iJRASET
International Journal For Research in
Applied Science and Engineering Technology

Volume: 6 **Issue:** I **Month of publication:** January 2018

DOI: http://doi.org/10.22214/ijraset.2018.1182

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

CFD Analysis of Heat Transfer Prediction for Corrugated Shell & Tube Heat Exchanger

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Abstract: ***Corrugated shell and corrugated tube were employed instead of smooth shell and smooth tube through a shell and tube heat exchanger in this Paper. Distinct arrangements of concave and convex type of corrugated tubes were investigated. Previous studies have focused on only thermal characteristics of corrugated tubes. Hence, in the present work heat transfer coefficient is studied for a shell and tube heat exchanger made of corrugated shell and corrugated tube by using software solid works and heat transfer rate is evaluated for different arrangements of corrugated tubes. Maximum heat transfer was observed for heat exchanger made of convex corrugated tube and concave corrugated shell. This paper mainly focuses on improving the heat transfer capability in a shell and tube heat exchanger by varying tubes geometry using solid works. Study carried out on the design of the heat exchanger and by increasing diametrical ratio to prove more heat transfer is possible.***

Keywords: Heat Transfer, Corrugated Shell and tube, Solid works, Flow simulation.

I. INTRODUCTION

Engineering have many important processes there are enormous amount of design studies which can be evaluated in the time being. Coming to the heat exchanger industry the very common heat transfer method is a convection method. this project compliments the convection method along with the heat transfer rate improvement. One of the very elite process in the engineering is the exchange of heat by flowing fluids this type of heat transfer method can be used in the various industries like petrol chemical food processing harnessing power generation hvac and much more, as far a design is considered the current models have been employed majorly in the terms of many industrial applications including space sciences. Of all the heat exchangers the most common type of heat exchanger is s&t heat exchanger here's means shell and t means tube.

because of its higher transfer of heat and surface to volume ratios there are much less heat exchanger which full fill the needs of the shell and tube exchanger because of its simple design and manufacturing processes they are made in variety of shapes and sizes. And they vary with different flow configurations. In a simple way to say is they are reusable they are very easy to dissemble and assembly at any period of time for maintenance and other purposes they can be operated in high pressures also which gives the advantage of more applications. The shell and tube are designed with the bundle of tube put together with a baffle geometry the hot fluid flows through the tubes and the cold fluid flows through the shell in any case the heat transfer between the hot fluid and cold fluid is pretty high. Compared to other cases therefore the industrial applications of S& T Heat exchangers very high in the sense of gratitude.

Out of all the comparison and problems faced and solved by the different scientists and scholars the key finding is that the variation of geometry has much effect in the efficiency of heat exchanger therefore the findings of Rossi et 3 al. [1] have suggested that the helical baffle and comparison of the smooth baffle helically corrugated shell and tube. Turbulence is the key factor to achieve the maximum heat transfer Barba et al. [5] has done the experimental investigation and presented on corrugated and found out that pressure drop most effectively which can be used in the food processing industry.

Many of the scholars have studied the experimental investigations over the time and found out heat transfer characteristics of the nature of the corrugated tube therefore experimentation is an impossible thing which requires a full-scale mockup with large test rigs and high scale equipment's which requires high capital, As the technology has been developed and advanced with the time there is no need now to perform lengthy and time taking tasks to get the results or to get the job done. When the very first simulation has started the capability of simulations have gone thus par with the time now the faculties in computational domain are much more advanced than before therefore to avoid cost that comes with the experimentation and complete the project in a time effective away we are employing the advanced simulation techniques in this project initially the design have been designed in the solid works and then the flow simulation is carried out to determine the heat transfer rates of the models we have done.

In general the heat exchanger is a devise which transfer heat from the hot to cold fluid where cold fluid gains the heat and hot fluid losses the heat this process is called convection heat transfer process and the ability of s & t have scaled high over the years so that it have the capability of the working at any different temperature and the and at any different fluid the s & t heat exchanger is very widespread in various fields like automotive food processing , chemical processing , electronics cooling HVAC air conditioning etc. . In this chapter we deal with the basic working mechanism and theory of the heat exchanger and classification of it

II. CLASSIFICATION

Due to many number of the arrangements and heat transfer application it is messy to remember every single detail of a particular heat exchanger so therefore a system is employed to determine use and establish the required heat exchanger for the known types of heat exchangers. Some of them are.

A. The very basic kind of heat exchanger in the arena now a day are Regenerator and the recuperator.
B. There are some heat exchangers which employ process like direct contact and indirect contact.
C. The very common heat transfer Geometry construction is an extended surface concept and there are other types like tubes plates surface contact etc.
D. There are different fluids that are to be used during the process some of them include only single-phase flow like Gases or liquids some of them also requires the two-phase flow like a gas and a liquid.
E. There are many types of flow arrangement in my understanding a flow arrangement is a passage in the solid domain where the passes of the two fluids considered to be cross flow counter flow and parallel flow conditions.

III. METHODOLOGY

A. CATIA V5 is an Integrated Computer Aided Engineering apparatus:

1) Incorporates CAD, CAM, CAE, and different applications
2) Completely re-composed since CATIA V4 and still a work in progress
3) CATIA V5 is a local Windows application
4) User neighbourly symbol based graphical UI
5) Based on Variationally/Parametric innovation
6) Encourages outline adaptability and configuration reuse
7) Supports Knowledge Based Design A Flexible Modellingconditions
8) Ability to effectively adjust models, and actualize configuration changes
9) Support for information sharing, and information reuse

B. Information Empowered

1) Capture of plan limitations, and outline purpose and in addition last model geometry
2) Management of non-geometric and additionally geometric plan data

The 3D Part is the Master Model

Illustrations, Assemblies and Analyses are acquainted to the 3D sections. On the off chance that the parts configuration changes, the downstream models with change as well.

C. Applications

1) Product Structure
2) Part Design
3) Assembly Design
4) Sketcher
5) Drafting (Interactive and Generative)
6) Wireframe and Surface

IV. RESULTS AND DISCUSSION

A. Outer Concave Inner Concave

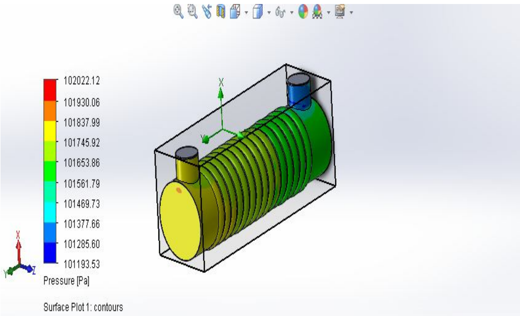


Fig.1: Pressure Distribution Outer Concave Inner Concave

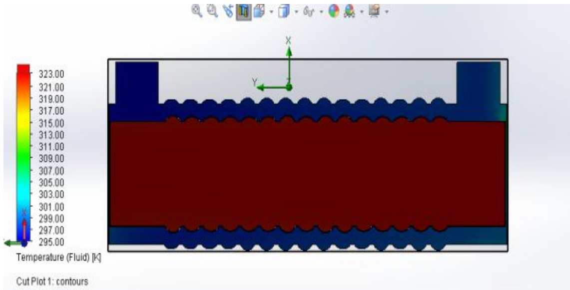


Fig.2 Cut plot Temperature Distribution of fluid in section plane Outer Concave Inner Concave

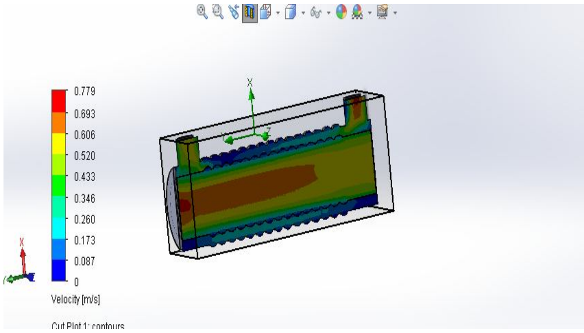
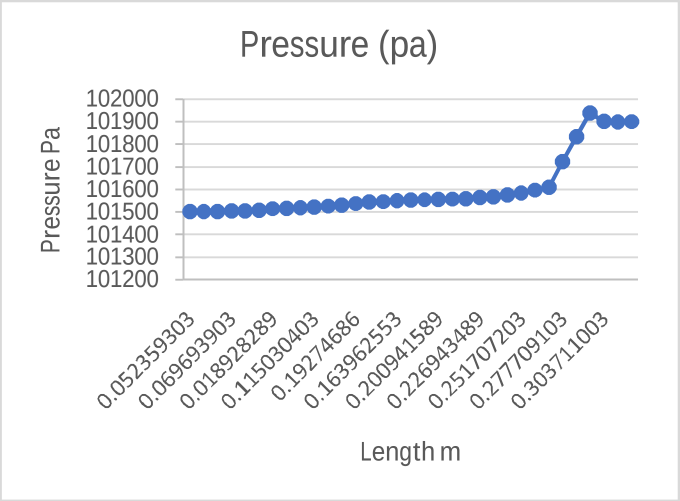
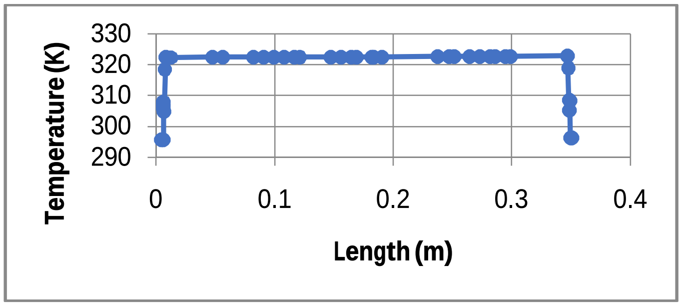


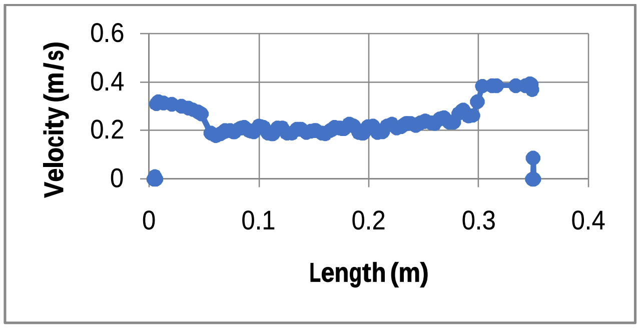
Fig.3: Outer Concave Inner Concave Velocity Profiles



Graph 4(a) Pressure along the length of the heat exchanger



Graph 4(b) Temperature along the length (l)



4 (c) Velocity of the Fluid Inlet to outlet

B. Inner convex outer convex

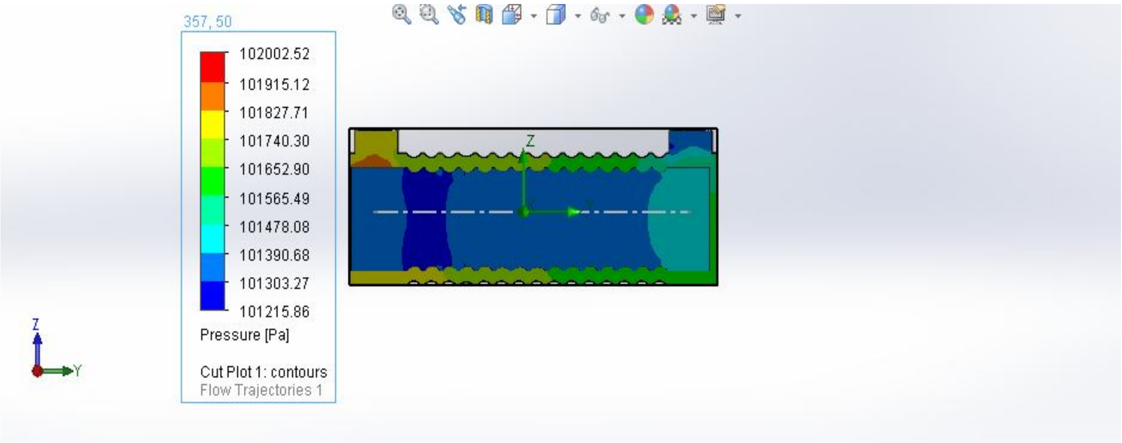


Fig.5: Pressure distribution over Outer Convex Inner Convex

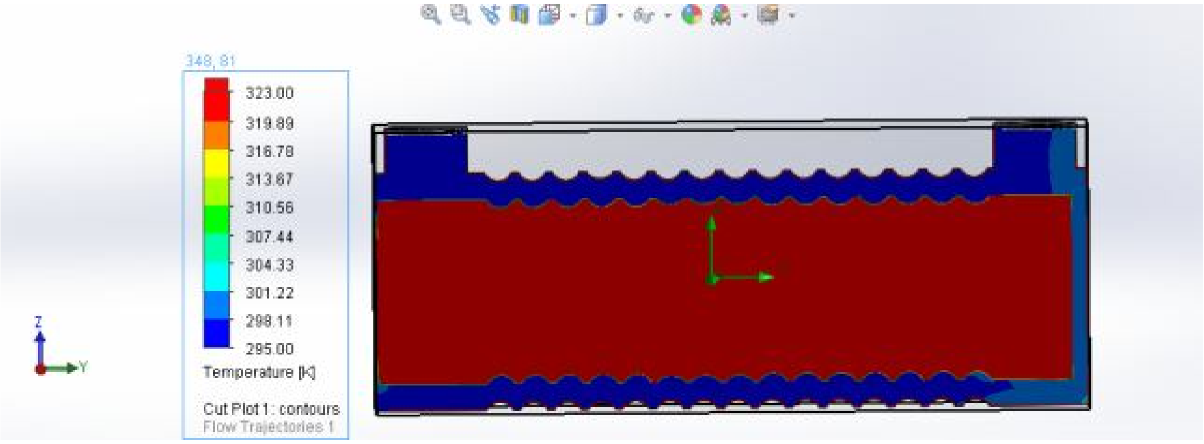


Fig.6: Cut plot Temperature Distribution of fluid in section plane Outer Convex Inner Convex

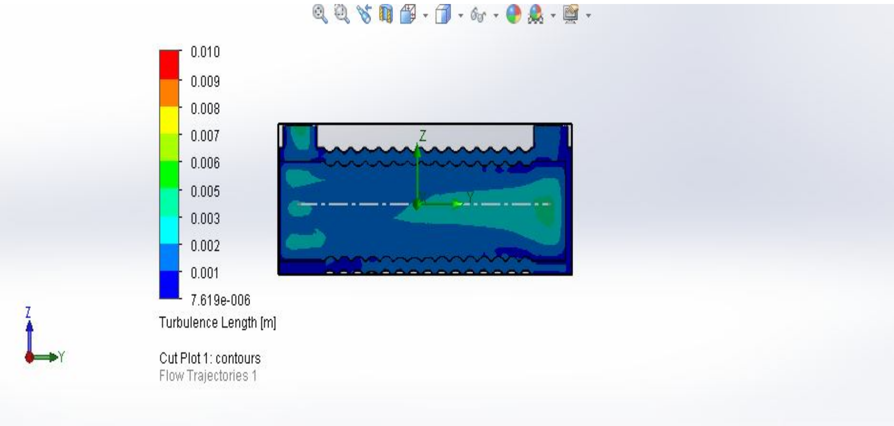
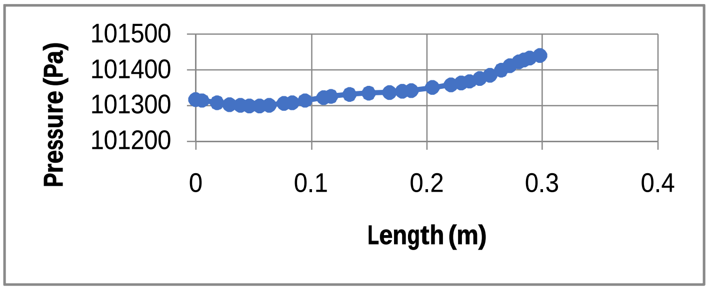
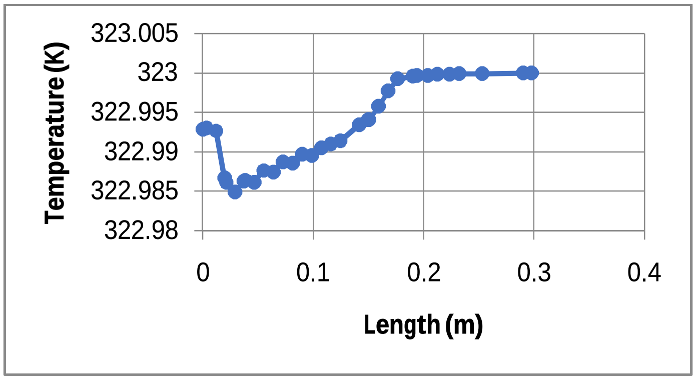


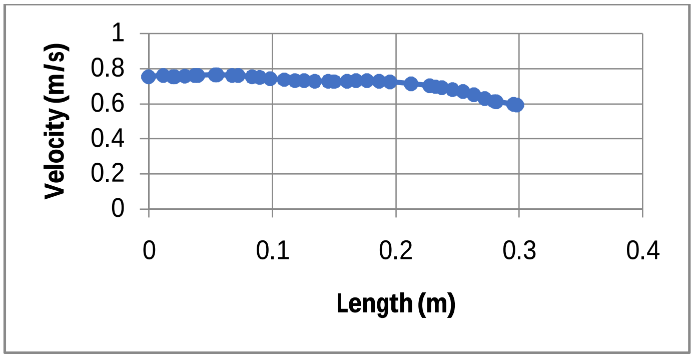
Fig.7: Outer convex inner convex velocity profiles



Graph 8(a) Pressure along length (l)



Graph 8(b) Temperature along length (l)



Graph 8(c) Velocity along the length (l)

C. Inner Smooth Outer Smooth

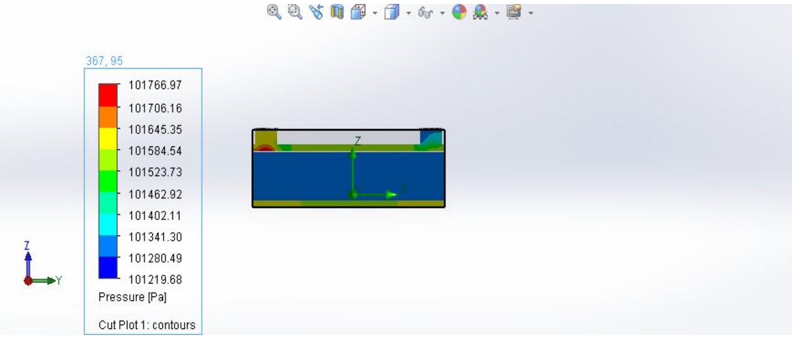


Fig.9: Pressure Cut plot for Outer Smooth Inner Smooth

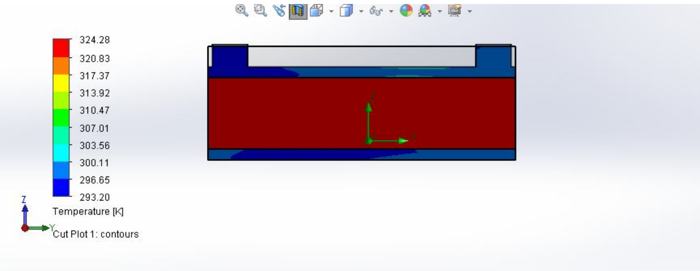


Fig.10: Cut plot Temperature Distribution of fluid in section plane Outer Convex Inner Convex

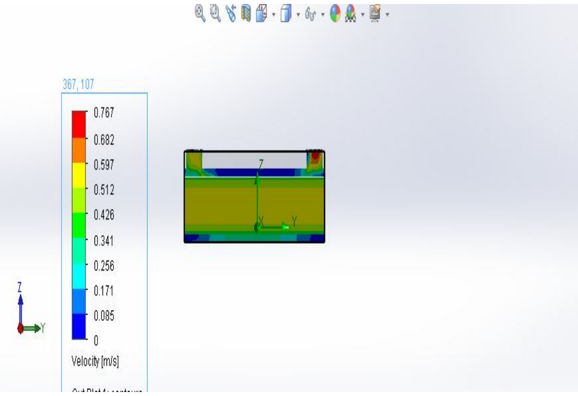
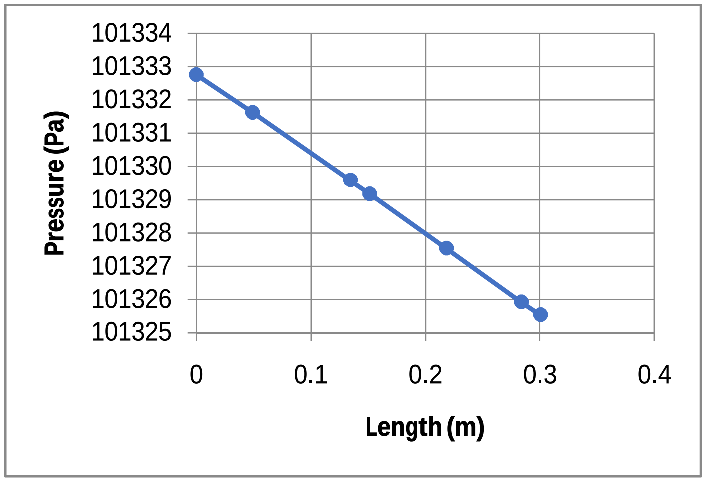
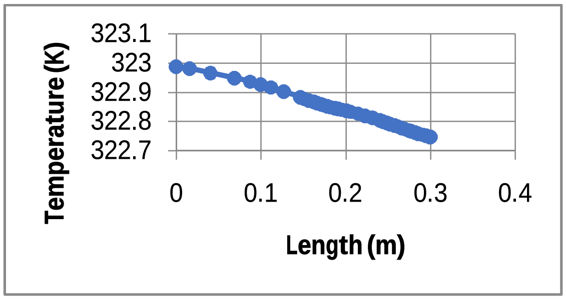


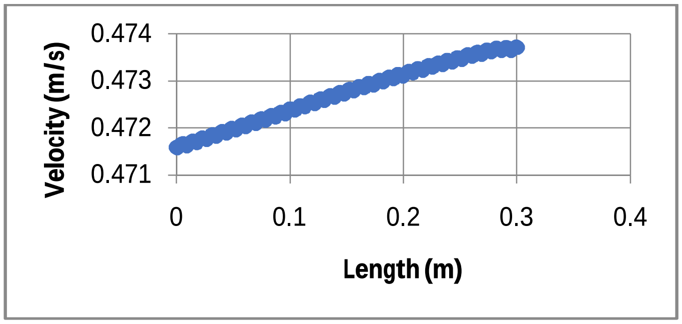
Fig.11: Velocity Cut plot for Outer Smooth Inner Smooth



Graph 12(a)Pressure along length (l)



Graph 13 (b) Temperature along length (l)



Graph 14 (c) Velocity along the length (l)

The increase in velocity represents the heat gain of a fluid i.e., due to the geometrical shape and the simulation the heat is transferred from cold fluid to hot fluid therefore the resultant graph occurs.

D. Outer Smooth Inner Concave

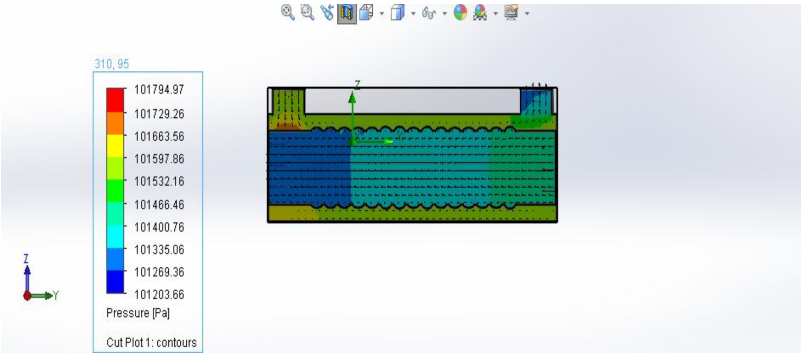
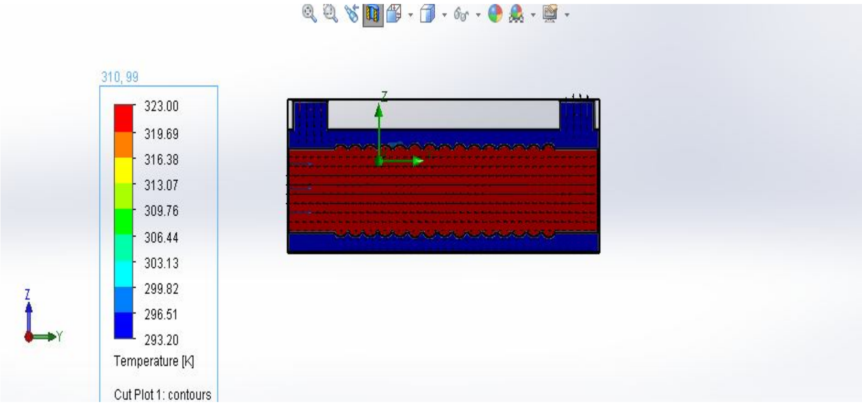


Fig15: Pressure Cut plot for Outer Smooth Inner concave



Distribution of fluid in section plane Outer Smooth Inner Concave

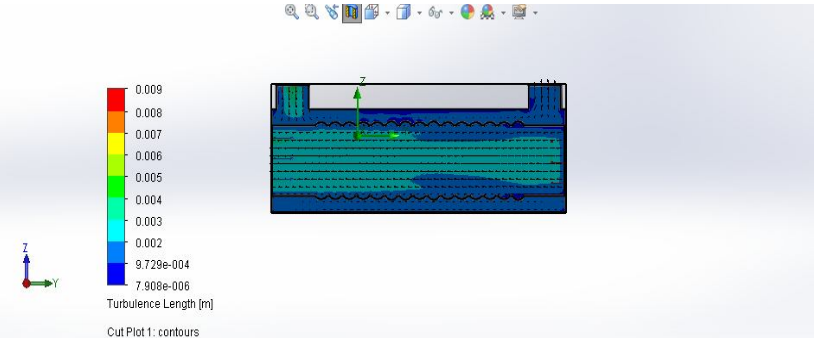
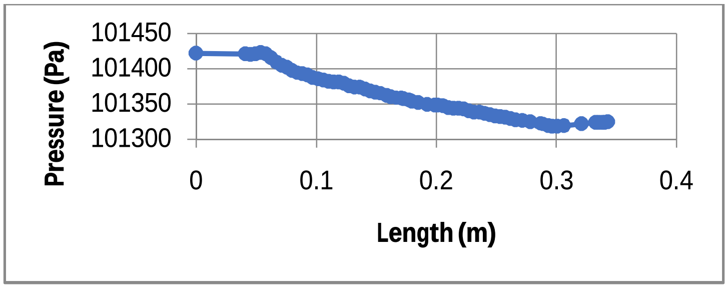
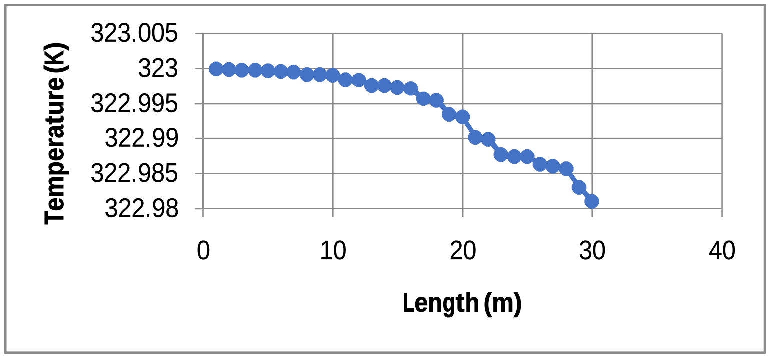


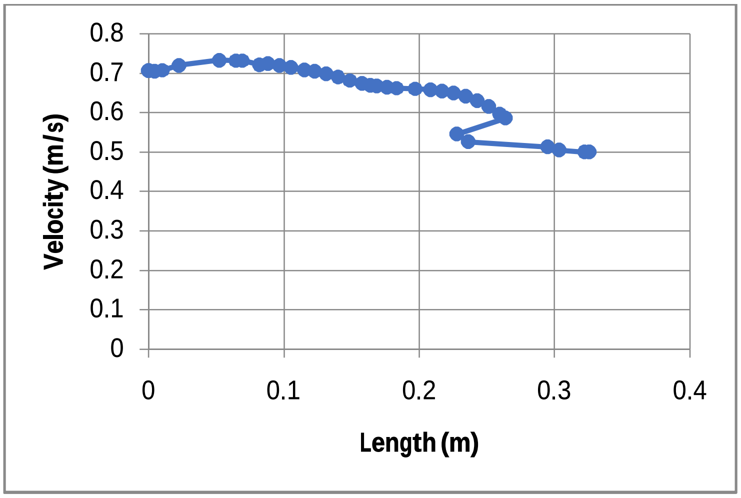
Fig.17: Outer smooth inner concave velocity profiles



Graph 18(a) Pressure along length of the heat exchanger



Graph 18(b) Temperature along length of the heat exchanger



Graph 18 (c)Velocity along length of the heat exchanger

E. Outer Smooth Inner Convex

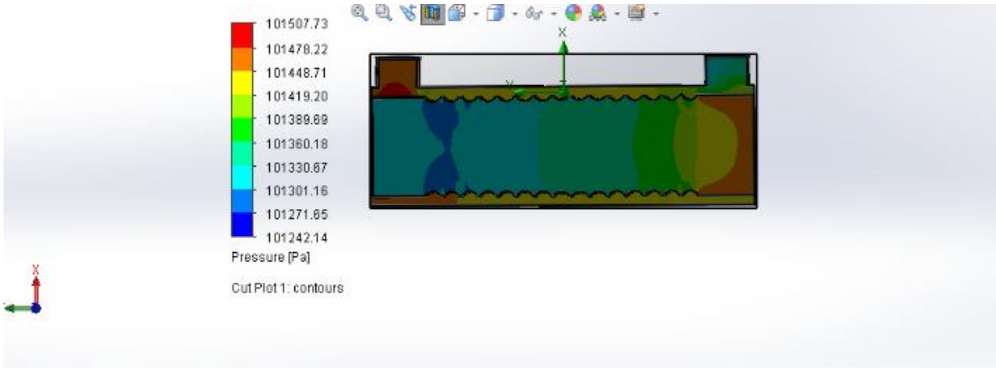


Fig.19**:** Cut plot of Pressure outer smooth inner convex

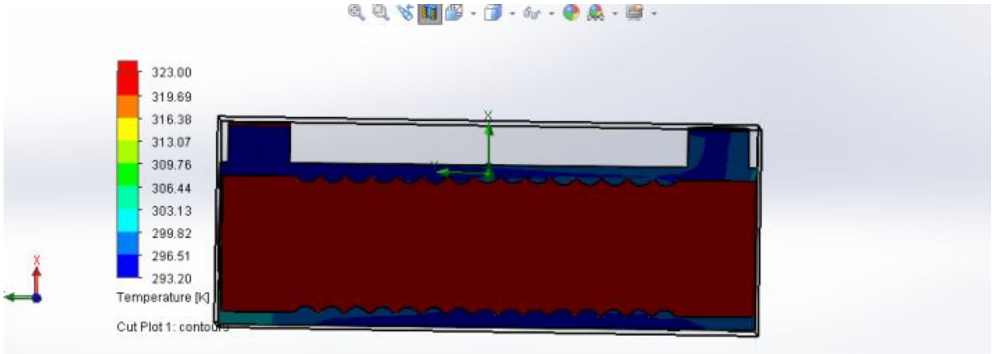


Fig.20: Cut plot Temperature Distribution of fluid in section plane OuterSmooth Inner Convex

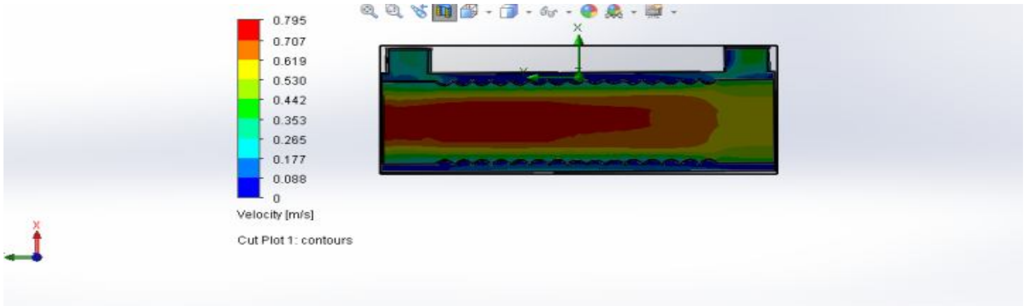
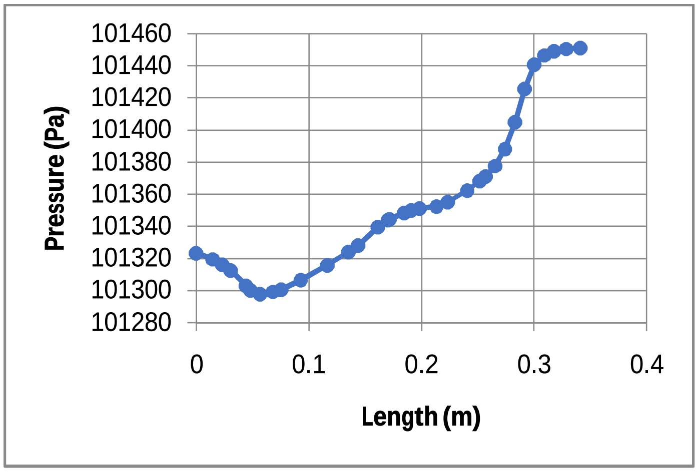
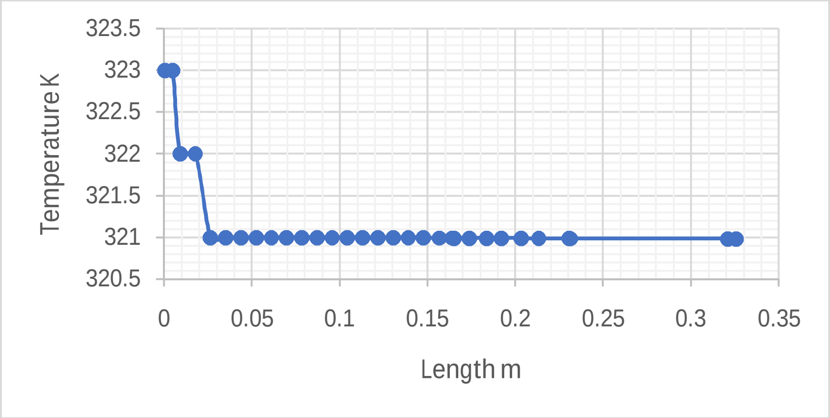


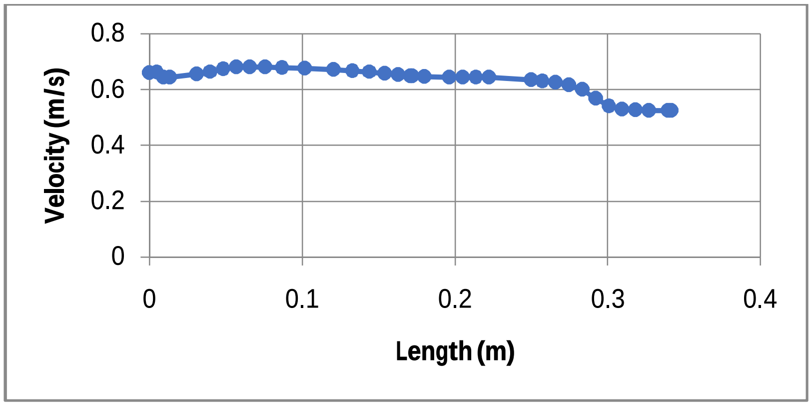
Fig.21: Velocity Cut plot for Outer Smooth Inner convex.



Graph 22(a) Pressure distribution along the length of the heat exchanger



Graph 23(b) Temperature distribution along the length of the heat exchanger



Graph 23(c) Velocityalong length of the heat exchanger

F. Inner Convex Outer Concave

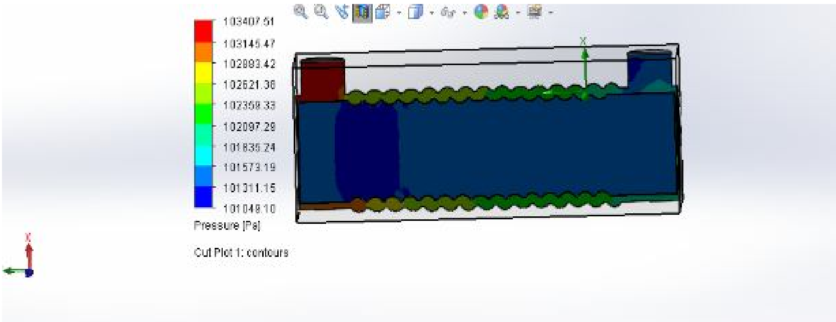


Fig.24: Cut plot of the Pressure distribution along the Model

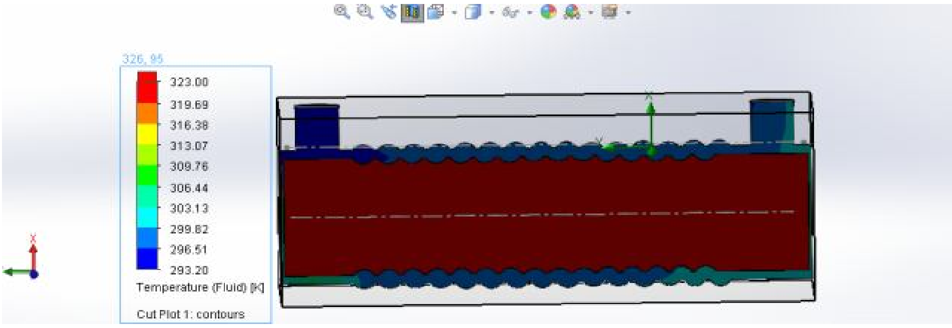


Fig.25: Cut plot Temperature Distribution of fluid in section plane Outer Smooth Inner Convex

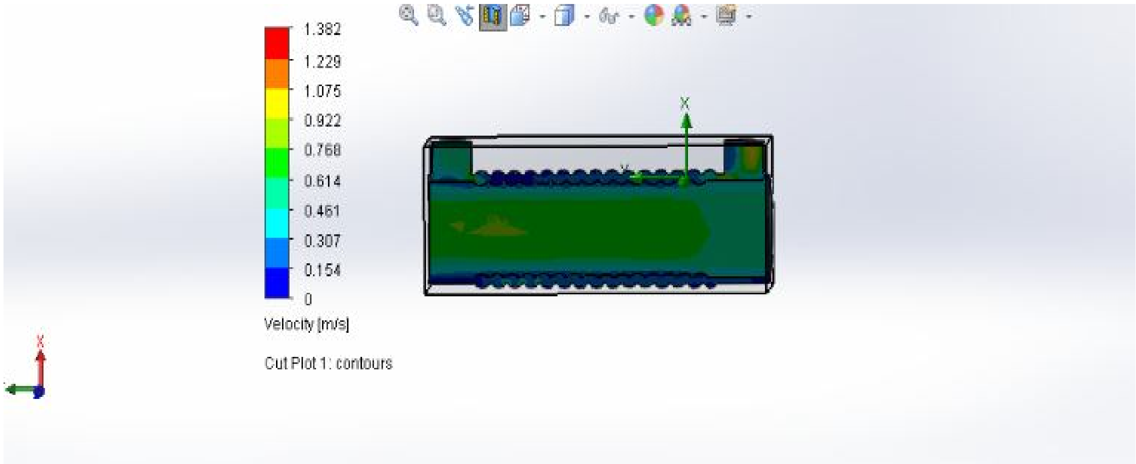
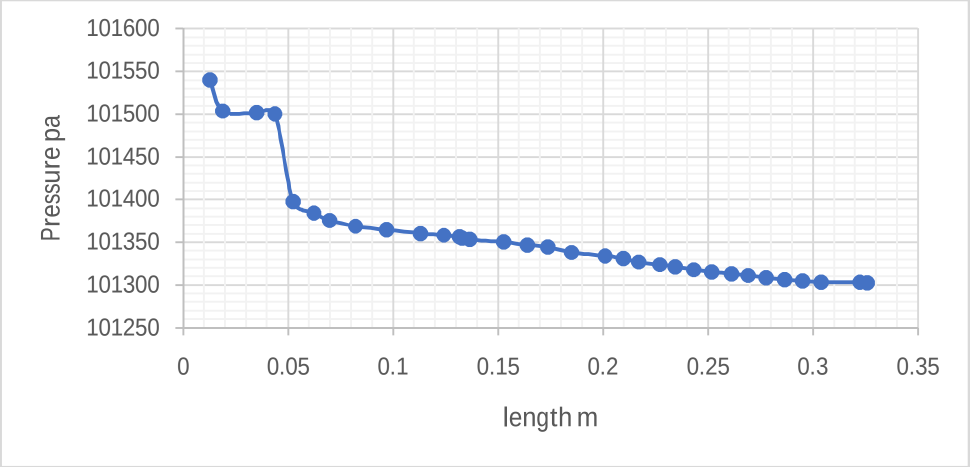
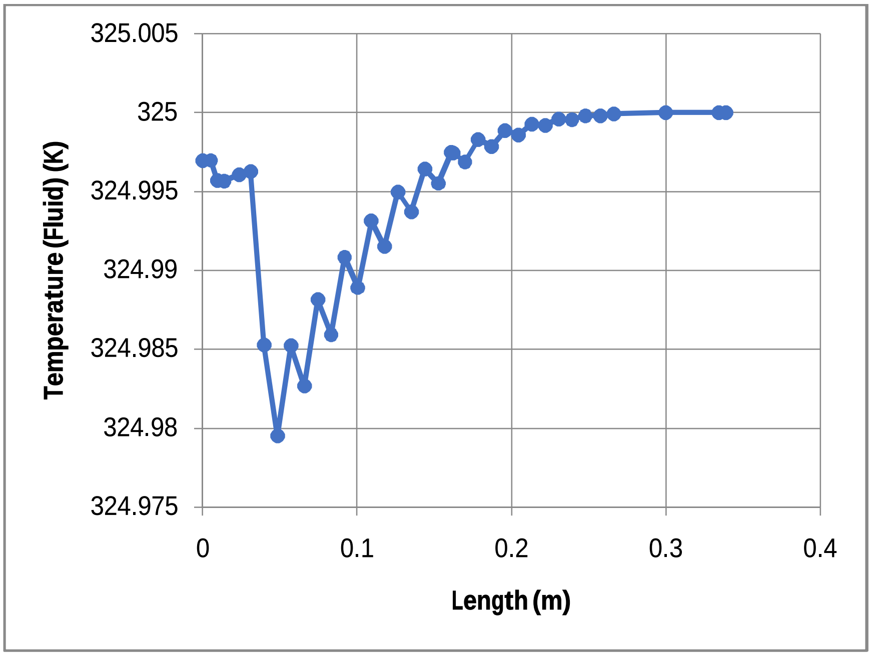


Fig.26:outer concave inner convex velocity profiles



27(a) Pressure along length of the heat exchanger



Graph 27 (b) Temperature along length (l)

Result table:

ARRANGEMENTS ⇒ PROPERTY ⇓	Inner smooth outer smooth	Outer smooth inner convex	Outer smooth inner concave	Outer convex inner convex	Inner concave outer concave	Outer concave inner convex
HEAT TRANSFER RATE(W)	0.34	0.40	0.55	0.59	0.62	0.712
HEAT TRANSFER COFFICIENT(W/M^{2}K)	544.73	637.14	657.72	742	746	756.37
NTU	0.026	0.046	0.068	0.07	0.078	0.092

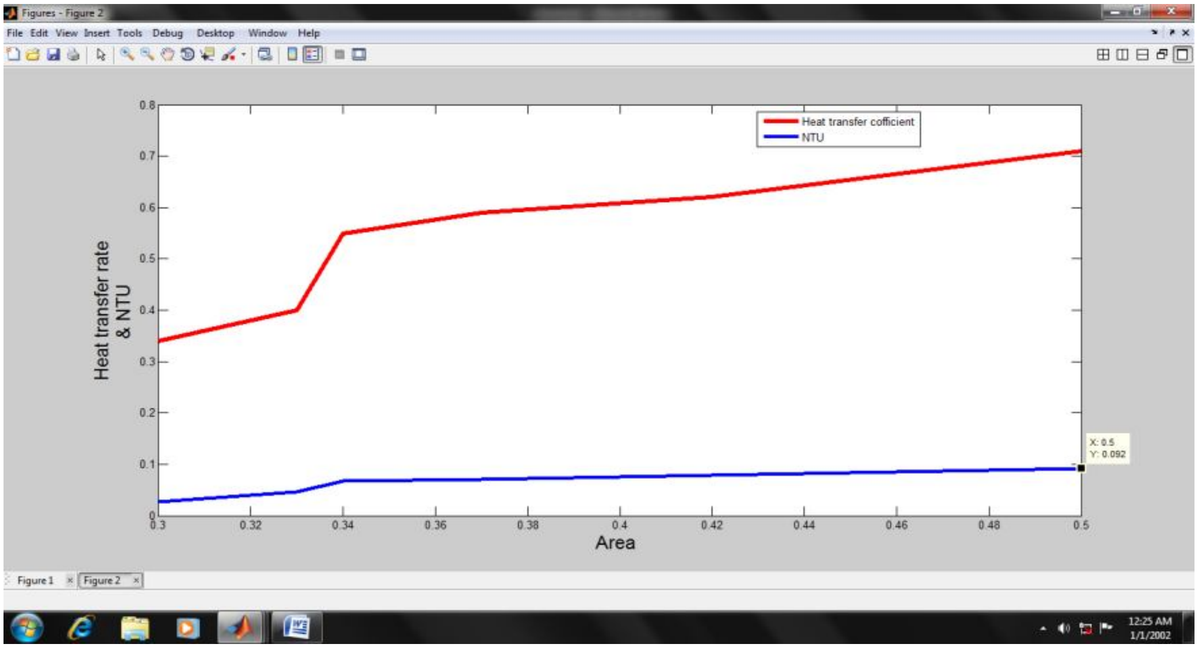
% of NTU Improvement = (Maximum Value- Minimum value)/Maximum Value *100
= (0.092-0.026)/0.092*100
=71.7%
% of NTU Improvement = (Maximum Value- Minimum value)/Maximum Value *100
= (0.046-0.026)/0.046*100
=43.4%

G. Key Findings

1) Heat transfer coefficient increased from 544.73(W/M^{2}K) to 756.37 (W/M^{2}K) for smooth shell smooth tube arrangement to concave shell and convex tube arrangement

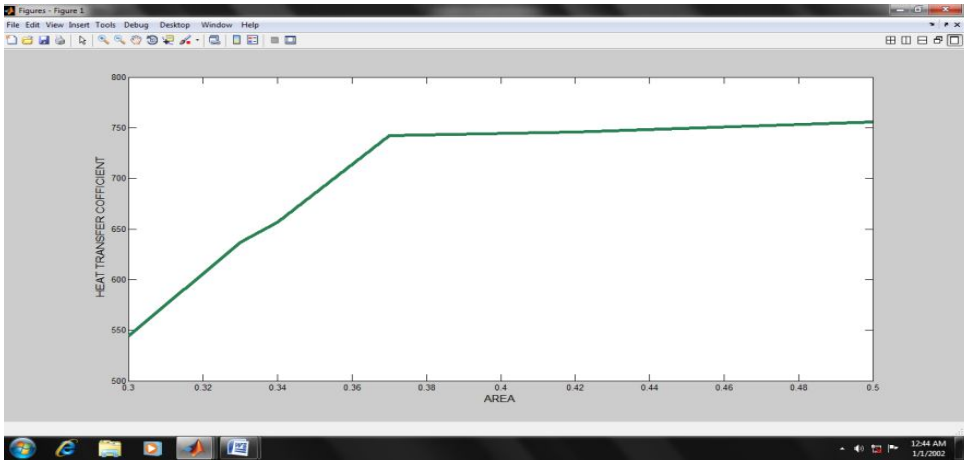
2) Number of heat transfer units increased to 43.4% to 71.7% because of improved diametrical ratio.

3) Heat transfer rate is increased from 0.34W to 0.71W.



Area Vs heat transfer coefficient and NTU

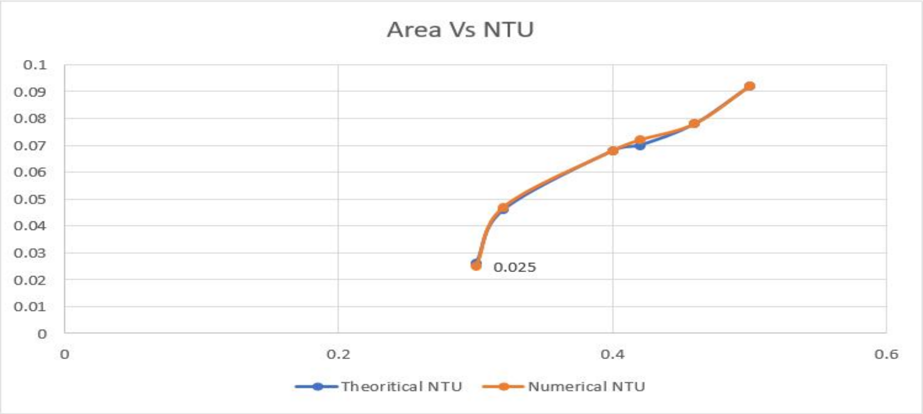
The above graphs represent the Area vs Heat transfer rate and NTU where X-axis and Y-axis is heat transfer rate the heat transfer rate in the graph is is increasing when area is increasing hence more is the surface area more is the heat transfer rate so as the behavior of the NTU



Area Vs Heat Transfer Coefficient

The above graphs represent the Area vs Heat transfer coefficient and NTU where X-axis and Y-axis is heat transfer Coefficient. The heat transfer Coefficient in the graph is increasing when area is increasing hence more is the surface area more is the heat transferred.

H. Validation



The above graph is the validation of both theoretical and numerical calculation of the corrugated shell and tube heat exchanger with different calculations and configurations of Inner Smooth Outer Smooth, Outer Smooth Inner Convex, Outer Smooth Inner Concave, Outer Convex Inner Convex, Inner Concave Outer Concave, Outer Concave Inner Convex. Defines with the area

V. CONCLUSION

Various arrangements of convex and concave corrugated tubes were studied. The key findings are summarized as follows:

Heat transfer coefficient increased from 544.73(W/M^{2}K) to 756.37 (W/M^{2}K) for smooth shell smooth tube arrangement to concave shell and convex tube arrangement

of heat transfer units increased to 43.4% to 71.7% because of improved diametrical ratio.

Heat transfer rate is increased from 0.34W to 0.71W.

The results of solid works are approximate to the experimental values so it is considered able to do the analysis in solid works and the analysis is done by changing the diametrical ratio for various arrangements of corrugated shell and corrugated tubes in shell and tube heat exchanger.

By comparing results of various arrangements of shell and tube heat exchangers made corrugated shell and corrugated tube, it is clearly concluded that average heat transfer coefficient, heat transfer rate is increased and NTU is also increased. This is because as the surface area increases due to the use of corrugated tubes and also by improving diametrical ratio.

Maximum heat transfer coefficient was obtained for heat exchanger made of concave corrugated shell and convex corrugated tube

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