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Analysis of Thermal and Flow Characteristics of Baffle Factor in Shell and Tube Heat Exchangers

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Abstract— ***The recent rise in oil prices and concerns about global warming have stoked a renewed interest in finding ways to reduce carbon emissions and maximize energy efficiency. There are a wide variety of industrial uses for heat exchangers. Reviews of the available literature show that Shell and Tube heat exchangers account for more than 60% of all industrial heat exchangers because they are cheap, simple, and straightforward to set up and maintain. In addition, it provides excellent dependability and productivity. The thermal efficiency of a Shell and Tub heat exchanger can be increased by careful regulation of key design parameters, which is why this area of study is currently receiving a great deal of attention. In this analysis, we recover the primary design parameters of the baffle plate and investigate the effect of scale on heat transfer velocity. The optimal value of the baffle plate has been determined using commercially available software. As the baffle plate height was varied from 50% to 78% and the number of baffles was varied, the performance was monitored (4, 6, 8, 10).***

Index Terms— **carbon emissions, energy efficiency, thermal efficiency, Shell and Tub heat exchanger, baffles, CFD.**

I. INTRODUCTION

Heat exchangers are devices that facilitate the exchange of heat between two fluids that are at different temperatures, through a surface. Heat exchangers can be used in various types of processes, from domestic heating and air conditioning systems to chemical processes and production of power in large power plants. (CENGEL & GHAJAR 2012). Considering the various areas of application were developed of the various types of heat exchangers, such as: direct contact (when fluids mix), indirect contact (the exchange takes place by the contact area of the fluids with a surface), of double tube, serpentine, hull and tubes, and finally those of the type placa. The difference between each of them is how they exchange heat, and how they are constructed. Among the various types of heat exchangers, the hull and tube exchanger is considered to have the greatest versatility compared to other types, such as example the simplicity of its construction, the low cost, and still presents a good thermal yield (BICCA, 2006). This model of heat exchanger may consist of an external cylinder (hull) with several tubes inside, separated evenly and in rows, and to increase yield are used some deflectors (increased turbulence and fluid flow speed (FELIPPE, 2018). Heat exchangers with cross drains. (a) Flip-beded (a) Parallel flow. (b) Counter current flow with both unmixed fluids. (b) Not summing with one mixed fluid and the other not mixed.

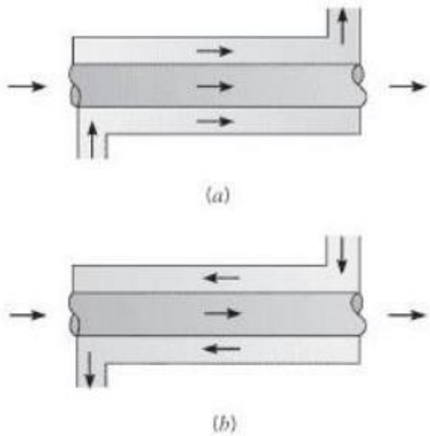

Fig.1. Heat exchangers of concentric tubes. (a) Parallel flow. (b) Counter current flow

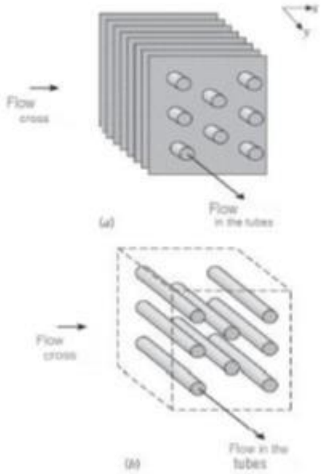

Fig.2. Heat exchangers with cross drains. (a) Flip-bedded with both unmixed fluids. (b) Not summing with one mixed fluid and the other not mixed

The two configurations differentiate by the flow of fluid on the pipes in mixed and unmixed. Figure 2a states that the fluid is not mixed, because the fins prevent movement in the direction (y) that is transverse to the direction (x) of the main flow. The mixture, the movement of the fluid mixes in the transverse direction. (BERGMAN, et al. 2017). The most common configuration is the hull heat exchanger and pipes, Figure 3. Specific forms of this type of heat exchanger are characterized by the number of passes in the hull and tubes. The two most common forms are those that have a single pass on the pipes and the hull Heat exchanger hull and pipes.

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- With a pass on the hull and a pass in the tubes.
- With one pass on the hull and two passes in the tubes.

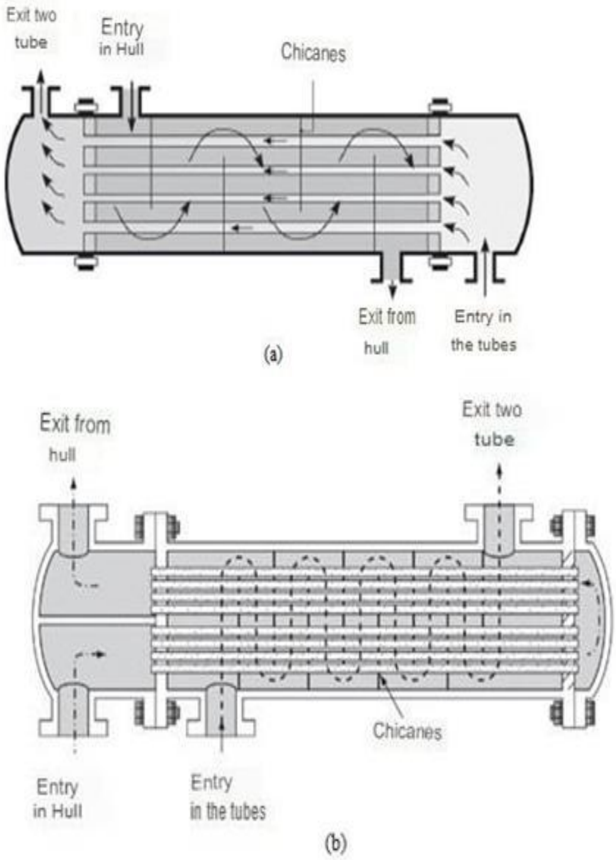

Fig.3. Two passes in the tubes for a single hull

The development of this device consists briefly of two stages: the construction of the prototype and the detailed calculations of the mechanical design. In the construction of the equipment, it is necessary to size the entire structure. At this stage, parameters to be used, such as the type of material, diameter, thickness and length of the hull, quantity, diameter, thickness and compresses of the pipes and the spacing between the chicanes. After assembly, calculations will be performed to have knowledge of efficiency, the amount of heat exchanged, the heat lost, among other variables, and these will be confirmed by the functionality of the heat exchanger.

Research Background

Due to the recent rise in oil prices, there is a lot of concern about the use of paper efficiency, and due to global warming; there is a great deal of interest in how to get carbon dioxide. The carbon dioxide reduction method can be used as a method of recovering the generated carbon dioxide and the method of retrieving the generated carbon dioxide. However, in the case of self-extraction, the technology developed to ash is economically efficient in terms of carbon dioxide. there are many restrictions on recovery treatment. Therefore, it can be said that the method of connecting carbon dioxide from the source to the source is actually a human solution.

Heat exchangers are used as key devices in almost every field of industry, transportation, and domestic use. Heat exchanger type shell-and heat exchangers and type heat exchangers are the most widely used heat exchangers in the industrial field, and since 2000, they have become many type heat exchangers. Compared to shell and tube heat exchangers, plate heat exchangers have high single-surface sugar heat ratio, high corrosion resistance, high wear resistance, small size, light weight, and excellent temperature resistance. However, liquids containing solid particles of 0.5mm or more, heat is more than 2500m2, 25kg/cm2 250°C or more, phase change and fluid velocity is less than 0.1m/s. Shell-and-tub heat exchangers are the most widely used heat exchangers, which can obtain a wide range of heat months, so the solvent is very wide, reliable and efficient. It can be manufactured in a variety of sizes, not only at high temperatures of more than 260°C. In addition, it has good pressure resistance for high pressure of more than 30 atmospheres, so its application field is air Conditioning equipment, chemical lantern foot equipment, etc. Industrial process heat exchanger furnaces are used. According to the literature, this heat exchanger accounts for more than 60% of the body industry process heat exchanger. However, the shape of the inlet outlet of the fluid, the shape of the head,

Due to the variety of design factors to consider, such as the shape spacing of the Baffle, and the complexity of the ten lunar phases in the shell, there is a limit to its characteristics. The design factor supports the vessel silver group and allows the flow of fluid in the cylinder to be orthogonal to the group and increases the flow rate to increase the turbulent strength and better mixing within the shell of the heat exchanger. It will increase the amount of ten months. However, increasing the amount of heat exchange is large Increasing the number of vessels will increase the limit of heat exchange performance and pressure drop. Female firms power requirements and production costs are high, which reduces competitiveness. Therefore, it is necessary to go into more detail the characteristics of the main design factors to be considered in terms of improving thermal efficiency.

II. LITERATURE REVIEW

Shell- tube heat exchangers are widely researched as heat exchangers that are being used. A lot of research is being done. Shell- tube design factor distribution research is carried out at home and abroad according to the size, slope and number of ships, thermal moon performance and pressure drop downside. Looking at overseas research data, Tinker shows the flow field inside the heat exchanger shell containing double in one study on pressure drop and heat exchanger performance. III. However, at this time, computers were not developed, so they presented the ideal population, but they could not interpret the interaction between the niche flow and the lateral flow.

Stehilk et al. consider the effect of tilting the vessel as a method of reducing pressure loss in the heat exchanger while maintaining the heat effect, as a way to reduce pressure loss in the heat exchanger while maintaining the heat effect.

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Huadong Li et al. studied the heat moon and pressure drop system according to the vessel interval in a shell-and-tube heat exchanger. Within a gently developed vessel compartment, the local heat moon coefficient of the surface of each tube was shown, and the pressure strength at the same Reynolds number was studied by the scent given by the vessel interval through the average heat moon coefficient, and Shah (10) et al. studied the scent on ten moons according to the number of ships. Looking at domestic research data, Lee Sang-cheon et al. measured the thermal lunar overheating lunar coefficient when changing the flow conditions according to the number of times intervals and times of various values through experiments. A new equation is proposed by comparing the measurement results with the thermal lunar superheat moon coefficient calculated according to the Bell-Delaware method to consider the uneven interval correction coefficient. Park Myung (11, 12) etc. (tube) length TEMA (Tubular Exchanger Manufacturers Association) E-type heat exchanger is studied through experiments. Kim Eun-pil uses numerical analysis to determine the belly cut (20-30%) and the belly inclination angle (0, 18, 25 Fig) and study in detail the pear-tube-pear-cell, etc. Jinho et al. used porosity modeling of shell- tube heat exchangers to perform numerical analysis to determine the number of fold cuts (15, 21%) and pear number considering various shape factors, the best it also suggests a system direction.

III. OBJECTIVE

Following objective is find out from literature gaps as follows

1.Numerical analysis of baffle plates in shell and tube heat exchanger varying number of baffle plates and its heights ranging from 50% to 78% and (4, 6, 8, 10) respectively

2. Numerical Investigation of stream line effect of flow, velocity difference, heat transfer rate and pressure drop.

3. Finding optimized design for above heat exchanger problem

IV. METHODOLOGY

A. CAD Modeling

When it comes to numerical analysis, the first thing to do is to design a model. Experimental equipment the heat exchanger part is designed software CATIA (Computer Aided).

Three-dimensional Interactive Application) to model in three dimensions as shown in Figure 4 The shell surface assumes that there is no heat transfer, so the two of the shells are not taken into account. Since the change in flow caused by the fold is not considered, the thickness of the vessel is not taken into account by assuming that there is no movement of heat through the third-round modeling. In the original sphere, each model is required for the angular factor, so the shell and tube are fixed, as shown in Table 4.1, and the three-dimensional model ring is done by number of baffle and baffle height, respectively.

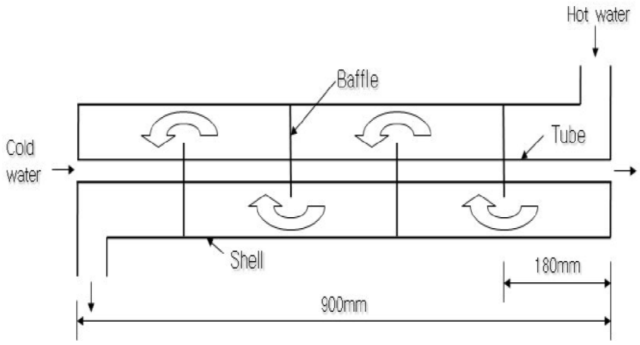

Fig.4. 2D geometry of analysis model

Fig.5. 3D geometry of analysis model

Table.1 Shell and Tube configuration for analysis model

	contents	size(mm)
Tube	D_{at}	15.88
	t_t	0.9
	L_t	900
Shell	$D_{o,s}$	114.3
	t_s	2.8
	L_s	900
Baffle	Number of baffle	4, 6, 8, 10
	Height	54.35~83.7

B. Meshing

To perform numerical analysis, it is necessary to create a grid. This is because there are many errors in numerical results depending on the type of case. In this study, ICEMCFD, which is used for mesh, is used to organize hexamesh, which is an alignment grid, and the number of meshes is about 1 million. Figure 5 shows an in-mesh type image. Hexamesh takes longer to configure than Tetramesh, but in this study, multiple models need to be configured with the same mesh, so we use Hexamesh that allows you to configure the mesh as your own intention. III. There is one that can work as many mesh numbers.

Even if you increase the degree of numerical analysis, the tube part where the ten months occur It is necessary to organize the grid in minutes. Therefore, as shown in Figure 6 we create a grid with three parts of Shell, Tube, and Coldwater, and perform numerical analysis by combining each part. At this time, the mesh-nodes in each part do not work, resulting in errors in the analysis. In ANSYSCFDV.11, the commercial station used in this study, there is a feature called GGI that causes nodes to mismatch can be compensated.

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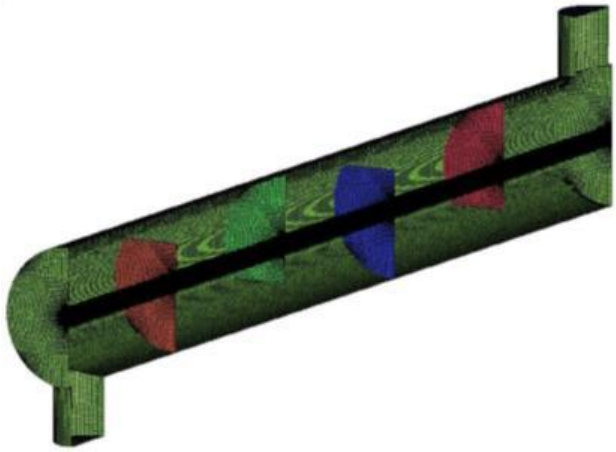

Fig. 6: Comprehensive mesh for analysis model

C. Numerical Analysis Method

When performing numerical analysis of the heat exchanger, ten months of design is designed to improve performance. In the past, numerous models have been manufactured and modified to improve performance, but this method costs a lot of money and time to build. Therefore, in recent years, research through CFD has been actively established. It is being lurked. In this study, numerical analysis was performed to determine the commercial stone software

ANSYS is used to simulate the flow thermal performance and pressure drop of hot water and cold water in a shell-and-tub heat exchanger by configuring HexaMesh, an alignment grid, using CFD. Before performing numerical analysis, some assumptions are required, and the assumptions used in this study are as follows:

(1) Perform the analysis in a steady state.

(2) The fluid has a three-dimensional incompressible turbulent flow.

(3) The turbulence model uses the SST turbulence model.

(4) The flow temperature entering the inlet is constant.

(5) Shell The outer surface is insulating.

(6) It is assumed that there are no ten months through Baffle.

D. Boundary Conditions In flow Conditions

Three-dimensional numerical analysis requires boundary conditions, which are very necessary. Table 3 is the result of an experiment with the inflow conditions. This results in the same model as the test unit with the size of the vessel (83.7mm) and the number of vessels (4), using the inflow conditions of Table 2. Numerical analysis is performed by comparing the results of the experiment with the results of the experiment to verify the validity of numerical analysis for the pear factor performed in this study. Looking at the boundary conditions during numerical analysis, the flow temperature of the water entering the Shell tube inlet was constant with the inlet conditions in Table.3. The exit condition uses 1 ATM as the table air pressure. One Shell surface and Baffle are hypothesized to have thermal months only through the tube (copper) between Hot water and Coldwater, assuming there is no movement of heat given the thermal insulation conditions.

Table 3 shows the inflow conditions used in this analysis, and Table shows the boundary conditions. Here, the boundary condition is the boundary condition when performing numerical analysis according to the control factor.

Table.2 Inlet conditions

No.	T_t(°C)	T_s(°C)	Vt(l/min)	V_s(l/min)
1	17.5	70	2.05	12
2	12.7	70.9	3.78	12
3	11	70.8	4.51	12
4	10.6	70.4	4.97	12
5	9.8	70.6	5.24	12
6	9.1	70.4	6.44	12
7	8.6	70.1	8.44	12

Table .3 Boundary conditions

Hot water	Inlet temperature	17.5(°C)
	Flowrate	6,12,18,24,36 (l/min)
	Outlet condition	1atm
Coldwater	Inlet temperature	70(°C)
	Flowrate	2.05(l/min)
	Outlet condition	1atm
Shell surface	Adiabatic	
Baffle		

E. Control Factors

In this study, based on information on the heat exchanger shape of the experimental device, the shell-tube Put the control factor baffle on the ten-month performance depending on the change in the size and number of vessels Let's look at how much it affects the pressure drop, and consider the following control factors to see the trend. III. The control factors and details are listed below, and the detailed schematics for these control factors are given.

1. Orientation Due to Changes in Baffle Height

Change in Baffle height Heating lunar performance Discover the scent of pressure drop change the Baffle height to 54.35, 59.35, 62.29, 64.35, 65.35, 66.35, 68.35, 70.35, 72.35, 73.35, 74.35, 83.7mm, reducing the thermal lunar pressure drop. In this case, the inflow condition is used No.1 in Table 3.

2. Changes in Number of Baffle

Change of Number of baffle heating lunar performance Calculate the effect of pressure drop Adjust the spacing of the vessel to change the number of vessels to 4, 6, 8, and 10 At this time, the inflow condition is Table 3 to No.1 is used, and Baffle height uses 83.7mm, the same as the experimental unit.

3. *Fragrance due to changes in the flow rate of hot water*

Each Baffle height, Number of baffle depends on the change in the hot water flow rate. To find out the effect of the thermal lunar performance pressure drop, we changed the flow rate of the hot water to 6 to 36 l/min. At this time, under the same conditions as Figure 7 and 8, the inflow

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condition No.1 was used to change the amount of oil in Hot water.

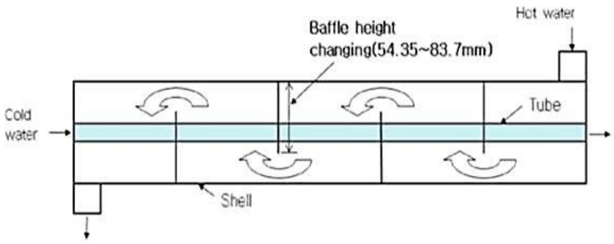


Fig.7. Schematics of changing Baffle height

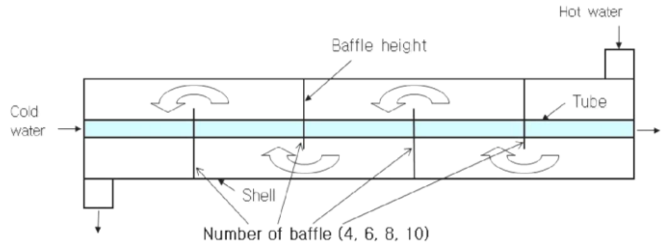


Fig. 8. Schematics of changing number of baffle

V. RESULTS

A. Speed distribution with Baffle height changes

Figure 9, Figure 10, Figure 11, Figure 12, Figure 14, Figure 15 by learning how the ship has a scented effect on the size of the ship distribution. Here, the ship sizes are 54.35mm, 59.35mm, and 64.35mm, respectively, 69.35mm, 74.35mm, 83.7mm

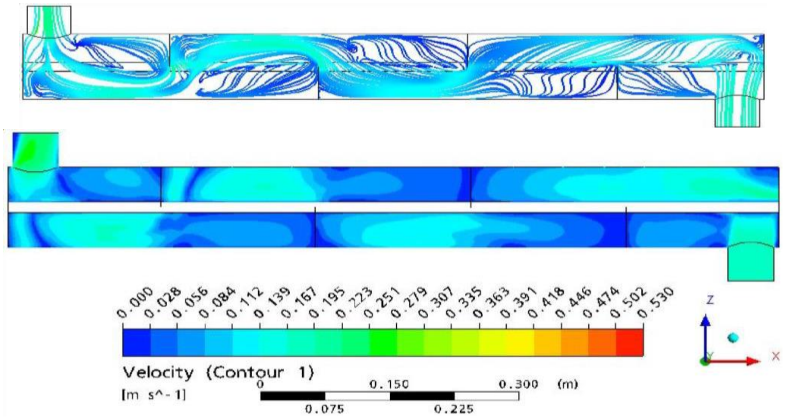


Fig 9: Streamline and velocity distribution with a Baffle height of 54.35mm

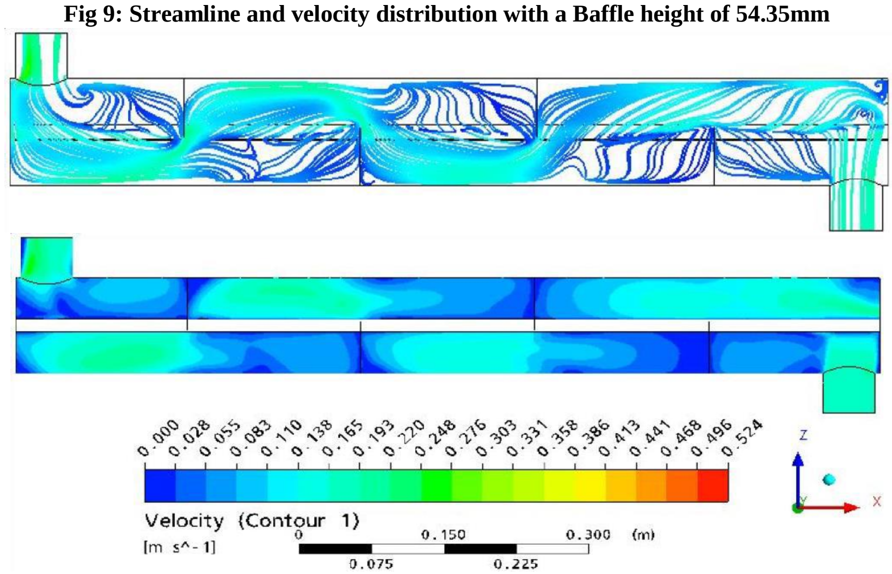
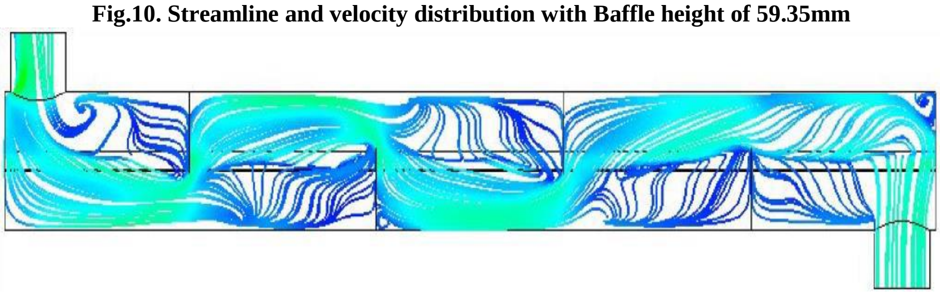


Fig.10. Streamline and velocity distribution with Baffle height of 59.35mm



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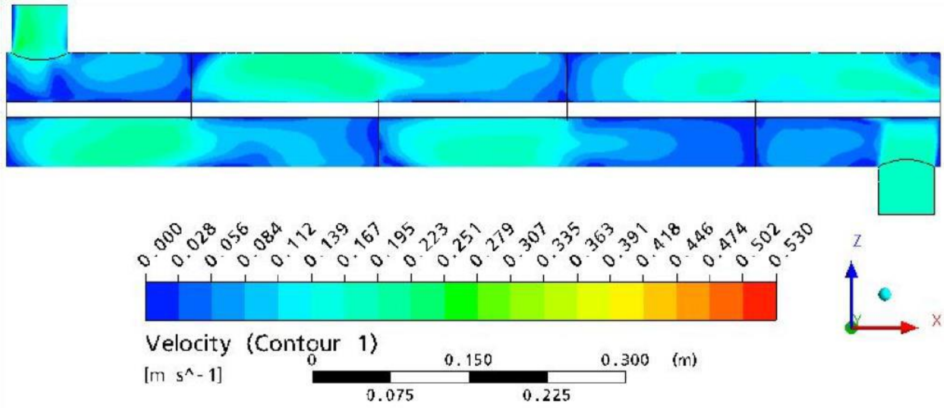


Fig. 11. Streamline and velocity distribution with a Baffle height of 64.35mm

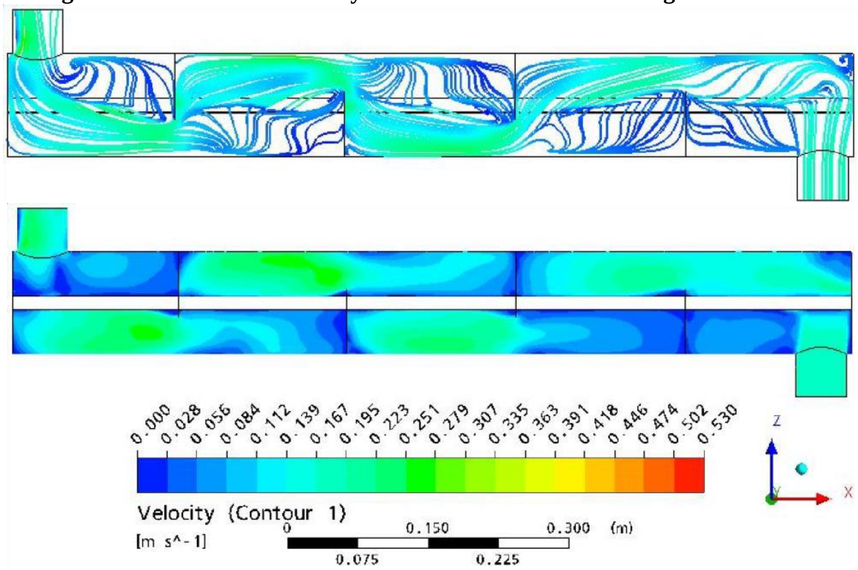


Fig.12. Streamline and velocity distribution with a Baffle height of 69.35mm

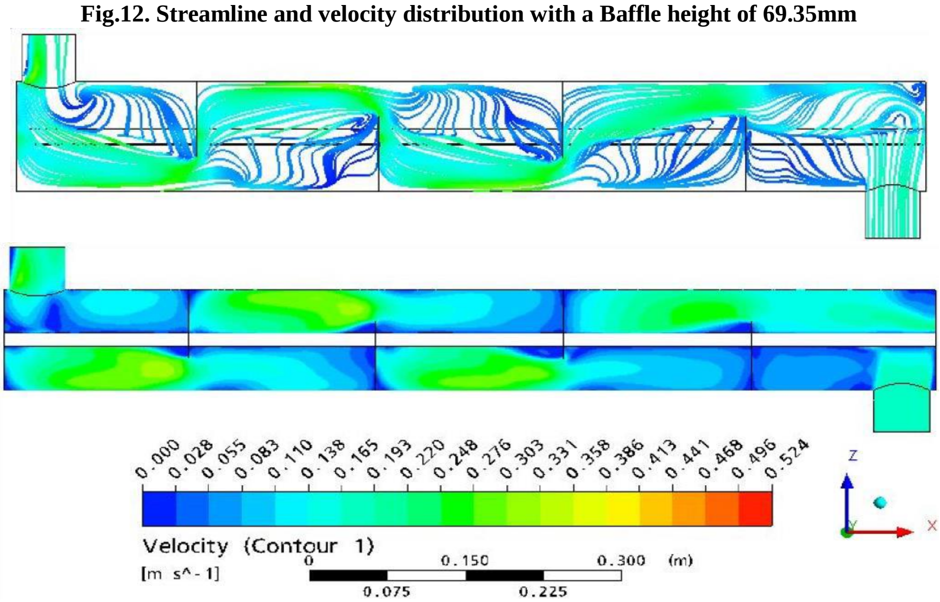
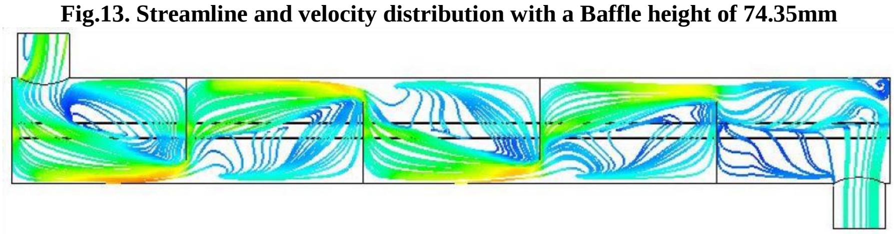


Fig.13. Streamline and velocity distribution with a Baffle height of 74.35mm



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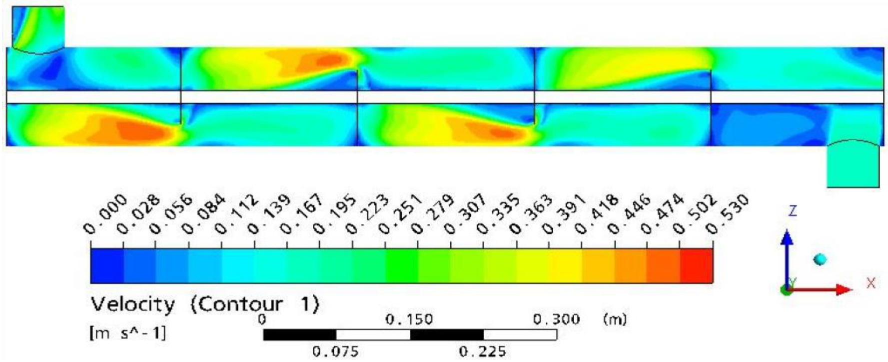

Fig.14. Streamline and velocity distribution with a Baffle height of 83.7mm

B. Number of baffle velocity distribution with change

Figure 16, Figure 17, Figure 18 show the Streamline velocity distribution by figuring out how the ten-moon incense is applied according to the change in the number of ships. The number of ships here is 4, 6, 8, and 10, respectively

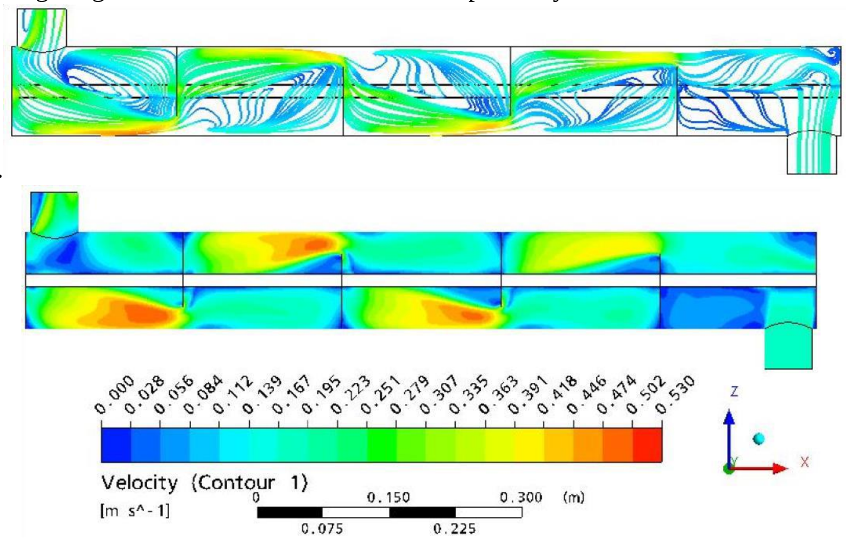

Fig.15. Streamline and velocity distribution with four baffles

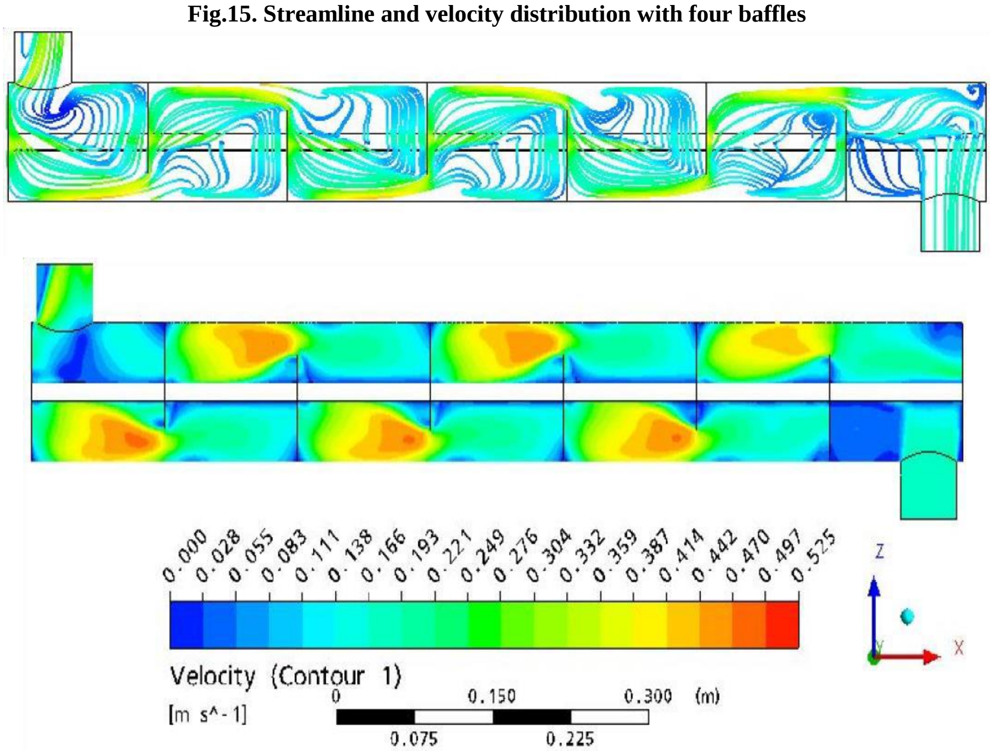

Fig.16. Streamline and velocity distribution with six baffles

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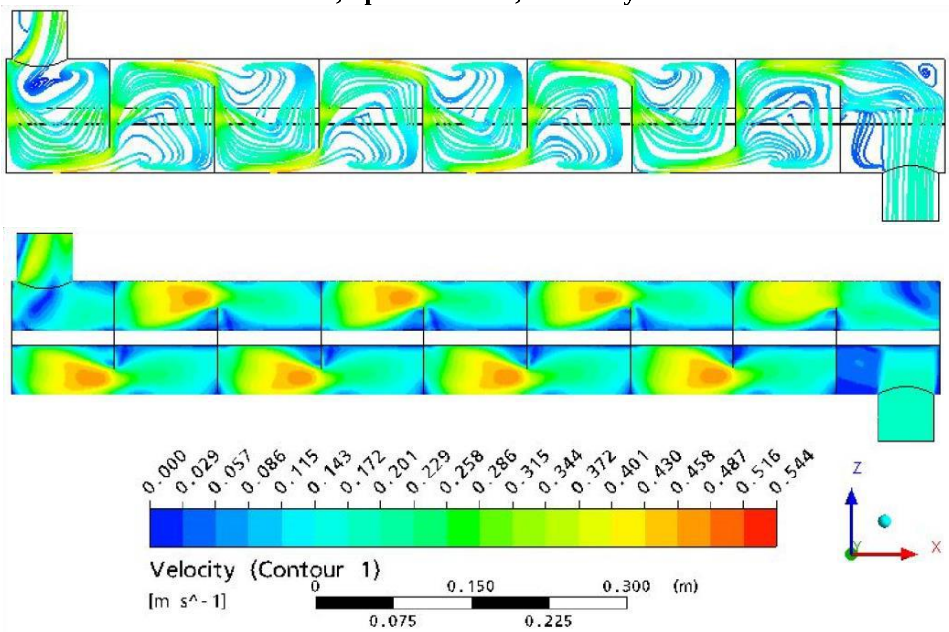

Fig.17. Streamline and velocity distribution with eight baffles

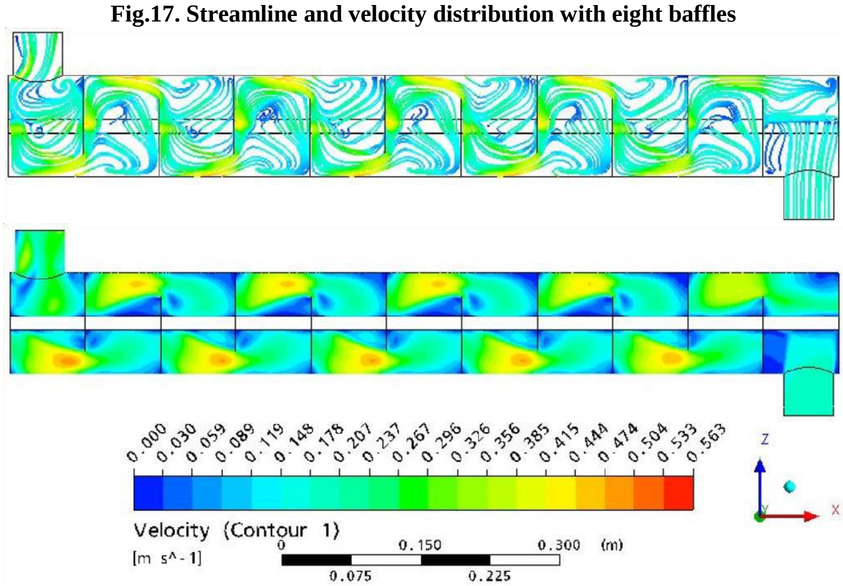

Fig.18. Streamline and velocity distribution with ten baffles

VI. CONCLUSION

In this study, numerical analysis is done with the baffle height 54.35~83.7mm Number of baffle 4. The effect of 10 changes on the heat transfer performance and pressure drop of the work exchanger was analyzed, and the effect of changing the hot water flow rate of 6~36 l/min for each control factor was also analyzed. As a result, the following conclusions were obtained.

(1) The amount of heat transfer according to the size of the baffle increases constantly until the tube is completely covered, but decreases as the size of the baffle increases, due to the separation of the fluid, vortex, velocity, contact area with the tube, and residence time. showing an increase again.

(2) The heat transfer according to the increase in the number of baffles increases up to a certain number, but decreases when the number is exceeded. This is also determined to be caused by the contact area with the tube, speed, residence time, peeling and vortex.

Therefore, in order to maximize the recovery when manufacturing a cell-tube heat exchanger, deriving and manufacturing the optimal baffle size and number of baffles through numerical analysis is considered to be a very good method in terms of reducing trial and error as well as economically.

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