Heat Transfer Augmentation Through Alumina And Shell Thermia-B Nano Fluid For Close Fluid Heat Transfer Systems

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Abstract

Augmentation of Heat transfer performance is one of the primary requirements of many industries. On the other hand the insufficient thermal conductivity is one of the limitations to meet the desired results in heat transfer. Nano-fluids are engineered by suspending metallic or non-metallic nanometer-sized solid particles on the base fluid like water, oil, ethylene glycol etc. Here the thermal conductivity augmented by synthesized and tested alumina and shell thermia-B nano-fluid. The test rig designed and fabricated for testing the heat transfer augment capability. Experiments have shown that nano-fluids have substantial higher thermal conductivities compared to the base fluids.

Keywords: *Thermia –B, Nano-fluid, Heat Transfer, alumina, volumetric concentration, Heat exchanger, thermal conductivity****.***

1. Introduction

Nowadays enhance the heat exchanger performance other than heat transfer rate are downsizing, cost or weight of the heat exchanger system, but primary objective is increase the heat transfer per unit area include developing new geometries and increasing thermal conductivity of the medium. Improving the conventional fluid is a best option to achieve the thermal conductivity. Nano technology helps in this regard to prepare nano fluids for heat exchangers. The ultrafine nano sized (1 to 100nm) metallic or non metallic particles suspended over ethylene glycol, oil or water called Nano fluids [1]. Masuda et al. [2] experimented by dispersing the TiO2, SiO2 and Al2O3, nano particles though the application of electrostatic repulsion technique on the base fluid and reported that the thermal conductivity in directly proportionate to the volumetric concentration of nano particles. The convective heat transfer varies with particle properties like size, concentration and its thermal conductivity [3,4]. According to Pak and Cho [3] and Xuan and Li [4], convective heat transfer using nano-fluids varies depending on the physical and thermal properties of the nano-particles like particle size and volumetric fraction. [5] achieved the local heat transfer coefficient improvement 47% than base fluid by use of Al2O3 nano fluid with volumetric concentration of 1.6%.

Al the flow of Re 600 32% of heat transfer co-efficient improved with CNT and Water nano fluid [6]. [7] improved the HT coefficient by use of 3.7% volume concentration of silicon carbide in water as nano-fluid [7]. [8] reported that The high pressure homogenizer was responsible stability of dispersion of nano particles in the nano fluid. And also said that prepared CNT based nano-fluid found stable 10 more than days, with the volumetric concentration of 0.24% the thermal conductivity improve by 17%. [9] Characterized the SiC/deionized water (DIW) nanofluids and reported that the creative maximum viscosity increased by 102% when volumetric concentration is 3% and the overall effectiveness improved by 7.2%. [10] experimentally investigated the ethylene glycol mixture based SiC nano-fluids and concluded that the highest thermal conductivity reached than base fluid at 20OC temperature, with the 1% volumetric concentration is 33.84%. This paper focuses the augment heat transfer by alumina and water nano-fluid. The nano fluid is synthesized, tested and discussed in the following section.

2. Materials and Methods

Alumina is preferred metallic nano powder to prepare the proposed nanofluid with consideration of the following merits. Hard, wear-resistant

- Excellent dielectric properties
- Resists strong acid and alkali attack at elevated temperatures
- Good thermal conductivity
- Excellent size and shape capability
- High strength and stiffness

Available in purity ranges from 94% to 99.8% for the most demanding high temperature applications.

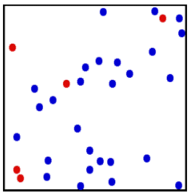
2.1 Nano Fluid

Preparing nano-fluids preparation, is not a simply mixing the solid powders and liquid, it is an elusive process which requires more attention and care. i.e., it is not a simple solid–liquid mixture. The nano-fluid must possess the followings such as, the particles lasting suspensions without agglomerations, stable, without chemical alterations of the fluid [11]. The Al2O3spherical high surface area metal Nano-particles with an average size of 70 - 100 nm range with a specific surface area of approximately 5 - 10 m2/g was purchased. The base fluid the Shell branded Heat Transfer Oil S2 that is THERMIA-B. It is a highly refined mineral oils chosen for their ability to provide superior performance in indirect closed fluid heat transfer systems. The physical treatment for mixing the nano powders with base fluid by means of a bath SONICATOR, ball mill (mixers), and an ultrasonic disruptor with a SONOTRODE were usually employed; here the SONICATOR used, that is a high frequency ultrasonic waves were applied to disperse the nano-particles in the base fluid and thereby achieving Brownian motion in it. The purpose of SONICATORS includes the particle size reduction, dispersing and de-agglomerating.

(a)

(b)

(c)



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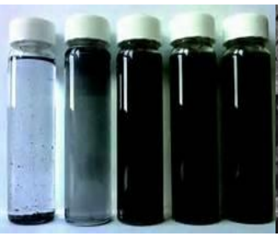

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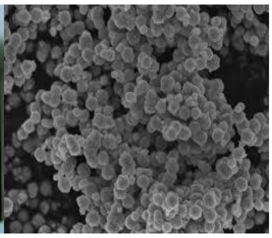

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Figure 1 (a) Al2O3 Nano-Powder (b) THERMIA-B heat transfer oil (c) SONICATOR (d) Brownian motion visualisation (e) nano-fluid Samples (f) Al2O3 Spherical Nano-particle under SEM: 30-50nm (g) Heater (f) thermometer (i) Test –Rig

Table 1 Properties of THERMIA-B heat transfer oil (Left), Aluminum Oxide (Right)

S.No.	Description	Specification
	Density at 15OC	0.868 Kg/l
2	Flash Point	220 ^{O}C
3	Fire point	255 ^{O}C
4	pour point	-12 ^{O}C
5	kinematic viscosity at 0	230 mm^2/s
6	kinematic viscosity at 40	25 mm^2/s
7	kinematic viscosity at 100	4.7 mm^2/s
8	kinematic viscosity at 200	1.2 mm^2/s
9	Initial Boiling Point	>355 ^{O}C
10	Auto ignition Temperature	360 ^{O}C
11	Water content	<0.1%m/m
12	co efficient of Expansion	.0008 l/^{O}C

S.No.	Property	Specification
1	Thermal conductivity (KS)W/mK	40
2	Density (ρp)kg/m3	3970
3	Specific heat (CP) J/kg K	765

2.2 Test RIG

The apparatus consists of a pipe which is shown in Figure 1 (i). It can hold up to 3 litres of fluid. The heater is flanged at one end with the thermostat. The dial micrometer is attached to the other end of the tank and it is made sure that stem of the thermometer does not touches the heater or tank. The heater of 230V/AC / single phase/2kW is fitted in the RIG to generate heat electrically. The thermostat is also fixed to regulate and maintain the temperature of the fluid. A digital thermometer provided with the Range of -50 to +70 A deg Celsius and the temperature display resolution 0.1, for indicating the temperature of the fluid.

2.3 Experimentation

There are four kind of fluids considered they are: THERMIA-B heat transfer oil, nano-fluid of 99% of vol. of THERMIA-B heat transfer oil and remaining 1% of Alumina (NF1), nano-fluid of 98% of vol. of THERMIA-B heat transfer oil and 2% of Alumina (NF2) and nano-fluid of 97% of vol. of THERMIA-B heat transfer oil and 3% of Alumina (NF3), the test procedure is fill the tank with fluid to be tested, then heat added by the heater uniformly to the nano-fluid and observe the time consumed to reach specified temperature. The concept behind this is the measure of the thermal conductivity by response to the heat transfer. If the thermal conductivity is more the fluid reach the specified temperature short period of time vice versa. The observations are presented in the Table 3

Table 3 Experimental observation of Heat transfer time in seconds

Temperature	THERMIA-B heat transfer oil	NF1	NF2	NF3
30	0	0	0	0
50	96	79	64	45
55	108	91	78	62
60	115	102	87	71
65	122	109	94	79
70	132	119	106	94
75	142	128	115	102
80	150	134	121	105
85	162	146	129	111
90	176	158	137	118

95	185	162	144	122
100	195	173	156	133

3. Results and Discussions

The each fluid filled the test rig and tested three to four times and the average value of them were recorded and presented in the table 1. The Figure 2 shows the trend of the time taken by the base fluid and the nano fluids. The trend followed by each fluid is similar and proportionate from the room temperature to the 100^{O}C. The figure 3 indicates the individual comparison at each stage of measurement. There is a linear variation of the thermal conductivity. In other words the increase of volumetric concentration of Alumina in the thermiya b base fluid increases. The test conducted at static phase. In case of dynamic the performance of fluid will be superior.

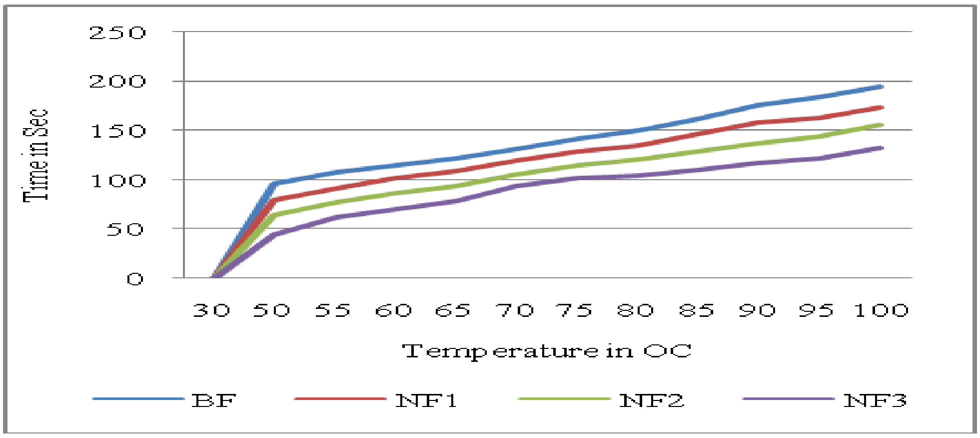

Figure 2: Trend of Time taken by Fluids

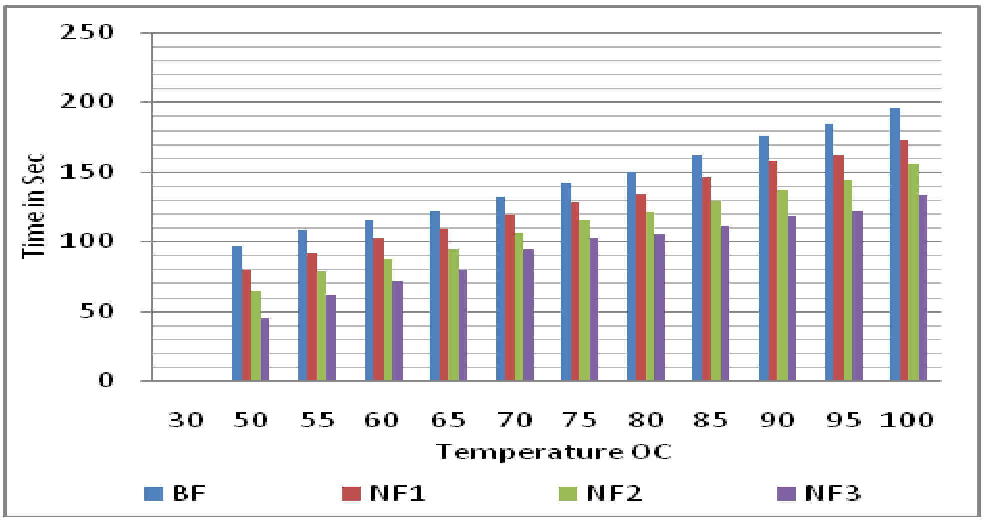

Figure 3 Comparison of fluids thermal conductivity performance

4. Conclusion

Experiment concluded that the addition of nano-particle to the base fluid alters the heat transfer coefficient and other physical properties such as density, viscosity. Here it is found that the time taken to absorb the heat was less for the nano-fluid when compared to base fluid. Variation in the properties of base fluid will depend upon the volume fraction of nano-particle added, Hence by using nano-particle the efficiency of heat transfer fluid used in the industry can be increased.

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