Enhancement of Heat Transfer Rate in Shell and Tube Heat Exchanger of Using Base Fluids and Nano Fluids

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Abstract- **The development of Nanotechnology has witnessed an emergence of new generation of heat transfer fluids known as Nano fluids. Nano fluids are used as coolants which provide excellent thermal performance in the device called heat exchangers. However, the viscosity of these fluids increases with the addition of nanoparticles. Furthermore, Various Nano fluids are potential working fluids for heat transfer applications, according to the studies, using Nano fluids increase the thermal conductivity and conductive heat transfer coefficients compare to the base fluids. In heat exchangers, due to the high thermal performance of Nano fluids than Base fluids, it can be used in various processes of cooling and heating.**

In this project we are introducing the nanofluids like alluminium oxide in the shell and tube heat exchanger and we are comparing the base fluids and nano fluids by using them in heat exchanger. By using Flow simulation, we are going to prove that which is enhancing the heat transfer rate and improving the effectiveness of heat exchanger.

Keywords: **Nano technology, Effectiveness, Flow simulation, base fluids and nanofluids.**

1. INTRODUCTION

In this project we are introducing Shell and tube heat exchangers are widely used in various industries for transferring heat between fluids. These heat exchangers consist of a bundle of tubes, with one fluid flowing through the tubes and the other flowing on the outside of the shell. The efficiency of heat transfer in these heat exchangers can be enhanced by using base fluids and nanoparticles that have high thermal conductivity.

The use of nanofluids, such as aluminum oxide (Al2O3) nanofluid, has gained attention in recent years as a means of improving heat transfer in shell and tube heat exchangers. These nanofluids are characterized by the addition of small amounts of nanoparticles to base fluids, which have a much higher thermal conductivity than the base fluids alone. As a result, they can significantly enhance the heat transfer by increasing the rate of heat transfer across the shell and tube surface.

The heat transfer enhancement properties of nanofluids have been extensively studied in recent years, and research has shown that the addition of nanoparticles significantly increases the thermal conductivity of base fluids, which in turn leads to a higher rate of heat transfer. Furthermore, since the viscosity of these nanofluids is lower than that of the base fluid, the pressure drop across the heat exchanger is reduced, which can further improve the efficiency of heat transfer.

The use of aluminum oxide in nanofluids has been shown to have particularly good heat transfer enhancement properties. This is because aluminum oxide has a high thermal conductivity and excellent stability, making it an ideal material for use in heat transfer applications.

Overall, the use of nanofluids, particularly those containing aluminum oxide, can significantly enhance the efficiency of heat transfer in shell and tube heat exchangers. As such, they represent an attractive option for improving the performance of these important devices in various industrial applications.

2.LITERATURE SURVEY

2.1 MODELLING AND ANALYSIS OF HEAT EXCHANGER

Heat transfer is a crucial process in various industrial applications, such as chemical and petrochemical industries, power plants, and refrigeration systems. Shell and tube heat exchangers are widely used for their high-heat transfer coefficient and thermal efficiency. However, due to the limitations of conventional heat transfer fluids, researchers have been exploring various alternatives to enhance heat transfer, of which nanofluids have gained significant attention.

This literature survey presents an overview of recent studies focused on enhancing heat transfer in shell and tube heat exchangers using base fluids and aluminum oxide nanofluids.

There have been several studies on the use of base fluids to improve the heat transfer coefficient in shell and tube heat exchangers. For instance, Das et al. (2018) investigated heat transfer performance in a shell and tube heat exchanger using water and ethylene glycol-based blends. Their results showed that the ethylene glycol-blended fluid significantly enhanced the heat transfer coefficient due to its superior thermal properties compared to water.

In recent years, researchers have focused on investigating the potential of nanofluids in enhancing heat transfer in shell and tube heat exchangers. Aluminum oxide (Al2O3) nanofluids have been the focus of many studies due to their favorable properties, such as high thermal conductivity, low viscosity, and stability. For example, Siddique et al. (2019) conducted experiments on a shell and tube heat exchanger using Al2O3/water nanofluids. Their results demonstrated that the heat transfer coefficient increased with the addition of Al2O3 nanoparticles up to a certain concentration. However, beyond that concentration, heat transfer performance decreased due to increased fluid viscosity.

Similarly, Mousavi et al. (2020) investigated the performance of Al2O3/water nanofluids with different particle sizes in a shell and tube heat exchanger. They found that the heat transfer coefficient increased with nanofluid concentration and particle size, but the pressure drop increased as well. On the other hand, Babakhanian et al. (2019) studied the effect of hybrid nanofluids (Al2O3-TiO2/water) on heat transfer in a shell and tube heat exchanger. Their results showed that the heat transfer coefficient of the hybrid nanofluid was higher than that of the base fluid, owing to the synergistic effect of the two nanoparticles.

In summary, the literature survey indicates that enhancing heat transfer in shell and tube heat exchangers using base fluids and aluminum oxide nanofluids is an active research area. While base fluids with improved thermal properties can enhance heat transfer, the addition of nanoparticles has shown significant potential. However, determining the optimal concentration and particle size are crucial factors for maximizing heat transfer efficiency without significantly increasing pressure drop. Further research is required to explore the potential of hybrid nanofluids and optimize the performance of shell and tube heat exchangers.

3. MODELLING

Following are the dimensions of a shell and tube heat exchanger

3.1. Shell dimensions

S.No	Dimensional parameters	Dimensions (mm)
1.	Outer diameter	440
2.	Shell length	1000
3.	Inner diameter	400
4.	Shell thickness	10

3.2. Tube dimensions

S. No	Dimensional parameters	Dimensions (mm)
1.	Tube outer diameter (d_o)	25
2.	Tube inner diameter (d_i)	22.5
3.	Tube thickness	2.5
4.	No of Tubes	26
5.	Length of the tube	1060

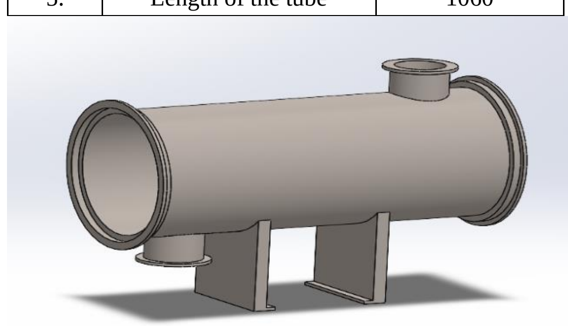


Fig.1. Solidworks model of shell

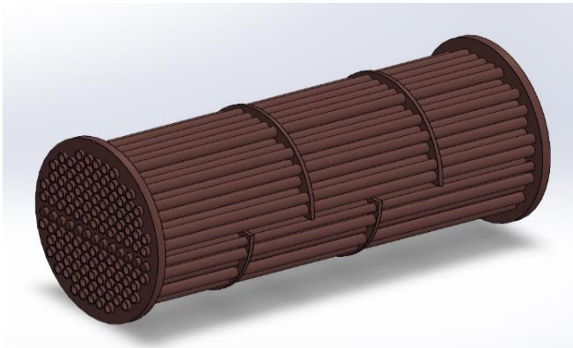


Fig.2. Solidworks model of tubes and baffles

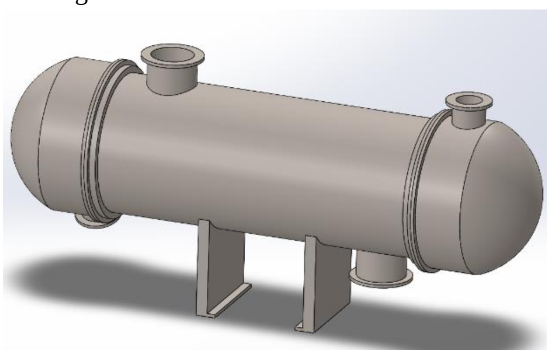


Fig.3 Shell and tube heat exchanger

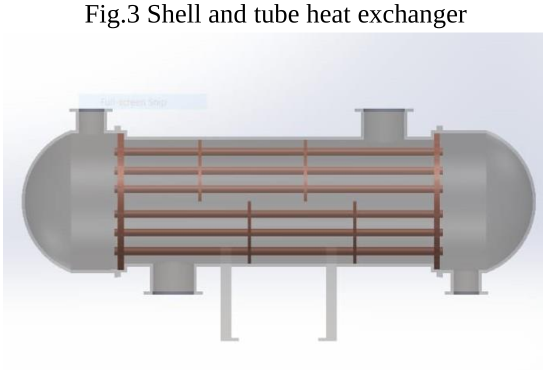


Fig.4 Shell and tube heat exchanger with internal tubes and baffles

4. SIMULATION

In this project we used FLOW SIMULATION METHOD in solid works software. In this analysis we are going to find the outlet fluid temperatures by using input parameters like inlet fluid temperatures and nano fluid properties, here we used copper material for tubes. We all know that heat transfer takes place between two fluids here we perform the analysis with base fluids and comparing with Nano fluid. We used AL_2O_3 as a Nano fluid. We considered the properties of aluminium oxide like specific heat ratio, molecular mass, dynamic viscosity, specific heat, thermal conductivity of it.

MATERIALS AND ITS PROPERTIES

Material	Density	Specific heat	Thermal conductivity
Copper	8979	381	385

PROPERTIES OF NANO FLUID:

Property	Values
Specific heat ratio	1.035
Molecular mass	0.10196 kg/mol
Dynamic viscosity	1.09 Pa*s
Specific heat	880J/(Kg*k)
Thermal conductivity	30W/(m*k)

4.1 FORMULAE

The effectiveness (ϵ) of a heat exchanger is defined as the ratio of the actual heat transfer to the maximum possible heat transfer.

- $\in$ = actual heat transfer / maximum possible heat transfer

Actual heat transfer

$$Q = m_h C_{ph} (t_{h1} - t_{h2}) = m_c Cpc (t_{c2}-t_{c1})$$

Where,

$m_h . C_{ph} = C_h$ = hot fluid capacity rate

$m_c . C_{pc} = C_c$ = Cold fluid capacity rate

Maximum possible heat transfer

$= Q_{max} = C_h (t_{h1} - t_{c1})$or

$= C_c (t_{h1} - t_{c1})$

Qmax is the minimum of these two values

$$Q_{max} = C_{min} (t_{h1} - t_{c1})$$

$$\in = C_h (t_{h1} - t_{h2}) / C_{min} (t_{h1} - t_{c1}) \text{ or}$$

$$= C_c (t_{c2} - t_{c1}) / C_{min} (t_{h1} - t_{c1})$$

The main basic Heat Exchanger equation is:

Q = U x A x ΔTm = The log mean temperature difference ΔTm is:

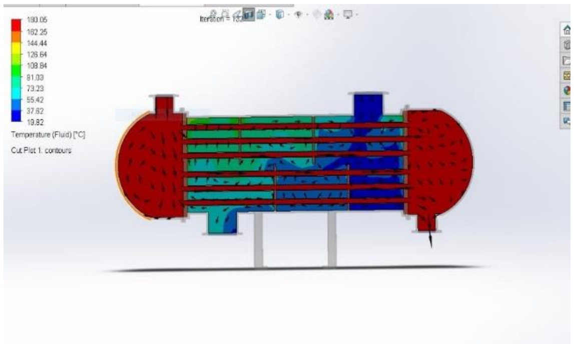
ΔTm = (T1 – t2) – (T2 – t1)

= °F. Where:

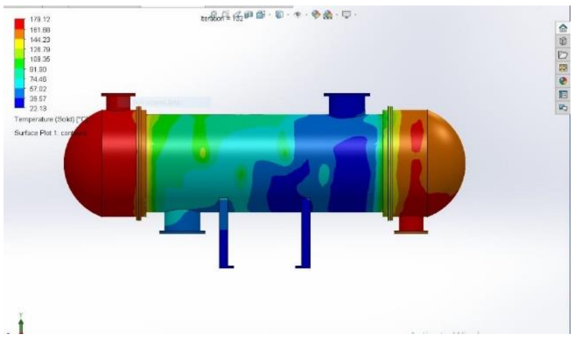
T1 = Inlet tube side fluid temperature; t2 = Outlet shell side fluid temperature;

ln (T1 – t2) (T2 – t1)

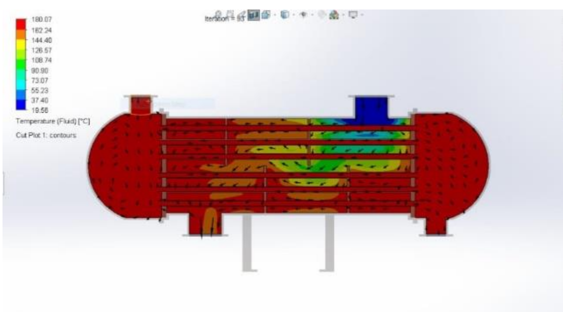
4.2 RESULTS



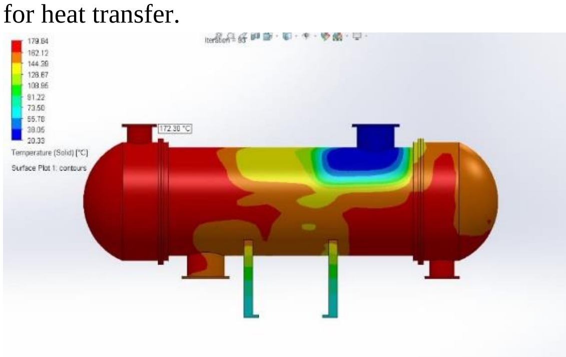
Temperature Result, when used base fluids for heat transfer.



Result for base fluids in solid shell temperature difference.



Temperature Result, when used Nano fluid (AL2O3) for heat transfer.



Result for Nano fluids (AL2O3) in solid shell temperature difference

Results for Temperature differences of base fluids and nanofluids.

Coolant type	Coolant inlet temp	Mass flow rate	Outlet coolant temp
	^0C	kg/s	^0C
Water	20	1.2	47
(AL2O3) nano fluid	20	1.2	142

5. CONCLUSION

Thus, the design and analysis of shell and tube heat exchanger is done and has the following conclusions.

- In conclusion, the use of nanofluids for heat transfer in shell and tube heat exchangers is a promising area of research. The addition of nanoparticles to base fluids has been shown to improve heat transfer characteristics.
- Especially when compared to traditional base fluids. In particular, the use of aluminium oxide nanofluids has been found to be a highly effective.
- This method of enhancing heat transfer in shell and tube heat exchangers. The results of various studies have consistently demonstrated that the use of aluminium oxide nanofluids can significantly increase the overall heat transfer coefficient, leading to improved thermal performance and overall efficiency.
- Thus, it can be concluded that the use of aluminium oxide nanofluids is a highly effective method for enhancing heat transfer in shell and tube heat exchangers.

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