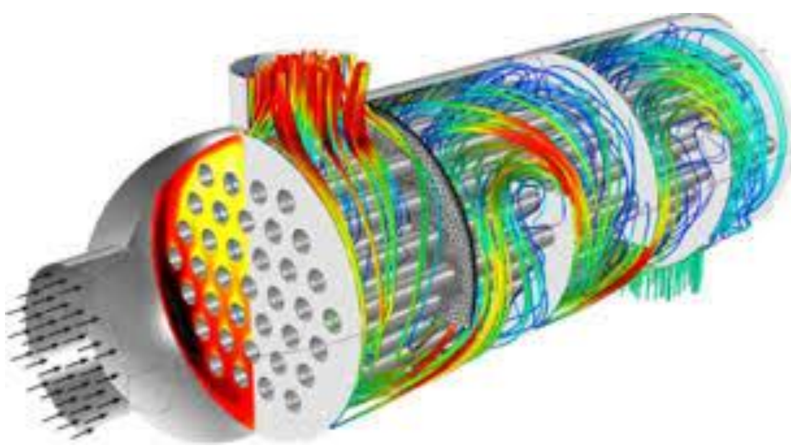
Koya University
Faculty of Engineering
Chemical Engineering department

(Heat Transfer Laboratory)
(Shell and Tube Heat Exchanger)



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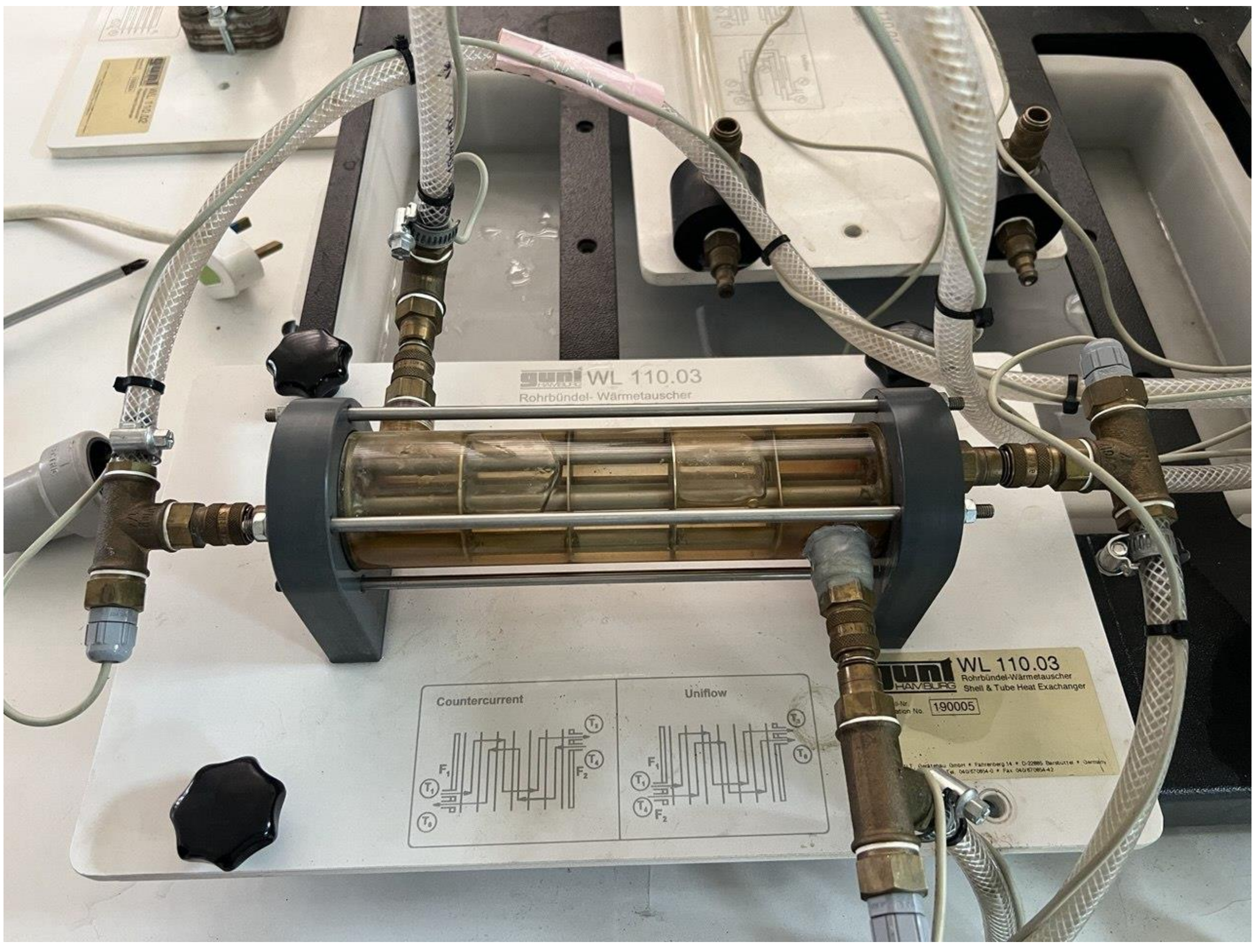
Aim Of Experiment

To calculate the overall heat transfer coefficient U in uniform flow.

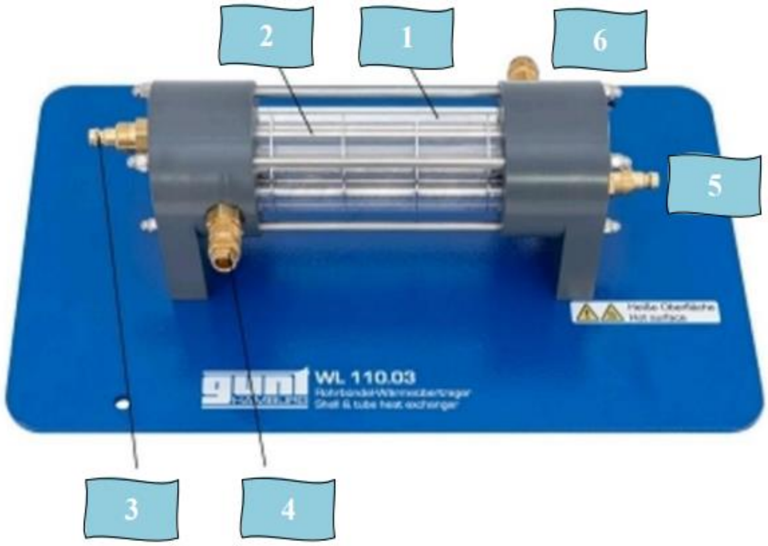
Introduction

A shell and tube heat exchanger is a type of heat exchanger that is commonly used in various industrial applications. It consists of a cylindrical shell that contains a series of tubes through which a fluid flows. One fluid, usually a liquid or gas, flows through the tubes while the other fluid flows over the outside of the tubes, in the shell side. The two fluids are separated by a metal wall, and heat is transferred from one fluid to the other through the metal wall, thereby exchanging heat between the two fluids. The shell and tube heat exchanger design is efficient, versatile, and can handle high pressures and temperatures. It is widely used in power plants, chemical plants, and oil refineries to transfer heat from one fluid to another in cooling and heating applications. The heat exchanger can be designed to meet specific requirements such as high temperature and pressure, corrosive environments, and fouling issues.



Instruments

Some instruments have been used during the experiment:



1)Shell

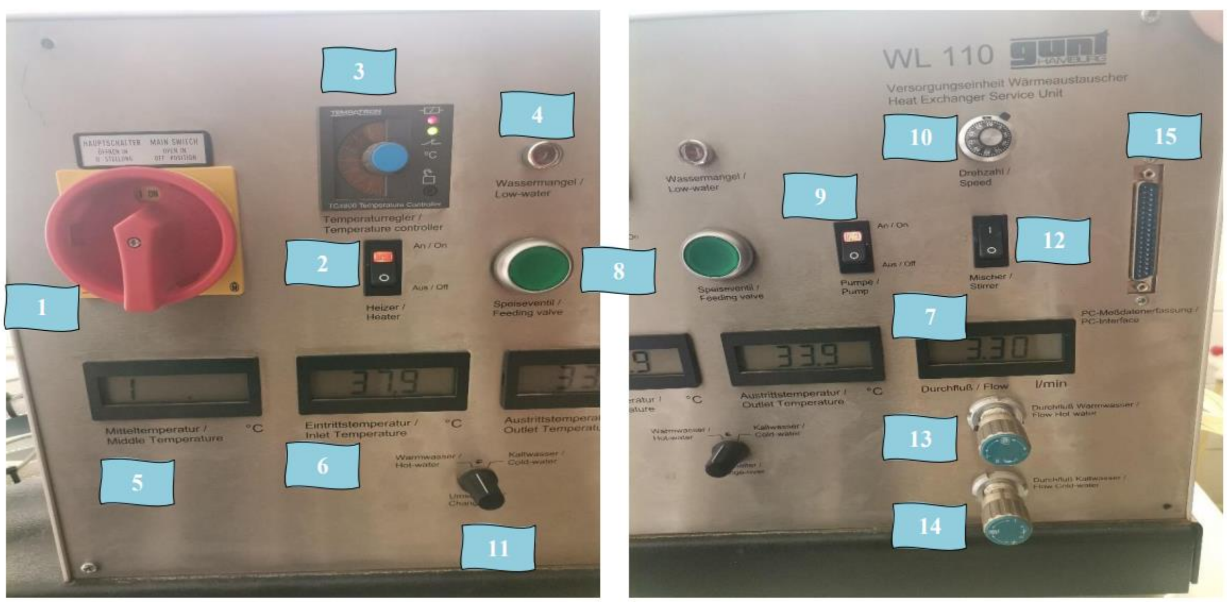
2)Tubes

3)Inlet for hot fluid

4)Inlet for cold fluid

5)outlet for hot water

6)outlet foe cold water

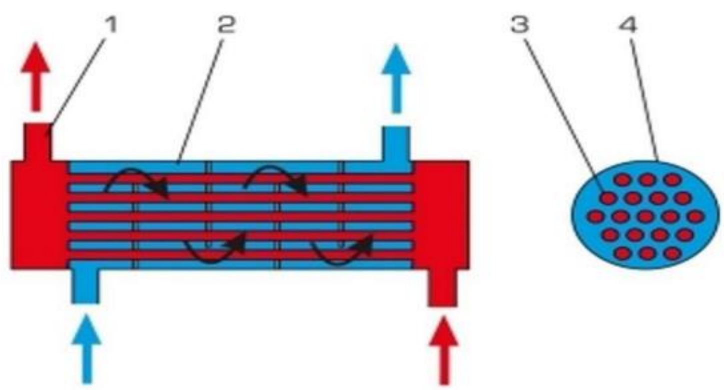


1- Main switch
2- Heater switch
3- Switch to change fluid temperature
4- Tank liquid level alert
5- Mid temperature display
6- Inlet temperature display
7- Outlet temperature display
8- Vent button
9- Pump switch
10- Stirrer speed adjuster
11- To switch between the displays from cold to hot.
12- Stirrer button
13- Flow adjuster for cold water
14- Flow adjuster for hot water
15- Computer thread

Procedure

[Procedure for uniflow]

- Connect the inlet and outlet hoses of the cold water to the service unit
- Connect the other inlet and outlet hoses of cold and hot fluid to the shell & tube heat exchanger.
- Turn on the main switch.
- Turn on the heater switch
- Adjust the temperature to a desired temperature and wait until it reaches the temperature.
- Turn on the pump switch
- Read the temperatures at the displays.
- The flow rate of each fluid can be adjusted via flow adjusters.
- If the stirrer is required can be turned on via the stirrer button
- After completing the experiment turn off the heater, pump , stirrer and the main switch.
- Ensure that there is no remaining fluid inside the devices to avoid any physical or chemical damage to the instruments.



Advantages of Shell and Tube Heat Exchangers

- Durability: Shell and tube heat exchangers are known for their durability and long service life, making them a popular choice for industrial applications.
- Versatility: They can handle a wide range of process fluids, including liquids, gases, and steam, and are suitable for use in a variety of temperature and pressure conditions.
- Compact Design: These heat exchangers are designed to be compact, making them ideal for use in space-constrained environments.
- Easy Maintenance: The modular design of shell and tube heat exchangers makes them relatively easy to maintain and repair.
- High Efficiency: The high heat transfer efficiency of these heat exchangers makes them an energyefficient choice for many applications.

Disadvantages of Shell and Tube Heat Exchangers

- High Cost: The initial cost of a shell and tube heat exchanger can be relatively high compared to other types of heat exchangers.
- Complex Design: The design of these heat exchangers can be complex, requiring specialized knowledge to properly design and manufacture them.
- Limited Heat Transfer Area: The heat transfer area of a shell and tube heat exchanger is limited by its size, which can limit its ability to handle large thermal loads.
- Susceptible to Fouling: The tubes in shell and tube heat exchangers can become fouled over time, reducing their efficiency and requiring frequent cleaning.
- Limited Flexibility: The design of shell and tube heat exchangers is relatively inflexible, making it difficult to modify or scale them to meet changing needs.

Conclusion

In this experiment, the overall heat transfer coefficient (UU) of a shell and tube heat exchanger was determined under uniform flow conditions. The results demonstrated that heat transfer efficiency is influenced by various factors, including fluid flow rates, temperature differences, and heat exchanger design. The experimental data aligned with theoretical heat transfer principles, confirming the effectiveness of shell and tube heat exchangers in industrial applications.

The findings highlight the importance of optimizing operational parameters to maximize heat exchanger performance and efficiency. Despite some challenges, such as fouling and high initial costs, shell and tube heat exchangers remain widely used due to their durability, versatility, and high heat transfer efficiency. Future studies could focus on the impact of different flow configurations and materials to enhance overall performance and longevity.

Discussion

(Mohamed kadhim)

The experiment aimed to determine the overall heat transfer coefficient (UU) in a shell and tube heat exchanger under uniform flow conditions. The results obtained provided valuable insights into the heat transfer efficiency and operational characteristics of this type of heat exchanger.

One key observation was the relationship between temperature difference and heat transfer rate. As expected, a higher temperature gradient between the hot and cold fluids resulted in an increased rate of heat transfer. This aligns with the fundamental principles of heat exchanger design, where heat transfer is driven by the temperature difference between the two fluids. Additionally, adjusting the flow rates of both fluids affected the overall heat transfer coefficient, confirming that flow velocity plays a crucial role in enhancing convective heat transfer.

The experiment also highlighted the impact of fouling and thermal resistance on heat exchanger performance. Over time, deposits and impurities can accumulate on the tube walls, reducing heat transfer efficiency. Although this was not a major factor in the short duration of the experiment, it is an important consideration in long-term industrial applications, where regular maintenance and cleaning are necessary to maintain optimal efficiency.

Another important aspect observed was the effect of flow configuration. The shell and tube heat exchanger can operate under co-current or counter-current flow conditions. In this experiment, a uniform flow setup was used, but counter-current flow typically provides better heat transfer efficiency due to the higher average temperature difference along the length of the exchanger.

Some sources of error that may have affected the accuracy of the results include temperature measurement inaccuracies, heat losses to the surroundings, and possible fluctuations in flow rates. Improving insulation and using more precise measurement instruments could enhance the reliability of future experiments.

Overall, the experiment successfully demonstrated the working principles of a shell and tube heat exchanger, reinforcing theoretical concepts and emphasizing the importance of operational parameters in optimizing heat exchanger performance. Further studies could explore different flow configurations, varying tube materials, and the effects of fouling over extended periods to gain a more comprehensive understanding of heat exchanger efficiency.

Twana Dler Mohsin

1. What is the purpose of the shell and tube heat exchanger experiment?
The purpose of this experiment is to analyze heat transfer in a shell and tube heat exchanger by measuring temperature changes, calculating heat transfer rates, and determining the overall heat transfer coefficient.
2. What are the key parameters measured in this experiment?
Key parameters include:

- Inlet and outlet temperatures of hot and cold fluids
- Flow rates of both fluids
- Heat exchanger dimensions
- Specific heat capacities of the fluids

3. Why do we make the hot water flow through the inner tubes?
There are three main reasons:

1. **Efficient heat transfer** – We want the heat to transfer to the cold water inside the heat exchanger first, rather than losing heat to the outer environment.
2. **Maintenance and longevity** – If the hot fluid contains impurities that cause some tubes to rust, those specific tubes can be sealed by welding while the heat exchanger remains operational.
3. **Handling viscous or fouling fluids** – Some fluids, such as oil, can clog tubes permanently. By using multiple tubes, we can still operate the heat exchanger even if some tubes become blocked.

4. What parameters did we control in this experiment?
The parameters controlled in this experiment were:

- **Temperature** of both hot and cold fluids
- **Flow rate** of the fluids
- **Fluid level** inside the heat exchanger

5. Define the overall heat transfer coefficient (UUU) based on its unit.
The overall heat transfer coefficient (UUU) represents the heat transfer capability of a heat exchanger. It means that **1 watt of heat energy is transferred through 1**

square meter of surface area for every 1 K (or 1°C) temperature difference between the two sides of the surface. Its unit is **W/(m²·K).**

6. Why does the cold water flow up and down through baffles?

The cold water flows up and down through baffles to **increase interaction with the surface of the hot water tubes**, improving heat transfer efficiency. The baffles also help create turbulence, which enhances heat exchange by reducing thermal resistance and preventing stagnant zones.

7. If the level of hot water drops, can we use cold water to compensate for it?

Yes, if the level of hot water drops, we can use cold water to compensate for the loss. This helps maintain the required fluid levels inside the heat exchanger, ensuring stable operation and preventing damage due to low liquid levels. However, adding cold water may affect the overall heat balance and efficiency of the system.

8. What factors affect the efficiency of heat transfer in a shell and tube heat exchanger?

Factors include:

- Flow rate of fluids
- Type of fluid and its properties (viscosity, thermal conductivity)
- Fouling and scaling on heat exchanger surfaces
- Tube arrangement and baffle design