International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 04 | April - 2023 Impact Factor: 8.176 ISSN: 2582-3930

DESIGN AND FABRICATION OF TUBE IN TUBE HEAT EXCHANGER

Manish Subhash Yadav, Adwait Ajay Gaonkar, Abhay Surendra Mali, Avinash Arvind Kamble, *Manoj Ashok Chaudhari

ARMIET, Shahapur, Thane, Mumbai University

*Corresponding Author Email id: maishmax48@gmail.com

ABSTRACT

A heat exchanger refers to a system that facilitates the transfer of heat between two or more fluids. This system is utilized in both heating and cooling processes, making it a crucial component in various industries. One of the most basic forms of heat exchangers is the tube-in-tube type. The design of this type of heat exchanger is relatively simple, and it is also easy to maintain. As such, it is widely used in small and medium-sized enterprises. Heat exchangers are commonly used in the industrial setting for heat recovery. This means that the system is used to capture and utilize the heat generated in a particular process, which would otherwise be wasted. Heat recovery can lead to significant cost savings, making it a critical process in many industries. In addition, heat exchangers can be used in a variety of other applications, including refrigeration, air conditioning, and power generation. Tube in tube heat exchangers are a specific type of heat exchanger design that utilizes two separate tubes, one within the other, to transfer heat between two fluids. Fabricating tube in tube heat exchangers requires a range of specialized equipment and components. In addition to the main tubes themselves, valves, pumps, thermocouples, geysers, digital displays, and other specialized tools are often employed to ensure efficient operation and accurate monitoring of the heat transfer process.

Overall, heat exchangers are essential tools for a wide range of industrial processes, helping to improve efficiency, reduce energy consumption, and maintain optimal operating conditions in a variety of different settings. By utilizing advanced technologies and equipment, manufacturers can continue to enhance the performance and capabilities of these critical components, ensuring reliable and effective operation in a variety of demanding industrial environment

1. INTRODUCTION

Thermodynamics is a field of science that deals with the study of heat energy and its movements, as well as its relationship with other forms of energy. The principles of thermodynamics are applied in various industrial and engineering applications, such as the construction of heat exchangers. Heat exchangers are devices that are used to transfer thermal energy between two fluids that are at different temperatures. There are three primary methods of heat transfer: conduction, convection, and radiation. A thorough understanding of these methods is crucial in comprehending the thermo-dynamics of heat exchangers. Conduction is the transfer of heat energy through a solid material or between two objects in direct contact with each other. Convection is the transfer of heat energy through the movement of fluids or gases. Radiation is the transfer of heat energy through electromagnetic waves. In most thermal engineering applications, convection is the primary method of heat transfer between two fluids. Heat exchangers use this method to transfer thermal energy between a hot fluid and a cold fluid. Some common examples of heat exchangers include car radiators, refrigerator condenser coils, air conditioners, solar water heaters, chemical companies, home boilers, heat engine oil coolers, and milk chillers in pasteurizing plants. One type of heat exchanger is the tube-in-tube heat exchanger. It consists of two pipes that are arranged in a concentric tube construction. One pipe is used to pass a lower temperature fluid, while the other pipe is used to pass a higher temperature fluid. The configuration of the tubes can either be parallel or counter flow.

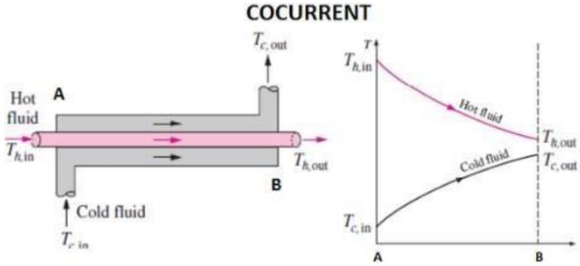
Parallel flow and counter flow are two types of fluid flow in heat exchangers. In parallel flow, the fluids flow in the same direction, while in counter flow, the fluids flow in opposite directions. Counter flow is more efficient than parallel flow because it provides the highest rate of heat transfer for a given surface area. This makes counter flow the preferred configuration for tube-in-tube heat exchangers. Tube-in-tube heat exchangers are designed and constructed to function in both parallel and counter flow configurations. The main purpose of a heat exchanger is to transfer heat from a high-temperature fluid to a low-temperature fluid. To achieve this, the tube material needs to be thin and made of a conductive material.

2. DESIGN

The tube-in-tube heat exchanger is a unique and compact device that offers numerous benefits to various industries. Its small size and distinctive

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 04 | April - 2023 Impact Factor: 8.176 ISSN: 2582-3930

shape make it ideal for applications that require high pressure, high temperature, and low flow rates. The design of this heat exchanger enables it to eliminate heat fatigue, increase productivity, and reduce the total size of the system. One of the most significant advantages of the tube-in-tube heat exchanger is its adaptability to specific client requirements and installation spaces. This feature enables the design to be tailored to fit any industrial application or installation site. Additionally, the use of flanged connectors in the design allows for easy dismantling, cleaning, and maintenance operations. As a result of its unique features and advantages, the tube-in-tube heat exchanger is increasingly gaining popularity in the OEM market and the wholesale replacement market. Major OEMs across the world are incorporating this device into their systems due to its straightforward design and easy installation process. Moreover, its compact size and high efficiency make it a perfect replacement for older and inefficient heat exchangers in the wholesale market.



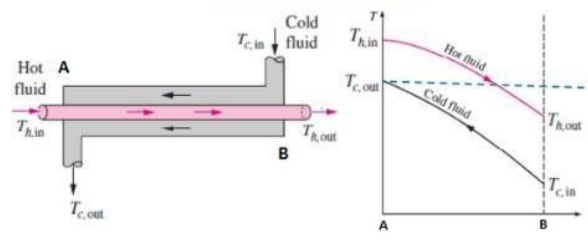


Fig 2.1 Double Pipe Heat Exchanger Parallel Flow and Counter Flow

3. COMPONENTS

1. K TYPE THERMOCOUPLE

A Type K thermocouple is a temperature sensor that utilizes Chromel and Alumel conductors to measure temperature. It is classified as a Type K thermocouple if it meets the output requirements specified in ANSI/ASTM E230 or IEC 60584 standards. This can include surface sensors or immersion sensors. It is important to note that any sensor, wire, or cable can be used as long as it meets the specifications outlined for a Type K thermocouple.

Fig 3.1 K TYPE THERMOCOUPLE

2. MULTIPOINT TEMPERATURE INDICATOR

A single access point can be equipped with a multipoint temperature sensor that allows for the detection of process temperatures across multiple locations. This sensor is designed to monitor and measure temperatures at various points within a system, and transmit this data to a central access point where it can be analyzed and used to make informed decisions about the system's performance. The multipoint temperature sensor is typically composed of several probes or thermocouples that are strategically placed throughout the system. These probes are connected to a central monitoring unit which collects temperature data from each individual probe and aggregates it into a single dataset. This allows for a comprehensive analysis of the system's temperature profile, identifying any hot or cold spots, and potential issues that may need to be addressed.

Fig 3.2 MULTIPOINT TEMPERATURE INDICATOR

3. ROTAMETER

The Rotameter is a widely used device that is reliable, uncomplicated, and cost-effective when it comes to measuring the flow of liquids or gases. This instrument is particularly popular because it features a conical tube with a floating internal element, which enables it to accurately gauge flow rates. Additionally, it is known by several names, including mechanical flow meter, variable area flow meter, or gravity flow meter. The Rotameter is a gravity flow meter because it must be oriented vertically to function correctly. The name "gravity" is derived from this requirement. The device works by utilizing the principles of gravity and fluid dynamics. The conical tube contains a float or other movable element, which moves up or down depending on the flow rate of the liquid or gas being measured. As the fluid flows through the tube, it pushes the float upward, and as the flow rate decreases, the float settles back down. The position of the float within the conical tube indicates the flow rate of the fluid. The flow rate can be read off a scale on the Rotameter, making it easy to measure the flow rate of the liquid or gas accurately. The scale is calibrated to the specific type of fluid being measured and is typically provided by the manufacturer of the device.

Fig 3.3 ROTAMETER

4. WATER TANK

There are two tanks that can be used for storing water: one is a plastic tank with a capacity of 15 liters, and the other is a metal tank with a capacity of 15 liters. Both tanks are suitable for holding water.

Fig 3.4 WATER TANK

5. GEYSER PIPE

Geyser pipes are an excellent choice for hot water plumbing systems. These pipes are specially designed to withstand high temperatures and pressure, making them ideal for use in hot water supply systems. Geyser pipes are manufactured using materials that undergo a rigorous chlorination process to enhance their quality and durability. This process ensures that the pipes are corrosion-resistant and can withstand the harsh conditions associated with hot water systems. For hot water supply systems, it is recommended to use

Geyser pipes with a 3/4-inch diameter. Typically, three such pipes are used for the inlet and outlet of the system, providing a reliable and efficient source of hot water. With their high-quality construction and durability, Geyser pipes offer a long-lasting solution for hot water plumbing needs.

Fig 3.5 GEYSER PIPE

6. COPPER TUBE

Copper tubes exhibit several desirable characteristics that make them a preferred choice for various applications. Firstly, copper tubes are relatively lightweight, which makes them easier to handle and transport. Additionally, copper has excellent thermal conductivity properties, which means that copper tubes can effectively transfer heat between different points.

Inner Diameter: 19 mm

Outer Diameter: 16 mm

Length: 0.5 meter

Fig 3.6 COPPER TUBE

7. M.S TUBE

Mild steel tubes are tubes made from mild steel, which is a type of carbon steel with low carbon content. They are commonly used in a variety of applications such as construction, automotive, and manufacturing industries. Mild steel tubes are known for their durability, strength, and versatility.

The outer coating of the copper pipe should meet the following specifications:

- Outer Diameter: 60 mm
- Inner Diameter: 57 mm
- Length: 0.4 meter

- Material: The outer coating material should be chosen based on the intended use of the copper pipe. If the pipe is going to be used for plumbing or HVAC applications, the outer coating may be made of a corrosion-resistant material such as PVC or polyethylene. If the pipe is going to be used for electrical applications, the outer coating may be made of a non-conductive material such as polypropylene or nylon.

Fig 3.7 M. S TUBE

8. THERMOCOL SHEET

Thermocol insulation sheets are a specialized type of material used to provide a layer of protection for various types of equipment and infrastructure that require temperature regulation. These sheets are commonly used to protect pipelines, cold storage facilities, boilers, tanks, and machinery that must be maintained at a specific temperature range. The insulation properties of thermocol sheets help to prevent heat transfer, either into or out of the protected area, and maintain a consistent temperature. This makes them an essential component of many industrial and commercial operations where temperature control is critical to the safety and efficiency of the process. With their high insulating properties, durability, and ease of use, thermocol insulation sheets are an ideal solution for a variety of applications where temperature regulation is necessary.

Fig 3.8 THERMOCOL SHEET

9. TEFLON TAPE

Teflon tape, also known as Heat Sealing Tape, Heat Sealer Tape, or Seal Bar Tape, is a type of tape that is commonly used in various industries, including electrical, electronic, thermoplastic, sealing heat, and packaging. It is made up of either glass cloth or pure PTFE (polytetrafluoroethylene) film, which is then coated with a layer of silicone adhesive. The tape is used for a variety of applications, including heat sealing and packaging of products, as it provides a non-stick surface that prevents the products from sticking to the seal bar or packaging machinery. In the electrical and electronic industries, Teflon tape is commonly used for insulation and protection of wires and cables, as it has excellent electrical properties, high temperature resistance, and chemical resistance.

Fig. 3.9 TEFLON TAPE

10. BALL VALVE

A ball valve is a type of shut-off valve that is commonly used to regulate the flow of liquids or gases. The valve consists of a spherical ball with a bore through its center that can be rotated around its axis to allow or prevent the medium from passing through. When the ball is aligned with the flow path, the medium can pass through the valve. However, when the ball is rotated 90 degrees, it blocks the flow, stopping the medium from passing through.

Fig. 3.10 BALL VALVE

11. WATER HEATER

A water heater with a 1500-watt power rating is a small electric water heater commonly used for point-of-use applications, such as under sink or countertop installation. Here are some things to consider when it comes to a 1500-watt water heater: Capacity: These water heaters have a relatively small tank capacity, usually ranging from 1 to 10 gallons. They are suitable for small households with low hot water demands. Power Consumption: A 1500-watt water heater consumes 1500 watts of electricity per hour of operation, which can result in high energy bills. Therefore, it's important to choose an energy-efficient model and use it judiciously. Installation: These water heaters can be installed easily and quickly, as they usually require only a 120V electrical outlet and a water supply line. Temperature Settings: Most 1500-watt water heaters come with adjustable temperature settings, allowing users to set the desired water temperature between 80°F to 140°F.

Fig. 3.11 WATER HEATER

12. CPVC PIPE

CPVC stands for Chlorinated Polyvinyl Chloride, which is a thermoplastic material used in the manufacturing of pipes and fittings for plumbing and industrial applications. CPVC pipes are a popular choice for hot and cold-water supply systems because they are resistant to corrosion, have a high temperature tolerance, and are easy to install. CPVC pipes are made by chlorinating PVC resin, which increases its heat resistance and chemical stability. This process also makes CPVC pipes more durable and able to handle higher temperatures than regular PVC pipes, making them ideal for hot water applications.

Specifications: -

Inner Diameter: - 22 mm

Outer Diameter: - 16 mm

Length: - Around 4 meters

Fig. 3.12 CPVC PIPE

4. WORKING PRINCIPLE

A tube-in-tube heat exchanger operates on a simple and easily understandable concept. The heat exchanger achieves a net countercurrent flow, allowing for temperature crossings that enable the cold fluid to be heated above the temperature of the hot fluid outlet. The key feature of this heat exchanger is that the fluid that is heating or cooling the hot or cold liquid never comes into direct contact with it. The heat exchanger consists of two concentric tubes - an inner tube and an outer tube. Both tubes can contain either hot or cold liquid, and the heat transfer occurs indirectly through the wall of the inner tube. The outer tube is usually the one that carries the fluid that needs to be heated or cooled, while the inner tube carries the fluid that transfers heat to or from the outer tube.

The fluid in the outer tube enters the tube from one end and flows towards the other end, where it exits. Meanwhile, the fluid in the inner tube flows in the opposite direction, entering from the end where the outer tube exits and flowing towards the end where the outer tube enters. This flow pattern is often referred to as counterflow or countercurrent flow. Tube-in-tube heat exchangers are particularly useful in applications where direct steam injection heat exchangers are not appropriate. For example, they are commonly used in the preheating and cooling sections of tube systems. In these sections, the heat exchangers use the indirect heat transfer technique, but direct heat is used for the final heating step. This final heating step often involves adding steam to the product, which is typically referred to as Direct Steam Injection or Direct Scalding Infusion.

5. EFFECTIVENESS OF THE HEAT EXCHANGE

A heat exchanger is a device that transfers heat from one fluid to another fluid. The performance of a heat exchanger can be assessed using the number of transfer units (NTU) method. This method is advantageous because it does not require the evaluation of mean temperature differences, which can be time-consuming and complex. Additionally, this method allows for the immediate determination of an unknown stream outlet temperature without the need for repeated computations.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 04 | April - 2023 Impact Factor: 8.176 ISSN: 2582-3930

6. PROJECT IMAGE

Image. 6.1. TUBE IN TUBE HEAT EXCHANGER

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 04 | April - 2023 Impact Factor: 8.176 ISSN: 2582-3930

7. GRAPH

Sensor no.1 Temperature = Hot Water Tank

Sensor no.2 Temperature = Cold Water Tank

Sensor no.3 Temperature = Hot Water Inlet

Sensor no.4 Temperature = Hot Water Outlet

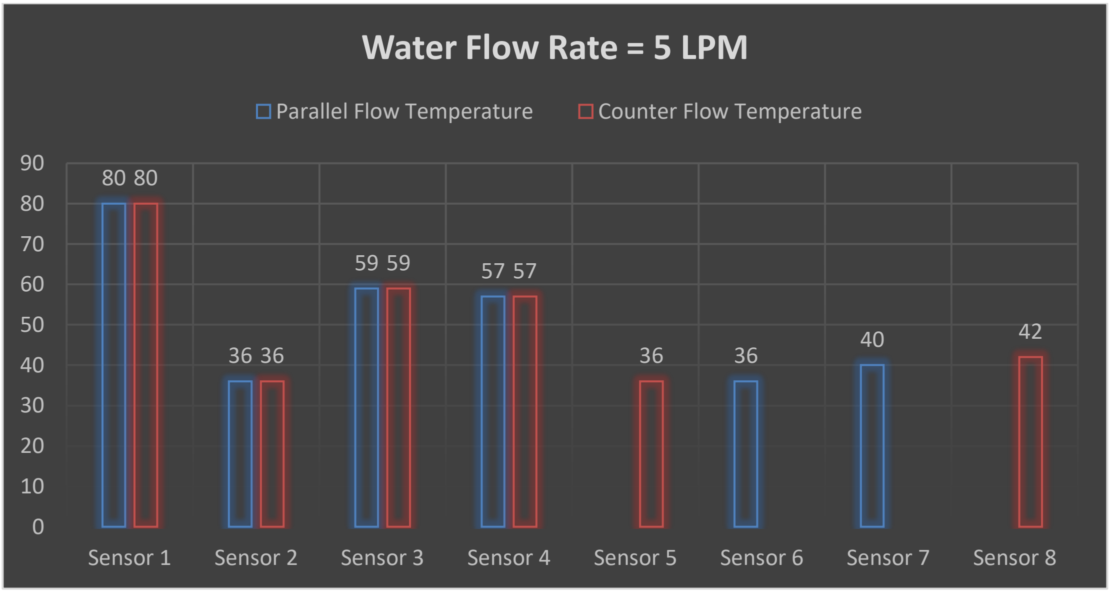
Sensor no.5 Temperature = Cold Water Inlet for Counter Flow

Sensor no.6 Temperature = Cold Water Inlet for Parallel Flow

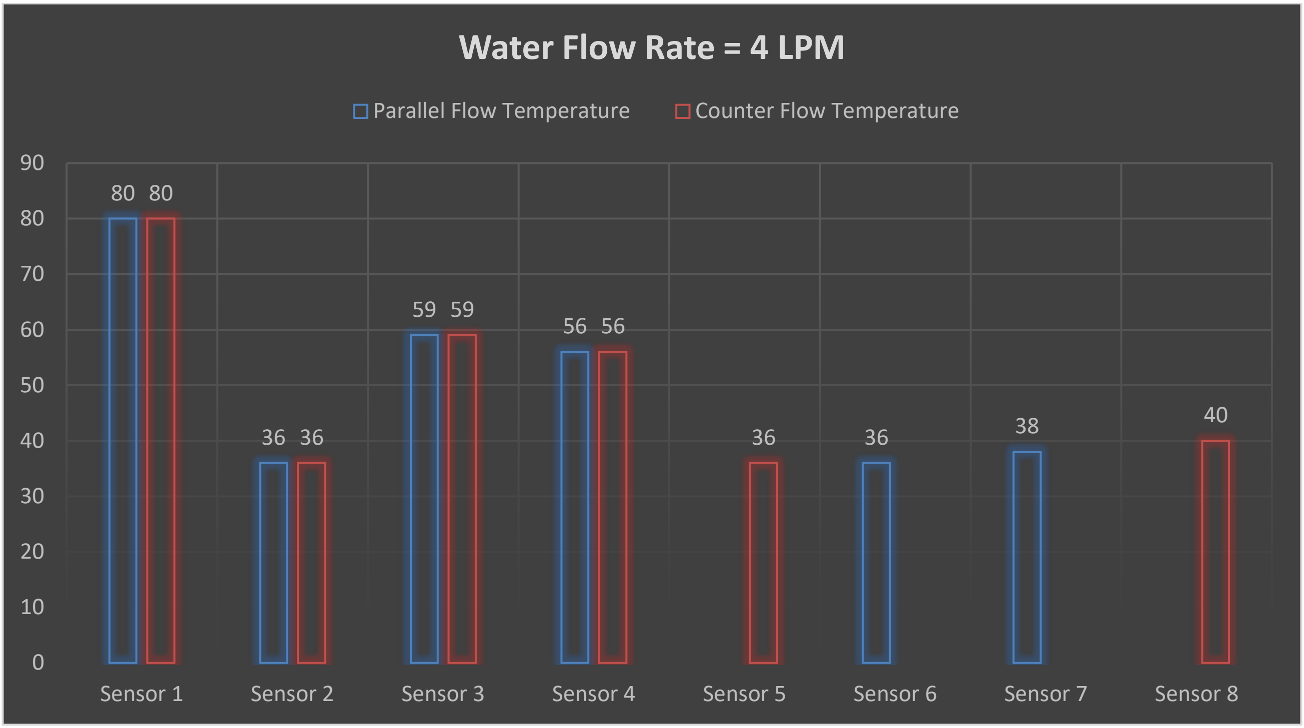
Sensor no.7 Temperature = Cold Water Outlet for Counter Flow

Sensor no.8 Temperature = Cold Water Outlet for Parallel Flow

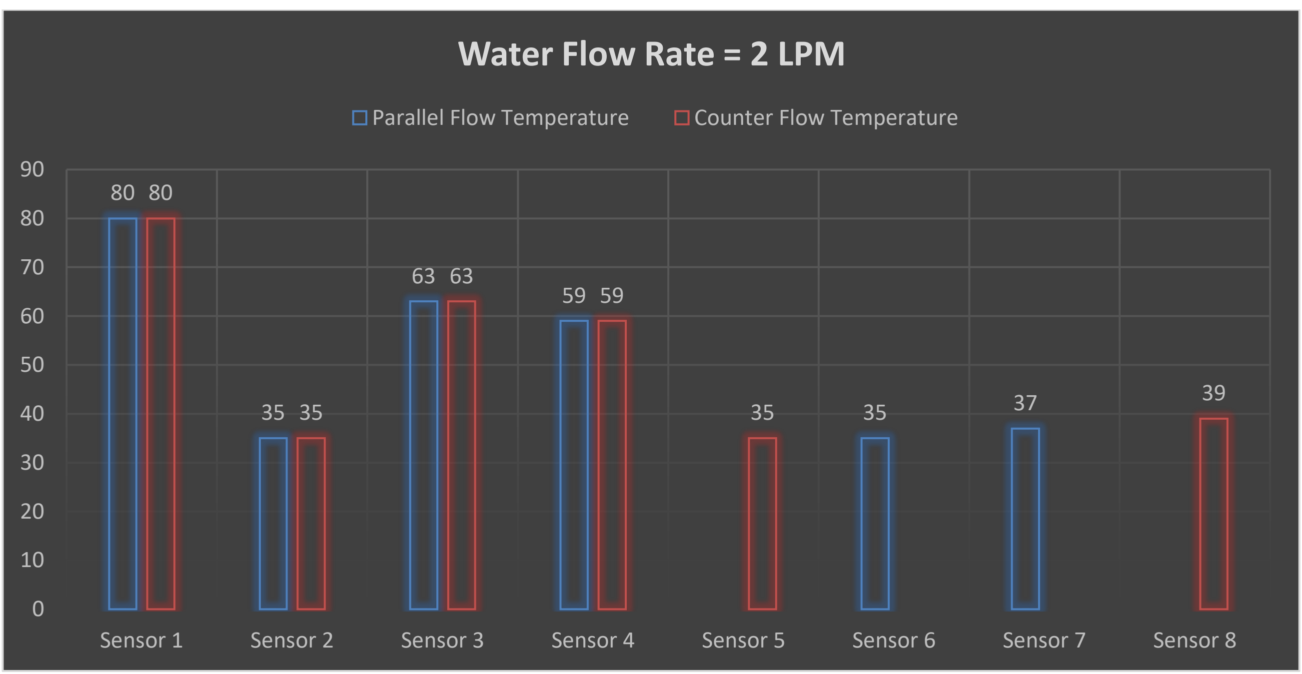
From graph 7.1, 7.2 and 7.3 It is seen that the rate of temperature exchange in Counter flow is more compare to the rate of temperature exchange in Parallel flow.



Graph. 7.1 Variation in Parallel Flow Temperature vs Counter Flow Temperature at 5 LPM



Graph. 7.2 Variation in Parallel Flow Temperature vs Counter Flow Temperature at 4 LPM



Graph. 7.3 Variation in Parallel Flow Temperature vs Counter Flow Temperature at 2 LPM

8. CONCLUSION

In this study, a tube-and-pipe heat exchanger was created, produced, and integrated with the entire mechanism. The tube-and-pipe system is considered the most straightforward and efficient type of heat exchanger. In order to evaluate the heat exchanger's efficiency, we conducted an analysis and discovered a negligible discrepancy between the measured heat transfer's experiential value and its theoretically predicted value. When producing a twin pipe heat exchanger, several elements need to be considered. Two of the most important factors are choosing the appropriate material for the inner and outer pipes, as well as determining the total pipe size based on the application. It is crucial to choose the appropriate materials that provide the most mechanical and financial benefits. By selecting the right materials, the heat exchanger's longevity and overall efficiency can be enhanced. Tube-and-pipe heat exchangers are commonly used in various industries, including textiles, pharmaceuticals, and chemical industries, due to their simplicity of manufacture and compact form. They have a larger range of applications and are suitable for many different purposes.

9. ADVANTAGES

- High efficiency may be attained at extremely cheap capital costs.
- Compared to shell and tube heat exchangers, these units are smaller.
- You don't require much room.
- It requires less upkeep than shell and tube heat exchangers.
- Its heat exchanger is also perfect for high-pressure and high-temperature applications like compressors and boilers because of its straightforward and compact design.
- Due to their widespread use, these heat exchangers all have standardized parts and are simple to maintain and fix.
- This heat exchangers design permits higher thermal expansion without enlarging the junction.

10. DISADVANTAGES

- Compared to shell and tube heat exchangers, double tube heat exchangers feature lower tubes. This indicates that compared to shell and tube heat exchangers, it has a lower heat transfer coefficient.

- Not available in the cross-flow version. Thus, no specific application may make advantage of these exchanges.
- Adding units increases the likelihood of leaks due to the increased number of connections.
- The likelihood of leakage on distant connections is considerable.
- These heat exchangers can be applied in small area applications despite their restricted heat transmission.

11. APPLICATION

Tube in tube heat exchangers is commonly used in various industries for different applications, such as:

- Slurries and multi-phase fluids: Tube in tube heat exchangers are ideal for handling fluids that contain solid particles or other impurities that can cause fouling in other types of heat exchangers. The inner tube can be designed to withstand the abrasive nature of these fluids while the outer tube provides a barrier to protect against leaks or contamination.
- High thermal stress: In applications where high temperatures or pressure differentials are present, tube in tube heat exchangers can provide a reliable and robust solution. The design allows for differential expansion between the inner and outer tubes, reducing the risk of thermal stress-related failures.
- Steam condensing: Tube in tube heat exchangers is commonly used for condensing steam in industrial processes. The design allows for efficient heat transfer while preventing the formation of condensate on the outer tube surface.
- Seal cooling: Tube in tube heat exchangers is often used to cool seals in rotating machinery, such as pumps or compressors. The design provides a compact and efficient solution for removing heat from the seal area, reducing the risk of premature failure.

12. REFERENCE

[1] Mrs. Kirti B.Zare , Ms. Dipika Kanchan , Ms. Nupur Patel," DESIGN OF DOUBLE PIPE HEAT EXCHANGER" Vol. No.5, Issue No. 12, December 2016.

[2] Anand Babu K, Naveena H S, Nagesh R, Prabhakar C G," EXPERIMENTAL INVESTI HEAT TRANSFER OF A DOUBLE PIPE HEAT EXCHANGER" Volume 8, Issue 8, August 2017, pp.203-210.

[3] Idongesit Effiong Sampson," Design and Operation of Double Pipe Heat Exchanger" Vol. 3. 2017.

[4] Patrick Mukumba, KeChrist Obileke," Thermal Performance Evaluation of a Double Pipe Heat Exchanger Installed in a Biomass Gasification System" Volume 2020 Article ID 6762489.

[5]Sadikkakac,Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, London New York Washington, D.C.1997.

[6] Rajeev Mukherjee,"Effective design of shell and tube heat exchanger", American Institute of Chemical Engineering, 1988.

[7] Yusuf Ali Kara, OzbilenGuraras, "A computer program for designing of Shell and tube heat exchanger", Applied Thermal Engineering 24(2004) 1797–1805.

[8] M.Serna and A.Jimenez, "A compact formulation of the Bell Delaware method for Heat Exchanger design and optimization", Chemical Engineering Research and Design, 83(A5): 539–550.

[9] Andre L.H. Costa, Eduardo M. Queiroz, "Design optimization of shell and tube heat exchangers", Applied Thermal Engineering 28 (2008) 1798–1805.

[10] Su Thet Mon Than, KhinAung Lin, MiSandar Mon, "Heat Exchanger design", World Academy of Science, Engineering and Technology 46 2008.