ANALYSIS OF CONCENTRIC PIPE HEAT EXCHANGER

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Abstract: *There is a wide application of concentric heat exchanger in the field of cryogenics and other industrial applications for its enhanced heat transfer characteristics and compact structure. Lots of researches are going on to improve the heat transfer rate of the concentric pipe heat exchanger. Here, in this work, an analysis has been done for a tube-in-tube concentric heat exchanger with constant heat transfer coefficient. There are various factors present that may affect the heat transfer characteristics of the heat exchanger. Here, the experiment has been done using different fluids. The analysis is done by using ANSYS 15.0 CFD methodology. The graphs have been analysed and discussed to find out the increase in heat transfer for a three-pipe heat exchanger.*

***Keywords*— Concentric heat exchangers , ANSYS R15.0, Meshing, Thermal properties.**

INTRODUCTION

A heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact. In heat exchangers, there are usually no external heat and work interactions. Typical applications involve heating or cooling of a fluid stream of concern and evaporation or condensation of single- or multicomponent fluid streams. In other applications, the objective may be to recover or reject heat, or sterilize, pasteurize, fractionate, distil, concentrate, crystallize, or control process fluid. In a few heat exchangers, the fluids exchanging heat are in direct contact.

Many industrial processes require simultaneous heat exchange between more than two fluids. There are also possibilities for combining several separate two-fluid heat-exchanging operations more economically in a single multi-fluid arrangement. In this study, the performance of three-fluid counter-flow heat exchangers is determined and presented graphically in terms of the temperature effectiveness of two of the fluids referred to the third fluid. The effectiveness is determined as a function of heat-exchanger size for sets of fixed operating conditions. Concentric heat exchangers are widely used, and they are manufactured in many Sizes, flow arrangements, and types. They can accommodate a wide range of operating Pressures and temperatures. The ease of manufacturing and their relatively low cost have been the principal reason for their wide spread use.

1. EXPERIMENTAL SET UP

For the modelling, copper is taken as the material for the pipes. It has good working properties compared to the other materials such as Silver, Cast Iron, Aluminium etc. The ANSYS R15.0 product line covers mechanical and shape design, styling, product synthesis, equipment and systems engineering, NC manufacturing, analysis and simulation, and industrial plant design.

1.1 DIMENSIONS OF MODELLING

1.1.1 For Two-pipe

Length of the tube = 2000mm
Diameter of inner pipe = 20mm

Diameter of outer pipe =60mm
Thickness =2.5mm

1.1.2 For Three-pipe

Length of the tube = 2000mm
Diameter of inner pipe = 20mm
Diameter of middle pipe=40mm
Diameter of outer pipe=60mm
Thickness =2.5mm

2. THERMAL PROPERTIES OF COPPER

Table -1: Thermal properties of the solid.

Thermal conductivity	400 W m^{-1} C^{-1}
Density	8933 kg m^{-3}
Specific Heat	385 J kg^{-1} C^{-1}

3. Modelling of Heat Exchanger

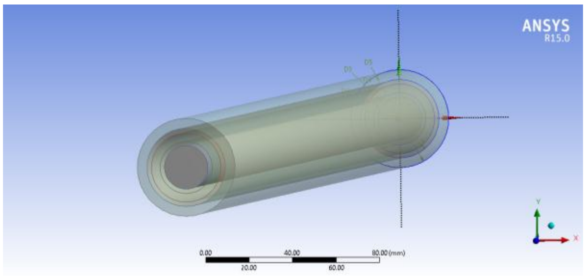

Fig -1: Model of a Concentric Pipe.

4. Meshing of Heat Exchanger

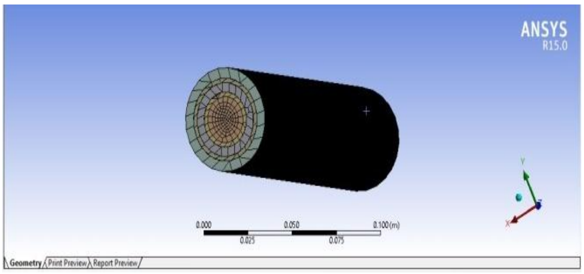

Fig -2: Mesh Section of a Geometry.

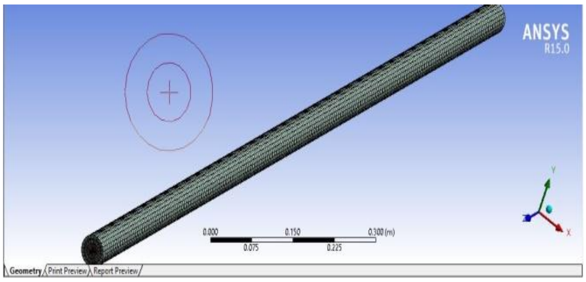

Fig -3: Meshing on the periphery.

5. FLUIDS AND THEIR PROPERTIES

Fluid	Density (kg/m^3)	Specific Heat (j/kg-k)	Thermal Conductivity (w/m-k)	Viscosity (kg/m-s)
Water	998.2	4182	0.6	0.001003
Acetone	791	2160	0.18	0.000331
Methanol	785	2534	0.2022	0.0005495
Mercury	13529	139.3	8.54	0.001523
Ethylene-glycol	1111.4	2415	0.252	0.0157

Table -2: Thermal properties of the fluids

6. HEAT TRANSFER ANALYSIS

The procedure for calculating heat transfer is as follows: -

[1] Select inlet conditions (temperature, flow rate).
[2] Select outlet conditions (temperature, flow rate).
[3] Select material for pipe.

6.1 For Two-pipe

[1] Select cold fluid for outer pipe.
[2] Select hot fluid for inner pipe.
[3] Calculate outlet temperature of cold fluid and hot fluid.

6.2 For Three-pipe

[1] Select cold fluid for outermost and innermost pipe.
[2] Select hot fluid for middle pipe.
[3] Calculate outlet temperature of cold fluid and hot fluid.

RESULTS

The heat transfer analysis for counter flow is done and following results are obtained: -

For Two-pipe

Hot fluid – Water
Cold fluid – Water

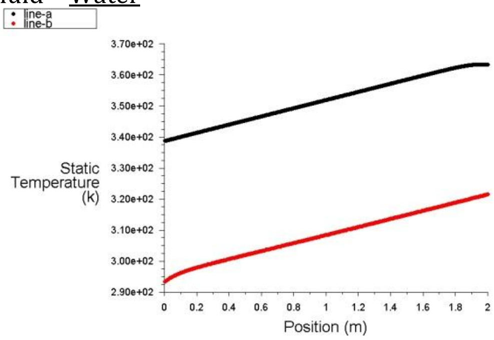

Chart -1: Temperature Graph for Water-Water

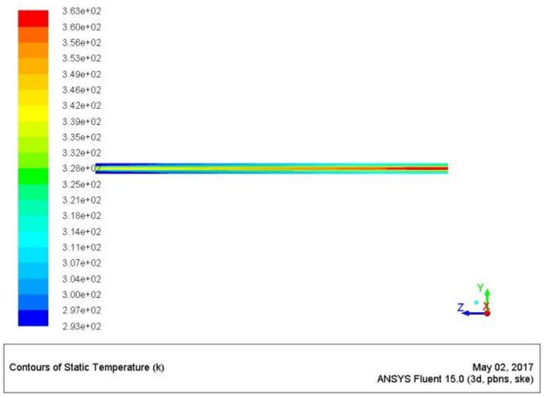

Chart -2: Contours of Static Temperature for Water-Water

RESULT ANALYSIS:- Counter flow heat exchangers are more efficient because they create a more uniform temperature difference between the fluids, over the entire length of the fluid path.
The temperature of water varies uniformly in both the pipes which can be seen from the contour.

For Three-pipe

Hot fluid – <u>Water</u>
Cold fluid – <u>Water</u>

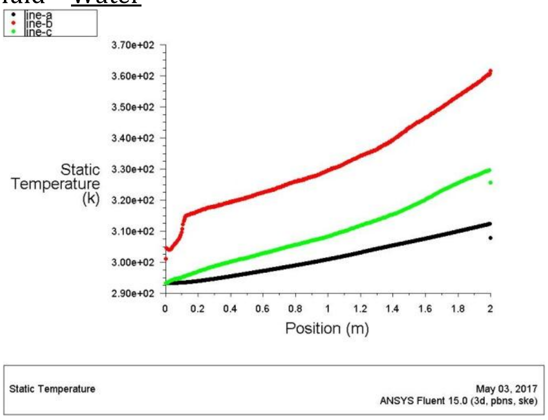

Chart -3: Temperature Graph for Water-Water

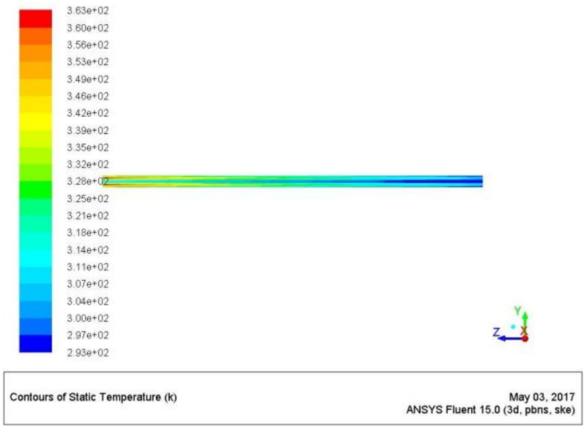

Chart -4: Contours of Static Temperature for Water-Water

RESULT ANALYSIS:- In this case, a lower temperature of water is obtained at hot outlet as compared to two-pipe heat exchanger. This is because now the hot water is surrounded by cold water from two sides which increases heat transfer area

For Two-pipe

Hot fluid – <u>Water</u>
Cold fluid – <u>Acetone</u>

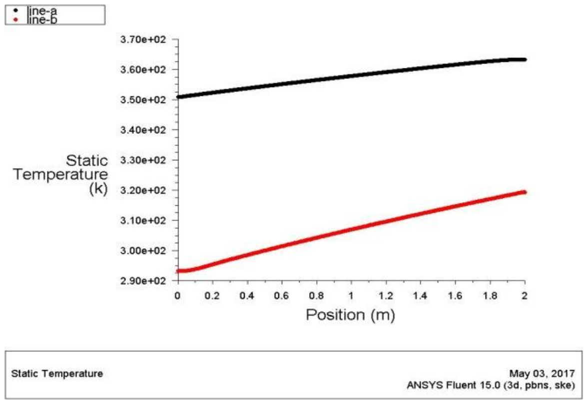

Chart -5: Temperature Graph for Water-Acetone

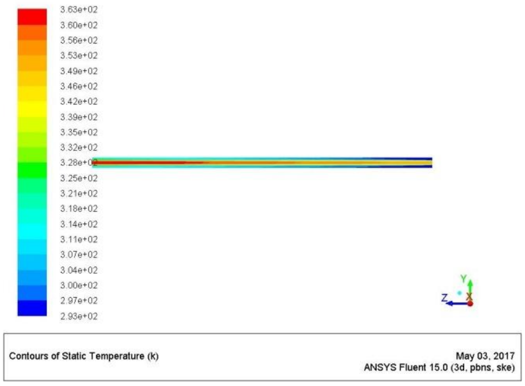

Chart -6: Contours of Static Temperature for Water-Acetone

RESULT ANALYSIS:- The specific heat of acetone is lower than that of water. Hence, a higher temperature of water is obtained at the hot outlet.

For Three-pipe

Hot fluid – <u>Water</u>
Cold fluid – <u>Acetone</u>

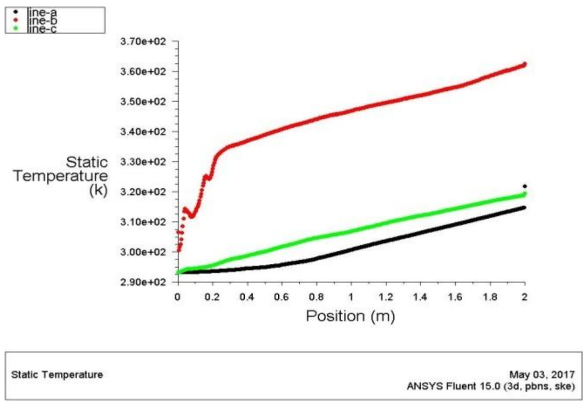

Chart -7: Temperature Graph for Water-Acetone

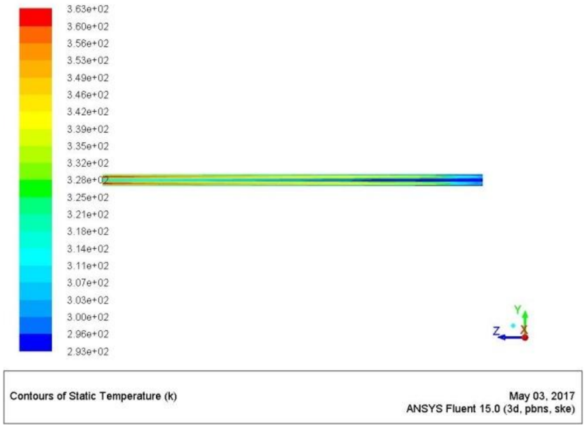

Chart -8: Contours of Static Temperature for Water-Acetone

RESULT ANALYSIS:- The temperature of hot water decreases greatly while the outlet temperature of acetone is not very high. This is because acetone has lower specific heat than water.

The result shows that heat transfer for three-pipe heat exchanger is greater than that for two-pipe heat exchanger. Similar results are obtained for the above mentioned fluids.

CONCLUSIONS

In this study, we calculated the heat transfer for three-pipe concentric heat exchanger and it was found to be greater than that for two-pipe heat exchanger.

The higher heat transfer is because of the increase in area through which heat is transferred.

- It can also be employed where simultaneous heat exchange between three fluids is required.
- For designing three-pipe heat exchanger, the third pipe is inserted between the two pipes thus the size of heat exchanger is not increased.

REFERENCES

[1] B.Jayachandriah, K. Rajasekhar “Thermal Analysis of Tubular Heat Exchangers Using ANSYS” International Journal of Engineering Research Volume No.3 Issue No: Special 1, pp: 21-25.

[2] Yimin Xuan, and Wilfried Roetzel., "Stationary and dynamic simulation of multipass shell and tube heat exchangers with the dispersion model for both fluids" Int. J. Heat Mass Transfer. Vol. 36, No. 17,4221A231.

[3] Lalot, S., P. Florent, Langc, S.K., Bergles, A.E., 1999, "Flow misdistribution in heat exchangers "Applied Thermal Engineering 19, pp 847-863.

[4] Prabhakara Rao Bobbili, Bengt Sunden, and. Das, S.K., 2006, "An experimental investigation of the port flow misdistribution in small and large plate package heat exchangers Applied Thermal Engineering 26, pp 1919-1926.

[5] Zakro Stevanovic, Gradimir, Ilić., Nenad Radojković, Mića Vukić, Velimir Stefanović, Goran Vučković., 2001, "Design of shell and tube heat exchangers by using CFD technique- part one: thermo hydraulic calculation" Facts Universities Series: Mechanical Engineering Vol.1, No 8, pp. 1091 – 1105