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INVESTIGATION OF PRESSURE DROP & HEAT TRANSFER CHARACTERISTICS IN SHELL AND TUBE HEAT EXCHANGER USING POROUS BAFFLE PLATE

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ABSTRACT
The shell- and- tube heat exchanger (STHE) is one of the most extensively used type of heat exchangers in the industry. For this reason, studies conducted to ameliorate the performance of STHEs are of great significance. In this study, probe of heat transfer rate in shell and tube heat exchanger by using baffle plates compared with the shell- and- tube heat exchanger with segmental baffles, abrupt change of fluid inflow is avoided that drop the pressure drop in the shell side. The numerical results indicated that the heat transfer measure per pressure drop of both the shell- and- tube heat exchangers with pervious baffles are advanced than that of the shell- and- tube heat exchanger with segmental baffles. Hence, it's veritably important to optimize the heat exchanger design. To ameliorate of the Heat transfer rate of the heat exchanger by revising the pervious baffle plate with the help of ANSYS Fluent software. The result suggested that the overall performance of the conventional model is more effective than the segmental pervious baffle plate heat exchanger**.**

Keywords:
STHE, ANSYS Baffles, Perforations

I. Introduction
The energy protection is one of the crucial issues of the twenty-first century, and it will absolutely be one of the most critical difficulties sooner rather than later. In this manner, researchers, architects and specialists are impressively attempting to address this significant issue. The advances made in heating or cooling in modern gadgets cause energy sparing and heat move improvement, and increment the operational existence of the hardware. Energy investment funds can be performed by the productive utilization of energy. Energy transformation, preservation and recuperation are a few courses for energy sparing. To previously mentioned reason, different sorts of heat exchangers are used in numerous modern territories, for example, power plants, atomic reactors, petrochemical industry, refrigeration, cooling, process industry, sun powered water heater, nourishment building, and concoction reactors. Various advances are utilized to improve the productivity of heat exchangers. For quite a long time, endeavors have been gained to ground heat move in heat exchangers, decline the heat trade time lastly improve the framework proficiency. A heat exchanger is a gadget used to move heat between at least two liquids. At the end of the day, heat exchangers are utilized in both cooling and heating procedures. The liquids might be isolated by a strong divider to forestall blending or they might be in direct contact. They are broadly utilized in space heating, refrigeration, air conditioning, power stations, synthetic plants, petrochemical plants, oil processing plants, flammable gas handling, and sewage treatment. The great case of a heat exchanger is found in an inward ignition motor in which a coursing liquid known as motor coolant moves through radiator loops and wind currents past the curls, which cools the coolant and heats the approaching air. Another model is the heat sink, which is an aloof heat exchanger that moves the heat produced by an electronic or a mechanical gadget to a liquid medium, frequently air or a fluid coolant.

The project presents a strong chance to address important issues in thermal engineering and looks into the rates of heat transfer in shell-and-tube heat exchangers with porous baffle plates. This research attempts to improve heat transfer efficiency by investigating the creative application of porous baffles, potentially changing heat exchanger design. The project has practical ramifications for companies that depend on effective heat exchange operations in addition to furthering our fundamental understanding of heat transfer systems. This project is an inspiring and significant option for individuals who are driven to push the limits of thermal science and engineering, as it promises to both advance academic understanding and offer practical solutions.

II. Literature

Liu et.al [1], in this paper it presents an original sort of shell and cylinder heat exchanger with changed overlay helical confuses and bent oblate cylinders is proposed to seal the spillage regions in the shell focal point of the shell and cylinder heat exchanger with overlap helical confounds. The warm and pressure driven properties of and for water chiller frameworks are researched by mathematical reproduction. Building energy utilization is a significant test in energy saving. Shell and cylinder heat exchangers broadly applied in water chiller frameworks, are key parts of the structure energy framework. All things considered, customary shell and cylinder heat exchangers with segmental puzzles utilized in water chill frameworks have various weaknesses, for example, stream no man's land, tube group vibration, low intensity trade productivity, enormous power utilization, short lifetime and so on. In this manner, working on the presentation of will be a powerful measure to adapt to the structure energy utilization challenge.

Pronczuk et.al [2], this paper presents a trial concentrate on a shell and cylinder scaled down heat exchanger (STMHE). The STMHE comprised of seven cylinders in a three-sided plan, with a 0.8 mm inward breadth and 1.0 mm external width. The intensity exchanger shell had an internal width of 11 mm, and the intensity exchanger had no puzzles. For the embraced working circumstances, the Reynolds number on the cylinder side changed in the scope of 300-3000, and 2000-12,000 on the shell side. The point of this study was to decide pressure drop values during liquid stream and Nusselt number relationships for the intensity move. This paper presents the consequences of exploratory examinations focused on assurance of the intensity move coefficient and tension drop, both inside the cylinders and in the shell side of the small-scale heat exchanger. The experimental recipes portraying the upsides of the Nusselt number contingent upon the upsides of dimensionless Reynolds and Prandtl numbers were formed. Another technique in light of enhancement was utilized to decide boundaries present in the situations. The outcomes were likewise contrasted and connection conditions accessible in the writing.

Lei et.al [3] two novel shell-and-cylinder heat exchangers with louver confounds are concocted and intended for energy preservation. A specific sum louver confuses at the tendency point between shell side stream course and louver bewilder are prepared in shell side to help tube groups. Mathematical recreations are completed to explore the thermo-water powered execution of the two improved shell-and-cylinder heat exchangers with louver bewilders. For examination, a shell-and-cylinder heat exchanger with traditional segmental perplexes likewise concentrated on in the paper. The mathematical outcomes showed that the intensity move coefficient per pressure drop of both the shell-and-cylinder heat exchangers with louver confuses are higher than that of the shell-and-cylinder heat exchanger with segmental astounds. This infers that at a similar intensity move amount, the siphoning force of the shell-and-cylinder heat exchangers 2 with louver puzzles is lower than that of the shell-and-cylinder heat exchanger with traditional segmental confuses.

Wu et.al [4], confounds with openings in various measurements (or HDD confuses) and narrowly layered tubes are separately longitudinal stream perplex and high-productivity heat trade tubes proposed by the creator. In this paper, vibrations of cylinder packs with HDD bewilders and liquid stream as well as intensity move inside narrowly layered tubes were mathematically mimicked, and

the intensity exchanger with narrowly folded tubes and HDD puzzles was tried for the intensity move productivity. Viewed as contrasted and the conventional segmental confounds, tube group vibrations in heat exchangers, on the off chance that utilizing the HDD confuses, can be altogether diminished. With respect to move effectiveness, conically corrugated tubes are obviously superior to smooth cylinders and, surprisingly, better than other high-productivity heat move tubes. Contrasted and the customary intensity exchangers, heat exchangers built with narrowly ridged tubes and the HDD confounds can give better intensity move effectiveness and less cylinder pack vibration.
Tahrour et.al [5] this paper expects to explore the impact of cylinder shapes on warm stream attributes of sinusoidal wavy finned-tube heat exchangers. Two column staggered pack with six calculations of cylinders (four level cylinder calculations, one oval cylinder and a round tube) are broke down for a scope of ($1600 \leq Re \leq 4800$). The review uncovered that the intensity motion and the tension drop decline with the cylinder levelness for all Reynolds values. In any case, the oval cylinder O_1 comes to, for all Reynolds esteems, the least upsides of intensity motion and strain drop. As to worldwide execution standard, the sinusoidal wavy balances with O_1 moulded tubes arrived at the most noteworthy worldwide execution values, being 14.8-24.4% and 31.6-36.3% higher than the blade with F_1 and O_2 tube math, separately.
Hayder Al-Lami et.al [6] this paper expects to research the intensity move, liquid stream and energy fields, perplexes are a high-level enhancer to further develop heat move and liquid blending by functioning as an impediment to the stream particles and afterward expanding the choppiness. The current paper mathematically explores the warm exhibition of a roundabout line with a unified perplex in two plans, with a Reynolds number (Re) (going from 10,000-50,000) under steady wall heat motion limit conditions. Ansys Familiar programming is utilized to tackle the stream field thinking about six funnels shaped bewilders with various Pitch proportions (PR) (from 1 to 5). Results show that confuses shape, game plan, and PR altogether affect the properties of stream and intensity move. The got results show a compelling job for the puzzles to advance warm execution when it is utilized in warmed pipes. Heat move rate is expanded for the confounded line by 1-2 contrasted and the smooth line.
Bellahcene et.al [7] the point of this work is to explore the constrained convective intensity move peculiarities and liquid progressions of water-based Al_2O_3 nanofluids in the astounded shell and cylinders heat exchanger (STHE). Water as a hot liquid streams in the side of the cylinders, and Al_2O_3 nanofluids as cooling liquid stream in the shell side. Mathematical examinations have been done in light of the congruity, force, and energy conditions which are addressed by utilizing the limited component technique with the assistance of the COMSOL 5.4 CFD programming.

III. Problem Statement

Heat exchangers are an indistinguishable piece of the enterprises, for example, power plants, process ventures, oil refining, etc. In the interim, the shell and cylinder heat exchangers (STHE) have 40% offer contraption of the diverse business. Along these lines, centre around this mechanical assembly is expected to improve the presentation of this gadget. Confounds and cylinder design and their course of action profoundly affect the presentation of this sort of heat exchanger. So, we are concentrating on baffle plate for act of spontaneity of heat transfer rate.

IV. Objectives

1. The design of shell-and-tube heat exchanger is designed by using CATIA V5R21 software.
2. Shell and tube heat exchanger with a conventional single plate and a new type of porous baffles plate is designed and tested by compared using CFD simulation in ANSYS Fluent software.
3. To understand the effect of baffle plate in Shell and tube heat exchanger for improvisation of heat transfer rate.
4. To manufacture shell-and-tube heat exchanger according to design parameter.

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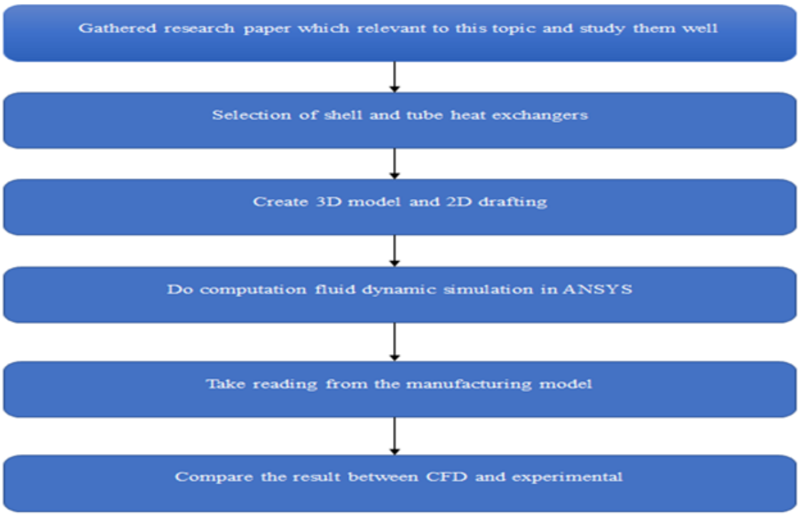
5. Comparison of experimental and CFD result of Shell and tube heat exchanger with a conventional single plate and a new type of porous baffles plate.

V. Methodology



VI. Existing Heat Exchanger

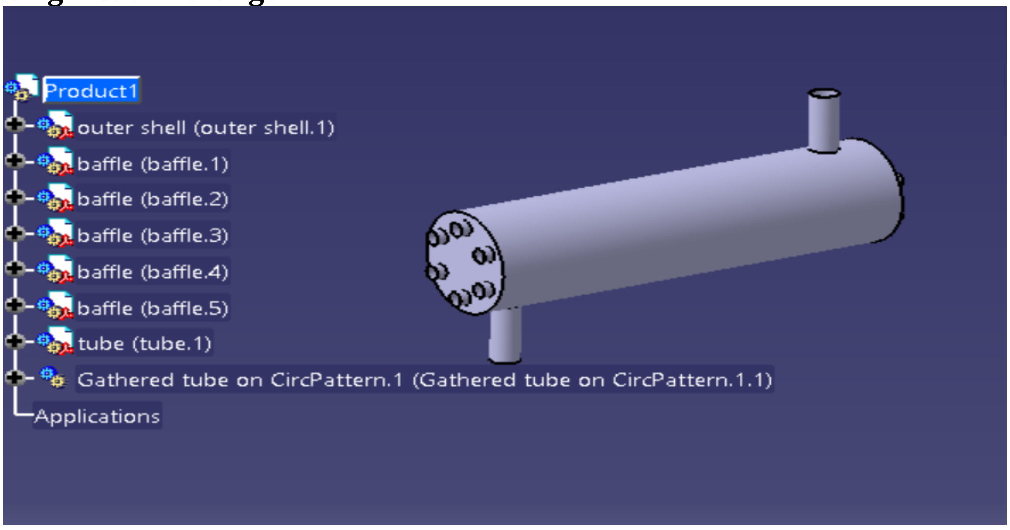


Fig 1. CATIA model of heat exchanger

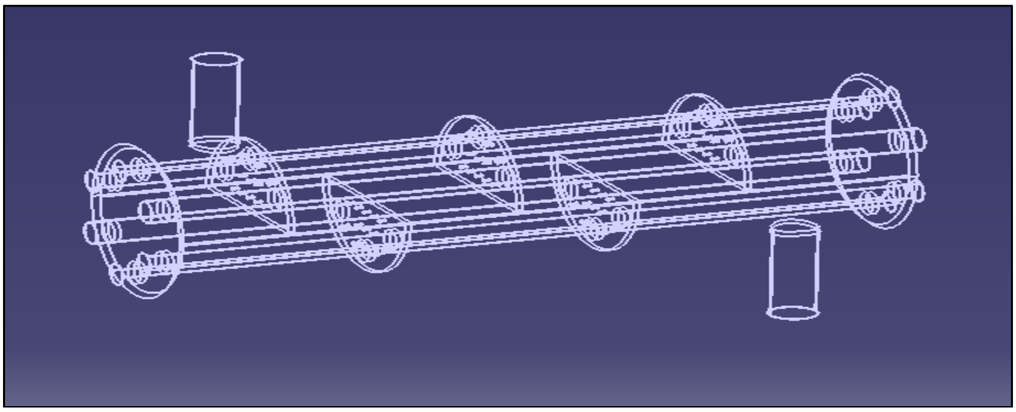


Fig 2. Wireframe geometry for internal view of baffles

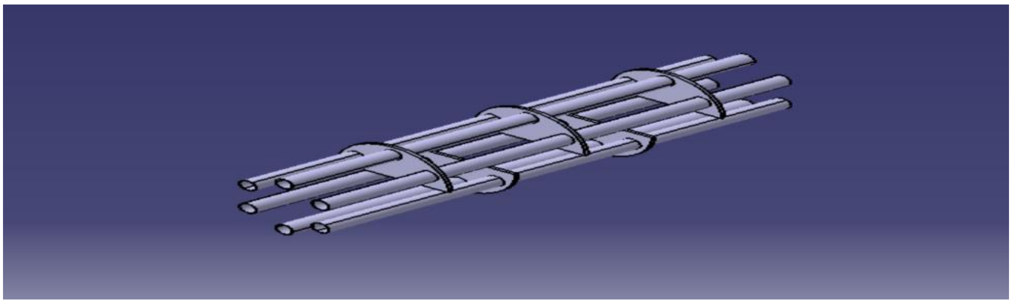


Fig 3. Solid geometry for internal view of baffles

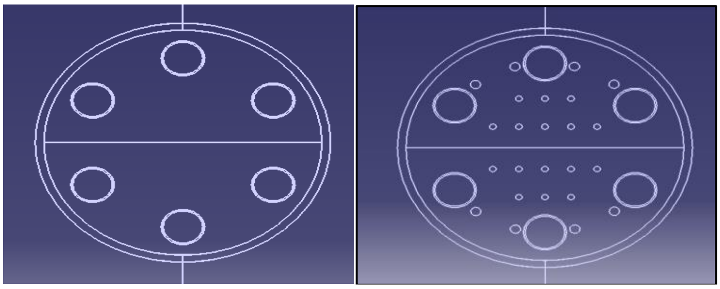


Fig 4. CATIA model of heat exchanger without and with perforation on baffles

VII. CFD Of Existing Heat Exchanger

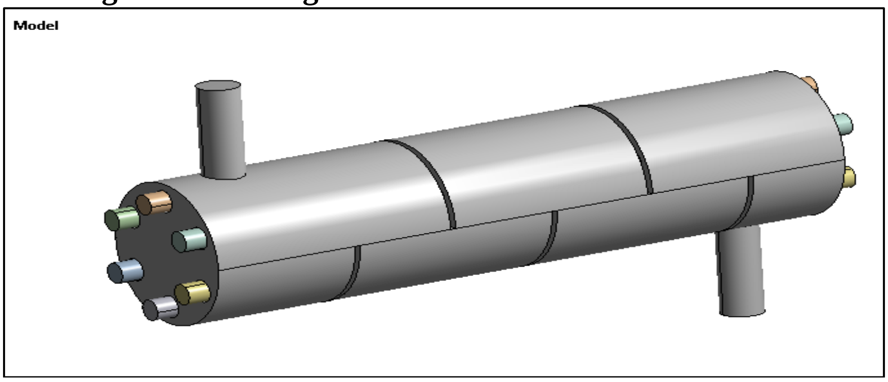
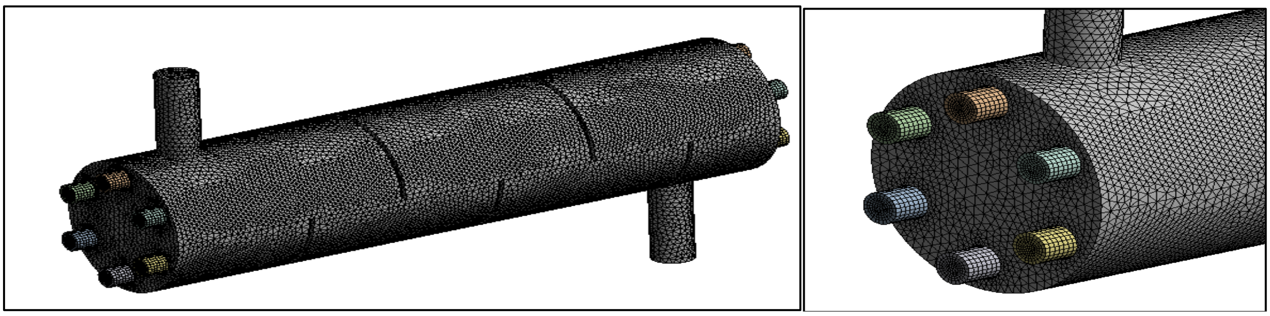


Fig 5. Geometry imported in ANSYS

7.1 Mesh

As the main link of finite element analysis, grid division can best reflect the idea of finite element. The quality of the web site not only affects the efficiency of model analysis, but also directly affects the accuracy of analysis results. Therefore, according to the existing hardware, without affecting the accuracy of the calculation results, the method of dividing the mesh can be appropriately selected to save calculation time



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Statistics	
Nodes	357886
Elements	1100751

Fig 6. Details of meshing of heat exchanger

Final existing heat exchanger mesh model, it contains 357886 nodes and 1100751 elements. Element size was 5 mm

7.2 Boundary condition

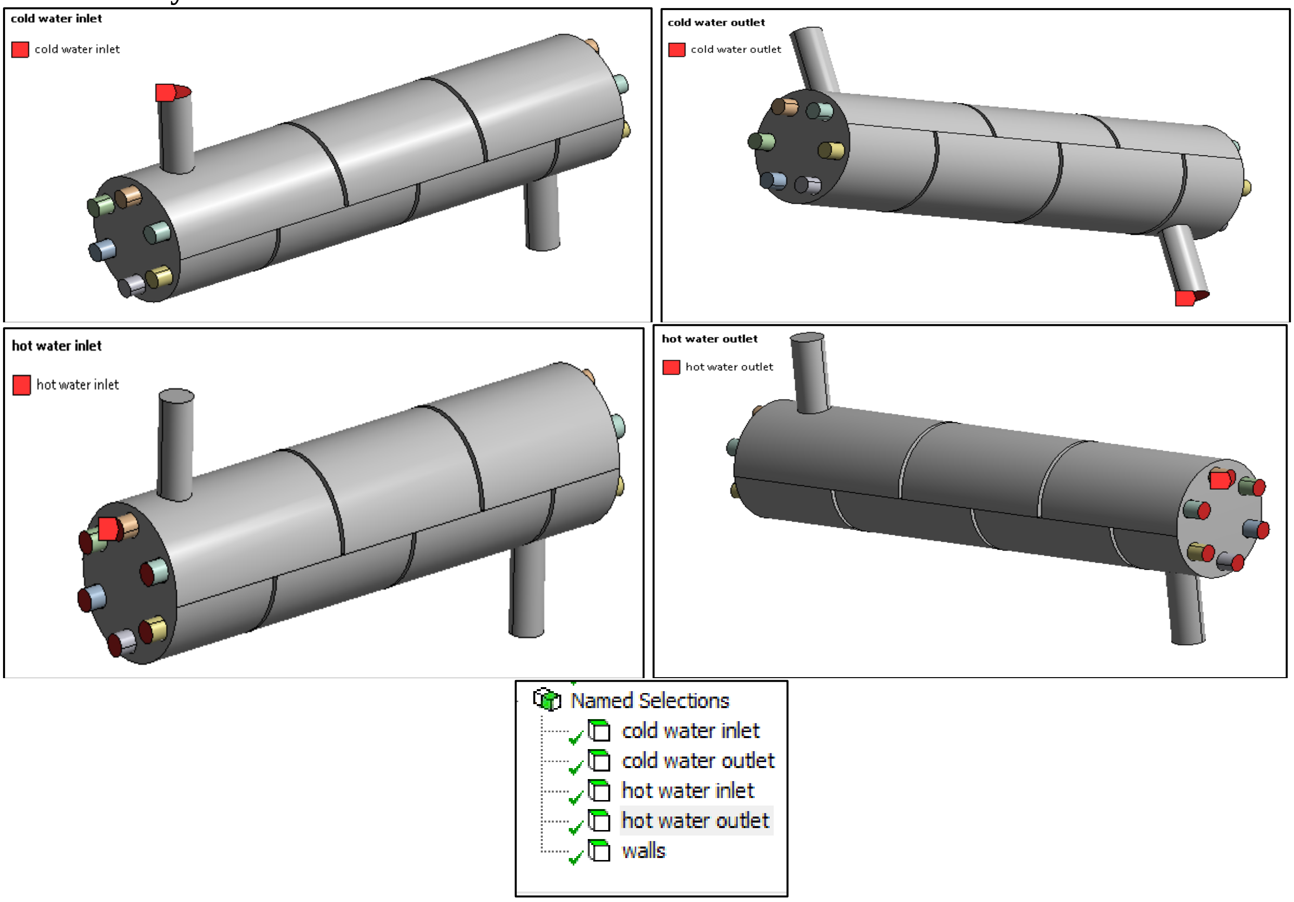

Fig 7. Details of named selection

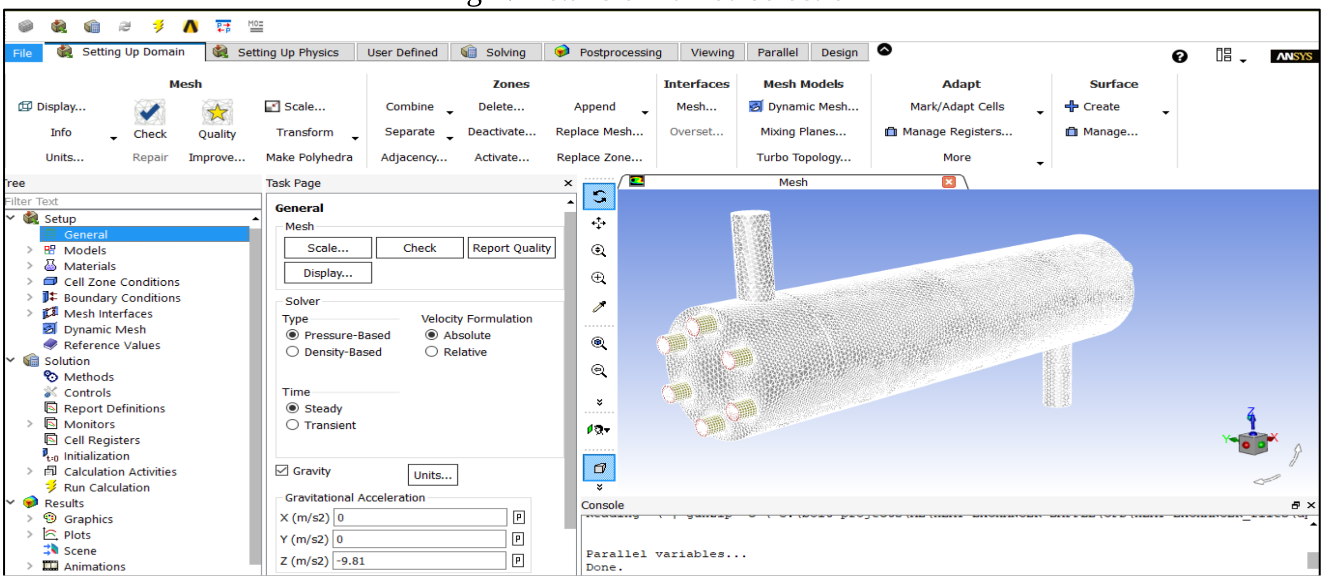

Fig 8. Setting up Domain

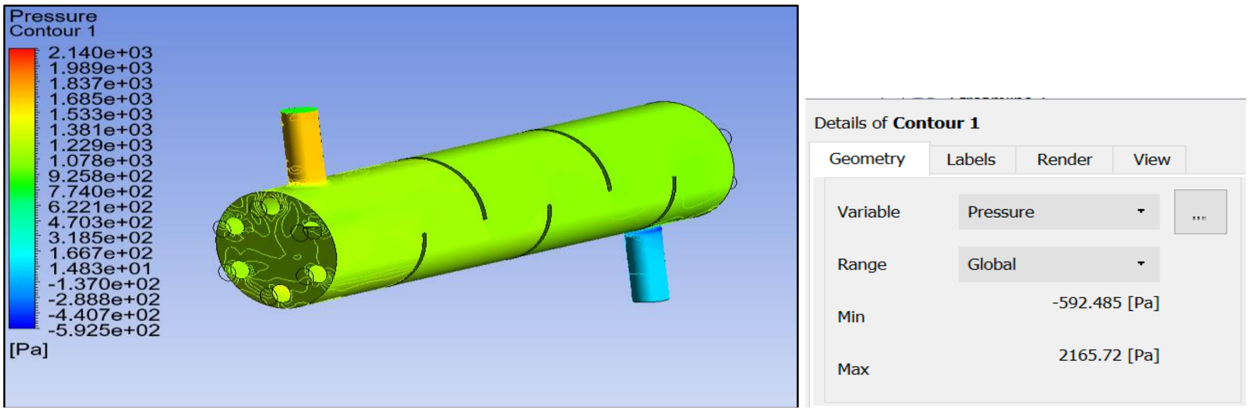

Fig 9. Details Of Pressure Contour 1

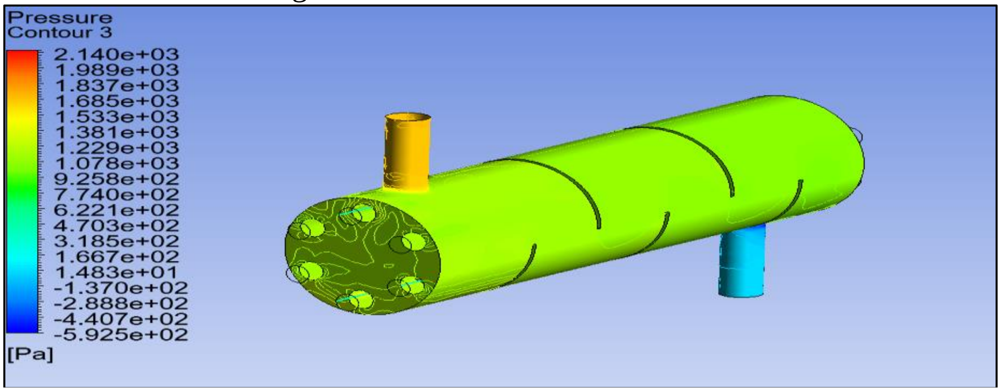

Fig 10. Details Of Pressure Contour 3

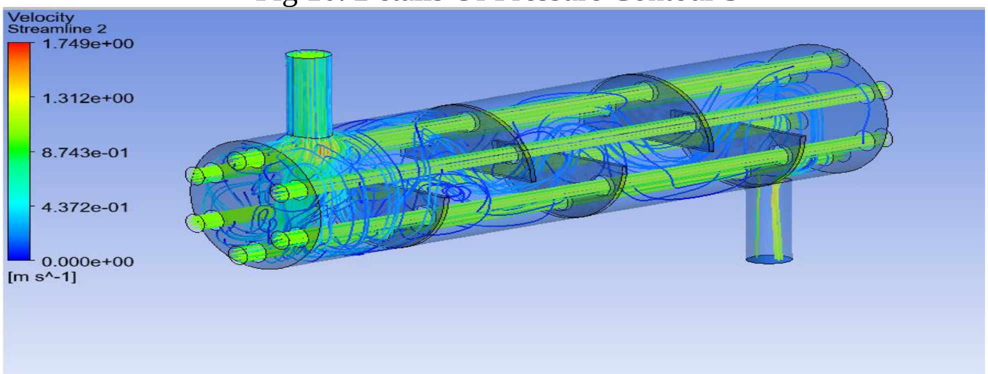

Fig 11. Details Of Velocity Streamline 2

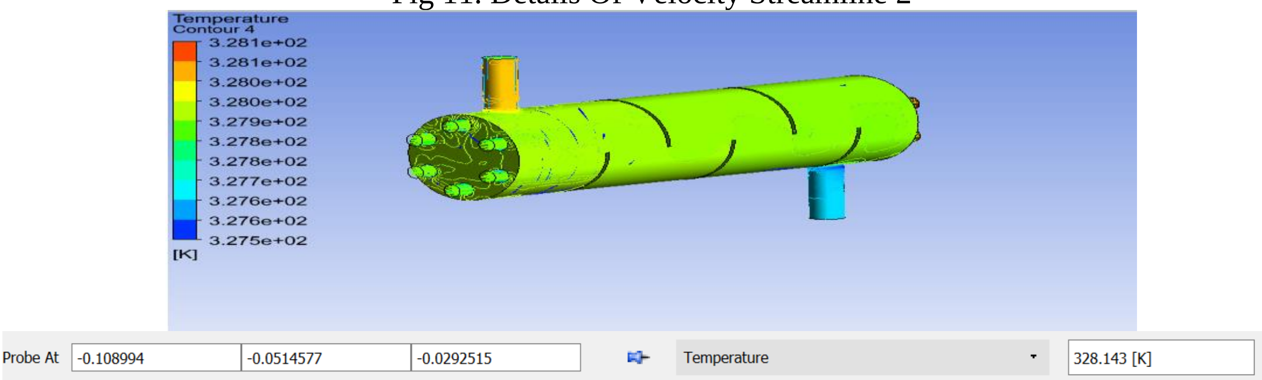

Fig 12. CFD contour for hot water outlet temperature

VIII. Modified Heat Exchanger

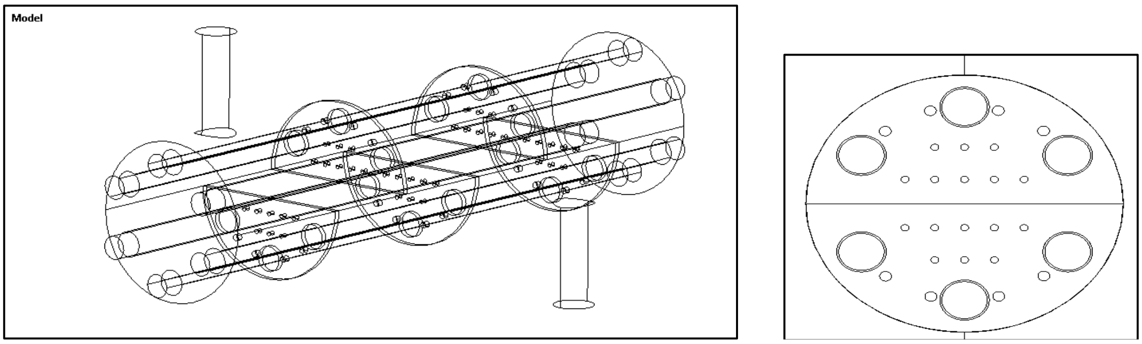

Fig 13. CATIA model of Modified heat exchanger

Perforation in the form of small hole with 4 (8 quantity) and 6 mm (4 quantity) diameter hole are performed to improve mass flow rate along with decrease in pressure drop

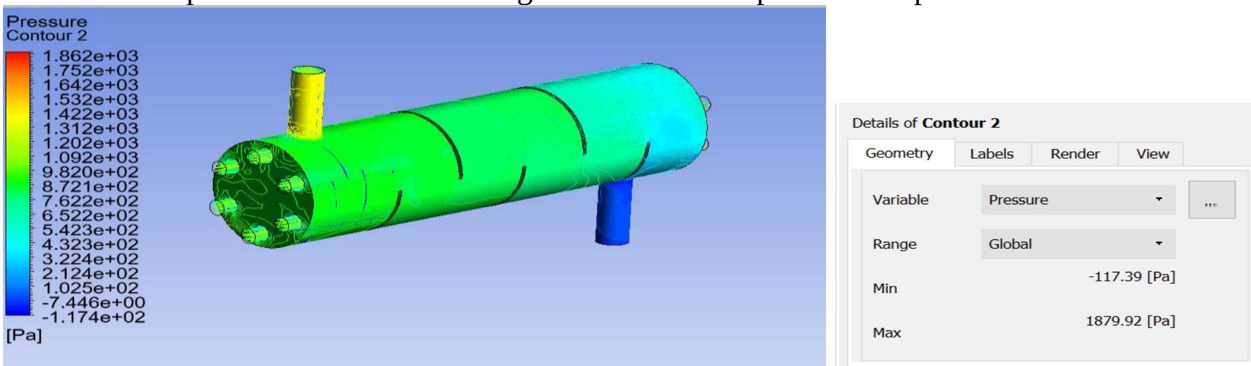

Fig 14. Details Of Pressure Contour 2

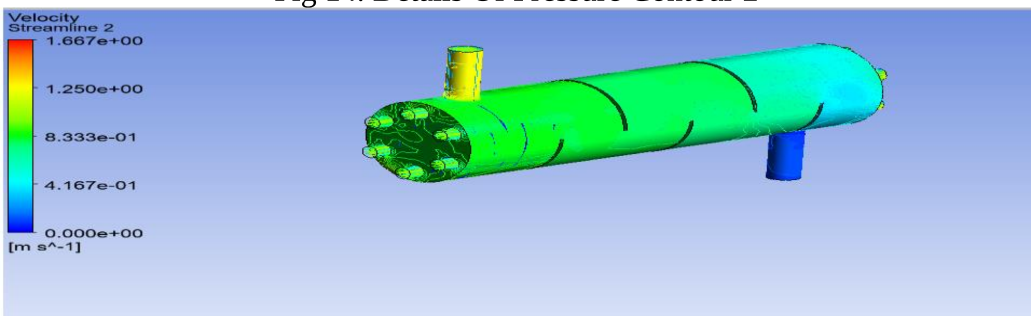

Fig 15. Details of Velocity Streamline 2

It is observed from pressure contour plot that baffles with perforation have improved mass flow rate along with decrease in pressure drop i.e. in existing geometry pressure was 2.165kPa but with modified geometry it is observed around 1.879 kPa.

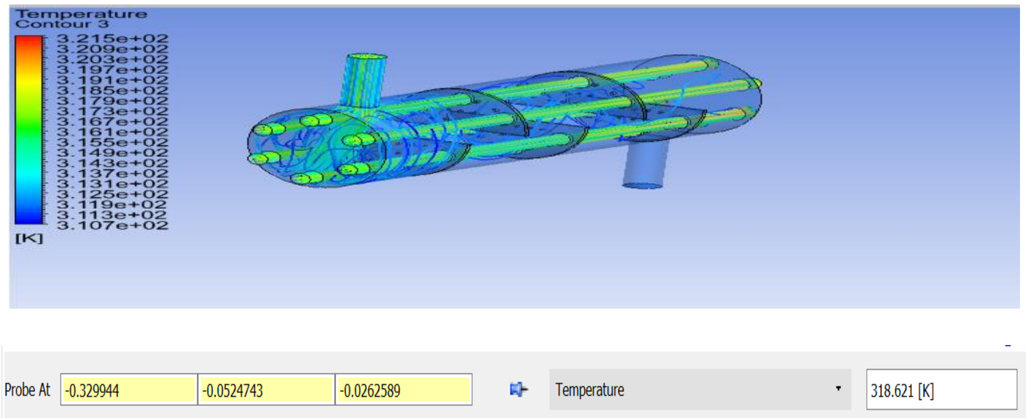

Fig 16. CFD contour for hot water outlet temperature

- Outlet at hot water temperature is observed around 318.621 k or 45.5 degree Celsius.

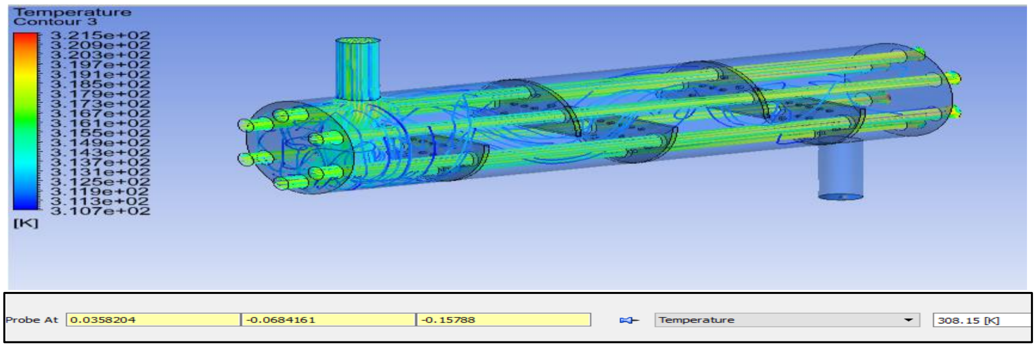

Fig 17. CFD contour for cold water outlet temperature

- Outlet at cold water temperature is observed around 308.15 k or 35 degrees Celsius

IX. Experimental Testing

- In present research heat exchanger with baffles with perforation is designed as per CFD simulation dimension.
- Pipe of respective dimension are selected and baffles are laser cut with perforation and baffles hole to hold pipes inside it and single outlet is made for hot water outlet.
- Initially hot water is boiled up to 50 degrees as per simulation boundary condition as hot water inlet and cold-water inlet is water at room temperature.
- Cold water is provided as inlet from top side of heat exchanger along with hot water inlet from right side as per figure below.
- Then with the help of submersible pump water is circulated.
- Hot and cold water is collected in respective tank with thermocouple attached to it to measure respective temperature.

Fig 18. Experimental setup

Parameters	CFD (Temperature)	Experimental (Temperature)
Hot water Inlet	50	48
Cold water Inlet	26	27
Hot water Outlet	45.5	44
Cold water Outlet	35	34

Table 1. Comparison of CFD and Experimental Result

X. CONCLUSION

- In present research heat exchanger with baffles and baffles with perforation is designed to observe the pressure drop for efficient use and manufacturing of setup for comparison of CFD and experimental result.

- It is observed from pressure contour plot that baffles with perforation have improved ta mass flow rate along with decrease in pressure drop i.e. in existing geometry pressure was 2.165kPa but with modified geometry it is observed around 1.879 kPa.
- Manufacturing of heat exchanger with perforation in baffles have been proved to be better design for pressure drop.
- Experimental testing of heat exchanger observed that temperature at separate junctions were analogous to the result attained by CFD simulation using thermocouple and inquiry at position in respective situations.

XI. FUTURE SCOPE

The present study has explored the thermal and hydraulic performance of a shell and tube heat exchanger with porous baffle plates. Future research directions and potential applications may include:

- Optimizing the design of porous baffle plates for specific industrial applications, such as oil refining or chemical processing.
- Investigating the use of different materials and manufacturing techniques for porous baffle plates to enhance durability and cost-effectiveness.
- Exploring the integration of porous baffle plates with other heat exchanger enhancements, such as helical tubes or vortex generators.
- Scaling up the design for large industrial applications, including power plants and HVAC systems.
- Developing advanced computational models to simulate the behaviour of porous baffle plates in various flow regimes.
- Investigating the potential of porous baffle plates in other thermal management applications, such as electronics cooling or aerospace engineering.
- Collaborating with industry partners to implement and test the design in real-world scenarios, leading to improved energy efficiency and cost savings.

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