTERISTICS OF NANOPARTICLES USED IN EXPERIMENT:

Manganese Dioxide (MnO_2):

Fig 5: Structure of MnO_2 Nano particles

Molar mass: 86.9368 g/mol

Melting point: 535 °C

Density: 5.03g/cm³

Specific heat : 480 J/kg

Thermal conductivity:30-60 w/mK

Aluminium Oxide (Al_2O_3):

Fig 2: Structure of Al_2O_3 Nano particles

Molar mass: 101.96 g/mol
Melting point: 2,072 °C
Density: 3.95 g/cm³
Specific heat: 451-955 J/kg k
Boiling point: 2,977 °C
Thermal conductivity:12-38.5 w/mK

GRAPHITE:

Fig 4: Structure of Graphite Nano particles

Optical properties :(–) Uniaxial

Crystal system : Hexagonal

Density: 2.09–2.23 g/cm³

Specific heat: 710-830 J/kg k

Thermal conductivity: 25-470 w/mK

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III. EXPERIMENTAL ANALYSIS

Table 1: Water as base fluid

S.NO.	T_{Ci} °C	T_{ho} °C	T_{Co} °C	T_{hi} °C	M_C LPM	M_h LPM	Q_C (Watts)	Q_h (Watts)	Q (Watts)	ΔT	U w/m²K
	T1	T2	T3	T4							
1	28.8	44.2	32.	49.2	1	0.8	244.24	279.13	261.87	16.13	458.81
2	28.3	41.3	31.0	45.6	1	1.2	188.41	360.08	274.24	13.78	551.44
3	28.3	40.8	31.5	42.8	1	1.5	223.30	209.35	216.32	11.24	430.35
4	27.8	38.9	31.9	40.8	1	1.8	286.11	238.65	262.38	9.95	746.11
5	27.4	37.2	30.6	39.3	1	2	223.06	293.09	258.19	9.23	791.46
6	27.2	36.8	29.5	38.3	1	2.2	160.50	230.28	195.39	9.19	601.56
7	26.9	35.4	29.0	36.7	1	2.5	146.54	226.79	186.66	8.09	692.82
8	27.9	38.6	30.5	39.1	1.5	0.8	212.16	280.13	275.61	9.18	841.86
9	30.9	39.3	31.2	41.8	1.5	1.8	210.96	330.96	291.64	8.13	723.62
10	30.3	37.1	32.8	40.6	1.5	2	180.56	260.89	199.67	9.74	801.34

Table 2: MnO_2 0.25% (25gm) per 10 lits of water

S.NO.	T_{Ci}	T_{ho}	T_{Co}	T_{hi}	M_C	M_h	Q_C	Q_h	Q	ΔT	U	Um/Uw
	T1	T2	T3	T4								
1	27.2	40.8	30.9	44.0	1	1.2	257.62	267.96	262.79	13.74	563.09	1.02
2	27.6	41.0	30.7	42.7	1	1.5	215.84	177.94	196.89	12.68	801.34	1.86
3	27.2	39.5	30.0	40.4	1	1.8	194.96	113.04	154.91``	11.32	884.92	1.18
4	27.0	38.5	29.9	39.9	1	2	201.92	195.39	198.65	10.73	701.82	1.12
5	27.2	36.9	30.0	38.6	1	2.2	194.96	260.98	227.97	9.13	786.48	1.13
6	28.1	37.4	31.2	40.8	1.5	0.8	211.16	250.68	225.71	10.16	830.69	1.29
7	28.2	38.8	30.6	41.0	1.5	1.2	189.63	299.37	244.56	10.01	799.68	1.38
8	27.9	37.8	30.1	39.8	1.5	1.8	228.36	179.86	198.67	11.67	1037.61	1.89
9	28.3	38.3	31.4	41.7	1.5	2	198.68	283.58	228.69	9.89	960.25	1.23
10	28.2	39.2	30.9	42.3	1.5	2.5	233.84	301.25	286.74	10.41	854.36	1.39

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Table 3: MnO_2 0.50% (50gm) per 10 lits of water

S.NO.	T_{Ci}	T_{ho}	T_{Co}	T_{hi}	M_C	M_h	Q_C	Q_h	Q	ΔT	U	Um/Uw
	T1	T2	T3	T4								
1	30.2	39.9	32.1	42.8	1	1.2	132.01	242.84	187.42	10.19	690.40	1.25
2	31.1	38.3	34.0	41.6	1	1.5	201.47	345.42	273.44	7.39	1046.92	2.43
3	29.8	36.9	33.2	42.0	1	1.8	236.21	640.61	438.41	7.91	1268.19	1.61
4	30.3	37.4	32.8	41.8	1	2	173.68	614.09	393.88	8.01	1391.32	2.31
5	30.4	38.1	33.1	42.7	1	2.2	187.58	706.20	446.89	8.61	1468.56	2.44
6	29.9	38.8	32.8	41.1	1.5	0.8	226.38	501.61	335.69	7.89	980.56	1.89
7	30.3	37.9	33.2	41.3	1.5	1.2	199.56	381.01	259.67	8.07	880.38	1.17
8	31.7	39.0	32.9	41.6	1.5	1.8	178.68	401.78	301.52	9.25	790.66	1.56
9	30.4	38.7	31.8	40.8	1.5	2	244.62	321.56	280.78	7.06	1021.88	1.13
10	30.2	39.6	31.9	40.6	1.5	2.2	251.44	311.75	274.35	8.16	978.26	1.27

Table 4: MnO_2 0.75% (75gm) per 10 lits of water

S.NO.	T_{Ci}	T_{ho}	T_{Co}	T_{hi}	M_C	M_h	Q_C	Q_h	Q	ΔT	U	Um/Uw
	T1	T2	T3	T4								
1	29.2	43.6	32.4	45.8	1	1.2	222.94	184.22	203.58	13.89	601.70	1.09
2	28.3	40.9	32.0	43.4	1	1.5	257.77	261.68	259.72	11.98	713.40	1.65
3	27.1	39.2	31.1	42.5	1	1.8	278.67	414.51	346.59	11.64	842.48	1.06
4	26.9	36.8	30.5	40.3	1	2	250.80	404.74	327.77	10.14	883.23	1.18
5	26.9	36.8	30.1	39.6	1	2.2	222.94	429.86	326.40	9.18	1006.01	1.67

S.NO.	T_{Ci}	T_{ho}	T_{Co}	T_{hi}	M_C	M_h	Q_C	Q_h	Q	ΔT	U	Um/Uw
	T1	T2	T3	T4								
1	28.2	35.1	29.6	38.3	1	0.8	96.83	178.64	137.75	7.76	602.18	1.11
2	29.8	37.6	32.3	40.2	1	1.2	172.91	217.72	195.31	7.84	794.86	1.84
3	29.9	38.1	30.6	40.0	1	1.5	48.41	198.88	123.64	8.76	898.43	1.20
4	29.4	36.0	31.2	39.8	1	1.8	124.49	477.31	300.91	7.55	1127.64	1.42
5	29.8	36.2	32.7	40.1	1	2.0	200.57	544.31	372.44	6.88	1531.66	2.54
6	29.9	36.7	32.0	40.5	1	2.2	145.24	588.38	366.81	7.61	1363.80	1.72

Table 5: MnO_2 1.0% (100gm) per 10 lits of water

Table 6: MnO_2 1.5% (150gm) per 10 lits of water

S.NO.	T_{Ci}	T_{ho}	T_{Co}	T_{hi}	M_C	M_h	Q_C	Q_h	Q	ΔT	U	Um/Uw
	T1	T2	T3	T4								
1	29.2	39.0	31.3	41.8	1	1.2	144.59	234.47	189.53	10.14	628.85	1.14
2	30.6	40.3	31.9	42.0	1	1.5	89.51	177.94	133.72	9.89	882.55	2.05
3	30.2	39.2	31.9	42.3	1	1.8	117.05	389.39	253.22	9.68	1040.14	1.39
4	29.9	38.6	31.4	41.1	1	2.0	172.14	348.91	260.52	8.64	953.14	1.20
5	30.3	40.2	32.9	42.8	1	2.2	179.02	399.16	289.09	9.64	848.50	1.41

Table 7: Graphite 0.25% (25gm) per 10 lits of water

S.NO.	T_{Ci}	T_{ho}	T_{Co}	T_{hi}	M_C	M_h	Q_C	Q_h	Q	ΔT	U	Ug/Uw
	T1	T2	T3	T4								
1	31.9	41.1	32.4	43.0	1	0.8	34.82	106.07	70.44	9.88	701.72	1.52
2	32.1	43.1	34.3	45.1	1	1.2	153.21	167.48	160.34	10.34	877.64	1.59
3	31.9	39.8	33.9	42.6	1	1.5	139.28	293.09	216.18	8.29	937.83	2.17
4	30.9	38.9	33.2	42.9	1	1.8	160.17	502.44	331.30	8.82	1062.79	1.42
5	30.8	39.0	32.9	42.0	1	2.0	146.24	418.70	282.47	8.64	925.02	1.16
6	31.4	38.8	33.4	42.3	1	2.2	139.28	537.33	338.30	8.12	1178.80	1.95
7	32.2	40.9	34.9	42.5	1.5	0.8	198.36	321.73	216.38	8.91	944.56	1.86
8	31.4	38.7	34.0	41.8	1.5	1.2	211.65	361.25	225.62	7.86	690.42	1.72
9	31.9	43.5	33.8	41.7	1.5	1.8	223.42	287.79	253.67	9.04	976.23	1.38
10	32.1	41.6	33.7	43.1	1.5	2	199.62	221.61	211.87	7.99	789.56	1.56

Table 8: Graphite 0.50% (50gm) per 10 lits of water

S.NO.	T_{Ci}	T_{ho}	T_{Co}	T_{hi}	M_C	M_h	Q_C	Q_h	Q	ΔT	U	Ug/Uw
	T1	T2	T3	T4								
1	32.2	39.6	33.9	41.9	1	0.8	187.64	128.40	158.02	8.19	645.91	1.40
2	31.9	39.1	32.8	42.0	1	1.2	162.54	242.84	152.69	8.15	830.08	1.50
3	31.6	39.9	32.7	41.3	1	1.5	176.44	146.54	111.49	8.44	973.75	2.26
4	31.0	38.3	33.6	42.3	1	1.8	180.69	502.44	341.56	7.97	1212.56	1.62
5	32.0	38.7	34.0	40.8	1	2.0	138.99	293.09	216.04	6.74	906.92	1.14
6	31.9	39.2	34.2	42.5	1	2.2	159.84	506.62	333.23	7.78	1211.88	2.01
7	32.6	38.8	33.5	41.0	1.5	0.8	188.65	391.78	230.78	8.16	789.66	1.02
8	32.7	37.9	34.8	40.9	1.5	1.2	192.36	241.36	218.26	7.91	801.32	1.26
9	32.3	38.9	34.0	42.1	1.5	1.8	201.33	302.55	229.36	6.89	1036.67	1.44
10	31.9	39.2	33.9	41.9	1.5	2	260.31	388.65	321.89	7.89	1136.65	1.38

Table 9: Graphite 0.75% (75gm) per 10 lits of water

S.NO.	T_{Ci}	T_{ho}	T_{Co}	T_{hi}	M_C	M_h	Q_C	Q_h	Q	ΔT	U	Ug/Uw
	T1	T2	T3	T4								
1	32.3	39.7	34.1	42.8	1	0.8	124.84	173.06	148.95	8.03	724.83	1.57
2	32.2	39.3	34.8	43.0	1	1.2	180.32	309.83	245.07	7.63	908.78	1.64
3	31.9	39.0	34.3	43.2	1	1.5	166.45	439.63	33.04	7.96	1077.16	2.51
4	32.0	38.6	33.9	42.9	1	1.8	131.77	540.12	335.94	7.73	1229.64	1.65
5	31.2	38.3	34.0	41.9	1	2.0	194.20	502.44	348.32	7.49	1315.81	1.66
6	31.0	38.0	33.6	41.6	1	2.2	180.32	552.68	366.50	7.48	1386.33	2.31

Table 10: Al_2O_3 0.25% (25 gm) per 10 lits of water

S.NO.	T_{Ci}	T_{ho}	T_{Co}	T_{hi}	M_C	M_h	Q_C	Q_h	Q	ΔT	U	Ua/Uw
	T1	T2	T3	T4								
1	33.9	41.2	35.6	44.4	1	0.8	118.39	178.64	148.51	8.02	723.93	1.57
2	33.7	40.9	35.4	44.8	1	1.2	118.38	326.58	222.48	8.25	763.01	1.38
3	33.8	41.3	36.9	45.0	1	1.5	215.89	387.29	301.59	7.79	1095.40	2.54
4	33.6	40.7	35.2	43.0	1	1.8	111.42	288.90	200.16	7.44	861.20	1.21
5	33.8	40.8	36.3	42.9	1	2.0	174.10	293.09	233.59	6.79	973.37	1.32
6	33.6	41.1	36.7	44.2	1	2.2	215.89	475.92	345.90	7.39	1324.34	2.21
7	33.9	41.4	36.1	43.9	1.5	0.8	211.68	301.56	511.36	7.01	976.21	1.89
8	33.5	40.7	35.9	42.7	1.5	1.2	188.63	337.59	223.65	8.26	699.36	1.13
9	33.7	42.0	35.7	44.0	1.5	1.8	210.56	281.63	243.28	6.97	1067.29	2.01
10	33.9	41.8	36.4	43.6	1.5	2	179.74	387.92	201.68	8.34	880.34	1.67

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Table 11: Al_2O_3 0.50% (50 gm) per 10 lits of water

S.NO.	T_{Ci}	T_{ho}	T_{Co}	T_{hi}	M_C	M_h	Q_C	Q_h	Q	ΔT	U	Ua/Uw
	T1	T2	T3	T4								
1	33.9	42.9	35.9	44.7	1	0.8	139.01	111.65	125.33	8.89	698.88	1.52
2	33.8	42.8	35.7	45.0	1	1.2	132.05	184.22	158.14	9.14	789.54	1.43
3	33.7	41.6	36.0	44.3	1	1.5	159.85	282.62	221.23	8.09	973.73	2.18
4	33.8	42.4	36.3	45.1	1	1.8	173.75	339.14	256.44	8.69	834.95	1.12
5	33.6	41.8	36.1	44.9	1	2	173.71	432.65	303.20	8.49	1010.45	1.27
6	33.8	42.0	35.8	44.5	1	2.2	139.01	383.80	261.40	7.64	1801.54	2.96
7	33.9	42.8	36.0	44.8	1.5	0.8	199.76	301.21	253.36	8.81	786.11	1.38
8	34.1	41.8	35.6	44.0	1.5	1.2	163.89	378.79	231.25	9.27	960.37	1.47
9	34.8	41.6	36.4	43.9	1.5	1.8	230.65	289.12	264.67	7.89	870.25	1.63
10	33.7	42.5	35.9	43.7	1.5	2	221.89	244.23	228.83	9.02	928.36	1.79

FORMULA'S USED

I) HEAT TRANSFER FROM HOT WATER

Q_h = M_h x C_{ph} (T_{hi} – T_{ho})

Where

M_h = mass flow rate, kg/ sec

C_{ph} = Specific heat, j/kg k

T_{hi} = Hot water inlet temperature in ◦c

T_{ho} = Hot water outlet temperature in ◦c

ii). **Heat Transfer to cold water**

Q_c = M_cx C_{pc} (T_{co} – T_{ci})

Where

M_c = mass flow rate, kg/ sec

C_{pc} = Specific heat, j/kg k

T_{ci} = Cold water inlet temperature in ◦c

T_{co} = Cold water outlet temperature in ◦c

iii). **Heat Transfer**

$Q = (Q_c + Q_h)/2$

iv). **Logarithmic Mean Temp Difference**

$$LMTD = \frac{\Delta T_A - \Delta T_B}{\ln\left(\frac{\Delta T_A}{\Delta T_B}\right)} = \frac{\Delta T_A - \Delta T_B}{\ln \Delta T_A - \ln \Delta T_B}$$

Where, ΔT_A = T_{hi} - T_{co}

ΔT_B = T_{ho} – T_{ci}

v). **Area of Heat Exchanger**

Area, A = π x d_i x L , m^2

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d_i = ID of inner tube = 15mm

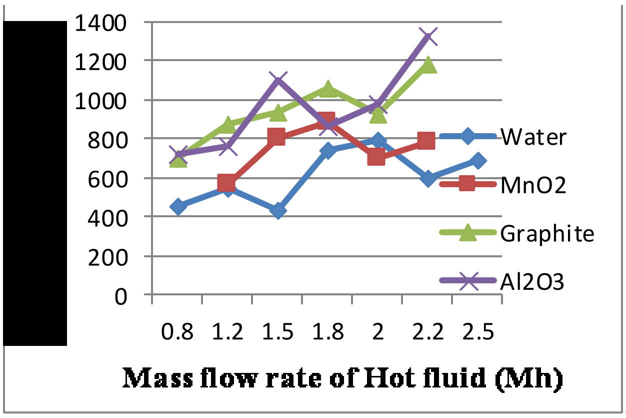
L = Length of tube = 750mm

IV. Results and Discussion

Figure 1 to 5 shows the variation of Overall heat transfer coefficient (U). It is plotted on Y axis and variation of hot water mass flow rate (M_h) on X axis a given cold water mass flow rates. Each graph is drawn for different concentration of Nano particles.

Figure 6 to 10 shows the variation of enhancement ratio of nano fluids with respect to base fluid as water. The Enhancement ratio defined as the ratio of the Overall heat transfer coefficient of Nano fluid to the Overall heat transfer coefficient of pure water.

The figure shows variation for 0.25% concentration of Nano particles. The overall heat transfer coefficient for pure water is varying from the values of 450 to 700 w/m^2 K when the mass flow rate of hot water varies from 0.8 to 2.2 while keeping cold water of mass flow rate constant at 1.0 LPM. The corresponding values for 0.25% concentration of MnO_2 in cold water vary from 580 to 800 w/m^{2}K. So there is a clear improvement of the overall coefficient when compared with pure water. Similarly, the corresponding values of Graphite is varying from 700 to 1200 w/m^2 K and also the corresponding values of Al_2O_3 is varying from 700 to 1300 w/m^2 K.



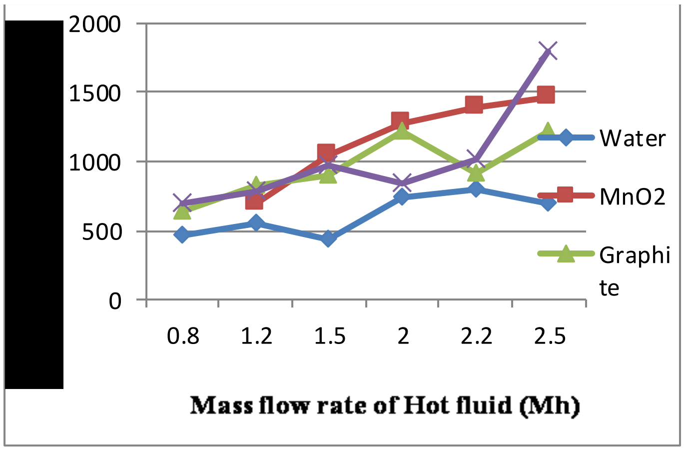
Graph 1: 0.25% at Mc=1 (25 gm of Nano particle in 10 lits of cold water)

The Graph 2 is plotted to show variation for 0.50% concentration of Nano particles. Mass flow rate of cold water is kept constant at 1.0 LPM while mass flow rate of hot water varied from 0.8 to 2.5 LPM. In the case of the overall heat transfer coefficient variation for the case of 0.5% concentration in cold fluid for MnO_2, Graphite and Al_2O_3. The

vi). Overall heat transfer coefficient

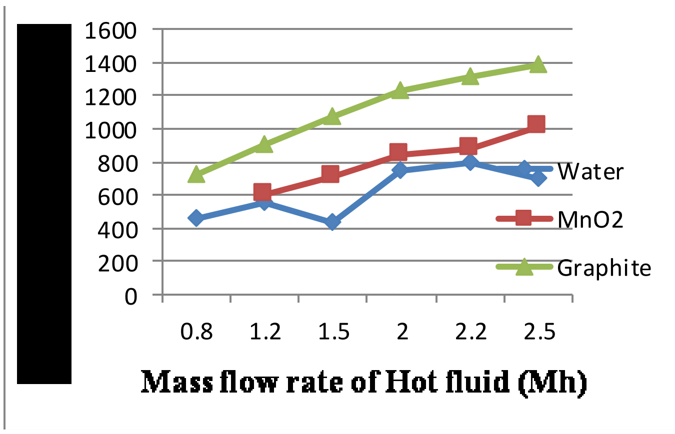
U = Q/ (A x LMTD)

overall heat transfer coefficient of the pure water is varying from 400 to 800 w/m^{2}K. Similarly the corresponding values of the overall heat transfer coefficient for MnO2 is varying from 700 to 1500 w/m^2 K. In graphite the overall heat transfer coefficient is varies from 600 to 1200 w/m^2 K and for Al_2O_3 the overall heat transfer coefficient is varying from 700 to 1800 w/m^2 K.



Graph 2: 0.50% at Mc=1 (50 gm of Nano particle in 10 lits of cold water)

The Graph 3 is plotted to show variation for 0.75% concentration of nano particles. Mass flow rate of cold water is kept constant at 1.0 LPM while mass flow rate of hot water varied from 0.8 to 2.5 LPM. In this case the pure water, the overall heat transfer coefficient is varying from 430 to 800 w/m^{2}K. Similarly the corresponding values of the overall heat transfer coefficient for MnO_2 is varying from 600 to 1000 w/m^2 K. Similarly in graphite the overall heat transfer coefficient is varying from 700 to 1800 w/m^2 K.



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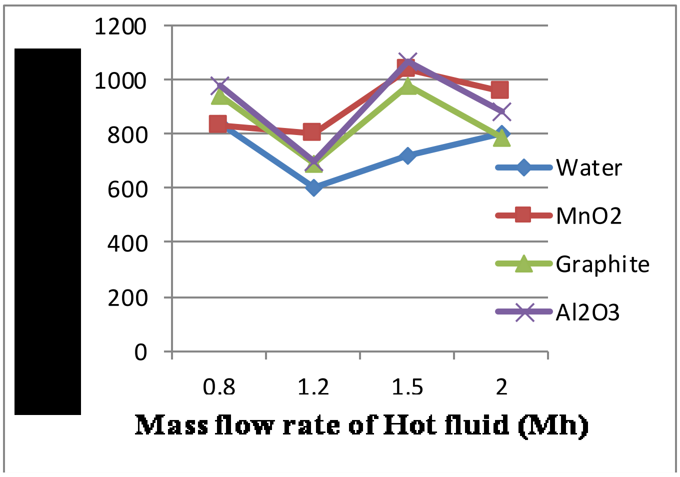
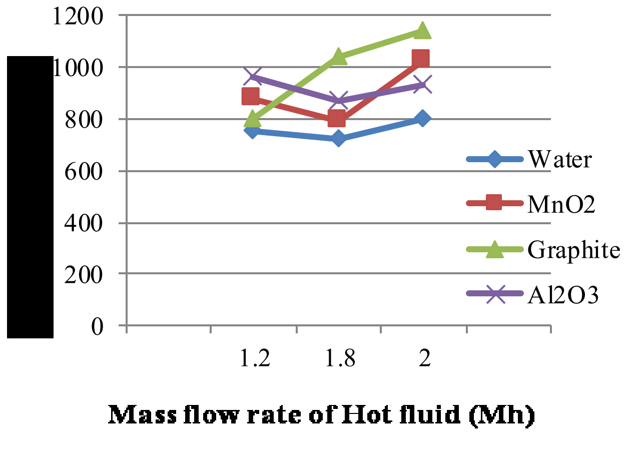
Graph 3: 0.75% at Mc=1 (75 gm of Nano particle in 10 lits of cold water)

The Graph 4 is plotted to show variation for 0.25% concentration of Nano particles. Mass flow rate of cold water is kept constant at 1.5 LPM while mass flow rate of hot water varied from 0.8 to 2.0 LPM. In this case pure water of the overall heat transfer coefficient is varying from 600 to 800 w/m^2 K. Similarly the corresponding MnO_2 of the overall heat transfer coefficient is varying from 800 to 1000 w/m^2 K, In graphite the overall heat transfer coefficient is varying from 700 to 900 w/m^2 K and for Al_2O_3 the overall heat transfer coefficient is varying from 700 to 1150 w/m^2 K.



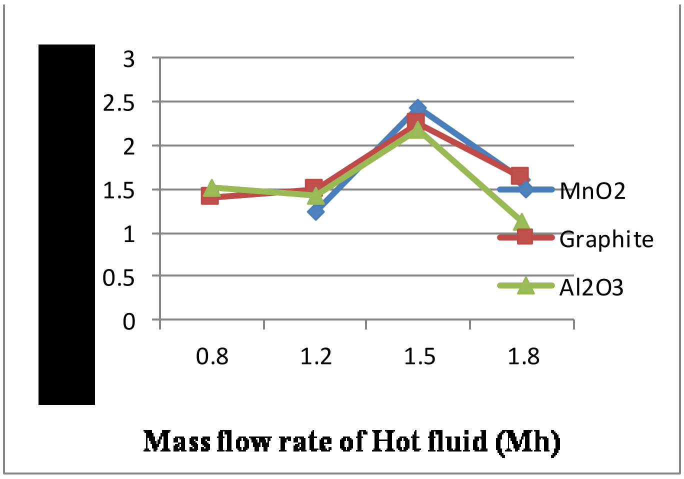
Graph 1: 0.25% at Mc=1.5 (25 gm of Nano particle in 10 lits of cold water)

The figure 5 showing variation for 0.50% concentration of Nano particles. Mass flow rate of cold water is kept constant at 1.5 LPM while mass flow rate of hot water varied from 0.8 to 2.0 LPM. In this case the pure water of the overall heat transfer coefficient varying from 750 to 800 w/m^2 K. Similarly the corresponding values of MnO_2 the overall heat transfer coefficient is varying from 900 to 1100 w/m^2 K, In graphite the overall heat transfer coefficient is varying from 800 to 1150 w/m^2 K and for Al_2O_3 the overall heat transfer coefficient is varying from 900 to 950 w/m^2 K.



Graph 2 : 0.50% at Mc=1.5 (50 gm of Nano particle in 10 lits of cold water)

The figure 6 showing for case of 0.25% of nano fluid with mass flow rate of the cold water as 1 LPM and by varying mass flow rate of hot water from 0.8 to 2 LPM. It is observed that for all the three fluids (MnO_2, graphite and Al_2O_3) average enhancement ratio is 1.5.



Graph 3 0.25% of Enhancement ratio at Mc =1 (25 gm of Nano particle in 10 lits of cold water)

Figure 7 showing for case of 0.50% of nano fluid to the mass flow rate of the cold water is 1 LPM when the varying mass flow rate of hot water from 0.8 to 1.8 LPM. In this observed that for all the three fluids (MnO_2, graphite and Al_2O_3) have average enhancement ratio is 1.6.

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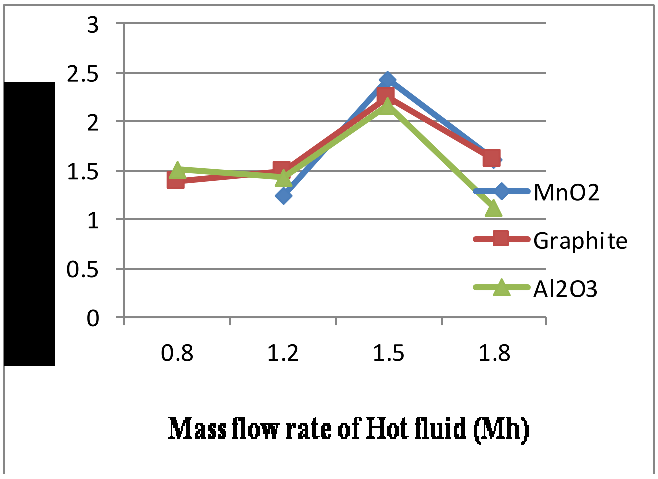
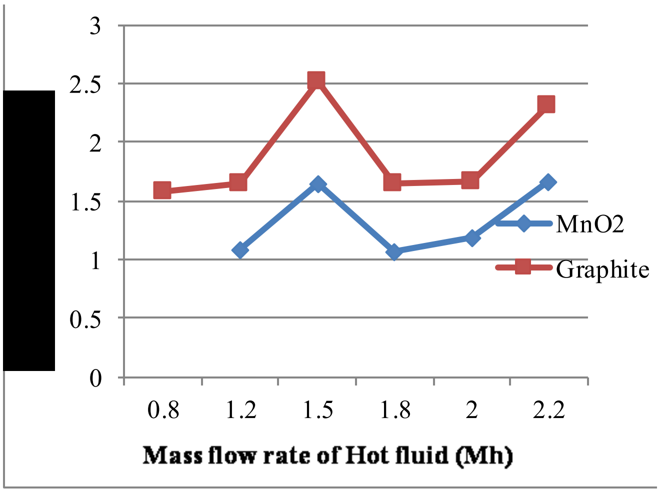


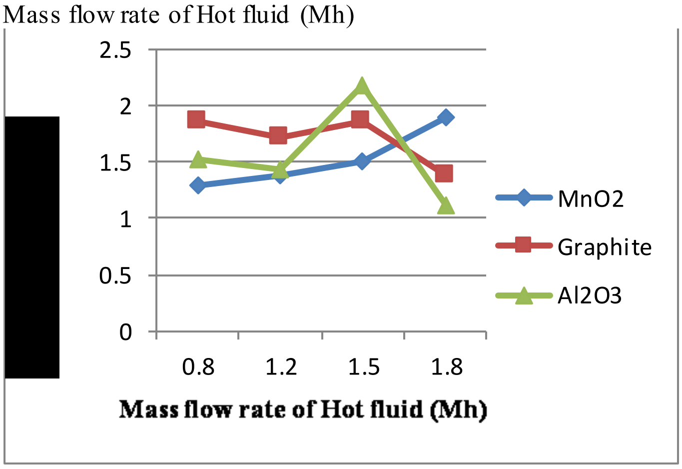
Graph 4: 0.50% of Enhancement ratio at Mc=1 (50 gm of Nano particle in 10 lits of cold water)

The figure 8 showing for case of 0.75% of nano fluid to the mass flow rate of the cold water is 1 LPM when the varying mass flow rate of hot water from 0.8 to 2.2 LPM. The enhancement ratio of MnO_2 is observed around 1.8, similarly observed in Graphite the enhancement ratio is 2.5.



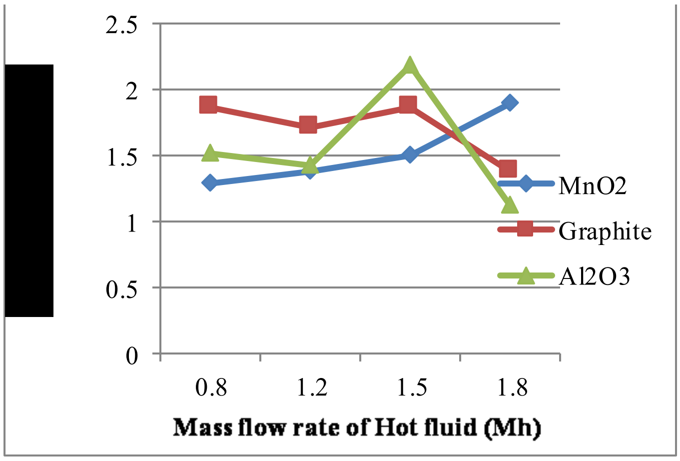
Graph 5 : 0.75% of Enhancement ratio at Mc=1 LPM (75 gm of Nano particle in 10 lits of cold water)

Graph 6 showing for case of 0.25% of nano fluid to the mass flow rate of the cold water is 1.5 LPM when the varying mass flow rate of hot water from 0.8 to 1.8 LPM. The enhancement ratio of MnO_2 is observed around 1.8, similarly observed in Graphite and Al_2O_3 are 1.4 and 1.2 respectively.



Graph 6: 0.25% of Enhancement ratio at Mc=1.5 (25 gm of Nano particle in 10 lits of cold water)

This figure 10 showing for case of 0.50% of nano fluid to the mass flow rate of the cold water is 1.5 LPM when the varying mass flow rate of hot water from 0.8 to 1.8 LPM. The enhancement ratio of MnO_2 is observed around 1.7, similarly observed in Graphite and Al_2O_3 are 1.3 and 1.4 respectively.



Graph 10: (0.50%) of Enhancement ratio at Mc=1.5 LPM (50 gm of Nano particle in 10 lits of cold water).

V. CONCLUSION

Based on the results of this study, the following specific conclusions were drawn:

Al_2O_3, MnO_2 and Graphite nano particles are mixed with base fluid and are termed as nano fluid. Here the base fluid is water and the entire experiment is done in the heat exchanger, initially the experiment is done with water and then with nano fluids. The nano fluids are prepared at different volume concentration (0.25 to 1.5%). Nano fluid readings are compared with base fluid (water) readings.

- At cold water flow rate of 1 LPM and particle concentration 0.25%, while the average overall heat transfer coefficient for water is 550 w/m2k corresponding values for MnO_2, graphite and Al_2O_3 are 700, 950 and 1000 respectively, as evident from figure1
- At cold water flow rate of 1. LPM and particle concentration 0.50%, while the average overall heat transfer coefficient for water is 600 w/m2k corresponding values for MnO_2, graphite and Al_2O_3 are 1100, 900 and 1250 respectively, as evident from figure 2
- At cold water flow rate of 1 LPM and particle concentration 0.75%,while the average overall heat transfer coefficient for water is 650 w/m2k corresponding values for MnO_2 and graphite are 800 and 1250 respectively, as evident from figure 3
- At cold water flow rate of 1.5 LPM and particle concentration 0.25%, while the average overall heat transfer coefficient for water is 700 w/m2k corresponding values for MnO_2, graphite and Al_2O_3 are 900, 800 and 950 respectively, as evident from figure 4
- At cold water flow rate of 1.5 LPM and particle concentration 0.50%, while the average overall heat transfer coefficient for water is 775 w/m2k corresponding values for MnO_2, graphite and Al_2O_3 are 1000, 975 and 925 respectively, as evident from figure 5

- At cold water flow rate of 1 LPM and particle concentration 0.25%, while the comparing with corresponding values (range of 0.8 to 2 LPM) of mass flow rate of hot water for the three fluids (MnO_2, graphite and Al_2O_3) of the average enhancement Ratio is 1.5, as evident from figure 6
- At cold water flow rate of 1 LPM and particle concentration 0.50%, when the comparing with corresponding values (range of 0.8 to 1.8 LPM) of mass flow rate of hot water for the three fluids (MnO_2, graphite and Al_2O_3) of the average enhancement Ratio is 1.6, as evident from figure 7
- At cold water flow rate of 1 LPM and particle concentration 0.75%, when the comparing with corresponding values (range of 0.8 to 2.2 LPM) of mass flow rate of hot water for the fluids of MnO_2, and graphite of the average enhancement Ratio is 1.8 and 2.5 respectively, as evident from figure 8
- At cold water flow rate of 1.5 LPM and particle concentration 0.25%, when the comparing with corresponding values (range of 0.8 to 1.8 LPM) of mass flow rate of hot water for the fluids of MnO_2, graphite and Al_2O_3 of the average enhancement Ratio is 1.8, 1.4 and 1.2 respectively, as evident from figure 9
- At cold water flow rate of 1.5 LPM and particle concentration 0.50%, when the comparing with corresponding values (range of 0.8 to 1.8 LPM) of mass flow rate of hot water for the fluids of MnO_2, graphite and Al_2O_3 of the average enhancement Ratio is 1.7, 1.3 and 1.4 respectively, as evident from figure 10

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