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"OPTIMIZATION OF PERFORMANCE OF DOUBLE-TUBE HEAT EXCHANGER USING FEM ANALYSIS"

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ABSTRACT

Heat exchangers assume a significant part in the activity of frameworks, for example, the cycle business, power plants and hotness recuperation frameworks. The fundamental goal of this work is to think about various arrangements of helical confuses in the chilly liquid side of a twofold cylinder heat exchanger. For this investigation twofold line heat exchangers are isolated into three distinct areas like two liquid spaces hot liquid in the internal cylinder and cold liquid in the external line and a strong area as helical perplexes on inward container of hot liquid. The high temp water streams inside the hotness exchanger tube, while the cool liquid streams in the external side toward counter stream. Mass stream rate cold liquid was changed from 0.1 kg/s to 0.3 kg/s while the stream rate in the internal cylinder for example boiling water was kept consistent at 0.1 kg/s. the bay temperature of hot liquid taken as 40oC while Cold liquid delta temperature taken as 15^{o}C. The familiar programming is utilized to work out the liquid stream and hotness move in the computational areas. The administering conditions are iteratively addressed by the limited volume plan with the straightforward calculation. Results show that that the most extreme temperature decrease of 10.9 ^{o}C for hot liquid and the greatest temperature climb of 11.9 ^{o}C for cold liquid are seen at 0.3 kg/sec mass stream rate for twofold line heat exchanger with twofold helical confounds. It has been likewise seen that the hotness move coefficient expanding with the expanding in the mass stream pace of cold liquid. The general hotness move coefficients contrast altogether by 20.4 % at same mass stream rate, in light of the fact that the impressive distinction between heat move surface region on the internal and external side of the cylinder bringing about a conspicuous warm upgrade of the cool liquid.

Key Words: CFD, helical baffle, ANSYS, heat exchanger

I. INTRODUCTION

Helical coil heat exchangers are of great use in industrial applications such as power generation, nuclear industry, process plants, heat recovery systems, refrigeration, food industry, etc due to its compact structure and high heat transfer coefficient. Helical coils of circular cross section have been used in wide variety of applications due to simplicity in manufacturing. Flow in curved tube is different from the flow in straight tube because of the presence of the centrifugal forces. These centrifugal forces generate a secondary flow, normal to the primary direction of flow with circulatory effects that increases both the friction factor and rate of heat transfer. The intensity of secondary flow developed in the tube is the function of tube diameter (d) and coil diameter (D). Due to enhanced heat transfer in helical coiled configuration the study of flow and heat transfer characteristics in the curved tube is of prime importance. Developing fluid-to-fluid helical heat exchangers (fluid is present on both sides of the tube wall) requires a firm understanding of the heat transfer mechanism on both sides of the tube wall. Though much

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investigation has been performed on heat transfer coefficients inside coiled tubes, little work has been reported on the outside heat transfer coefficients.

II. OBJECTIVE

There are following objective of the present work.

1. The main objective of the present work to performed three dimensional Computational Fluid dynamics analysis to evaluate the velocity, temperature, overall heat transfer coefficient for double pipe heat exchanger under condition of counter flow.
2. To design the different model of double pipe heat exchanger using Ansys design modular.
3. To perform CFD analysis for heat transfer in the heat exchanger under different operation conditions.
4. To compare the simulated results for different models of double pipe heat exchanger and propose best solution for better heat transfer

III. METHANOL

Algorithm used for Computational fluid dynamics analysis

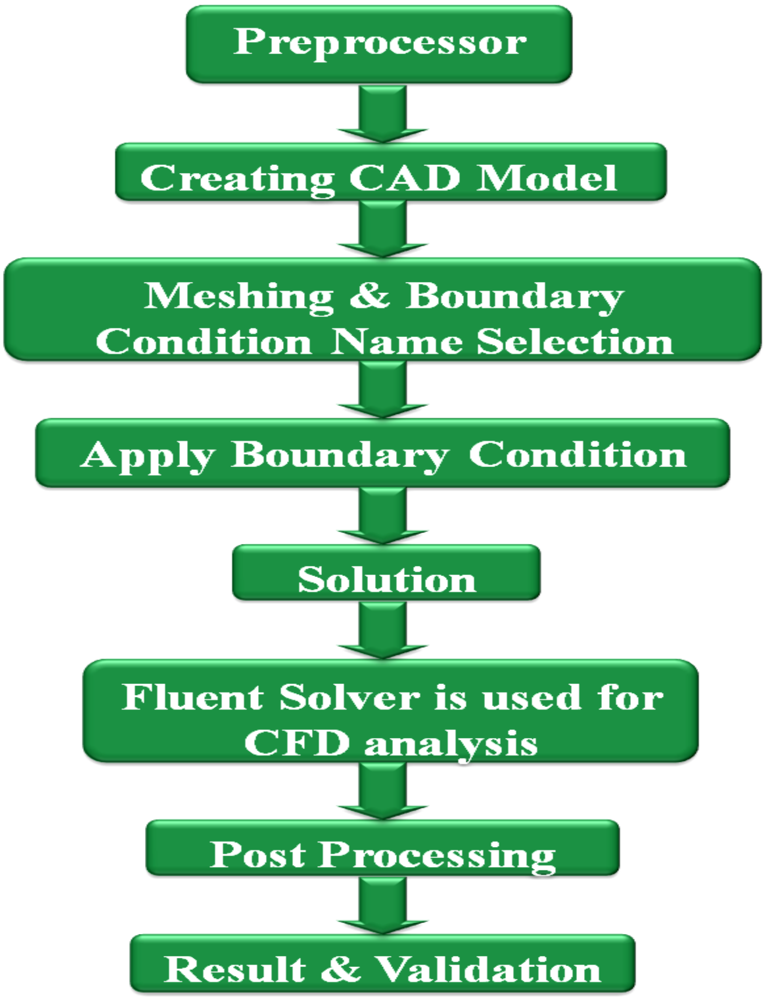

Fig. 1 Algorithm used for Computational fluid dynamics analysis

Boundary conditions

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1. To determine the temperature distribution need to on energy equation.
2. Turbulent model is K-epsilon realizable, scalable wall function is used.
3. Working fluid water liquid with density of 998.2 kg/m^3 and heat exchanger pipe material is stainless steel having thermal conductivity is k =15.2W/mk.
4. Cold inlet having mass flow rate is 0.1, 0.2 and 0.3 kg/sec, temperature 288K.
5. Hot inlet having mass flow rate is 0.1, 0.2 and 0.3 kg/sec, temperature 313K.
6. For the outlet boundary condition the gauge pressure needs to be set as zero because the fluid flowing inside the heat exchanger(hot & cold) is atmospheric
7. Rest of all surface treated as wall with no slip conditions set for solid walls where the heat flux is set as zero for the outer side wall to make adiabatic condition, while the inner tube walls and baffles is coupled.
8. The second order upwind scheme is used for the momentum energy turbulence and its dissipation rate.
9. The Fluent solver is used for CFD analysis.

A. Computational fluid dynamics analysis for double tube heat exchanger

a. CAD model of double tube heat exchanger without baffle

In the present work a three dimensional CAD model of double tube heat exchanger is created with the help of design modular of ANSYS workbench. The inner diameter of tube is 0.01 m, for hot fluid, inner diameter for cold fluid is 0.016 m with 0.001 mm pipe wall thickness. The length of heat exchanger is 0.1 m. Single helical baffles with spacing of 33 mm pitch from top to bottom on outside of hot fluid pipe as shown in figure no. 2.

Fig. 2 CAD model of double pipe heat exchanger without baffle; (a) Face side (b) Baffle (c) Volume of cold flow

IV. RESULTS

After performing computational fluid dynamics analysis of double pipe heat exchanger at different mass flow rate of hot and cold fluid varied from 0.1 kg/s to 0.3 kg/s while the inlet temperature of hot and cold fluid are 40^{o}C, and 15^{o}C respectively. The variation of temperature along the heat exchanger for hot and cold flow region as shown in below contours diagram.

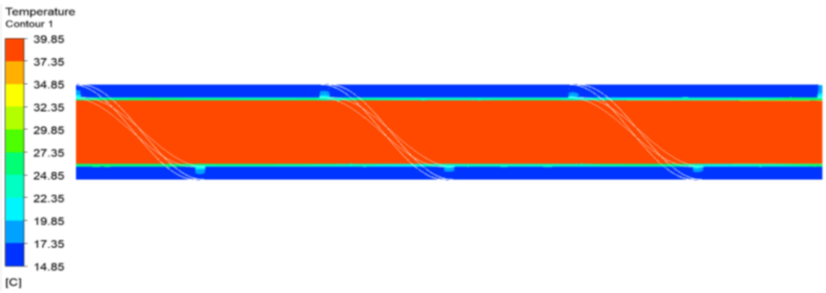

Fig. 3 Temperature contours of double pipe heat exchanger at mass flow of 0.3 kg/s heat exchanger mid plane

After performing computational fluid dynamics analysis of double pipe heat exchanger at different mass flow rate of

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hot and cold fluid the velocity streamlines along the heat exchanger for cold flow region as shown in below contours diagram.

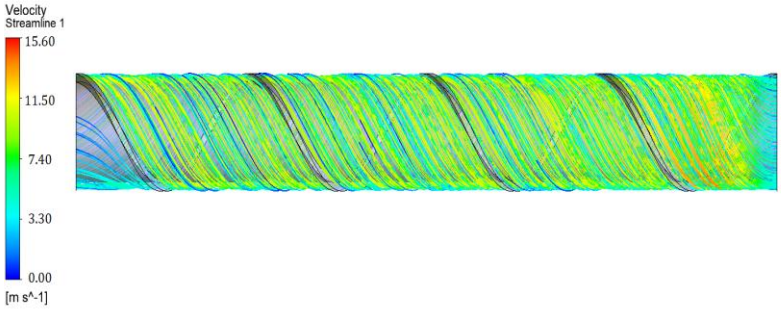

Fig. 4 Velocity streamlines at mass flow 0.3 kg/s

It has been observed that the maximal velocity of the cold fluid flowing in annulus side is near the inlet at the entrance region because of the sudden reduction in the flow area.

From the above validation work it has been observed that the compared result of temperature variation in cold fluid is about 1.23% and variation in velocity less than 1% from base paper which shows very good agreement with 1.23% error. After the validation from base model some other designs of double pipe heat exchanger have been used for computational fluid dynamics analysis to enhance the thermal performance of the double pipe heat exchanger.

It has been observed that the helically baffled in the laminar flow provides a better heat transfer characteristics then turbulent flow hence rest of all computational fluid dynamic analysis will performed using laminar flow.

A. *Computational fluid dynamics analysis for double pipe heat exchanger without baffles at 0.1 kg/sec mass flow rate:*

After performing computational fluid dynamics analysis of double pipe heat exchanger without baffles, cold fluid flowing at 0.1 kg/sec while the inlet temperature of hot and cold fluid are 40°C, and 15°C respectively. The hot fluid temperatures drop of 4.15% & cold fluid temperature rise of 7.5%. The variation of temperature along the heat exchanger for hot and cold flow region as shown in below contours diagram.

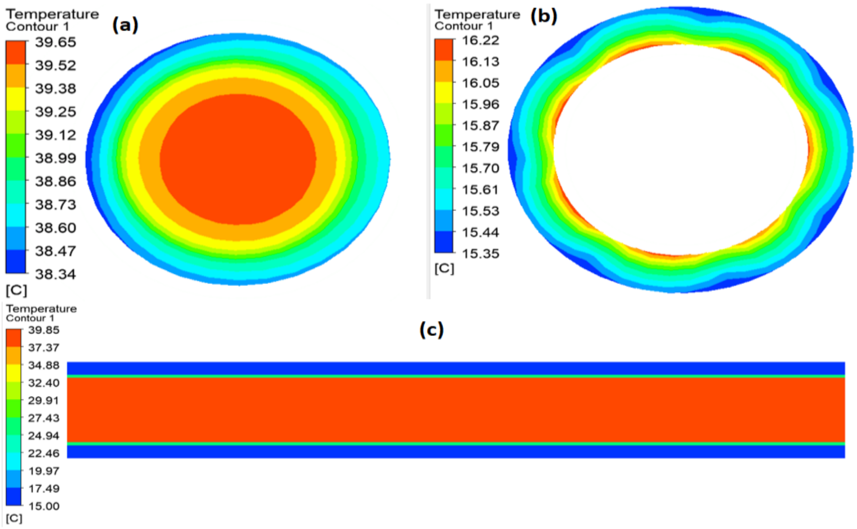

Fig. 5 temperature distribution for mass flow rate of cold fluid at 0.1 kg/sec (a) hot fluid at outlet (b) cold fluid at outlet (c) heat exchanger mid plane

B. *Computational fluid dynamics analysis for double pipe heat exchanger without baffles at 0.2 kg/sec mass flow rate*

After performing computational fluid dynamics analysis of double pipe heat exchanger without baffles, cold fluid flowing at 0.2 kg/sec while the inlet temperature of hot and cold fluid are 40°C, and 15°C respectively. The hot fluid temperatures drop of 4.95% & cold fluid temperature rise of 3.4%. The variation of temperature along the heat exchanger for hot and cold flow region as shown in below contours diagram.

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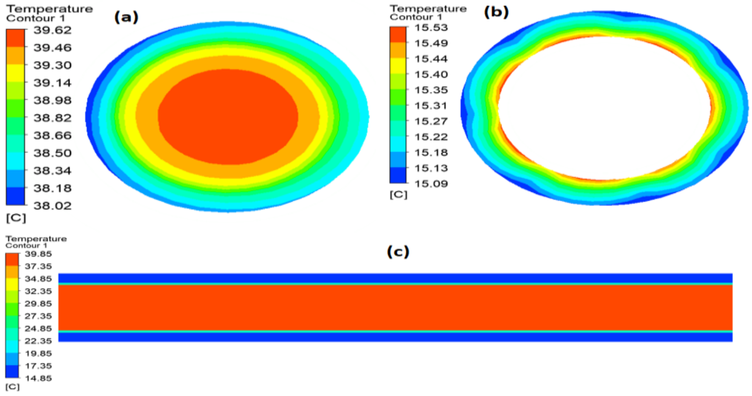

Fig. 6 temperature distribution for mass flow rate of cold fluid at 0.2 kg/sec (a) hot fluid at outlet (b) cold fluid at outlet (c) heat exchanger mid plane

C. Computational fluid dynamics analysis for double pipe heat exchanger without baffles at 0.3 kg/sec mass flow rate

After performing computational fluid dynamics analysis of double pipe heat exchanger without baffles, cold fluid flowing at 0.3 kg/sec while the inlet temperature of hot and cold fluid are 40^{o}C, and 15^{o}C respectively. The hot fluid temperatures drop of 5.3% & cold fluid temperature rise of 2.09%. The variation of temperature along the heat exchanger for hot and cold flow region as shown in below contours diagram.

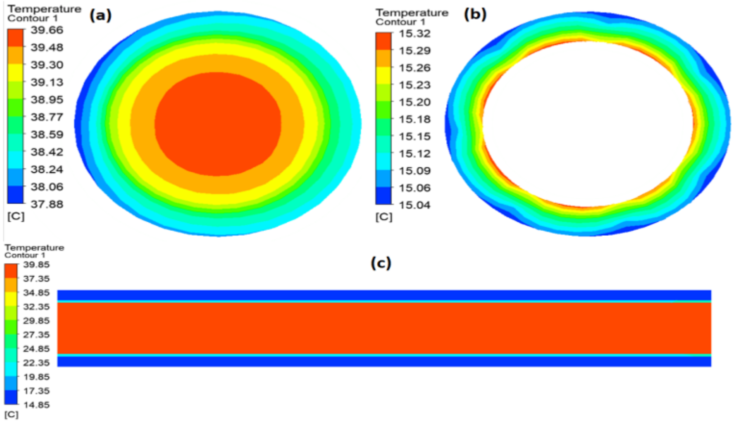

Fig. 7 temperature distribution for mass flow rate of cold fluid at 0.3 kg/sec (a) hot fluid at outlet (b) cold fluid at outlet (c) heat exchanger mid plane

D. Computational fluid dynamics analysis for double pipe heat exchanger with single baffles of 25 mm pitch length at 0.1 kg/sec mass flow rate

After performing computational fluid dynamics analysis of double pipe heat exchanger with single baffles, cold fluid flowing at 0.1 kg/sec while the inlet temperature of hot and cold fluid are 40^{o}C, and 15^{o}C respectively. The hot fluid temperatures drop of 4.55% & cold fluid temperature rise of 11.5%. The variation of temperature along the heat exchanger for hot and cold flow region as shown in below contours diagram.

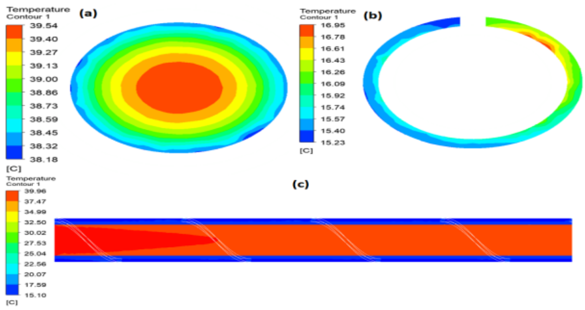

Fig. 8 Temperature contours for B = 25 mm at mass flow rate 0.1 kg/s (a) hot fluid at outlet (b) cold fluid at outlet (c) heat exchanger mid plane

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E. Computational fluid dynamics analysis for double pipe heat exchanger with single baffles of 25 mm pitch length at 0.2 kg/sec mass flow rate

After performing computational fluid dynamics analysis of double pipe heat exchanger with single baffles, cold fluid flowing at 0.2 kg/sec while the inlet temperature of hot and cold fluid are 40°C, and 15°C respectively. The hot fluid temperatures drop of 7.6% & cold fluid temperature rise of 14.53%. The variation of temperature along the heat exchanger for hot and cold flow region as shown in below contours diagram.

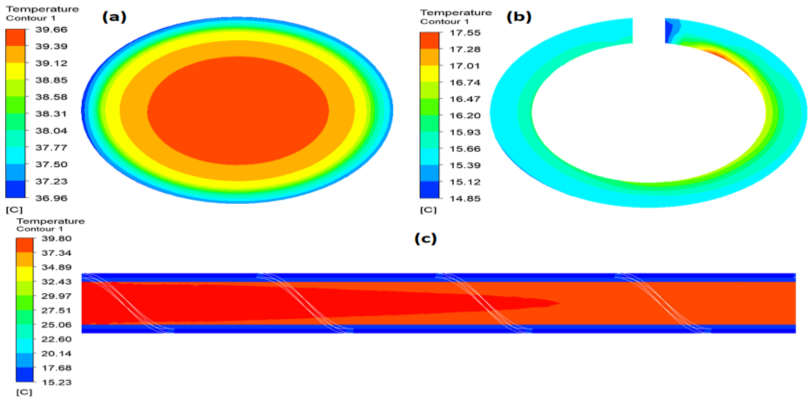

Fig. 9 Temperature contours for B = 25 mm at mass flow rate 0.2 kg/s (a) hot fluid at outlet (b) cold fluid at outlet (c) heat exchanger mid plane

V. CONCLUSION

In the current work computational liquid elements examinations have been performed for twofold line exchanger utilized helical puzzles with various separating on the hot liquid line. For this investigation twofold line heat exchangers are partitioned into three distinct spaces like two liquid areas hot liquid in the inward cylinder and cold liquid in the external line and a strong space as helical bewilders on internal container of hot liquid. Mass stream rate cold liquid was differed from 0.1 kg/s to 0.3 kg/s while the stream rate in the inward cylinder for example heated water was kept steady at 0.1 kg/s. the gulf temperature of hot liquid taken as 40oC while Cold liquid channel temperature taken as 15o^{0}C. Numerical and computational liquid unique examinations have been performed and analyzed the outcomes. There are following convincing focuses drawn from this work. it very well may be summed up that the most extreme temperature decrease of 10.9 °C (27.25%) for hot liquid and the greatest temperature increase of 11.9°C (44.23%) for cold liquid are seen at 0.3 kg/sec mass stream rate for twofold line heat exchanger with twofold helical perplexes. It has been likewise seen that the hotness move coefficient expanding with the expanding in the mass stream pace of cold liquid. The general hotness move coefficients vary essentially by 20.4 % at same mass stream rate, on the grounds that the impressive contrast between heat move surface region on the inward and external side of the cylinder bringing about an unmistakable warm improvement of the cool liquid.

VI. FUTURE SCOPE

The fundamental point of present work to think about various designs of helical puzzles in the cool liquid side of a twofold cylinder heat exchanger. The expansion of these mathematical elements changes the tension and speed appropriation along the chilly liquid side of the hotness exchanger and consequently the measures of hotness move rate and strain drop changes. The high temp water streams inside the hotness exchanger tube, while the chilly liquid streams in the external side toward counter stream. However this study is performed with most extreme truthfulness then likewise there is extension for additional improvement. A portion of the ideas for future review may be conceivable are clarified.

1. In the current work CFD investigation are performed on three distinct plans of twofold line heat exchanger with helical astounds however a few different plans may likewise be utilized for future improvement.
2. Variable components of the cylinders may likewise be utilized to examine the impact on heat move attributes.
3. In the current work hardened steel is utilized as cylinder material however a few different materials may likewise involve to read up for future improvement.

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