



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 9, September 2021

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.569

Plate Type Heat Exchanger (Milk Chillers)

Rutvik Deshmukh¹, Arif Abdul Aziz Pasha², AG Bansode³

Diploma, Student, Department of Mechanical Engineering, Sou. Venutai C Polytechnic, Pune, Maharashtra, India^{1&2}

Associate Professor, Department of Computer Engineering, Sou. Venutai C Polytechnic, Pune, Maharashtra, India³

ABSTRACT: Heat exchangers are generally utilized gadgets in various businesses, with a wide range of uses. The heat exchanger utilized in the fermenting program is a brazed plate and frame heat exchanger, so it can't be dismantled for cleaning. Because of this, the general productivity of the heat exchanger will be decreased, causing fouling, due to the development of fermenting material. To adequately battle this fouling, a heat exchanger should be built that can be dismantled for cleaning, and then, at that point reassembled effortlessly, while as yet having the option to play out a similar measure of heat move as the brazed framework. In particular, a gasketed plate and frame heat exchanger was developed for this reason, which uses elastic gaskets to seal the framework, rather than brazing. This heat exchanger was built utilizing twenty hardened steel plates, with four stream openings punched for the liquid ways, and orchestrated with the connected gaskets in a cross stream design. To test the adequacy of this framework, the heat exchanger will work utilizing cold water to chill off water heated to around 200⁰F. The yield temperature of the water will be estimated, to perceive how well the heat exchanger can move heat between the two liquids. The consequences of this test will demonstrate the reasonability of this framework, express the particular pace of heat move inside this framework, and contrast this worth with the recently used brazed heat exchanger.

KEYWORDS: Heat exchangers, brazed plate, frame heat exchanger.

I. INTRODUCTION

For this heat exchanger system, there are several key objectives that must be met. This heat exchanger will operate for fluid to fluid conditions, between a boiling brewing worth, and cold tap water. The key function statements can be seen as 1) to allow a heat exchange between two fluids of different temperatures. 2) Capable of cooling brewing worth to a temperature where yeast can be added. 3) Be small enough to allow for easy placement and movement. Allow for additional plates to be added, or subtracted, from the system if required. The main success criteria for this project, is to perform the same amount of heat transfer as the previously used brazed heat exchanger. Mainly, the heat exchanger must be able to take 200⁰F worth down to 70⁰F. Along with this, the system must be easily taken part for regular cleaning, and allow for plates to be added and subtracted as needed. Assuming those goals are met, then this project will be successful. This project will focus on the design and manufacturing processes for this heat exchanger. The biggest hurdle will be designing the plates required for the system, and finding a way to press a corrugated pattern into the thin stainless steel. For this 1/2" thick steel plates will be CNC machined with the plate patterns, and be used to press the pattern into the thin stainless steel. Additionally, the gaskets must fit into the grooves of the plates. A fairly basic steel-rubber adhesive will be utilized. Overall, the project will focus on the design and construction of a fairly basic modular plate and frame heat exchanger.

II. OBJECTIVE

The main objective of this project is to design and construct a plate and frame heat exchanger that can be utilized in the department's brewing system. Currently, the plate and frame heat exchanger used for brewing is brazed together, and thus cannot be taken apart. Due to this, the brazed heat exchanger cannot be cleaned, and has a build-up of hops, and other various brewing solids, which cannot be cleaned out. This new heat exchanger would utilize gaskets and bolts to lock together, and be able to be taken apart for cleaning. Additionally, this would allow the new plate and frame heat exchanger to be modular, and allow for the addition and subtraction of extra heat exchanger plates, to increase or decrease the rate of heat transfer of the system.

III. METHODOLOGY



IV. LITERATURE REVIEW

- The Plate Heat Exchanger was created during the 1920s in the food business (for the sanitization of milk). They are utilized for measure heating, cooling, in every cryogenic application, and as a middle of the road step in home-grown water heaters, where consumable boiling water (hot regular water) is delivered in a halfway heat exchanger from shut circle fuel-terminated high temp water, to limit strong statements. One more way of thinking said that the plate heat exchanger (PHE) was invented by Dr Richard Seligman in 1923; he also revolutionized methods of indirect heating and cooling of fluids.
- R. K. Shah and S. G. Kandlikar (1989) had presented classification of Plate Heat Exchangers on the basis of number of passes stream game plan and by considering end plate impact. Setups utilized for this review were 1 (1 Pass-1 Pass), 2-1, 2-2, 3-3, 4-1, 4-2, and 4-4 courses of action, and six designs for the 3-1 plan. Results were introduced for temperature adequacy, log-mean temperature contrast amendment factor as a component of number of move units, heat limit proportion and all out number of warm plates. The review gave rules to choice of proper Plate Heat Exchanger arrangement. A plate heat exchanger is a kind of heat exchanger that utilizes metal plates to move heat between two liquids. This enjoys a significant upper hand over a regular heat exchanger in that the liquids are presented to a lot bigger surface region on the grounds that the liquids spread out over the plates. This works with the exchange of heat, and incredibly speeds up the temperature change. The concept behind a heat exchanger is the use of pipes or other containment vessels to heat or cool one fluid by transferring heat between it and another fluid. In most cases, the exchanger consists of a coiled pipe containing one fluid that passes through a chamber containing another fluid. The walls of the pipe are usually made of metal or another substance with a high thermal conductivity, to facilitate the interchange, whereas the outer casing of the larger chamber is made of a plastic or coated with thermal insulation, to discourage heat from escaping from the exchanger.
- The plate heat exchanger (PHE) is a specialized design well suited to transferring heat between high pressure medium and low-pressure fluids. Welded, semi-welded and brazed heat exchangers are used for heat exchange between high-pressure fluids or where a more compact product is required. In place of a pipe passing through a chamber, there are instead two alternating chambers, usually thin in depth, separated at their largest surface by a corrugated metal plate. The plates used in a plate and frame heat exchanger are obtained by one piece pressing of metal plates. Stainless steel is a commonly used metal for the plates because of its ability to withstand high temperatures, its strength, and its corrosion resistance.
- Two-stage annular stream designs with heat move are predominant in numerous mechanical cycles. The dependable forecast of tension drop and heat move rates related with these cycles are crucial for growing more solid, productive and practical heat exchangers; diminishing or killing expensive closures brought about by gear disappointment; and accomplishing energy reserve funds through improvement of warm cycles. The annular stream design is one that much of the time happens related to evaporative heat move in tubes. Annular stream is described by an intrinsically flimsy fluid film streaming along the divider corresponding to a streaming fume center conveying entrained fluid drops. The fluid film structure is affected by numerous framework factors, some of which are framework math, stream direction (up, down, microgravity, or level stream), and fluid/fume speed distinction. Kenning and Cooper (1989) distinguished two heat move systems related with evaporative two-stage stream heat move: the convective system and the nucleate bubbling system. In the convective system, nucleate bubbling is totally smothered, and the heat move is administered by mass violent movement of the fluid film. Heat move in the nucleate bubbling system is represented by the beginning, development, and flight of fume rises along



the heating surface. Klausner and Mei (1995) and Thomcroft et al. (1996) as of late a dimensionless variable that can segregate the convective and nucleate bubbling heat move systems. This work is explicitly worried about two-stage annular upflow, downflow, and microgravity stream pressure drop and evaporative heat move in the convective system. Logical two-stage stream models ordinarily treat the stream as consistent, improve on the math of the stream construction, and use protection of mass, force, and energy to anticipate pressure drop and heat move rates. Such models are alluring, on the grounds that they endeavor to actually show the prevailing heat and force transport systems, and accordingly there exists potential for such models to have wide appropriateness. They likewise give itemized data on the stream and warm fields. The disadvantage of these models is that they require exact conclusion relations, and ordinarily these are tried against just a restricted scope of information. Two-dimensional (2-D) limited distinction models have been proposed by Lai (1992) for stream bubbling and Mandrusiak and Carey (1990) for annular stream with offset strip blades. Isolated stream models are those where one-dimensional (1-D) protection conditions are applied independently to the fume center and fluid film, and are coupled through conclusion relations applied at the fluid/fume interface. Isolated stream models have been examined exhaustively by Hewitt and Hall-Taylor (1970), Carey (1992), and some later models have been proposed by Stevanovic and Studovic (1995), Owen and Hewitt (1987), and Sun et al. (1994). These models have just been aligned over a tight scope of boundaries and, subsequently, don't have wide appropriateness.

V. EXPERIMENTAL RESULTS

A. Analytical Approach

The initial approach to the analysis required for this heat exchanger, was a bit complex. The first attempt for the analysis of this system was done trying to solve for the overall coefficient of heat transfer, U (BTU/h-ft²-°F), via calculation of each fluid flow heat transfer coefficient, h (BTU/h-ft²-°F). However, the calculation of h involves calculating each fluid's Reynolds number, and the associate Nusselt number for each flow path. Due to the unpredictable nature of fluids, the calculated values for these coefficients may not be extremely accurate. However, a U value of 360 BTU/h-ft²-°F was calculated. From here, the rate of heat transfer was calculated using $Q = UA\Delta T_{lm}$, to obtain a value of $Q = 36,740$ BTU/h. The calculations for these values can be found in Appendix A. However, as mentioned before this value is not going to be extremely accurate, so a second analysis was performed. The second approach to the analysis for this heat exchanger was done using a nominal overall heat transfer coefficient. From Fundamentals of Thermal-Fluid Sciences[1], a nominal U value was found, specifically from Table 22-1. In the next section are the calculations for the heat transfer rate for this heat exchanger, the hand calculations can also be found in Appendix A. The second method of analysis, which will provide the ideal heat transfer rate, were derived with: Heat Transfer Equation: $Q = U \cdot A \cdot n \cdot \Delta T_{lm}$

Hot Water:	Cold Water:
Th _{in} -200 °F	Te _{in} -60 °F
Th _{out} -70 °F	Te _{out} = 150 °F

Log Mean Temperature Difference:

$$\Delta T_{lm} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1 / \Delta T_2)}$$

$$\Delta T_{lm} = \frac{130^\circ\text{F} - 90^\circ\text{F}}{\ln(130/90)}$$

$$\Delta T_{lm} = 109^\circ\text{F}$$

Overall Heat Transfer Coefficient

$$U_{om} = 225 \text{ BTU/h-ft}^2\text{°F}$$



Plate Area:

$$A = (7.5 \text{ in} \times 3 \text{ in}) (1 \text{ ft}^2/144 \text{ in}^2)$$

$$A = 0.156 \text{ ft}^2/\text{Plate}$$

Number of Plates:

$$N = 20 \text{ Plates}$$

Heat Transfer:

$$Q = U \cdot A \cdot n \cdot \Delta T_{lm}$$

$$Q = 225 \text{ BTU/h-ft}^2\text{F} \cdot 0.156 \text{ ft}^2/\text{Plate}$$

$$\cdot 20 \text{ Plates} \cdot 109 \text{ }^\circ\text{F}$$

$$Q = 76640 \text{ BTU/h}$$

Contrasting the determined heat move rate above, to the rate determined utilizing the heat move coefficients of the two liquids, a distinction of about a factor of two is seen. That being, the subsequent technique, which is without a doubt going to give a more precise outcome, is about twice as high as the first strategy. In any case, the qualities would be a lot nearer if a similar temperature esteems were utilized, since in the subsequent investigation, more precise temperature esteems were utilized. Because of this, the log mean temperature distinction is twice as high in the subsequent examination, which is the thing that is causing that factor of two contrasts. Be that as it may, returning and subbing in the new region and log temperature esteems to the main examination, you get a worth 122,690 BTU/h this distinction is currently because of the distinction in generally heat move coefficients between the two strategies.

The U worth in the primary examination is a lot higher than the given scope of potential qualities however, so it tends to be accepted that the subsequent investigation gives a more reasonable heat move rate, which is the worth that will be utilized for the plans. With the end goal of this undertaking, the worth of 76,640 BTU/h will be used instead of the 122,690 BTU/h value, due to the inaccuracies of the first method of analysis. For comparison, a typical plate and frame heat exchanger can range in heat transfer rate from $Q = \sim 3,500 - 90,000 \text{ BTU/h}$. Looking at this range, the value of 76,640 BTU/h is near the upper limit for a typical heat exchanger, although this analytical value may not necessarily be close to the actual heat transfer rate of the heat exchanger.

B. Visual Description:

The main components of this heat exchanger are the plates that will be constructed. These plates will be 8-3/4" x 4" in dimensions, and made of 24 gauges (0.024") T-304 Stainless Steel. This steel will be purchased through the machine shop, and will conform to ASME SAE40 and ASTM A240 standards. The initial sketches for the plates can be found in Appendix B. Below are Solid Works renditions of the basic plate design. As seen in the Solid Works rendition, the plate will have several small grooves allowing for better flow and heat transfer. Additionally, the rubber gaskets that will be required are also shown in the model. When assembled, these plates will be stacked in alternating pattern, to allow an alternating cross flow.

The next two Figures are of the top and bottom plates. Notice that the top plate will have input and output tubing attached, and the bottom plate does not have any holes. Below are two Solid Works renditions of the fully assembled heat exchanger. The first is of the entire system assembled, and the second shows a sectional view of the system.



Figure 1 Single Heat Exchanger Plate Design 3 HE-001 & HE-002 gasket

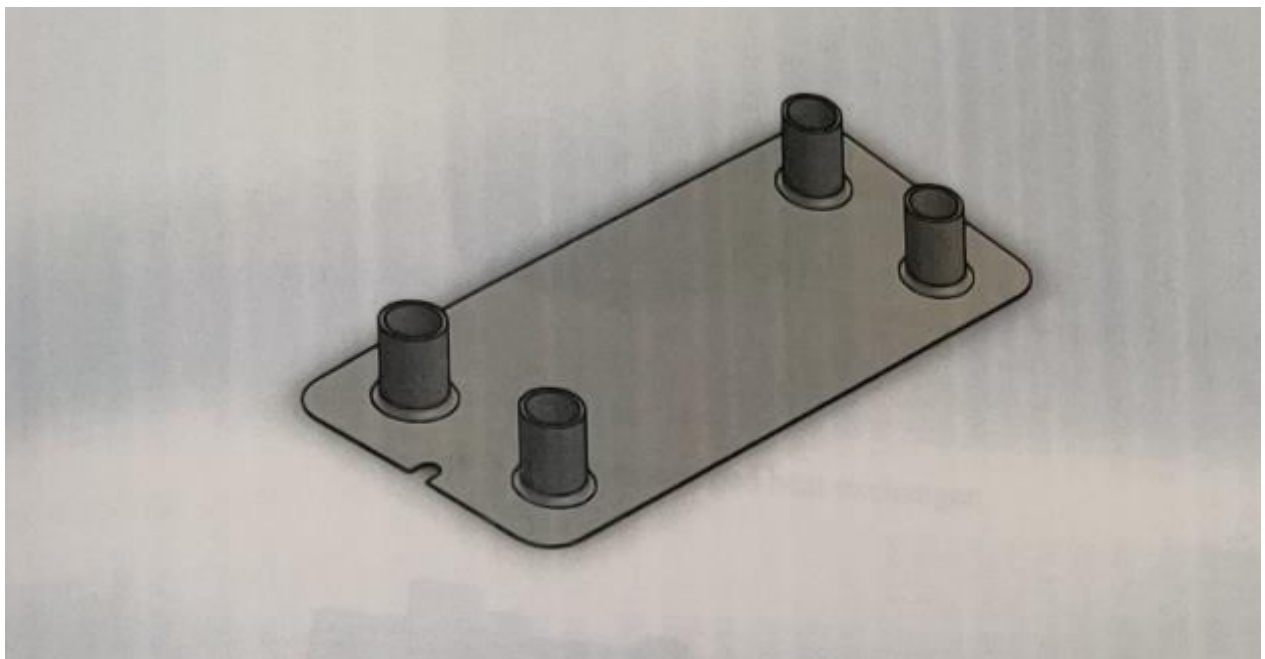


Figure 2 Top Plate, HE- 001



Figure 3 - Bottom Plate with Gasket , HE- 010 & HE – 002

C. Experimental Results:

The first tests performed were leakage tests, to make sure that the system would work properly. There were no leaks, and during this testing the back pressure and flow rate through each flow path was recorded. The two flow paths were the two copper colored hose attachments, and the two brass colored ones. For the temperature tests, the copper-copper flow path will be hot water, and brass-brass flow path will be cooling water. The next set of testing data includes temperature and flow rate values for both flow paths. From this data, you can see that the heat exchanger is working, although not effectively as intended. During testing, it was noted that there appeared to be a small internal leak, so after testing the system was taken apart and the gaskets were sealed. so that the next test would hopefully yield better results. The second set of testing was not as successful as the first, and the full data sheets can be found in Appendix I.

D. Design Evolution:

The design of this project has changed a great deal since the initial sketches. Initially, main plates were designed to have more ridges, although these ridges would be shallower. The second design of the plates featured less ridges, but with a greater depth. The main purpose of the change is to help increase turbulence in the system, which will allow for a better heat transfer between the opposing fluids. Additionally, the initial plate designs did not include any sort of alignment system. The redesigned plates included two holes, at the bottom and top of the plate that will allow for two alignment rods. In the design and analysis section of this report, the current plate designs can be seen. In total, the plates have gone through three redesigns, and the images comparing each design can be seen below. Another large change that has occurred since the inception of this project is the ideal thickness for the heat exchanger plates. Originally, the plates were going to be $\sim 1/16$ " thick stainless steel. After analysis and comparison to other heat exchanger designs, this thickness has been reduced to less than $1/32$ ". The thinner material will allow for a better heat exchanger between the fluids, and will also allow the steel to be formed much easier.

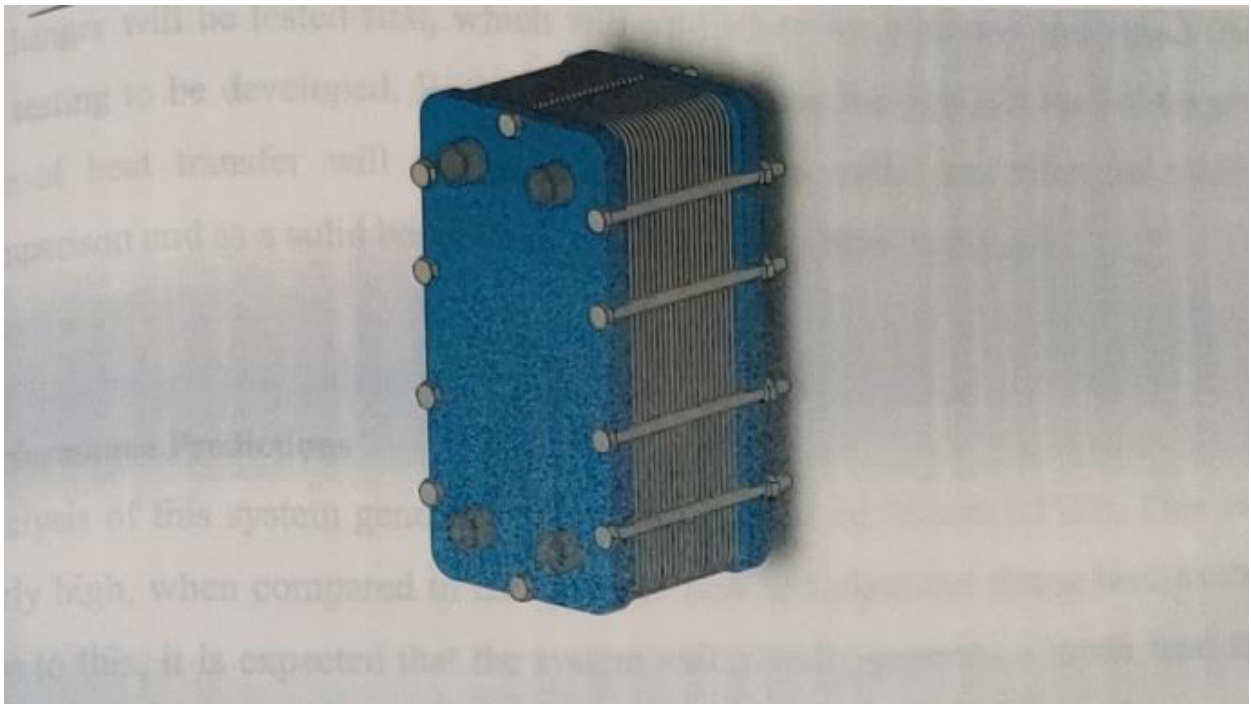


Figure 4 - Fully assembled Heat Exchanger

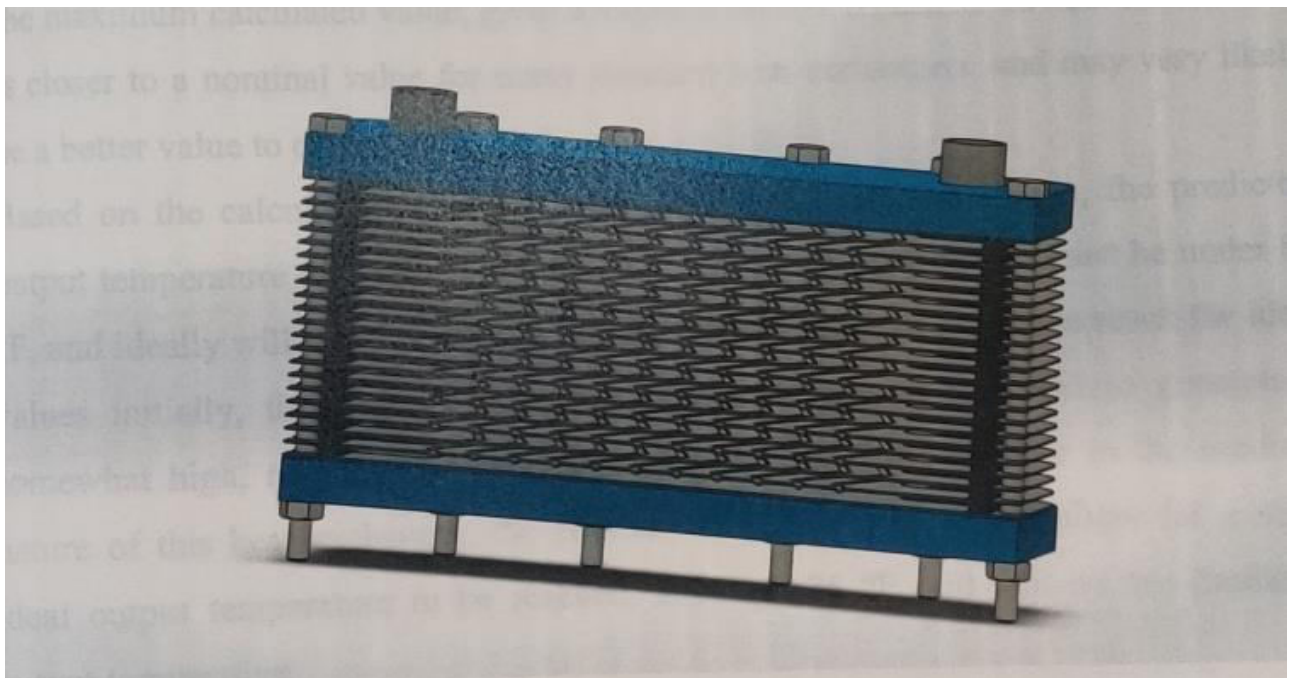


Figure 5 - Sectional View of Heat Exchanger



VI. CONCLUSION

The project has great engineering potential. Heat exchangers are a large part of many different vital systems, ranging from HVAC applications to nuclear reactors. Having the opportunity to design and construct a heat exchanger allows for a better understanding and appreciation of how these devices affect many different aspects of the real world. The completion of this project will cement key concepts from the more non-intuitive theoretical classes, such as: thermodynamics, fluid mechanics, and heat transfer, while also tying in materials, manufacturing, and project management. Overall, this project can provide a great learning experience touching on many different aspects of engineering.

REFERENCES

- [1] "Plate Heat exchangers". Gold-Bar Engineering Ltd. Retrieved 30 June 2015.
- [2] a b Hewitt, G (1994). Process Heat Transfer. CRC Press.
- [3] Sanei, Hamed (2016). "Numerical Investigation On The Effect Of Geometrical Shape Of Plate Heat Exchangers On Heat Transfer Efficiency".
- [4] international jurnal of Mechanical, Aerospace, Industrial, Mechatoronic and manufacturing Engineering. 10: 798–802.
- [5] Wang, J.Y. (2011). "Theory of flow distribution in manifolds". Chemical Engineering J. 168 (3): 1331–1345. doi:10.1016/j.cej.2011.02.050.
- [6] Bassiouny, M.K.; Martin, H. (1984). "Flow distribution and pressure drop in plate heat exchanges. Part I. U-Type arrangement.". Chem. Eng. Sci. 39 (4): 693–700. doi:10.1016/0009-2509(84)80176-1.
- [7] Sadik Kakac and Hongtan Liu (March 2002). Heat Exchangers: Selection, Rating and Thermal Design (2nd ed.). CRC Press. ISBN 0-8493-0902-6.
- [8] T. Kuppan (February 2000). Heat Exchanger Design Handbook (1st ed.). CRC Press. ISBN 0-8247-9787-6.
- [9] J. M. Coulson and J. F. Richardson (1999). Coulson & Richardson's Chemical Engineering Volume 1 (6th ed.). Butterworth Heinemann. ISBN 0-7506-4444-3.
- [10] D. Q. Kern, "Process Heat Transfer", McGraw-Hill Book Company, Int. ed. 1965.
- [11] V.K. Patel, R.V. Rao, "Design optimization of shell and tube heat exchanger using particle swarm optimization technique", Applied Thermal Engineering 30 (2010) 1417-1425.
- [12] F. P. Incropera, D. P. DeWitt, T. L. Bergman, and A. S. Lavine, "Fundamentals of Heat and Mass Transfer", 6th ed. (Wiley, 2007).
- [13] Mahuli, A. (s.f). Guía intercambiador carcasa y tubo. [PDF]. Recuperado de:
- [14] <https://operacionesunitarias1.files.wordpress.com/2011/07/unidad-iv-intercambiadores-de-calor.pdf>
- [15] Carrero, J. (1973). Equipos de transferencia de calor: una guía de estudio. Recuperado de :
- [16] <https://repositorio.unal.edu.co/handle/unal/55684>



**Impact Factor:
7.569**



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details