Thermal Analysis of Shell and Tube Heat Exchanger using Titanium Carbide, Titanium Nitride and Zink Oxide Nanofluids

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Abstract: Now a day's Heat exchangers are the most commonly used equipment in many process industries. Heat exchangers are used to transfer heat between two process streams. One can realize their usage that any process which involve cooling, heating, condensation, boiling or evaporation will require a heat exchanger for these purpose. Process fluids, usually are heated or cooled before the process or undergo a phase change. In this research paper, analytical investigations are done on the shell and tube heat exchanger, using forced convective heat transfer to determine flow characteristics of nanofluids by varying volume fractions and mixed with water, the nanofluids are Titanium Carbide, Titanium Nitride and Zinc Oxide nanofluids and different volume concentrations (0.02,0.04,0.07 and 0.15)% with base fluid under turbulent conditions. Thermal analysis is done on the heat exchanger by applying the properties of the nanofluid with different volume fractions to obtain results of maximum temperature and heat flux. 3D model of the heat exchanger will be done in Pro/Engineer and analysis will be performed in Ansys. Here we are chosen materials for shell and tube heat exchanger are Aluminum and Copper.

Key Words: *Titanium Carbide, Titanium Nitride, Zinc Oxide, Thermal Analysis, Nanofluid. etc*

I. INTRODUCTION

Heat exchanger is nothing but a device which transfers the energy from a hot fluid medium to a cold fluid medium with maximum rate, minimum investment and low running costs. Heat exchanger using nano fluid is a device in which the heat transfer takes place by using nano fluid. In this the working fluid is nano fluid. Nano fluid is made by the suspending nano particles in the fluid like water, ethylene glycol and oil, hydrocarbons, fluorocarbons etc.

A. Shell And Tube Heat Exchanger

A shell and tube heat exchanger is a class of heat exchanger designs. It is the most common type of heat exchanger in oil refineries and other large chemical processes, and is suited for higher-pressure and higher-temperature applications. As its name implies, this type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids. The set of tubes is called a tube bundle, and may be composed by several types of tubes: plain, longitudinally finned, etc

B. Nano Fluid

Nano fluids are dilute liquid suspended nano particles which have only one critical dimension smaller than ~100nm. Much research work has been made in the past decade to this new type of material because of its high rated properties and behavior associated with heat transfer The thermal behavior of nano fluids could provide a basis for an huge innovation for heat transfer, which is a major importance to number of industrial sectors including transportation, power generation, micro manufacturing, thermal therapy for cancer treatment, chemical and metallurgical sectors, as well as heating, cooling, ventilation and air-conditioning. Nano fluids are also important for the production of nano structured materials, for the engineering of complex fluids, as well as for cleaning oil from surfaces due to their excellent wetting and spreading behavior

TABLE 1: TITANIUM CARBIDE NANO FLUID PROPERTIES

Volume Fraction	Thermal Conductivity (W/m-K)	Specific Heat (J/Kg-K)	Density (Kg/m^3)	Viscosity (Poise)
0.02	0.644	988.314	1076.836	1.05315×10^{-3}
0.04	0.7006	1003.4207	1155.472	1.10033×10^{-3}
0.07	0.7838	1013.0708	1273.426	1.178525×10^{-3}
0.15	1.04597	1098.8511	1587.97	1.379125×10^{-3}

TABLE 2: TITANIUM NITRIDE NANO FLUID PROPERTIES

Volume Fraction	Thermal Conductivity (W/m-K)	Specific Heat (J/Kg-K)	Density (Kg/m^3)	Viscosity (Poise)
0.02	**0.6447**	**3835.55316**	**1083.036**	**1.05315×10^{-3}**
0.04	**0.69182**	**3539.4391**	**1167.872**	**1.10033×10^{-3}**
0.07	**0.7671**	**3168.005**	**1325.072**	**1.178525×10^{-3}**
0.15	**1.00057**	**2460.2749**	**1744.272**	**1.379125×10^{-3}**

TABLE 3: ZINC OXIDE NANO FLUID PROPERTIES

Volume Fraction	Thermal Conductivity (W/m-K)	Specific Heat (J/Kg-K)	Density (Kg/m³)	Viscosity (Poise)
0.02	25.32	3798.58	1091.736	1.05315×10^{-3}
0.04	27.52	3475.68	2175.27	1.10033×10^{-3}
0.07	31.868	3076.77	1325.576	1.178525×10^{-3}
0.15	54.091	2334.98	2550.97	1.379125×10^{-3}

II. LITERATURE REVIEW

Brief review of the work carried by various researchers on shell and tube heat exchangers by using various nano fluids is presented following. Prof. Alpesh Mehta et al. [1] have studied the improvement in performance of STHE with Using of Nanofluids. Jaafar Albadr et al. [2] have reported an experimental study on the forced convective heat transfer and flow characteristics of a nanofluid consisting of water and different volume concentrations of Al2O3 nanofluid (0.3–2)% flowing in a horizontal shell and tube heat exchanger counter flow under turbulent flow conditions are investigated. S.Gh. Etemad et al. [3] have reported that the heat transfer characteristics of nanofluid enhance significantly with increasing higher overall heat transfer coefficient, convective heat transfer coefficient and Nusselt number respectively.

A. Research Gap & Problem Description

In the thesis, the shell and tube heat exchanger is taken in the water with various temperatures. In this thesis, along with water, Titanium carbide, Titanium Nitride, Zinc Oxide nanofluid at different volume fractions (0.02, 0.04, 0.07 and 0.15) of the shell and tube heat exchanger is analyzed for heat transfer properties, temperature, pressure, velocity and mass flow rates in thermal analysis, two materials Copper and Aluminum are considered for heat exchanger. Modeling is done in Pro/Engineer,

Table 4: Geometric dimensions of shell and tube heat exchanger

Heat exchanger length, *L*	600mm
Shell inner diameter, *Di*	90mm
Tube outer diameter, do	20mm
Tube bundle geometry and pitch Triangular	30mm
Number of tubes, *Nt*	7
Number of baffles, *Nb*	6
Central baffle spacing, *B*	86mm
Baffle inclination angle, θ	0 to 40⁰

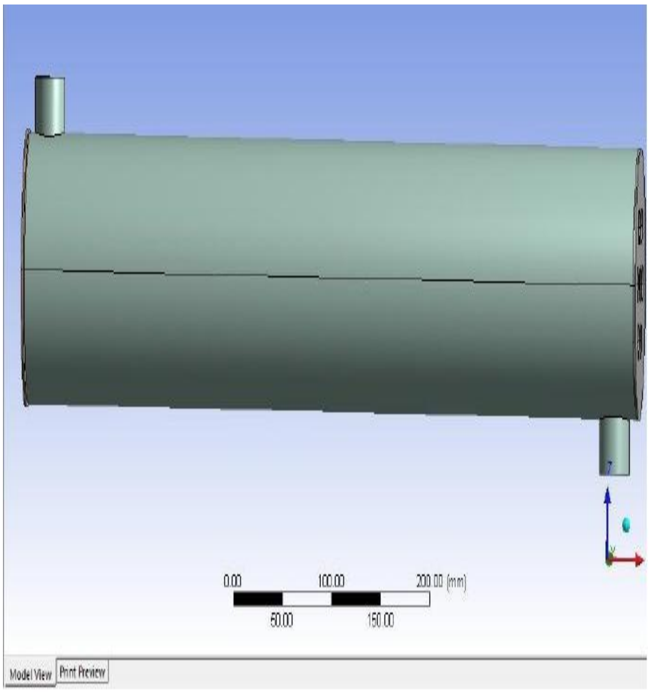

Fig. 1 Shell and Tube heat Exchanger 3D model

III. THERMAL ANALYSIS OF SHELL AND TUBE HEAT EXCHANGER

Here we have done Thermal analysis as followed by below fig 3.1 showing flow chart. This shows that different nano fluids with various volume fractions are used to obtain the results are Temperature distribution, Heat flux.

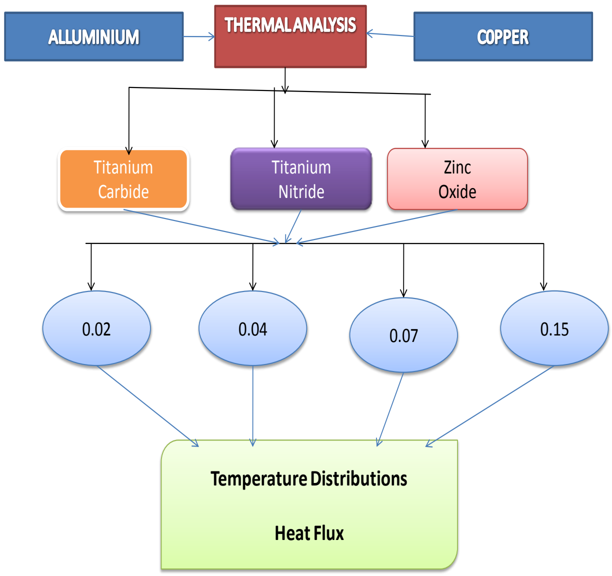

Fig 2 Thermal analysis flow chart

A. Heat Flux Values For Aluminium STHE

The effect temperature distribution and Heat flux in shell and tube heat exchangers is observed in CFD analysis by using Ti C, Ti N and Zn O with volume fractions of 0.02, 0.04, 0.07 and 0.15 are shown in below.

a. Heat Flux Values For Aluminum STHE Using Ti C

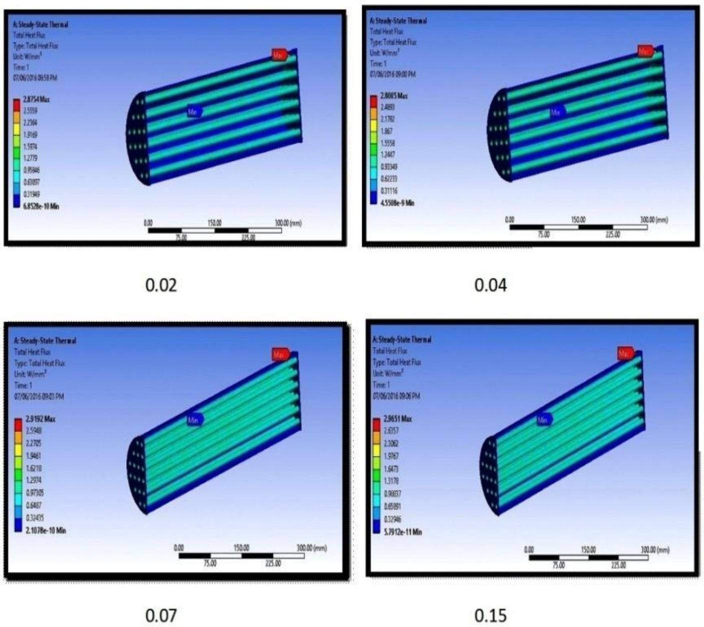

Fig. 3 Heat flux values of Titanium Carbide at various volume fractions for Aluminum STHE

b. *Heat Flux Values for Aluminum STHE using Ti N*

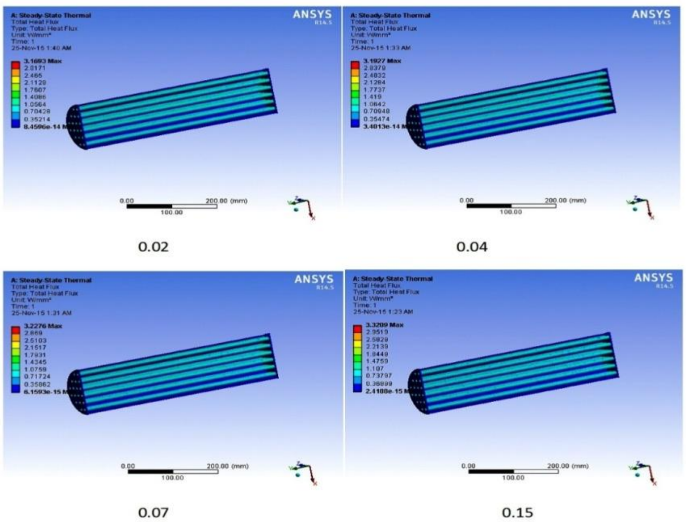

Fig. 4 Heat flux values of Titanium Nitride at various volume fractions for Aluminum STHE

c. *Heat Flux Values for Aluminum STHE using Zn O*

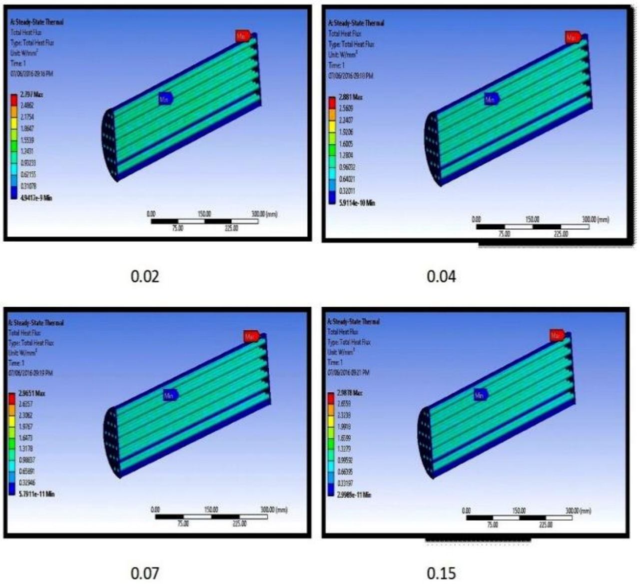

Fig. 5 Heat flux values of Zinc oxide at various volume fractions for Aluminum STHE

B. Heat Flux Values For Copper STHE

a. *Heat Flux Values for Copper STHE Using Ti C*

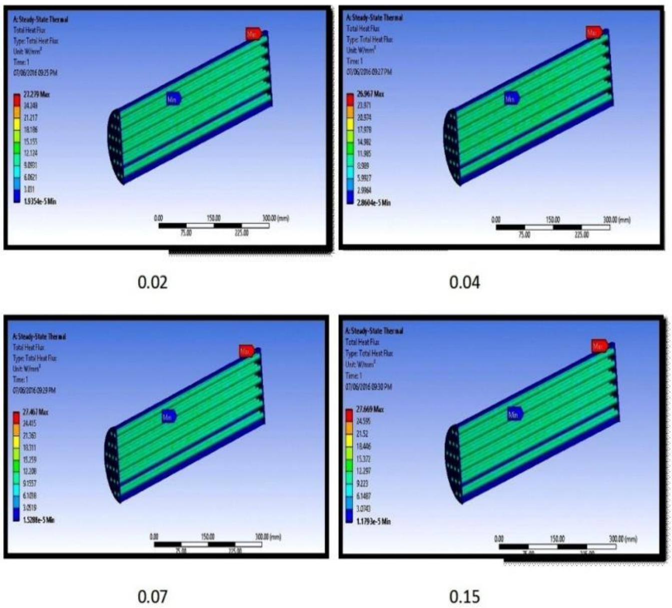

Fig. 6 Heat flux values of Titanium Carbide at various volume fractions for Copper STHE

b. Heat Flux Values for Copper STHE Using Ti N

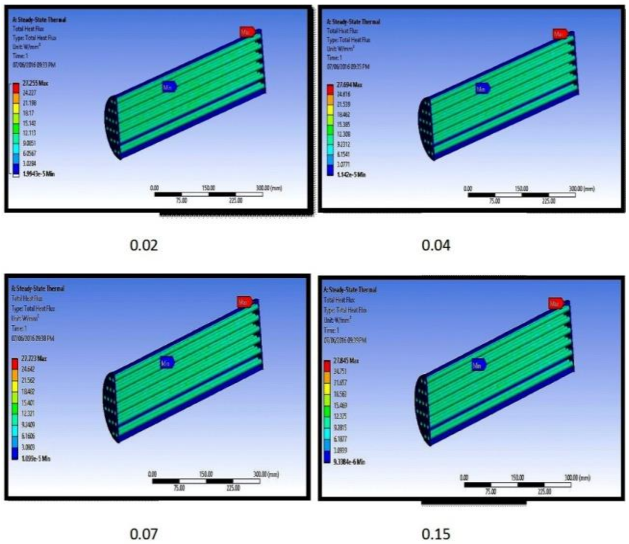

Fig. 7 Heat flux values of Titanium Nitride at various volume fractions for Copper STHE

c. Heat Flux Values for Copper STHE Using Zn O

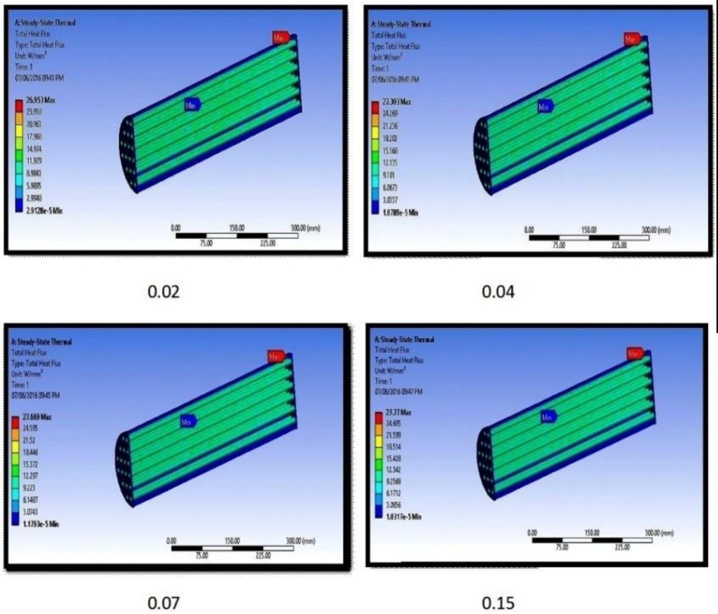

Fig. 8 Heat flux values of Zinc oxide at various volume fractions for Copper STHE

IV. RESULTS AND DISCUSSIONS

In this thermal analysis we have used Titanium Carbide, Titanium Nitride and Zinc oxide nanofluids with varying volume fractions of 0.02, 0.04, 0.07 and 0.15 with base fluid water. But here we have used aluminum and copper materials for shell and tube heat exchanger. Thermal analysis is done both aluminum and copper heat exchangers. We are going to analysis heat flux and maximum temperature. After the analysis we are deciding that the maximum heat flux is achieved in 0.15 volume fraction where using Titanium Nitride. And also we have observed that flux is gradually increases when increasing the volume fractions of nano fluids during Thermal Analysis

Type of Nano Fluid	Volume Fraction	Aluminium			Copper		
		Max Temp (K)	Min Temp (K)	Heat Flux (W/mm²)	Max Temp (K)	Min Temp (K)	Heat Flux (W/mm²)
Ti C	0.02	353.15	295.15	2.8754	353.15	295.94	27.279
	0.04	353.15	295.15	2.8005	353.15	296.69	26.967
	0.07	353.15	295.15	2.9192	353.15	295.67	27.467
	1.15	353.15	295.15	2.9651	353.15	295.49	27.669
Ti N	0.02	353.15	295.15	2.8697	353.15	295.98	27.255
	0.04	353.15	295.15	2.9706	353.15	295.47	27.694
	0.07	353.15	295.15	2.9711	353.15	295.45	27.723
	1.15	353.15	295.15	3.0042	353.15	295.38	27.845
Zn O	0.02	353.15	295.15	2.797	353.15	296.74	26.953
	0.04	353.15	295.15	2.881	353.15	295.9	27.301
	0.07	353.15	295.15	2.965	353.15	295.49	27.669
	1.15	353.15	295.15	2.987	353.15	295.42	27.777

TABLE. 5: THERMAL ANALYSIS RESULTS

The table 5 is extracted from thermal analysis results for shell and tube heat exchanger. In thermal Analysis results are clearly indicating that the Titanium Nitride nano fluid is better in heat flux at volume fraction of 0.15 in both aluminum and copper materials comparing to titanium carbide and Zinc oxide nanofluids. Because of titanium nitride nanofluids consist of better thermal properties like thermal conductivity, specific heat is more than titanium carbide and zinc oxide. In which copper material gives more heat flux compared to aluminum material. Because of copper material consist of high thermal properties than aluminum. Fig.6.4 shows that Comparison of Total Heat transfer rate between three nano fluids at different volume fractions and same way Fig 6.5 shows for copper material respectively.

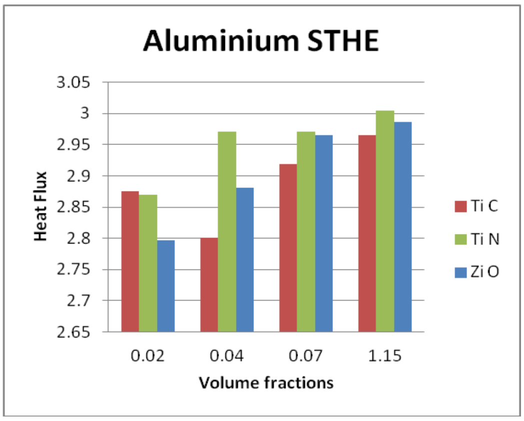

Fig. 9 Comparison of Heat flux between three nano fluids at different volume fractions for Aluminum STHE

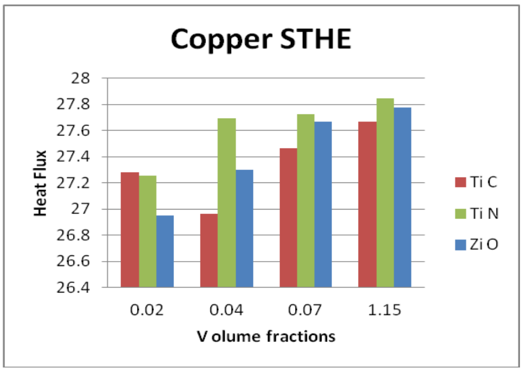

Fig. 10 Comparison of Heat flux between three nano fluids at different volume fractions for Copper STHE

V. CONCLUSION

In this paper, analytical investigations are done on the shell and tube heat exchanger, using forced convective heat transfer to determine flow characteristics of nanofluids by varying volume fractions and mixed with water, the nanofluids are Zinc Oxide, Titanium Carbide and Titanium Nitride nanofluids and different volume concentrations (0.02,0.04,0.07and 0.15)% flowing under turbulent flow conditions. Thermal analysis is done on the heat exchanger and the materials considered for shell and tube heat exchanger are Aluminum and Copper. By observing the results, the heat flux values are increasing by increasing the volume fractions. The values are more when Titanium Nitride is used than other two fluids. When the material Copper is used, heat flux is more. So heat transfer rate is more.

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