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Heat Transfer Enhancement by Modification in Hexagon Tube

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Abstract: ***For the conservation of energy in heat exchanger , the function of it should be optimum. The primary function of a heat exchanger is to exchange the heat from one fluid to another fluid. This paper presents a new idea to improve rate of heat transfer in a heat exchanger by modifying the geometry of duct. Hexagonal duct are modify for enhance heat transfer and results are compare with n circular, square and regular hexagon tube of equal cross section . Analysis done for three case of mass flow rate. Heat transfer, temperature change, heat transfer coefficient and pressure drop are numerically analysed with help of ANSYS 14.5. Comparison result indicate that modify hexagon transfer maximum amount of heat and also it is subjected to highest heat transfer coefficient and conclusion is that use of modified hexagon can improve the effectiveness and efficiency of a heat exchanger.***

Keywords: Heat exchanger tube, Modified hexagonal tube, Heat transfer, Heat Transfer coefficient, Comparison with other geometry tube

I. INTRODUCTION

Pipes, duct and tubes have very important roles in engineering application. These are the applications of fluid mechanics as well as heat transfer. For conservation of energy the optimization of pipes tubes and ducts are play important. In pipe, duct and tube most important factor to evaluating heat loss or gain. Pipe may be circular or orthogonal and may be metallic or non metallic [1 &2]. Basic difference among pipe tube and ducts are that pipe have circular cross section where as ducts have non circular cross section (Hexagonal, Rectangle). Pipes are generally used for flow of liquid fluid and ducts are used for gaseous fluid. Smaller diameter of pipe is referred as tube. Tubes are generally used in heat exchanger. Enhancing the Rate of heat transfer is the great challenge in case of heat exchanger tube, whereas pressure drop is challenge in case of fluid transportation [3&4]. Physical quantity such as Heat transfer coefficient , wall share stress, mean flow velocity, mean temperature and many dimensionless quantity such as Reynolds number, Nusselt number, Prandtl number etc are the performance parameter of tube which govern heat transfer and pressure drop of fluid ,pressure drop are the performance parameter[5]. Knowledge of these performance parameters is necessary for heat transfer design and calculation processes. Pipe ducts and tubes are manly applicable in oil and gas flow processes, power generation process and also in A/C and refrigeration systems. To increase heat transfer rate in tube, there are many opportunity like introducing secondary flow, thermal dispersion, use of secondary heat transfer surface, enhancing thermal conductivity of material, using low viscous fluid, inserting twisted tape , modifying angle of twist, tapering the geometries etc[6&7]. In this numerical study heat transfer enhanced by increasing the area of heat transfer. As per Newton law of convection heat transfer is function of surface area and temperature difference of fluid and material. So that increases in surface area causes increase the heat transfer rate. In this analysis a new geometry introduced named as modify hexagon. Description of this geometry explained in set-up description section. The study based comparison on same cross section and same mass flow rate for different geometry. This paper has three aims. First aim that to compare of heat transfer among the circular and square and hexagonal (non –circular) tube to enhance the rate of heat transfer to produce more effective heat exchanger tube and this is Second aim. Third aim of study is that detect the effect of mass flow rate in the temperature drop. Another aim of study is to analyse heat transfer coefficient and pressure drop for different geometries.,For whole analysis process water is taken as working fluid. Thermal properties like viscosity, density and thermal conductivity are taken as per mean bulk temperature. Copper is taken as pipe material laving 3 meter length.

II. SET UP DESCRIPTION

Followings are the geometrical and boundary conditions of heat exchanger tube.

A. Geometry Descriptions

All geometry of tubes has constant flow area of 176.71 mm^2. Area is taken on basis of circle having diameter of 15 mm so the cross section is equal to 176.71 mm^2. So all other geometry having dimensions to accomplish 176.71 mm^2 area. Length of tube taken as 3 meter and thickness tube taken 2mm. Length and area both are taken from literature priyanka [8]. Hydraulic diameter calculated by formula 4A/P. Where A is cross sectional area or flow area and P is the perimeter [10].Table 1 shows the complete geometrical description of different geometry. Copper is taken as tube material and water is working fluid which flow inside the tube. In geometry description a new name comes that is modify hexagon. In normal or regular hexagon having equal side but in modified hexagon the dimensions of side changed but total cross section area maintained. New hexagon dimensions design as per increase the surface area. A new term also introduced aspect ratio also introduced on it. The aspect ratio is defined as the width of geometry in minor axis to height of geometry in major axis [8].

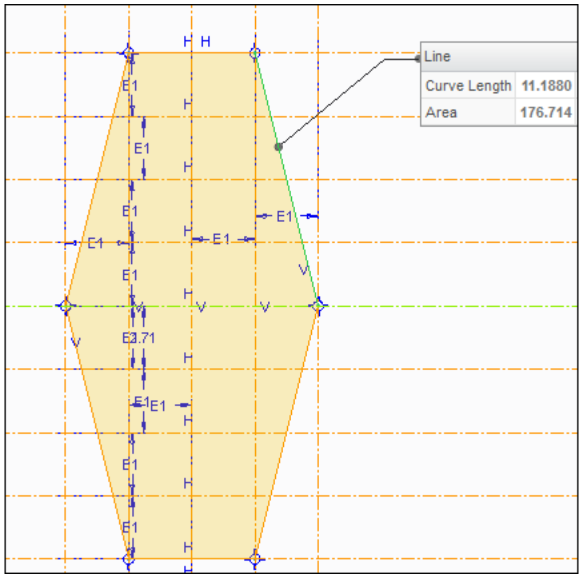

Figure 1 Modified Hexagon

Figure 1 shows the details of modified hexagon. The dimensions are related to mm. The aspect ratio of geometry is on. Aspect ratio can be calculated as follow

$$AR = \frac{Width}{Hight}$$

$$AR = \frac{4E_1}{8E_1} = 0.5$$

TABLE 1 GEOMETRY DETAILS

Geometry Details of Heat Exchanger Tube						
Geometry	Area(mm^2)	Sides/Dai(mm)	Perimeter(P)(mm)	Length(m)	Hydraulic Diameter(mm)	Wall Thickness(mm)
Hexagon	176.71	8.247	49.482	3	14.28479043	2
Square	176.71	13.2932	53.1728	3	13.29326272	2
Circle	176.71	15	47.1	3	15.00721868	2
Modify Hexagon	176.71	11.18(I) & 5.427(H)	12.7	3	55.65669291	2

In table 1 side description box I stands for the inclined sides dimensions and H stands for dimension of horizontal side.

B. Boundary Conditions

Table 2 shows the boundary conditions which applied to the tube. Three mass flow rate 0.2624 Kg/sec, 0.3498 Kg/sec and 0.5248 Kg/sec taken. The surrounding conditions applied 5000w/m^{2}k convection having free stream temperature of 400k.

Example of these boundary conditions is condenser of steam power plant. Steam offered convection rate of about 5000w/m2k and temperature 400 k. Outlet pressure is taken as 1 atm. The mass flow rate taken from the literature priyanka Bhist[8].

TABLE 2 BOUNDARY CONDITIONS

Boundary conditions of Heat Exchanger Tube					
Geometry	Mass Flow Rates(Kg/sec)	Inlet Temperature(K)	Outlet Pressure(bar)	Convection (W/m^2-K)	Free Stream Temperature
Hexagon	0.5248	300	01.00	5000	400
	0.3498	300	01.00	5000	400
	0.2624	300	01.00	5000	400
Square	0.5248	300	01.00	5000	400
	0.3498	300	01.00	5000	400
	0.2624	300	01.00	5000	400
Circle	0.5248	300	01.00	5000	400
	0.3498	300	01.00	5000	400
	0.2624	300	01.00	5000	400
Modify Hexagon	0.5248	300	01.00	5000	400
	0.3498	300	01.00	5000	400
	0.2624	300	01.00	5000	400

C. Selection of Pipe Materials

Table 3 shows the duct materials properties like Thermal conductivity, Density and specific heat. Copper selected as a tube t material because it have higher thermal conductivity. Hence conduction heat transfer rate will be higher.

TABLE 3 PIPE MATERIAL DETAILS

Pipe Material Details			
Material	Thermal conductivity	Density	Specific Heat
Copper	381 .6 W/m-K	8978 Kg/m^3	381 j/Kg-K

D. Fluid properties

Table 4 shows the thermal properties of fluid. The properties are taken as per mean bulk temperature. The properties are taken by trial and error method. Mean bulk Temperature is equal to average of inlet and outlet temperature and properties taken from HMT design data book and thermopedia.

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Table 4 Fluid Properties

Fluid Properties							
Geometry	Mass Flow Rates(Kg/sec)	Inlet Temp (K)	Outlet Temp (K)	Mean Bulk Temp(°C)	Viscosity (Kg/m-s)	Density (Kg/m^3)	Specific Heat(KJ/Kg-K)
Hexagon	0.5248	300	321.702	37.851	0.000678	993	4178.2
	0.3498	300	328.578	41.289	0.000632	991.6	4178
	0.2624	300	334.138	44.069	0.000607	990.5	4177.8
Square	0.5248	300	323.055	38.5275	0.000666	993	4178.2
	0.3498	300	330.43	42.215	0.00063	992	4178
	0.2624	300	336.341	45.1705	0.000598	990	4177.8
Circle	0.5248	300	320.847	37.4235	0.0069	993	4178.2
	0.3498	300	327.109	40.5545	0.000641	992	4178
	0.2624	300	332.767	43.3835	0.000618	991	4177.8
Modify Hexagon	0.5248	300	324.7	39.35	0.000664	993	4178.2
	0.3498	300	332.348	43.174	0.000611	992	4178
	0.2624	300	338.424	46.212	0.00058	990	4177.8

E. Meshing Details

After drawing the geometry it meshed in Ansys fluent. The details of meshing shown in table 4.All meshed geometry have orthogonal quality 0.9 which indicate the excellent mesh quality. Orthogonal mesh quality lies between 0 to 1 and quality closed to zero has poor quality of meshing. Skewness of meshing also kept in good mesh grade.

TABLE 5 MESHING DETAILS

Meshing Details			
Geometry	Relevance center	Smoothing	Inflation
Hexagon	High	Fine	Program controller
Square	High	Fine	Program controller
Circle	High	Fine	Program controller
Modify Hexagon	High	Fine	Program controller

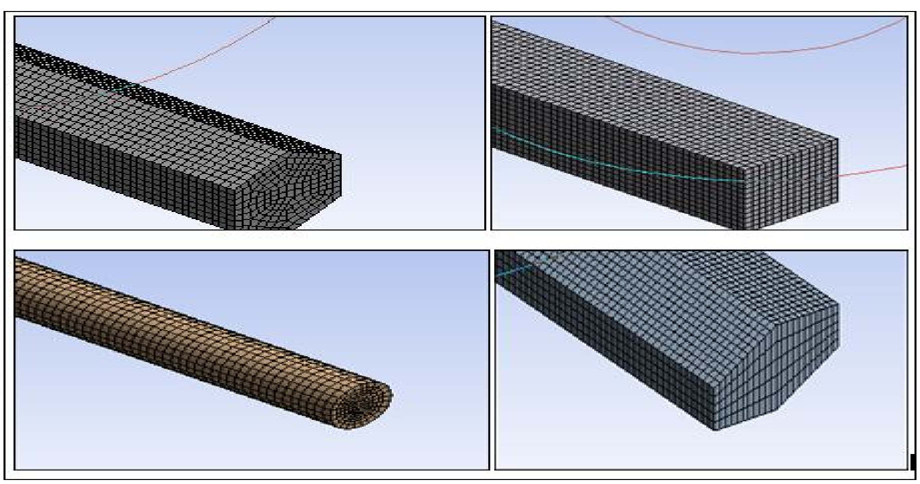

Figure 2 Meshing

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III.SOLUTION

The all calculation is carried out with the help “ANSYS Fluent 14.5”. ANSYS Fluent 14.5 is computational fluid dynamics software package to stimulate fluid flow problems. It uses the finite volume method to solve the governing equations for a fluid. Whole Solution is carried out with by energy equation, and k epsilon model. Solution also considers wall treatment, thermal effects and viscous heating model. Solution is carried out by SIMPLE scheme and least square cell spatial discretization based method.

IV.RESULTS

A. Average Heat Transfer Through Wall

From the wall of modified hexagon (hexagon of AR=0.5) transfer maximum amount of heat to surrounding. Whereas Circular wall transfer least amount of heat through its wall. Rectangular duct give good challenge to modified hexagon but it transfer less heat. for all geometry for mass flow rate 0.5248 Kg/sec, 0.3498 Kg/sec and 0.2624 Kg/sec.

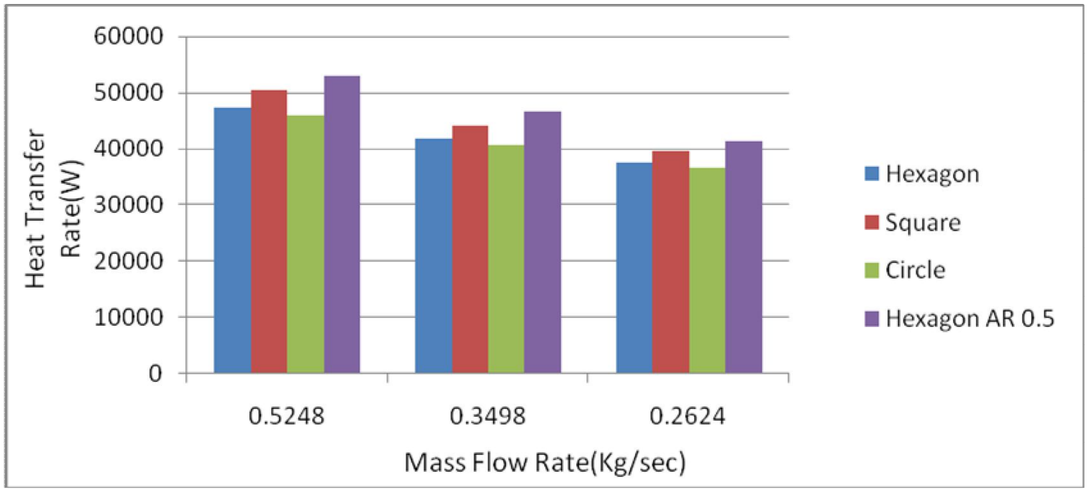

Figure 3 Comparison of Average Heat Transfer through wall

B. Temperature Drop

Temperature change of water is maximum when it flows in modified hexagon tube. Change in temperature calculated by outlet temperature minus inlet temperature. In the modified hexagon outlet temperature of water is highest. Then it seems that the modify hexagon suitable for hexagon tube. Change in temperature of water in circular tube is found less. It is also observable that as per increase in mass flow rate, change in temperature decreases.

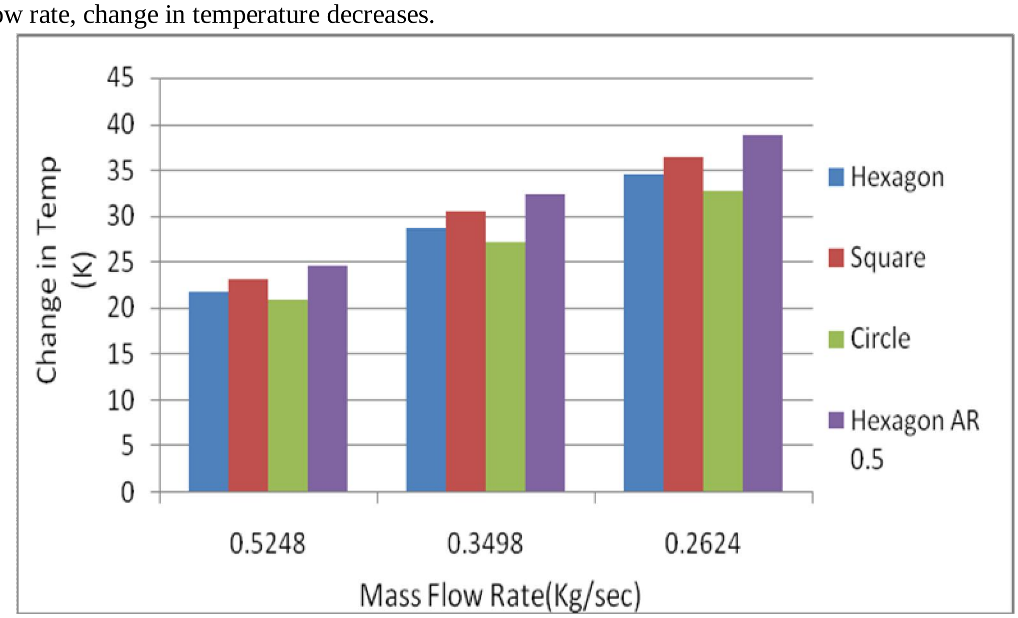

Figure 4 Comparison of Change in Temperature of Water

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C. Heat Transfer Coefficient

Again in heat transfer coefficient found highest in modified hexagon. Signification of Heat transfer coefficient (HTC) is that tendency to do thermal effect of any fluid. Here modified hexagon has highest tendency to cool the wall of pipe. HTc found lowest in

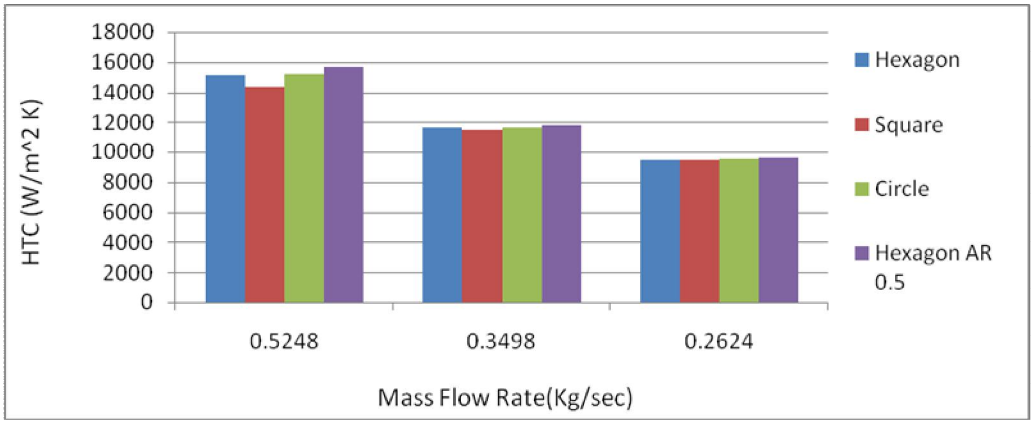

Figure 5 Comparison of average heat transfer coefficient (HTC) in wall

D. Pressure Drop

Figures 4 show that pressure drop found highest in modified hexagon. It is because modified hexagon has highest perimeter. Then the surface for friction will be maximum in it. Hexagonal duct have lowest pressure drop. Circle and rectangle both are middle of them.

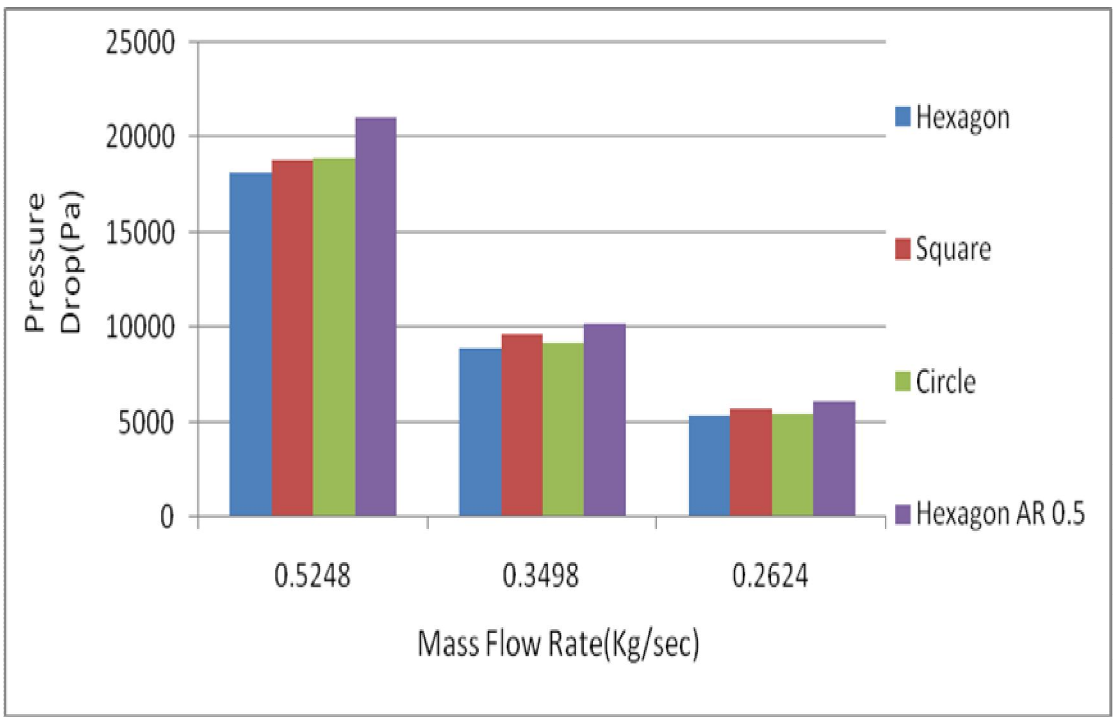

Figure 6 Comparison of pressure drop

V. COMPARISON WITH LITERATURE

In literature heat transfer coefficient compared between circular and rectangular. Now the comparison result of this results with modified hexagon indicate that also in this case modified hexagon has highest heat transfer coefficient. Figure 5 show the comparison graph figure 6 show Nusselt number comparison.

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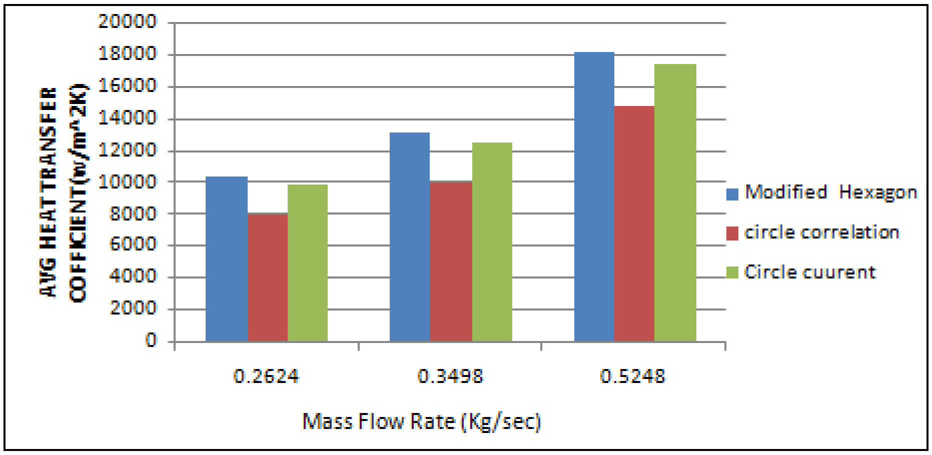

Figure 7 Comparison of heat transfer coefficient between literature study and current study

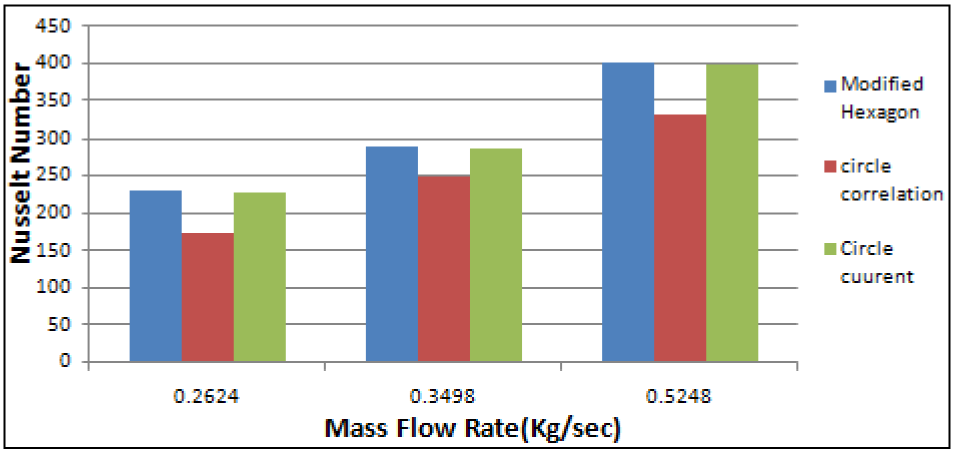

Figure 8 Nusselt number comparison between literature study and current study

VI. CONCLUSION

In this analysis we conclude that the hexagonal duct having aspect ratio 0.5 is best choice for heat exchanger tube. It transfer maximum amount of heat through wall and temperature drop of fluid also highest in this modified hexagon. The heat transfer coefficient also highest for all mass flow rate in hexagon of Aspect ratio 0.5. Followings are the other conclusion we obtain from research work.

A. Temperature drop of fluid deceases with increase in mass flow rate. Hence for best results keep mass flow rate smaller when the system fluid flow inside the duct. Other benefit of this logic is that pressure drop will also be decrease.
B. Heat Transfer coefficient decrease with decrees in mass flow rate. Hence for the better result keeps mass flow rate higher when external fluid flowing inside the duct.
C. As per the temperature of cooling fluid increases, then decrease in viscosity. Hence heat transfer coefficient increase
D. Modified hexagon transfers maximum amount of heat through wall.
E. Modified Hexagon change the temperature of water maximum.
F. Friction loss highest in modified hexagon
G. Modified hexagon will be better choice as compare to circular and square duct to transfer maximum amount of heat.

REFERENCES

[1] BheeshamDewangan and SSK Deepak, "Analysis of duct for performance improvements", - International Journal of Scientific & Engineering Research. Volume (2017), September, 8, Issue 9.
[2] A. Bhatia," HVAC Ducting-Principal and Fundamental,(2012), PDHonline course M246(4PDH)
[3] BheeshamDewangan and SSK Deepak, "Analysis of problem occurring in performance of ducts and pipes" IJSRD , (2018) Vol. 5, Issue 12, 2018 | ISSN (online): 2321-0613.
[4] Yunis A. Cengel. Heat and Mass Transfer. Tata McGraw-Hill publishing company limited New Delhi,2007

[5] BheeshamDewangan and SSK Deepak, “Analysis of the performance parameter of ducts for optimization”, Research Journal of Recent Sciences (2018), February, Vol. 7(2), 1-6.

[6] S.W. Chang a, K.F. Chiang b, T.C. Chou, " Heat transfer and pressure drop in hexagonal ducts with surface dimples," SCIENCE DIRECT , Experimental Thermal and Fluid Science 34 (2010) 1172–1181 21181. BheeshamDewangan and SSK Deepak, “Proposal of Hexagonal Ducts for Analysis”,International Journal of Advanced in Management, Technology and Engineering Sciences”(ISSN NO : 2249-7455, Volume 8, Issue III, MARCH/2018

[7] M.Udayakumar, M.ManzoorHussian and Md.Yousuf Ali, “Turbo-lent Heat Transfer, Nusselt Number and Friction Factor of Square Duct," IJIRSET (2014), December,.2014.0312035. Vol. 3, Issue 12, ISSN: 2319-8753.

[8] PriyankaBhista Manish JoshiȦ and AnirudhGuptaȦ , “Comparision of heat transfer between a Circular and rectangular Tube heat exchan-gerby using fluent”, IJTTE, (2014) June ,ISSN 2277-4114,Vol 4 No. 2.

[9] BheeshamDewangan and SSK Deepak, “Proposal of hexagonal duct” IJAMTES, (2018), March, Vol. 8(3), .

[10] Dipak P. Saksena, “Entropy generation analysis for fully developed laminar convection in hexagonal duct subjected to constant heat flux and minimization of entropy generation by adjusting the shape of the cross section”,International Journal of Engineering Science Invention (2013), July, ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org Volume 2 Issue 7 PP.17-29.