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SIMULATION OF FORCED CONVECTION IN A PIPE WITH NANO FLUIDS USING CFX SOFTWARE

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ABSTRACT

Conventional fluids such as water, ethylene glycol normally used as heat transfer fluids. Various techniques are applied to enhance the heat transfer, the low heat transfer performance of these conventional fluids obstructs the performance enhancement. The use of additives is a technique applied to enhance the heat transfer performance of base fluids. Recently as an innovative material, nanometer-sized particles have been used in suspension in conventional heat transfer fluids. The fluids with these solid-particle suspended in them are called Nano fluids. The suspended metallic or non-metallic nanoparticles change the transport properties and heat transfer characteristics of the base fluid. In this project we have considered the problem of forced convection flow of fluid inside a uniformly heated tube that is submitted to a constant and uniform heat flux at the wall. The heat transfer coefficient was analyzed at the same Reynolds number for both base fluids and nanofluids in the CFX software. The base fluids used for this work is water and ethylene glycol. The nanoparticles to suspended in the base fluids used for this work are aluminum, aluminum oxide, copper, copper oxide and silver. And also a comparative work is done between the thermal conductivity models.

Keywords: Nano fluids, Nano particles, CFX

CHAPTER 1

1.1 GENERAL

Conventional fluids such as water, ethylene glycol are normally used as heat transfer fluids. They play an important role in many industry sectors including power generation, chemical production, air-conditioning transportation and microelectronics. Various techniques are applied to enhance the heat transfer; the low heat transfer performance of these conventional fluids obstructs the performance enhancement and the compactness of heat exchangers. The use of solid particles as an additive suspended into the base fluid is a technique for heat transfer enhancement. Improving of the thermal conductivity is a key idea to improve the heat transfer characteristics of conventional fluids. Since a solid metal have large thermal conductivity than a base fluid, suspending metallic solid fine particles into the base fluid is expected to improve the thermal conductivity of that fluid.

1.2. THE NANOMETER

The nanometre (International spelling as used by the International Bureau of Weights and Measures; SI symbol: nm) or nanometre (American spelling) is a unit of length in the metric system, equal to one billionth of a meter. The name combines the SI prefix Nano- (from the Ancient Greek , Nanos, "dwarf") with the parent unit nanometre (from Greek, metron, "unit of measurement"). It can be written in scientific notation as 1×10 −9 m, in engineering notation as 1 E−9 m, and is simply1 m / 1,000,000,000. One nanometer equals ten Angstroms.

1.3 NANOFLUIDS PROPEERITES

Nano particles are of great scientific interest as they are, in effect, a bridge between bulk materials and atomic or molecular structures. A bulk material should have constant physical properties regardless of its size, but at the nano-scale size-dependent properties are often observed. Thus, the properties of materials change as their size approaches the nanoscale and as the percentage of atoms at the surface of a material becomes significant. For bulk materials larger than one micrometer (or micron), the percentage of atoms at the surface is 4 insignificant in relation to the number of atoms in the bulk of the material. The interesting and sometimes unexpected properties of nanoparticles are therefore largely due to the large surface area of the material, which dominates the contributions made by the small bulk of the material.

Nanoparticles often possess unexpected optical properties as they are small enough to confine their electrons and produce quantum effects. For example gold nanoparticles appear deep-red to black in solution. Nanoparticles of yellow gold and grey silicon are red in color. Gold nanoparticles melt at much lower temperatures (~300 °C for 2.5 nm size) than the gold slabs (1064 °C) Absorption of solar radiation is much higher in materials composed of nanoparticles than it is in thin films of continuous sheets of material. In both solar PV and solar thermal applications, controlling the size, shape, and material of the particles, it is possible to control solar absorption.

1.4 HEAT TRANSFER ENHANCEMENT

Heat transfer enhancement is an active and important field of engineering research. Based upon the research three possible mechanisms proposed for heat transfer enhancement. They are decreasing the thermal boundary layer, increasing the flow interruptions and increasing the velocity gradient near the heated surface. The addition of small particles to the fluid can sometimes provide heat transfer enhancement. However the works in this area provide the suspension of micro to macro size particles bear the following major
disadvantages.

- The particles settle rapidly, forming layer on the surface and reducing theheat transfer capacity of the fluid.
- If the circulation rate of the fluid is increased sedimentation is reduced by the illusion of the heat transfer devices, pipe lines etc. increase rapidly.
- The large size of the particles tends to clog the flow channels particularly if the cooling channels are narrow.
- The pressure drop in the fluid increase considerably.

1.5 LITERATURE SURVEY

1. Analysis on Heat Transfer in Nanofluids for Al 2 O 3 / Water

Anchupogu.Praveen,Penugonda Suresh Babu, Venkata Ramesh Mamilla

Nano fluid is a fluid having nanosize particles, normally particle size less than 100 nm dispersed in the conventional base fluids such as water, engine oil, ethylene glycol, transformer oil which tremendously enhances the heat transfer characteristics of original fluid. Because of solid nanoparticles these fluids have thermal conductivities several hundred times higher than that of conventional
Fluids. Nanofluid show better stability, higher thermal conductivity, and no penalty in pressure drop. In the paper , a theoretical study has been carried out predict heat transfer coefficient of nanofluids Al2O3 / water The heat transfer coefficient calculated for different temperature ranging from 25 o C to 80 o C with volume concentrations ranging from 1 to 5% and heat transfer coefficient is compared with pure water. The results show that the percentage increase in heat transfer coefficient Al2O3 / water with nanoparticle concentration was determined.

2. Heat Exchanger Using Nano Fluid

Prof. Alpesh Mehta, Dinesh k Tantia,Nilesh M Jha,Nimit M Patel

This paper shows the research work on heat exchanger using nano fluid. In this paper we are using compact heat exchanger as heat transferring device while $Al_2 O_3$ as a nano fluid. The effect of the nano fluids on compact heat exchanger is analyzed by using 6 –NTU rating numerical method on turbo-charged diesel engine of type TBD 232V-12 cross flow compact heat exchanger radiator with unmixed fluids consisting of 644 tubes made of brass and 346 continuous fins made of copper. Comparative study of Al2O3+ water nano fluids as coolant is carried out.

3. Computer-Aided Simulation of Heat Transfer in Nanofluids

A.M. Sharifi, A. Emamzadeh, A. A. Hamidi, H. Farzaneh, M. Rastgarpour

Numerical simulation and experimental investigation were used for study of laminar forced convective heat transfer of Al2O3/water Nano fluid. Single phase model with temperature dependent properties was employed for numerical simulation of transport phenomena in Nano fluid. The results of experiments and computer-aided simulation indicated remarkable enhancement of convective heat transfer of base fluid, by adding small amounts of Al2O3 nanoparticles. The convective heat transfer in Nano fluid enhanced with increasing of nanoparticle

Concentration and flow Reynolds number. Increasing of ethylene glycol in the base fluid composition resulted in decreasing of heat transfer coefficient.

1.6 SCOPE OF THE PROJECT

The major improvement in heat transfer capabilities have suffered a major lacking as a result and it is important to need skills to develop new strategies in order to improve the effective heat transfer behaviours of conventional heat transfer fluids.

To improve the heat transfer rate of conventional fluids the Nano particles are suspended in the base fluid. In this project the two base fluids are selected namely water and ethylene glycol. To enhance the heat transfer rate of the above said base fluids the Nano particles of Aluminum, Aluminum oxide, copper, copper oxide and silver were chosen. The properties of the nano fluids are calculated by formulas. The thermo physical properties of water, ethylene glycol, Aluminum, Aluminum oxide, copper, copper oxide and silver are tabulated and it is substituted in the formulas for finding the properties of nanofluids. In order to analyze the heat transfer rate of the base fluid and nanofluid CFX software is used. The nano fluids and the base

Fluids are analysed under the same Reynolds number. And also a comparative work is done between the thermal conductivity models namely Maxwell, Hamilton and Crosser, Jeffrey, Davis, Bruggeman and Suresh models.

CHAPTER 2

2.1 THERMOPHYSICAL PROPERTIES OF NANOFLUIDS

S. No	Property	Aluminum oxide	Aluminum	Copper	Copper oxide	Silver
1	Thermal conductivity (k_s)W/mK	40	237	400	20	429
2	Density (ρ_p)kg/m^3	3970	2710	8933	6500	10500
3	Specific heat (C_P) J/kg K	765	900	385	535.6	234

Properties of base fluids

S.No	Property	Water	Ethylene glycol
1	Thermal conductivity (k_L)W/mK	0.605	0.252
2	Density (ρ_f)kg/m^3	997.1	1111
3	Specific heat (C_f)J/kgK	4179	2415
4	Dynamic viscosity $(\mu)_0$ Kg/m^3	0.001003	0.0157

2.2 DENSITY OF NANO FLUID

The density of a nano fluid can be calculated by using the mass balance as:

$$P_{nf} = (1-\phi)\,\rho_{f} + \phi\rho_p \quad \text{----------------- (2.1)}$$

For typical nanofluids with nanoparticles at a value of volume fraction less than 1%, a change of less than 5% in the fluid density is expected.

2.2.1 SAMPLE CALCULATION

For one percent nano particles mixes with the base fluid water the sample calculation for density is shown below:

From equation 2.1. $P_{nf} = (1-\phi)\,\rho_{f} + \phi\rho_p$

$= (1-0.01) * 997.1 + 0.01 * 3970$

$= 1027.11$ Kg/m^3

Using the formula in equation 2.1 the density is calculated for nanoparticles percentages from one to thirty. In the table 2.3 the density of nano fluids is listed i.e. the combinations of a) aluminum +water b) aluminum oxide + water c) copper + water d) copper oxide + water e) silver + water.

Density of nano fluid Kg/m3 (Water + Nanoparticles combination)

Nano particle percentage	Aluminum + water	Aluminum oxide +water	Copper +water	Copper oxide +water	Silver +water
1	1014.22	1027.11	1076.45	1052.63	1092.12
2	1029.53	1056.03	1156.78	1093.42	1123.67
3	1048.74	1084.95	1243.56	1132.45	1256.89
4	1069.04	1113.87	1301.45	1211.56	1357.92
5	1082.74	1145.74	1393.89	1272.26	1472.24

6	1099.45	1167.82	1456.72	1311.04	1578.93
7	1018.72	1193.47	1572.78	1399.63	1632.03
8	1039.92	1229.86	1623.47	1423.87	1782.41
9	1054.63	1262.88	1700.03	1500.08	1835.63
10	1168.39	1294.39	1790.69	1547.39	1945.34
11	1184.67	1325.61	1823.56	1599.58	2003.45
12	1198.23	1367.82	1917.62	1623.48	2134.56
13	1118.62	1389.04	2008.34	1711.28	2267.80
14	1135.80	1421.67	2099.72	1795.67	2357.91
15	1254.03	1443.03	2187.48	1822.53	2422.53
16	1271.53	1478.91	2256.89	1893.46	2499.80
17	1284.67	1501.23	2371.64	1906.72	2569.04
18	1296.54	1534.71	2411.83	1999.03	2674.32
19	1318.76	1561.55	2501.32	2034.52	2789.56
20	1339.68	1591.68	2584.28	2097.68	2897.68
21	1353.91	1624.56	2698.75	2134.23	2934.56
22	1375.02	1651.53	2756.24	2245.11	3012.57
23	1392.31	1683.47	2815.63	2298.04	3123.48
24	1411.56	1722.31	2901.87	2314.56	3265.89
25	1425.32	1740.32	2981.07	2372.82	3372.82
26	1441.52	1777.80	3059.03	2458.89	3582.57
27	1472.89	1792.45	3123.49	2501.57	3623.67
28	1483.67	1835.81	3199.84	2580.45	3700.82
29	1499.71	1861.04	3287.65	2602.34	3799.32
30	1510.97	1888.97	3377.87	2647.97	3847.97

Density of Nano fluid Kg/m3 (C2H6O2 + Nanoparticles combination)

Nano particle %	Aluminum + $C_2H_6O_2$	Al_2O_3+ $C_2H_6O_2$	Copper + $C_2H_6O_2$	Copper oxide + $C_2H_6O_2$	Silver+ $C_2H_6O_2$
1	1126.99	1139.59	1189.22	1164.89	1204.89
2	1135.62	1153.32	1256.67	1179.08	1297.76
3	1156.71	1198.78	1342.34	1201.34	1367.83
4	1174.68	1214.56	1412.54	1300.65	1452.84
5	1190.95	1253.95	1502.14	1380.45	1580.45
6	1200.87	1269.04	1598.74	1411.56	1653.79
7	1225.68	1284.69	1623.56	1497.70	1789.03
8	1246.35	1300.64	1699.04	1511.25	1892.36
9	1259.08	1342.18	1745.63	1598.03	1904.57
10	1270.95	1396.89	1893.46	1649.93	2049.87
11	1289.60	1403.78	1967.43	1699.82	2134.78
12	1296.73	1436.78	1999.45	1723.47	2256.80
13	1318.73	1499.04	2000.34	1823.57	2368.21
14	1337.65	1521.11	2156.78	1899.03	2478.01
15	1350.85	1539.84	2284.32	1919.35	2519.43
16	1368.57	1567.83	2341.23	1987.12	2638.56
17	1380.53	1587.34	2457.67	2011.24	2746.23
18	1395.42	1600.09	2547.34	2099.56	2800.12
19	1412.32	1642.34	2600.12	2111.04	2900.12
20	1430.82	1682.81	2675.42	2188.82	2988.83

21	1452.45	1699.04	2789.56	2234.56	3012.21
22	1473.57	1723.46	2845.67	2364.58	3124.56
23	1484.89	1789.45	2899.03	2399.03	3245.89
24	1497.04	1800.09	2967.84	2421.12	3367.92
25	1510.75	1825.75	3066.53	2458.25	3458.26
26	1534.73	1843.23	3012.23	2499.04	3533.23
27	1553.85	1859.02	3149.82	2568.93	3645.87
28	1570.92	1894.50	3246.78	2673.46	3798.03
29	1581.24	1945.67	3387.64	2700.03	3851.23
30	1590.72	1968.74	3457.67	2727.72	3927.73

2.3 DYNAMIC VISCOSITY OF NANO FLUIDS

The effective dynamic viscosity of nano fluids can be calculated using different existing formulas that have been obtained for two-phase mixtures. It can be calculated as:

$\mu = \mu_0 (123 \phi^2 + 7.3\phi + 1)$ ---------------- (2.3)

2.3.1 SAMPLE CALCULATION

For one percent nano particles mixes with the base fluid water the sample calculation for specific heat is shown below:

From equation 2.3.

$$\mu = \mu_0 (123 \phi^2 + 7.3\phi + 1)$$

$$=0.001003*(123*0.012+7.3*0.01+1)$$

$$= 0.0010885 \text{ kg/ms}$$

Using the formula in equation 2.3 the dynamic viscosity is calculated for nanoparticles percentages from one to thirty. In the table 7 the dynamic viscosity of nano fluids is listed i.e. the combinations of nano particle with water and the combination of nano particle with ethylene glycol.

Dynamic viscosity of nano fluids (kg/ms)

Nano particle percentage	Nano particle + Water	Nano particle + Ethylene glycol
1	0.0010885	0.0170350
2	0.0011131	0.0173472
3	0.0011407	0.0178539
4	0.0011989	0.0187641
5	0.0013333	0.0208765
6	0.0014936	0.0233719
7	0.0018853	0.0298213
8	0.0021798	0.0351595
9	0.0025311	0.0413373
10	0.0029688	0.0464728
11	0.0032531	0.0531361
12	0.0036671	0.0687516
13	0.0039475	0.0753784
14	0.0041395	0.0835340
15	0.0048745	0.0917855
16	0.0053872	0.0998195
17	0.0059824	0.1034907
18	0.0065803	0.1072735
19	0.0071836	0.1119258
20	0.0074021	0.1158669
21	0.0080185	0.1242284
22	0.0087238	0.1397918
23	0.0017250	0.1484582
24	0.0099367	0.1533814
25	0.0105438	0.1672418
26	0.0112828	0.1795753
27	0.0121177	0.1873519

28	0.0129380	0.1991674
29	0.0013759	0.2108963
30	0.0142473	0.2238828

2.5 THERMAL CONDUCTIVITY OF NANO FLUIDS

Many theoretical and empirical models have been proposed to predict the effective thermal conductivity of nanofluids. The commonly used models are listed below with their formulas:

2.5.1 MAXWELL MODEL

$$K = K_L \frac{K_S + 2K_L + 2(K_S - K_L)\phi_S}{K_S + 2K_L - (K_S - K_L)\phi_S} \quad \text{-------(2.4)}$$

2.5.2 HAMILTON AND CROSSER MODEL

$$K = K_L \frac{K_S + (n-1)K_L - (n-1)(K_L - K_S)\phi_S}{K_S + (n-1)K_f + (K_L - K_S)\phi_S} \quad \text{--- (2.5)}$$

Where n depends on particle shape and K_S/K_L, $n = 3/\psi$ for $K_S/K_L > 100$, n=3 for other cases

Thermal conductivity of nanofluids (Water + Aluminum oxide)

Nano particle percentage	Maxwell	Hamilton and crosser
1	0.6225	0.6224
2	0.6403	0.6458
3	0.6585	0.6642
4	0.6771	0.6771
5	0.6992	0.6923
6	0.7106	0.7134
7	0.7234	0.7254
8	0.7459	0.7465
9	0.7682	0.7611
10	0.7968	0.7902
11	0.8255	0.8298
12	0.8568	0.8557
13	0.8825	0.8824
14	0.9003	0.9054
15	0.9287	0.9265
16	0.9452	0.9487
17	0.9506	0.9521
18	0.9617	0.9603
19	0.9839	0.9867
20	1.0034	1.0034
21	1.0456	1.0487
22	1.0578	1.0591
23	1.0934	1.0954
24	1.1235	1.1274
25	1.1678	1.1619
26	1.2153	1.2123
27	1.2457	1.2405
28	1.2789	1.2722
29	1.3018	1.3086
30	1.3348	1.3297

Thermal conductivity of nanofluids (Ethylene glycol + Aluminum oxide)

Nano particle percentage	Maxwell	Hamilton and crosser
1	0.2594	0.2594
2	0.2671	0.2674
3	0.2749	0.2703
4	0.2828	0.2816
5	0.2913	0.2912
6	0.3008	0.3034
7	0.3134	0.3145
8	0.3256	0.3256
9	0.3276	0.3309
10	0.3387	0.3467
11	0.3412	0.3534
12	0.3545	0.3603
13	0.3608	0.3745
14	0.3634	0.3813
15	0.3765	0.3945
16	0.3808	0.4036
17	0.3965	0.4178
18	0.4334	0.4297
19	0.4275	0.4365
20	0.4487	0.4423
21	0.4578	0.4645

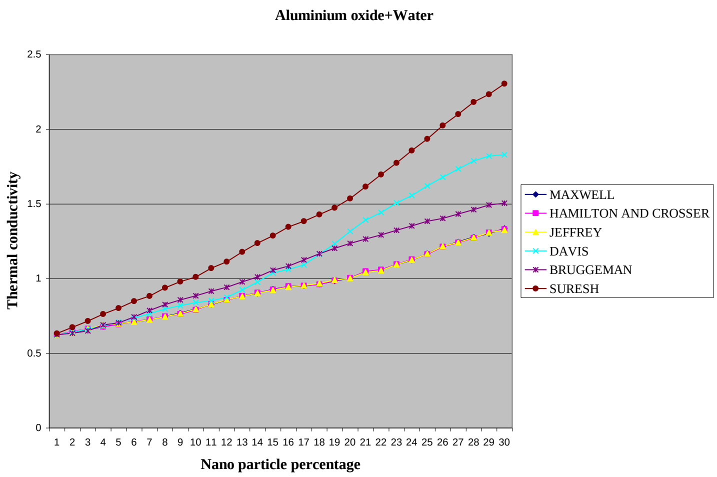
22	0.4654	0.4767
23	0.4732	0.4887
24	0.4821	0.4865
25	0.4927	0.4945
26	0.5078	0.5146
27	0.5193	0.5323
28	0.5326	0.5435
29	0.5591	0.5536
30	0.5674	0.5652

Thermal conductivity of nanofluids (Water + Aluminum)

Nano particle percentage	Maxwell	Hamilton and crosser
1	0.6238	0.6231
2	0.6318	0.6456
3	0.6564	0.6628
4	0.6810	0.6800
5	0.6998	0.6917
6	0.7113	0.7049
7	0.7229	0.7224
8	0.7436	0.7436
9	0.7647	0.7657
10	0.7986	0.8067
11	0.8257	0.8359
12	0.8532	0.8503
13	0.8824	0.8810
14	0.9081	0.9041
15	0.9253	0.9226
16	0.9447	0.9483
17	0.9517	0.9547
18	0.9624	0.9614
19	0.9836	0.9987
20	1.0531	1.0412
21	1.0844	1.0823
22	1.1160	1.1239
23	1.1453	1.1434
24	1.1771	1.1871
25	1.2174	1.2108
26	1.2469	1.2421
27	1.2878	1.2838
28	1.3289	1.3245
29	1.3546	1.3557
30	1.3751	1.3719

Thermal conductivity of nanofluids (Ethylene glycol + Aluminum)

Nano particle percentage	Maxwell	Hamilton and crosser
1	0.2592	0.2560
2	0.2644	0.2658
3	0.2716	0.2774
4	0.2802	0.2866
5	0.2911	0.2903
6	0.3015	0.3078
7	0.3124	0.3134
8	0.3254	0.3256
9	0.3292	0.3385
10	0.3376	0.3405
11	0.3417	0.3584
12	0.3509	0.3658
13	0.3676	0.3711
14	0.3663	0.3869
15	0.3743	0.3935
16	0.3825	0.4063
17	0.3924	0.4112
18	0.4337	0.4223
19	0.4277	0.4345
20	0.4454	0.4476
21	0.4537	0.4682
22	0.4691	0.4734
23	0.4783	0.4887
24	0.4871	0.4809
25	0.4925	0.4976
26	0.5047	0.5153
27	0.5178	0.5321
28	0.5339	0.5463
29	0.5569	0.5529
30	0.5724	0.5701



Thermal conductivity of nanofluids (Water + Aluminum oxide)

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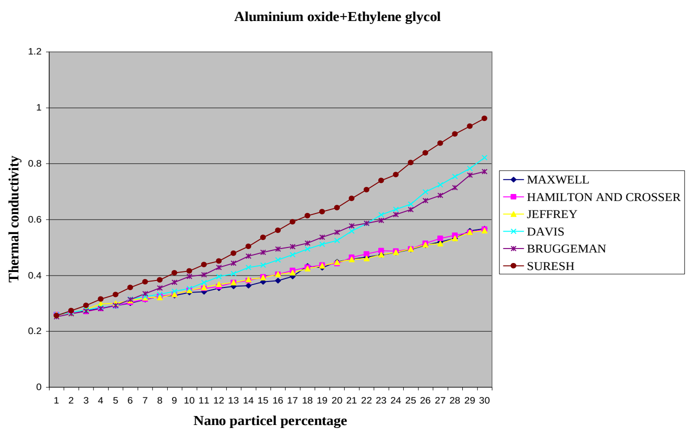
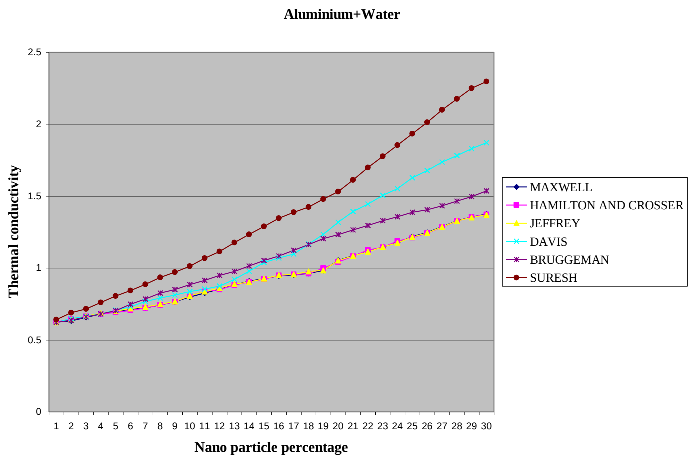
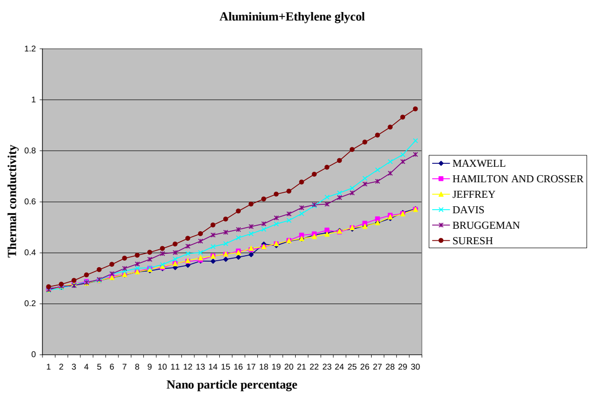


Thermal conductivity of nanofluids (Ethylene glycol + Aluminum oxide)



Thermal conductivity of nanofluids (Water + Aluminum)



Thermal conductivity of nanofluids (Ethylene glycol + Aluminum)

CHAPTER 3

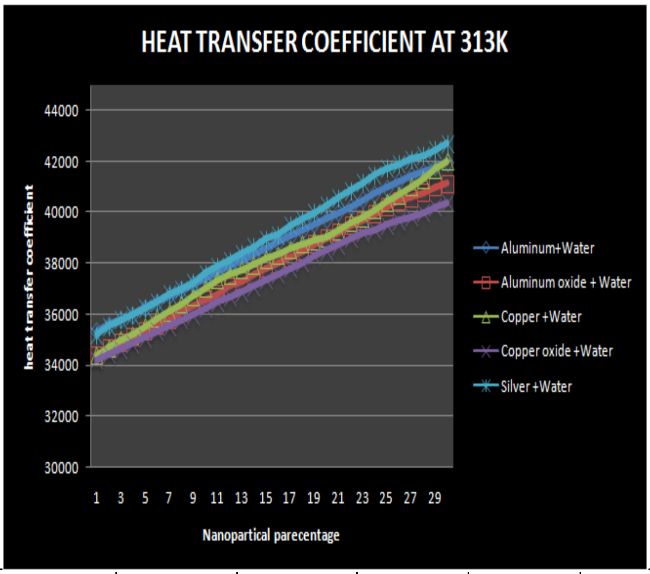
RESULTS AND DISCUSSION

3.1 HEAT TRANSFER CO-EFFICIENT AT 313K (FOR WATER WITH NANOPARTICLES)

Heat transfer co-efficient of water 313K (At 400c) = 31785.81kW/m2K. The results obtained in the CFX software for the heat transfer coefficient of combinations of water with nanoparticles at 313K are listed in the table 3.1 and the comparison is shown in figure

Heat transfer co-efficient of nanofluids (Water with nanoparticles) at 400c

Heat transfer co-efficient of nanofluids (Water with nanoparticles) at 400c

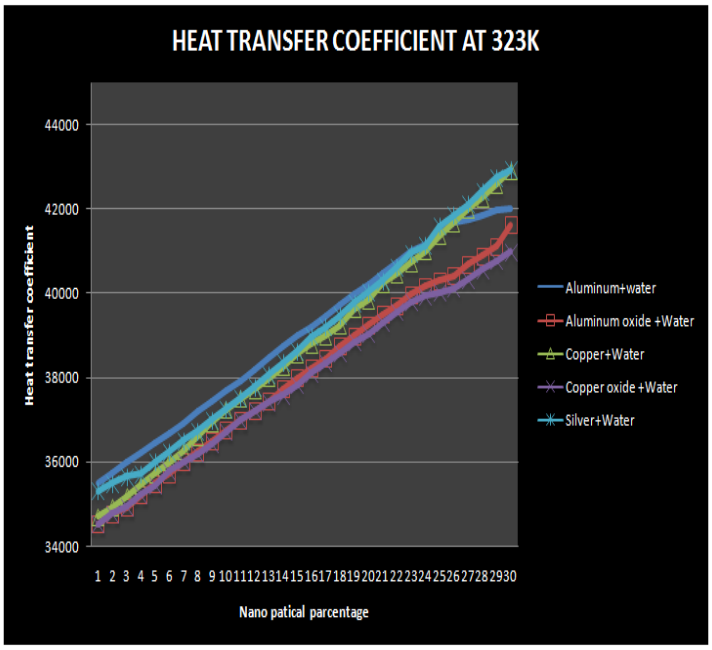


Nano particle percent age	Alumin um + water	Alumin um oxide +water	Coppe r +wate r	Coppe r oxide +wate r	Silver+ water
1	35347. 23	34421. 71	34398. 26	34210. 14	35212. 47
2	35578. 93	34657. 92	34689. 37	34436. 75	35523. 34
3	35795. 62	34883. 18	34993. 46	34645. 71	35784. 83
4	35998. 03	35109. 53	35208. 79	34853. 23	35999. 03
5	36256. 92	35338. 74	35511. 26	35079. 03	36224. 57
6	36502. 42	35565. 31	35843. 47	35345. 82	36485. 66
7	36734. 58	35794. 55	36106. 74	35549. 83	36788. 60
8	36953. 64	36098. 27	36416. 45	35782. 05	37000. 73
9	37198. 64	36342. 94	36712. 67	35989. 63	37259. 05
10	37427. 39	36578. 62	37025. 43	36246. 78	37599. 78
11	37673. 92	36801. 66	37346. 86	36489. 04	37883. 46

12	37893.70	37094.72	37557.05	36685.61	38111.39
13	38110.81	37311.26	37756.13	36889.43	38395.73
14	38354.68	37569.41	37945.78	37112.55	38658.07
15	38589.05	37795.32	38167.81	37367.83	38954.31
16	38834.56	37998.35	38342.66	37589.48	39136.09
17	39069.79	38231.75	38553.83	37812.63	39488.62
18	39296.45	38489.40	38758.61	38043.26	39756.31
19	39542.93	38763.75	38901.47	38312.69	39999.58
20	39732.46	38999.03	39004.41	38519.74	40289.52
21	39989.05	39211.65	39289.53	38745.93	40583.46
22	40230.69	39479.53	39599.47	38997.62	40859.21
23	40498.35	39697.45	39811.26	39211.83	41175.14
24	40743.25	39935.69	40104.73	39318.94	41489.54
25	40987.19	40208.56	40409.68	39511.26	41749.81
26	41235.83	40478.54	40711.34	39679.29	41911.24
27	41467.83	40599.53	41001.45	39823.64	42107.42
28	41599.46	40794.57	41328.76	40000.92	42237.71
29	41799.83	40998.57	41699.47	40211.35	42456.74
30	41986.82	41145.49	42018.04	40396.53	42716.47

3.2 HEAT TRANSFER CO-EFFICIENT AT 323 K (FOR WATER WITH NANOPARTICLES)

Heat transfer co-efficient of water 323K (At 50^0c) = 32129.18 kW/ (m^2.K).The results obtained in the CFX software for the heat transfer coefficient of combinations of water with nanoparticles at 50^0c listed in the table 5.2 and the comparison is shown in figure



Heat transfer co-efficient of nanofluids (Water with nanoparticles) at 50^0c

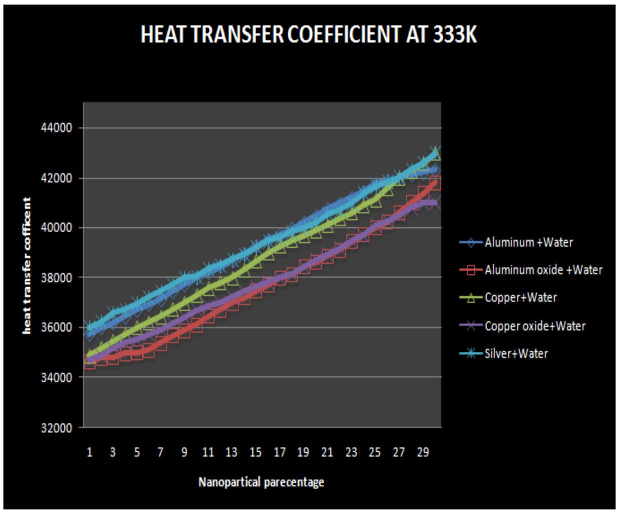
Heat transfer co-efficient of nanofluids (Water with nanoparticles) at 50^0c

Nano particle percentage	Aluminum + water	Aluminum oxide +water	Copper +water	Copper oxide +water	Silver+ water
1	35516.18	34535.16	34711.35	34535.29	35319.36
2	35745.57	34767.82	34926.71	34778.93	35497.65
3	35985.61	34916.93	35189.62	34936.72	35658.91
4	36210.93	35210.38	35467.93	35231.79	35729.04
5	36435.68	35498.73	35729.04	35447.93	35996.11
6	36684.92	35724.73	35998.51	35782.38	36244.53
7	36911.52	35998.05	36258.92	35998.70	36513.83
8	37198.77	36241.83	36613.47	36200.74	36729.06
9	37418.73	36498.77	36925.88	36426.79	36998.47
10	37699.05	36747.06	37249.82	36719.84	37253.81
11	37928.74	36991.25	37511.38	36998.42	37528.75

12	38194.87	37211.70	37725.69	37217.64	37787.93
13	38472.10	37446.37	37993.49	37429.88	38073.47
14	38724.03	37728.71	38249.63	37589.41	38351.28
15	38999.47	37998.63	38562.40	37836.04	38639.82
16	39211.35	38223.64	38798.35	38117.83	38984.57
17	39458.92	38459.81	38998.48	38362.47	39211.38
18	39713.64	38749.03	39238.74	38588.39	39471.75
19	39997.30	38999.31	39634.95	38853.07	39781.64
20	40213.58	39256.71	39837.04	39047.81	40041.28
21	40477.82	39498.09	40231.73	39311.65	40295.61
22	40728.95	39714.57	40459.83	39562.94	40628.74
23	40994.69	39975.50	40727.84	39789.83	40952.38
24	41174.38	40167.53	40999.31	39947.62	41138.71
25	41413.93	40299.53	41365.82	40015.63	41589.72
26	41672.39	40411.53	41682.49	40119.85	41849.55
27	41749.57	40696.53	41996.52	40341.54	42119.48
28	41853.72	40894.52	42268.55	40569.31	42428.76
29	41993.27	41111.73	42593.58	40783.02	42748.77
30	42017.21	41629.37	42911.21	40986.57	42938.67

3.3 HEAT TRANSFER CO-EFFICIENT AT 333K (FOR WATER WITH NANOPARTICLES)

Heat transfer co-efficient of Water (At 60^0c) = 32894.55 kW/ (m^2.K).The results obtained in the CFX software for the heat transfer coefficient of combinations of water with nanoparticles at 60^0c listed in the table 5.3 and the comparison is shown in figure



Heat transfer co-efficient of nanofluids (Water with nanoparticles) at 313K

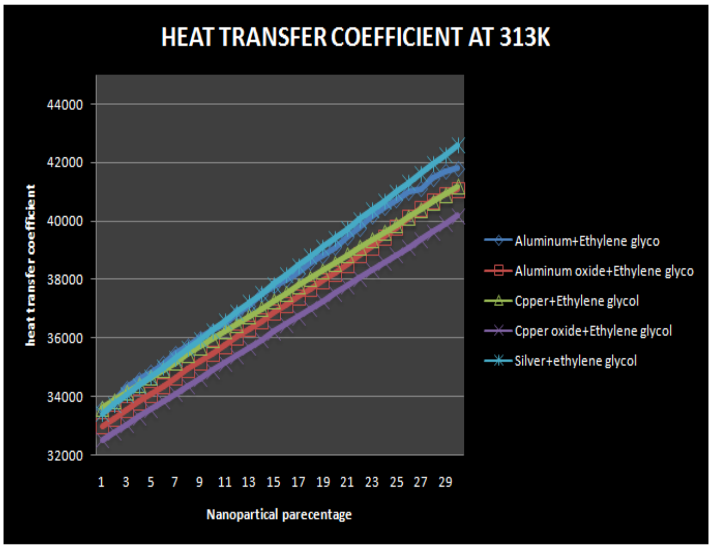
Heat transfer co-efficient of nanofluids (Water with nanoparticles) at 60^0C

Nano particle percentage	Aluminum + water	Aluminum oxide +water	Copper +water	Copper oxide +water	Silver+ water
1	35719.23	34618.73	34873.28	34685.33	35998.78
2	35998.73	34781.58	35187.64	34889.03	36238.71
3	36197.38	34819.85	35458.93	35174.58	36583.49
4	36446.87	34972.39	35724.16	35389.72	36711.97
5	36723.49	35000.19	35997.62	35528.95	36979.03
6	36914.58	35112.38	36210.84	35738.37	37210.18
7	37119.84	35379.06	36442.38	35911.59	37452.83
8	37452.38	35672.49	36738.92	36174.14	37731.27
9	37724.84	35893.52	36999.49	36428.69	37998.66
10	37997.60	36118.73	37295.61	36693.48	38058.39
11	38209.85	36457.63	37582.18	36849.03	38374.51
12	38428.79	36711.80	37794.59	36999.47	38514.50
13	38679.81	36997.64	38000.07	37210.83	38739.27
14	38955.75	37197.83	38334.10	37451.28	38915.73

15	39276.58	37475.07	38678.55	37639.19	39213.54
16	39528.47	37714.59	38995.73	37825.60	39479.07
17	39731.28	37997.48	39264.31	37996.53	39615.49
18	39948.35	38108.50	39485.67	38128.47	39828.68
19	40198.74	38437.69	39672.38	38429.65	40002.52
20	40473.49	38611.42	39887.50	38711.31	40218.57
21	40749.82	38864.97	40112.73	38942.73	40542.95
22	40999.03	39110.05	40374.95	39169.28	40717.68
23	41217.84	39452.38	40592.19	39478.53	40999.25
24	41449.81	39726.53	40893.58	39711.90	41369.84
25	41759.83	39991.36	41116.77	40089.43	41658.72
26	41883.94	40218.73	41589.04	40272.69	41846.92
27	41997.49	40628.17	41996.51	40498.41	42018.69
28	42107.61	41000.88	42274.58	40796.52	42318.95
29	42218.75	41389.74	42583.49	40991.27	42598.77
30	42308.51	41818.29	42989.65	41018.29	42976.81

3.4 HEAT TRANSFER CO-EFFICIENT AT 313K (FOR ETHYLENE GLYCOL WITH NANOPARTICLES)

Heat transfer co-efficient of ethylene glycol (At 40^0c) = 30982.19 KW/m^2.K. The results obtained in the CFX software for the heat transfer coefficient of combinations of ethylene glycol with nanoparticles at 40^0c are listed in the table 5.4 and the comparison is shown in figure



Heat transfer co-efficient of nanofluids (Ethylene glycol with nanoparticles) at 400c

Heat transfer co-efficient of nanofluids (Ethylene glycol with nanoparticles) at 400c

Nano particle percent age	Aluminum + Ethylene glycol	Aluminum oxide + Ethylene glycol	Copper + Ethylene glycol	Copper oxide + Ethylene glycol	Silver+ Ethylene glycol
1	33586.73	32981.51	33611.18	32511.93	33418.27
2	33815.47	33256.38	33872.54	32775.24	33734.58
3	34284.52	33534.66	34138.38	33037.71	34057.74
4	34583.91	33818.47	34394.71	33301.34	34368.17
5	34829.07	34083.74	34650.93	33567.17	34680.49
6	35118.75	34356.52	34918.24	33834.59	34991.69
7	35482.88	34648.85	35177.65	34095.84	35314.82
8	35716.40	34923.33	35436.49	34358.08	35636.92
9	35999.59	35199.91	35699.57	34623.48	35945.08
10	36261.83	35475.17	35960.68	34888.64	36262.97
11	36500.37	35750.24	36227.75	35151.15	36578.41
12	36842.68	36038.08	36481.55	35410.66	36890.02
13	37113.49	36331.82	36743.27	35679.52	37217.80

14	37492.73	36582.64	37007.11	35942.40	37526.61
15	37781.03	36867.36	37268.43	36207.74	37842.53
16	37992.27	37125.57	37526.82	36475.98	38158.19
17	38221.49	37414.29	37789.51	36738.25	38475.84
18	38582.55	37679.13	38048.36	36999.81	38796.71
19	38815.36	37959.06	38309.74	37263.68	39110.05
20	39087.88	38228.35	38574.51	37529.38	39422.45
21	39472.13	38525.94	38831.98	37791.03	39736.85
22	39761.74	38834.71	39091.3	38055.19	40051.70
23	40174.38	39126.41	39352.84	38319.79	40371.58
24	40469.09	39453.61	39617.69	38583.04	40682.66
25	40715.84	39780.75	39875.77	38847.56	41007.06
26	40999.47	40116.19	40136.16	39108.28	41311.51
27	41114.30	40434.24	40397.29	39375.10	41634.10
28	41469.29	40695.61	40655.42	39637.65	41950.44
29	41714.55	40917.37	40919.37	39903.33	42266.77
30	41818.77	41088.11	41194.18	40182.51	42596.28

3.5 DISCUSSION

The heat transfer coefficient of water at 313K (40^{0}c) is 31785.81 kW/m^{2}K. From table 3.1 it is clearly shows that the nanofluids (i.e.) nanoparticles of aluminum, aluminum oxide, copper, copper oxide and silver mixes with water shows that increased heat transfer coefficient than the water in all percentages. The heat transfer coefficient of water at 323K (50^{0}c) is 32129.18 kW/m^{2}K. From table 3.2 it is clearly shows that the nanofluids (i.e.) nanoparticles of aluminum, aluminum oxide, copper, copper oxide and silver mixes with water shows that increased heat transfer coefficient than the water in all percentages. The heat transfer coefficient of water at 60^{0}c is 32894.55 kW/m^{2}K. From table 3.3 it is clearly shows that the nanofluids (i.e.) nanoparticles of aluminum, aluminum oxide, copper, copper oxide and silver mixes with water shows that increased heat transfer coefficient than the water in all percentages. The heat transfer coefficient of ethylene glycol at 40^{0}c is 30982.19 kW/m^{2}K. From table 3.4 it is clearly shows that the nanofluids (i.e.) nanoparticles of aluminum, aluminum oxide, copper, copper oxide and silver mixes with water shows that increased heat transfer coefficient than the water in all percentages. The heat transfer coefficient of ethylene glycol at 50^{0}c is 31233.57 kW/m^{2}K. From table 5.5 it is clearly shows that the nanofluids (i.e.) nanoparticles of aluminum, aluminum oxide, copper, copper oxide and silver mixes with water shows that increased heat transfer coefficient than the water in all percentages. The heat transfer coefficient of ethylene glycol at 333K (60^{0}c) is 31694.82 kW/ m^{2}K.

4.CONCLUSION

The convective heat transfer features of, in a uniform heated tube were analyzed at temperatures 313K, 323K and 333K for following fluids.

a. Water (Base fluid)
b. Ethylene glycol (Base fluid)
c. Water + Aluminum (Nano fluid)
d. Water + Aluminum oxide (Nano fluid)
e. Water + Copper (Nano fluid)
f. Water + Copper oxide (Nano fluid)

The results shows that the nano fluids have large heat transfer co-efficient than the original base fluids under the same Reynolds number (1000). The suspended nano particles remarkably increased the forced convective heat transfer performance of the base fluid. At the same Reynolds number the heat transfer of the nano fluid increased with the particle volume fraction.

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