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SIMULATION ANALYSIS OF SHELL AND TUBE HEAT EXCHANGER USING DIFFERENT FLUIDS

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Abstract - There are many models to characterize the behavior of the heat exchangers encountered in many industries. There are several correlations available, so that the heat transferred and the thermal stresses can be evaluated. Shell and Tube heat exchangers are having special importance in boilers, oil coolers, condensers, and pre -heaters. They are also widely used in process applications as well as the refrigeration and air conditioning industry. The robustness and medium weighted shape of Shell and Tube heat exchangers make them well suited for high pressure operations.

The present work deals with the design and analysis of water-cooled shell and tube condenser and we have shown how to done the thermal analysis by using theoretical formula, for this we have chosen an industrial problem of 8 ton capacity of counter flow shell and tube heat exchanger of water type. The condenser is designed using theoretical procedures. The condenser is modeled by using the dimensions obtained from the design procedures. Then thermal analysis is carried out in SOLIDWORK flow simulation. The results obtained through the analysis are discussed in detail and compared with analytic values.

.***Key Words***: Heat exchanger, Perforated rings, Reynolds number, Overall heat transfer coefficient.

1.INTRODUCTION

Heat Transfer Mechanisms:

Water-cooled shell & tube condenser is an important component of the refrigeration and air-conditioning systems. The condenser removes the heat from refrigerant carried from evaporator and added by compressor and convert the vapor into liquid refrigerant. It is a heat exchanger in which heat transfer takes place from high temperature vapor refrigerant to low temperature water, which is used as cooling medium. These condensers are always preferred where adequate supply of clean and inexpensive means of water disposal are available.

Shell & tube condensers are those in which heat transfer occurs between two fluid streams, which do not mix or physically contact each other. The fluids so involved are separated from one another by a tube as well as wall, which may be involved in the heat transfer path. Heat transfer will thus occur by convection from the hot fluid surface, by conduction through the solid and again by convection from the solid surface to the cooler fluid.

Conduction:

Conduction is the transfer of energy from the more energetic particles of a substance to the adjacent less energetic ones as a result of interactions between the particles. Conduction can take place in solids, liquids, or gases. In gases and liquids, conduction is due to the collisions and diffusion of the molecules during their random motion. In solids, it is due to the combination of vibrations of the molecules in a lattice and the energy transport by free electrons. A cold canned drink in a warm room, for example, eventually warms up to the room temperature as a result of heat transfer from the room to the drink through the aluminium can by conduction.

CALORIMETER DESCRIPTION

The secondary system calorimeter has the useful compressor capacity measurement range of 1750 Watt (6000Btuh) to 7320 Watts (25000 Btuh). The calorimeter is capable of conducting various tests for the air-conditioning and heat pump compressors.

General arrangement of the equipment is as follows:

a) The insulated Compressor Chamber and the Insulated Secondary Pot Chamber are mounted side by side. Each chamber has the Heating-Cooling Arrangement mounted at the bottom. The arrangement consists of a Centrifugal Blower, a Cooling Coil and Heaters.

b) The Insulated Secondary Evaporator Pot is located inside the pot chamber.

c) The **Insulated Return Gas Control pot** is located on the backside of the.

Heat transfer coefficient:

The heat transfer coefficient or film coefficient, or film coeffectiveness in thermodynamics and in mechanics is the proportionality constant between the heat flux and the thermodynamic driving force for the flow of heat (i.e., the temperature difference, T):

The overall heat transfer rate for combined modes is usually expressed in terms of an overall conductance or heat transfer coefficient, U. In that case, the heat transfer rate is:

$$\dot{Q} = hA(T_2 - T_1)$$

2. Methodology

Many types of condensers have been developed to meet the widely varying applications. " Shell & Tube" arrangements are often used, where heat transfer effectiveness and reliability are important. The present industrial services require water-cooled shell & tube condenser, as the quantity of heat to be transferred is large. These condensers occupy considerable ground area.

2.1 Copper :

As a metal, copper is ductile and malleable and valued for its high thermal and electric conductivity. Copper occurs naturally but its greatest source is in minerals like chalcopyrite and bornite, and you can easily identify it by its reddish- gold colour.

2.4 Experimental set up :

a) **DESIGN OF WATER-COOLED SHELL AND TUBE CONDENSER**

b) **Known Parameters: -**

Refrigerant Capacity : 2 Ton

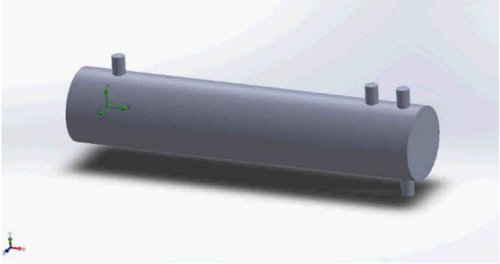
fluid Used : 1%AL203+99%WATER
Condensing Temperature : 55°C
Inlet temperature of water, t_{wi} : 30°C
Outlet temperature of water, t_{wo} : 46.8°C
Temperature rise of water, Δt_w : 16.8°C

Water tube outer diameter, d_{wo} : 8 mm
Water tube inner diameter, d_{wi} : 6 mm

Design & Ansys simulation

2.8 Design

The Catia software is open the part design to be designing copper tube and nozzle. A copper tube with geometry is first drawn in the catia software. Then a conical nozzle with required dimension is first drawn and then perforated hole is provided



shell and tube heat exchanger

3.Observation and result

3.1 Observations

Al2O3-1		
Pressure [Pa]	Velocity [m/s]	Temperature (Fluid) [K]
101325.5558	0.019949847	328
101325.0015	0.023509442	319.8145848
101374.0488	0.011092198	305
101325.0044	0.01329332	322.5914792

Table:6.1 AL203 1%+99% water readings

Al2O3-2		
Pressure [Pa]	Velocity [m/s]	Temperature (Fluid) [K]
101325.5553	0.019949847	328
101325.0047	0.013258371	323.0068923
101376.3634	0.01104978	305
101325.0021	0.023519898	320.4278744

Table: 6.2 AL203 2%+98% water readings

SiO2-1		
Pressure [Pa]	Velocity [m/s]	Temperature (Fluid) [K]
101325.558	0.019949847	328
101325.0025	0.02355719	317.937088
101372.4453	0.011383896	305
101325.0045	0.013645461	320.759435

Table: 6.3 si02 1%+99% water readings

SiO2-2		
Pressure [Pa]	Velocity [m/s]	Temperature (Fluid) [K]
101325.5571	0.019949847	328
101325.0021	0.023398994	317.9352704
101372.9936	0.011243259	305
101325.0046	0.013477976	320.7845438

Table: 6.4 si02 2%+98% water readings

3.3 Results from Ansys :

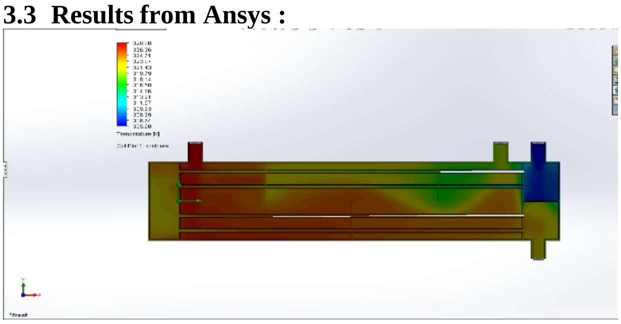
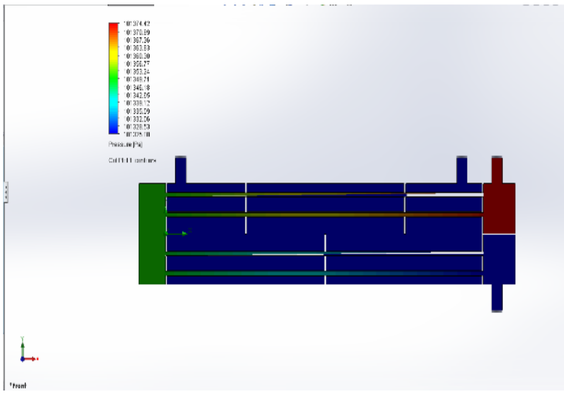
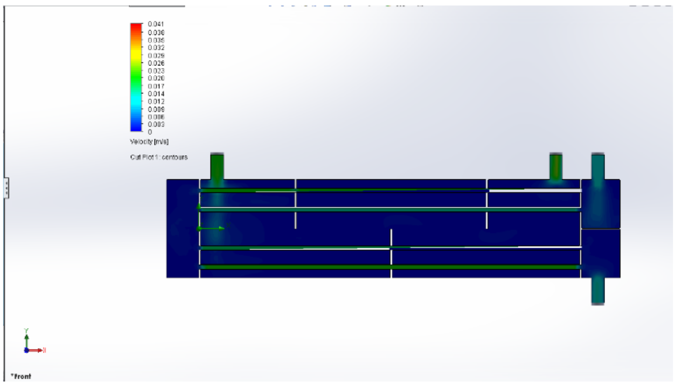


Fig -3.1 Ansys simulation for velocity with four nozzles



Pressure distribution in shell and tube



Velocity distribution of shell and tube

4. Conclusion & Future Scope

4.1 Conclusion

It is observed that the thermal conductivity of water is not much change with temperature. As we go for higher concentration (0.1 to 0.5%).the thermal conductivity increases but at temperature 54°C drop in conductivity is observed. It is found that the thermal conductivity increases significantly with the nanoparticle volume fraction. With an increase of temperature, the thermal conductivity increases for a certain volume concentration of nanofluids, but the viscosity decreases. The temperature and volume fractions have significant effects on the thermal conductivity and viscosities are investigated. Addition of small amount of alumina nanoparticles transforms the Newtonian behaviour of nanofluid to a non- Newtonian fluid and it behaves as Bingham plastic with small yield stress. Viscosity of nanofluid (Al2O3/water and sio2 and water) is less than base fluid water. Specific heat of nanofluid decreases with the concentration as increases. (1 to 2 %). Density of nanofluid (Al2O3/water and sio2 and water) decreases with temperatures but the density of nanofluid is higher than base fluid's density .The density of nanofluid increases with concentrations.

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