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Performance of Refrigerants using CFD in Heat Exchangers

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Abstract*: *This paper deals with a comparative study of heat exchange rates between the two fundamental stream courses of action like parallel flow and counterflow. Computational fluid dynamics analysis and thermal analysis were conducted on the heat exchanger for different fluids by taking hot water and refrigerants R22, R134A, R600A and various materials. For heat exchangers,. 3D simulations are conducted in Pro-Engineer and ANSYS. Keywords: parallel flow, counter flow, coolant, hot water, Pro- and Ansys engineer

Keywords: Parallel flow, Counter flow, refrigerants, hot water, Pro- Engineer and Ansys.

I. INTRODUCTION

The design of a heat exchanger is fundamentally based on hot and cold fluids and also considered a very crucial area of mechanical engineering. These are used in industries without direct contact for heating and cooling of various substances. They are very important today in houses, offices, shops, shopping malls, vehicles, buses, trailers, aircraft and other means of transport, both for cooling and heating. They are used in units such as paper, oil, and many others.Typically, heat exchangers are categorized by flow arrangement and construction form. Three forms of exchangers used in industrial practice will be included in this introductory procedure. The simplest heat exchanger is one where in a combined tube (or double tube) construction, hot and cold liquids stream in the equivalent or inverse ways. In the parallel flow process, the hot and cold liquids join at the same end, travel in the same direction and exit at the same end. In the counter-flow method, the liquids enter opposite ends, flow opposite to each other and exit at other ends. This exchanger has a shell in pipes and allows the flow to pass through the pipe. Buffles are normally designed for increasing the convection coefficient of the shell side by causing choppiness and expanding cross-flow speed. The cross-flow heat exchanger is built with a stack of thin plates bonded to parallel pipes in series. These act as fins to boost the heat move and keep up traverse the channels. Usually, the gas courses through the surfaces of the blades and cylinders while liquid moves through the cylinder. Such kind of exchangers are utilized for air cooling and heat removal applications.

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II. LITERATURE SURVEY

The design of fluid flow and temperature profiles depends on the fluid properties as well as the wall temperature. This problem of thermal access is well known as the problem of grates[1]. The velocity profile can be designed for any material with prenatal numbers, supplied that the temperature and velocity profiles start at the same point [2]. Poiseuille flow was assumed for the original Grates problem and formula is used to describe the fluid velocity field flowing through constant tubing of the wall temperature.et al [3] Where the Grates problem is expanded, this velocity equation is also used. A constant value of inlet velocity is considered and finite element method is adopted in this paper. This means the adoption and evaluation of a changed Grates problem. During analysis, engine oil was supposed to stream through the inner pipe made of copper and cooled through the outer concentration tube into which water flowed. Surface properties have been obtained such as complex viscosity, thickness, amount of Prandtl and thermal conductivity[4]. Graetz found a solution in the form of an infinite series that filled the Sturm-Louisville system with its own values and functions. While only the the first two terms were established by Graetz himself, Sellars, Tribus and Klein were able to extend the challenge and decide the first ten eigenvalues. et al [5] . While this further developed the original solution, the series solution had extremely poor convergence at the entrance of the tubing, where up to 121 terms would cause the arrangement to combine Schmidt and Zeldin et al [6] Extended the Graetz to incorporate hub heat conduction issue for high Peclet numbers (Reynolds number multiplied by the Prandtl number).Hwang et al estimated pressure drop and warmth move coefficient in completely created laminar channel stream utilizing consistent HEAT FLUX conditions. In view of the trial results they indicated that the exploratory rubbing factor was in acceptable concurrence with the hypothetical forecasts utilizing the Darcy condition. Bianco et al watched just a limit of 11% distinction among single and two-stage results for the laminar system. Akbari et al Two separate two-phase models and a single-phase model were compared for the first time in the laminar regime and it has been found to predict similar but very different thermal hydrodynamic fields.

In Bejan, "Convective heat transfer coefficient," 1994, the equation characterizing the speed dispersion in a channel stream by means of violent stream is determined and outlined.

III. METHODOLOGY:

The approach explains the step-by-step phase of this analysis. Computational fluid dynamics analysis and thermal analysis were conducted on the heat exchanger for different fluids by taking hot water and refrigerants R22, R134A, R600A and various materials.analyzing the Pressure, velocity, temperature ,heat transfer coefficient.

Process based on the following methodology.

1.Heat Exchanger Analysis

2.Fluid Properties

3.CFD Analysis

a) Pressure,
b) velocity
c) Temperature
d) heat transfer coefficient

4.Thermal Analysis

a) Temperature of heat exchanger with fluid R22 and material aluminum
b) Heat flux of heat exchanger with fluid R22 and material aluminum

IV. HEAT EXCHANGER ANALYSIS

After the inlet length Le, the viscosity value reaches the core of the pipe, hydrodynamically developed flow is achieved in a pipe. The velocity assumes at this point a certain average pipe profile that is not influenced by edge effects resulting through the entry side. True fluid movement has viscous effects in the tube discharge. An overview over all the experimental works show that the most of the experiments related to the forced convective heat transfer in pipe flow are conducted under constant boundary conditions of wall flux. In this paper, a comprehensive computational fluid dynamic analysis is carried out at constant wall temperature. The boundary condition takes the one-phase approach in a turbulent regime and the findings are contrasted with the results reported in the literature.

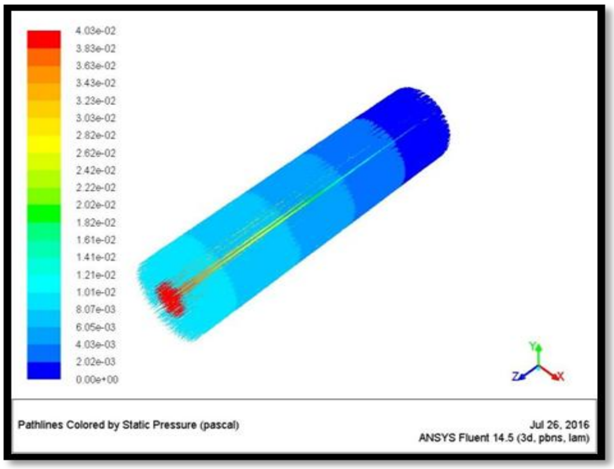
V. TABLE: 1 FLUID PROPERTIES

Fluid	Density (Kg/m3)	Thermal conductivity (W/m-K)	Specific heat (KJ/Kg-K)	Viscosity (Kg/m-s)
R22 (at 00 C)	1.282	0.095	0.67	218.22 x 10-6
R134 (at 00 C)	1.2987	0.092	0.88	271.08 x 10-6
R600A (at 0˚C)	0.5813	0.107	0.163	199.02 x 10-6
Hot water (at 320 C)	995.074	0.62	4.178	765 x 10-6

VI. CFD ANALYSIS

To evaluate temperature, coefficient of heat transfer and speed of heat transfer, the CFD analysis is performed on parallel flow and counterflow heat exchangers with hot water and various refrigerants R22, R134 and R600A

Pressure



Velocity

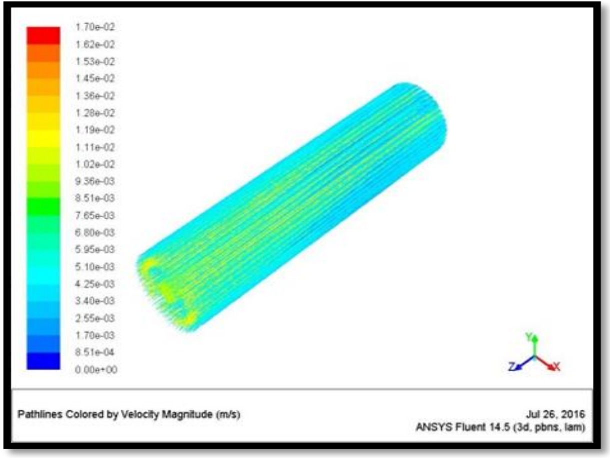
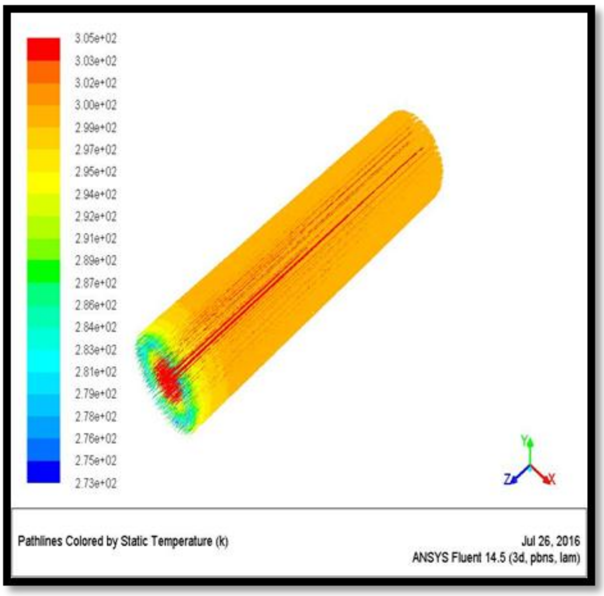


Fig.1.Pressure and velocity of Heat exchanger with hot water and refrigerant R22.

Temperature



Heat transfer coefficient

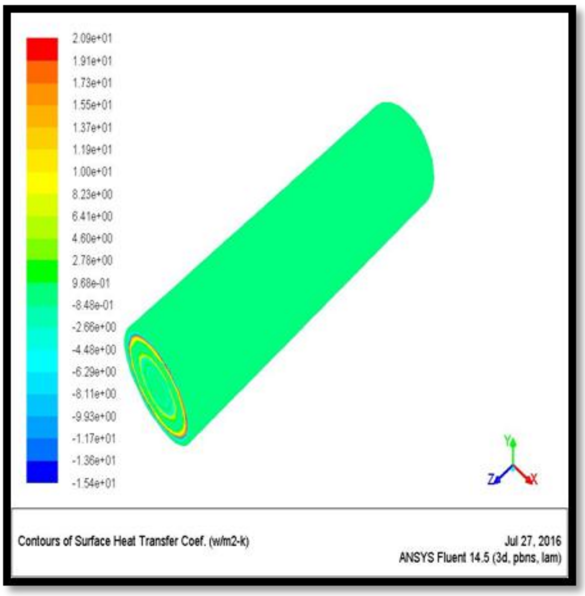


Fig 2.Temperature and heat transfer coefficient of heat exchanger with hot water and R22 refrigerant.

Table 2: Boundary conditions co- current flow - with hot water and R22 refrigerent

Inlet temperature(T)	273 K
Inlet pressure(P)	101325 Pa
Inlet velocity(V)	0.01 m/s

VII. THERMAL ANALYSIS

Thermal analysis is conducted on co-current and countercurrent flow heat exchangers, taking into account heat transfer coefficients from CFD testing by adjusting the aluminum and copper materials on Co- current flow fluid R22.

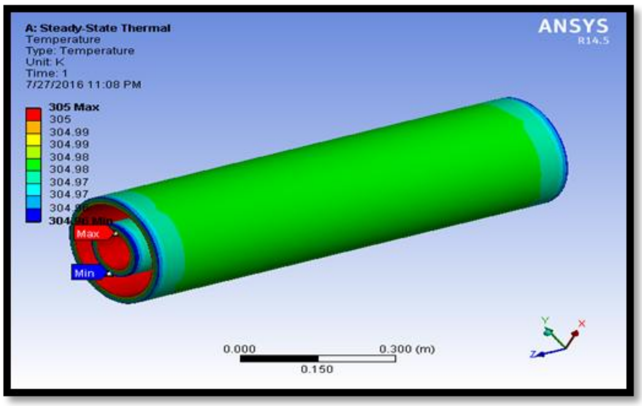


Fig.3. Temperature of heat exchanger with fluid R22 and material aluminum.

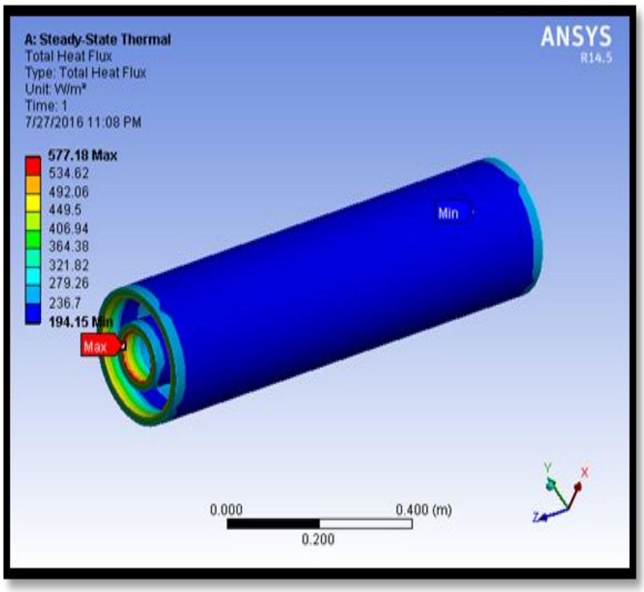


Fig.4. Heat flux of heat exchanger with fluid R22 and material aluminum.

Table 3: Boundary Conditions: Convection (W/m^2-K)

Co-Current Flow			Counter-Current flow		
R22	**R134a**	**R600a**	**R22**	**R134a**	**R600a**
20.9	**22.9**	**27.3**	**21.3**	**23.2**	**28.1**

Table 4: Material Properties of the heat exchangers

Property	Aluminum	copper
Thermal conductivity	**203.2 W/m-K**	**387.6 W/m-K**
Density	**2719 Kg/m3**	**8978 Kg/m3**
Specific heat	**871 J/Kg K**	**381 J/Kg K**

VIII. RESULTS & DISCUSSIONS

CFD Analysis

Hot Water with Refrigerants

In this CFD analysis, the heat transfer rate was found by using the different flow arrangements co-current flow and counter-current flow.

Table 5: Co-Current Flow

Refrigerants	Pressure (Pa)	Velocity (m/s)	H.T.Co (W/m2 K)	Heat transfer rate (w)	Mass flow rate(kg/s)
R22	**0.04**	**0.017**	**20.9**	**0.406**	**3.17E-06**
R134A	**0.03**	**0.0173**	**22.9**	**0.5**	**1.24E-06**
R600A	**0.053**	**0.0184**	**27.32**	**0.66**	**5.45E-07**

Table 6: Counter-Current Flow

Refrigerants	Pressure (Pa)	Velocity (m/s)	H.T.Co (W/m2 K)	Heat transfer rate (w)	Mass flow rate(kg/s)
R22	**0.0145**	**0.0112**	**21.3**	**0.306**	**9.53E-07**
R134A	**0.0393**	**0.0134**	**23.2**	**0.192**	**9.16E-07**
R600A	**0.0612**	**0.0348**	**28.1**	**0.43**	**1.25E-07**

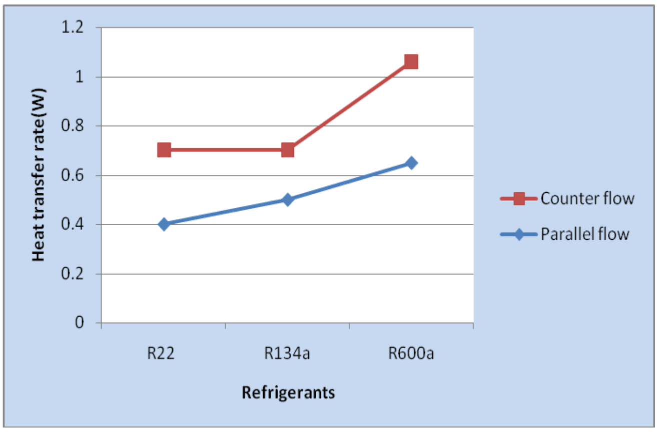


Fig.5.Heat Transfer rate values for different refrigerants

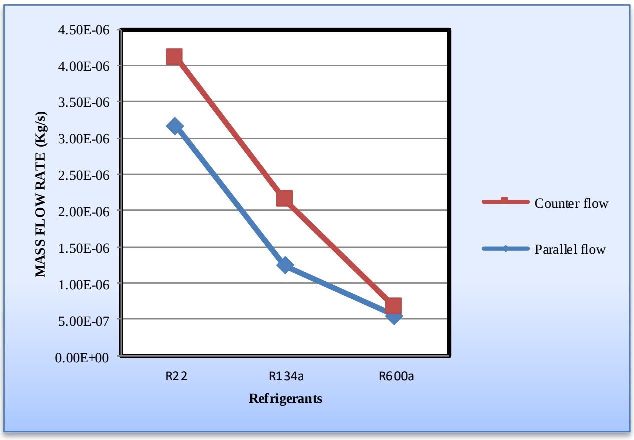


Fig.6.Comparision of mass flow rate values for parallel and counter flow for different refrigerants

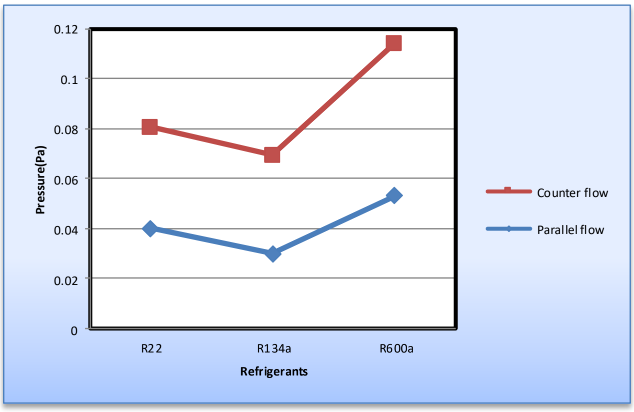


Fig7.Comparision of heat pressure values for parallel and counter flow for different refrigerants

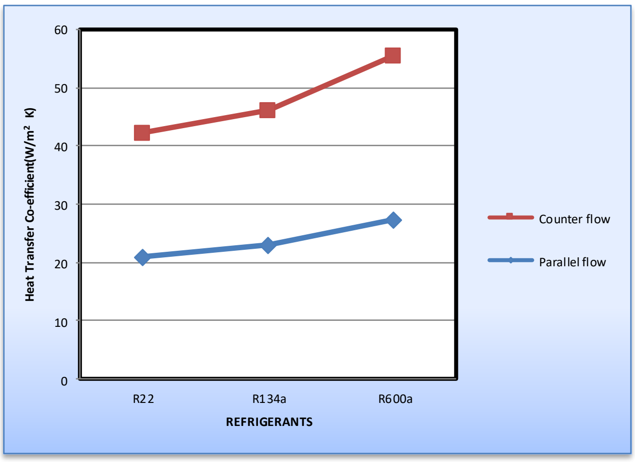


Fig.8.Comparision of coefficient of heat transfer for different refrigerants

Taking into account the effects of the above CFD study, the coefficient of heat transfer is more for counter flow, and the heat transfer frequency is less for counter flow heat exchanger due to more area than parallel flow. By comparing the results between fluids, the heat transfer coefficient and heat transfer frequency are higher for R600A.

Thermal Analysis

In this thermal analysis, the rate of heat transfer in the parallel flow and counter flow and different materials are used, the results are shown in below.

Table 7 Heat Transfer rate for different materials

		PARALLEL FLOW	COUNTER FLOW
Refrigerants	**Materials name**	**Heat flux (W/m2)**	**Heat flux(W/m2)**
R22	**Aluminium**	**577.18**	**588.19**
	Copper	**605.38**	**700.75**
R134A	**Aluminium**	**632.24**	**640.49**
	Copper	**753.31**	**763.16**
R600A	**Aluminium**	**753.81**	**773.87**
	Copper	**790.99**	**922.41**

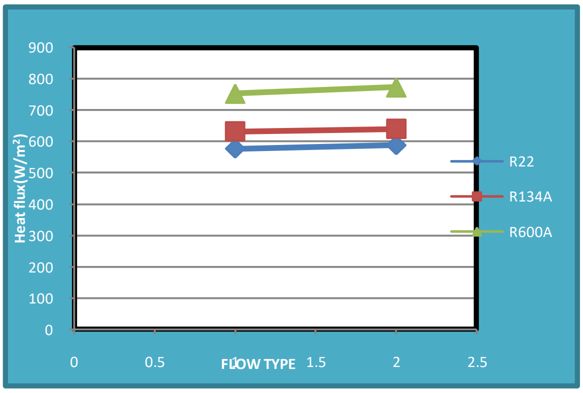


Fig: 9. Comparison of heat flux values for aluminium material and different refrigerants.

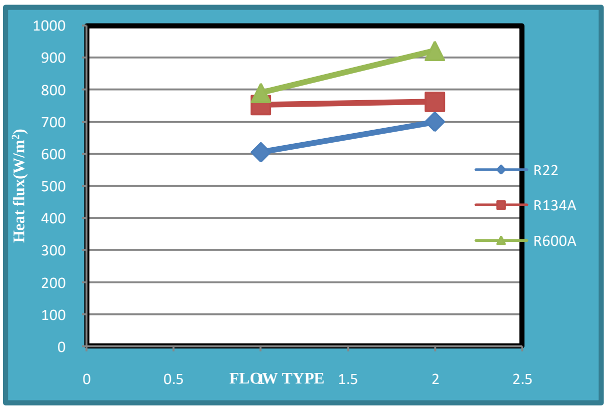


Fig: 10.Comparison of heat flux values for copper material and different refrigerants.

By analyzing the results, it is found that the heat flux is more for counter-stream sort of warmth exchanger when contrasted and equal stream heat exchanger. For copper material, when R600A is utilized as refrigerant, the most extreme warmth transition esteem is gotten for counter stream heat exchanger.

IX. CONCLUSION

The CFD study is performed with two forms of heat exchangers by taking R22, R134A, R600A and hot water as refrigerants. After evaluating the effects of the CFD test, the frequency and coefficient of heat transfer are compared between different liquids. The heat transfer proportion is higher for counter stream and the pace of warmth move is lower for counterflow heat exchangers because of more zone than equal stream.The coefficient of heat transfer and heat transfer frequency is higher for R600A by comparing the results between fluids.

Thermal testing of various liquids, R134A, R22, R600A and various materials Aluminum and Copper is conducted on the heat exchanger. The heat flux is more for a counter stream heat exchanger than for an equal stream heat exchanger by watching the outcomes. If Copper is used as a component material and R600A is used as a refrigerant, the most extreme warmth motion esteem is gotten for counter stream heat exchanger.

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