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Shell and Tube Heat Exchanger

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Abstract: *Heat exchangers are used to transfer heat from fluid at high temperature to fluid at lower temperature. Heat exchangers are used in industrial purposes in chemical industries, nuclear power plants, refineries, food processing, etc. Sizing of heat exchangers plays very significant role for cost optimization. Also, efficiency and effectiveness of heat exchangers is an important parameter while selection of industrial heat exchangers. Methods for improvement on heat transfer have been worked upon for many years in order to obtain high efficiency with optimum cost. In this research work, design of shell & tube heat exchanger with single segmented baffles and analyze the flow and temperature field inside the shell using Autodesk Simulation CFD 2015. When comparing the CFD analysis with experimental results, it was well correlation with negligible percentage of error. Thus, the series of baffles results in a significant increase in heat transfer coefficient per unit pressure drop in the heat exchanger.*

Keywords: Flow, Heat Transfer, Shell & Tube Heat Exchanger, CFD, Baffles

I. INTRODUCTION

Shell & Tube heat exchanger is one of the most widely used equipment in process industry like as in Oil refinery unit, milk dairy & also used in large chemical processes. Heat exchangers are used to transfer heat between two process streams. They are used for different applications such as heating, condensation, cooling and boiling or evaporation purpose. They give name according to their different application e.g. Heat exchanger is used for cooling are called as condenser and It used for heating or boiling are known as boiler. The required amount of heat transfer provides an insight about the capital cost and power requirement of heat exchanger. The tube side and shell side fluids are separated by tube sheet. Thin baffles are used for diverting the flow, support the tube for rigidity and obtained higher heat transfer coefficient. Helical baffles give the better performance than the single segmental baffles, but their manufacturing, maintenance and installation cost is high. Computational fluid dynamics is now industrial design tool having many advantages. CFD models of shell and tube heat exchanger is considered here.

II. TECHNICAL SPECIFICATIONS

The following table illustrates the technical specifications of Shell And Tube Heat Exchanger

Table2.1:Technical Specifications of Shell & Tube Heat Exchanger

Sr.No.	Parameters	Specifications
1	Diameter of the shell (Ds	90mm
2	Diameter of the tube (Dt)	70mm
3	Length of the shell (L	350mm
4	Baffle spacing (B)	70mm
5	Number of passes (Nt) Inside tube material	7 MS

III. LITERATURE REVIEW

Mr. MohdIshaq Patel et al (2018), Shell and tube heat exchangers result in high shellside pressure drop and formation of recirculation zones near the baffles. Most of the researches now a day are carried on helical baffles, which give better performance than single segmental baffles but they involve high manufacturing cost, installation cost and maintenance cost. The effectiveness and cost are two important parameters in heat exchanger design. So, In order to improve the thermal performance at a reasonable cost of the Shell and tube heat exchanger, baffles in the present study are provided with some inclination in order to maintain a reasonable pressure drop across the exchanger.

V. Salamon et al (2017), The use of nanoparticle dispersed coolants in automobile radiators improves the heat transfer rate and facilitates overall reduction in size of the radiators. In this study, the heat transfer characteristics of water/propyle ne glycol based TiO2nanofluid was analyzed experimentally and compared with pure water and water/propylene glycol mixture. Two different concentrations of nanofluids were prepared by adding 0.1 vol. % and 0.3 vol. % of TiO2 nanoparticles into water/propylene glycol mixture (70:30). The experiments were conducted by varying the coolant flow rate between 3 to 6 lit/min for various coolant temperatures (50°C, 60°C, 70°C, and 80°C) to understand the effect of coolant flow rate on heat transfer. The results showed that the Nusselt number of the nanofluid coolant increases with increase in flow rate. At low inlet coolant temperature the water/propylene glycol mixture showed higher heat transfer rate when compared with nanofluid coolant. However at higher operating temperature and higher coolant flow rate, 0.3 vol. % of TiO2nanofluid enhances the heat transfer rate by 8.5% when compared to base fluids.

Mukkera Hemanth and Sandeep Mulabagal(2017) Heat exchanger is a device used to transfer heat between one or more fluids. The fluids may be separated by a solid wall to Shell & Tube Heat Exchanger Department of Mechanical Engineering ZES'S Zeal Polytechnic, Pune 8 prevent mixing or they may be in direct contact. In this work, different NANO fluids mixed with base fluid water are analysed for their performance in the shell and tube heat exchanger without baffle and with baffle(900,300 and helical type baffle). The NANO fluids are Aluminium Oxide and Titanium carbide for two volume fractions 0.4, 0.5. Theoretical calculations are done determine the properties for NANO fluids and those properties are used as inputs for analysis. 3D model of the shell and elliptical tube heat exchanger is modelling in CREO parametric software. CFD analysis is done by ANSYS software.

Jami Paparao et al (2017) deals with performance of vapor absorption refrigeration system is used to produce refrigeration effect by using the recovery of thermal energy available at exhaust gases of internal combustion engine. The Net heat transfer in the generator from hot flue gases to aqua ammonia strong solution is purely depends up on the heat transfer surface contact area, these surface contact areas basically depends upon

MaysamMolana (2017) Low efficiency heat exchangers used in automotive as radiator may cause to serious dangers for the engine. Hence, thermal scientists and engineers always pursuit modern methods to enhance the heat removal of the engine. It seems nanofluids implementation in automotive cooling system promises to achieve high efficiency radiators. This paper reviews almost all performed studies in this area that are available in the literature. Author collects details about nanoparticles materials and size, base fluid, volume, concentration, flow regime and Reynolds number used in studies. Usually, maximum heat transfer enhancement and maximum need to pumping power occurs at the highest volume concentration of nanoparticles, simultaneously. On the other hand, using nanofluids, due to the enhanced heat carrying capacity of the nanofluids; the pumping power required will also be reduced.

Kumar Sai Tejes, P et al (2017) At present, the need for improvement in the efficiency of the IC engines has been increased rapidly, hence need a effective cooling system. Radiators are heat exchange devices in automobiles, responsible for carrying out the heat from the engines. In this work, car radiator was tested by the Nano fluids to increase its heat transfer capacity and new experimental results were reported. Zinc Oxide Nano fluids were prepared and tested by adding their nanoparticles in water and propylene glycol (60:40) with different volume fractions (0.15, 0.25 and 0.4) %. Experimentally, the effect of these concentrations were observed by varying a fluid flow rate from 6 to 16 liter per minute and the inlet temperature of fluid entering in radiator from 50 0 C to 80 0 C . The increase in heat transfer rate was observed as 46% by using ZnO Nano fluid with volumetric

IV. LITERATURE GAP

By addressing these literature gaps, researchers and engineers can develop more efficient, reliable, and sustainable shell and tube heat exchangers that meet the evolving needs of various industries. There is a need for an automatic, efficient and affordable Maize Sheller machine for the poor and marginalized farmers in developing countries. The performance of the Sheller machine is based on the moisture content, rate of material feeding, andspeed of the blade. The design of the Sheller takes into account the physical and mechanical properties of Maize. This design procedure has been adopted in the fabrication of an Automatic Corn Sheller machine which is durable, efficient, and can be used to generate high profits, while reducing human fatigue. After the entire process is complete, the shelling operation will provide a better understanding of the fabrication and design that was involved in this projec

V. METHODOLOGY

Understanding the methodology behind shell and tube heat exchangers involves grasping their design, operation, and the principles of heat transfer that govern them. Here's a breakdown:

Core Concepts:

Basic Structure:

A shell and tube heat exchanger consists of a cylindrical shell containing a bundle of tubes.

One fluid flows through the tubes (tube-side fluid), and the other flows around the tubes within the shell (shell-side fluid).

Heat Transfer:

Heat is transferred between the two fluids through the walls of the tubes.

The design aims to maximize this heat transfer while maintaining a safe separation of the fluids.

FIG.1.1 Baffle Fix Set Up, Stand.

Fluid Flow:

The flow arrangement (parallel flow, counterflow, or crossflow) significantly impacts heat transfer efficiency. Counterflow is generally the most efficient.

Baffles within the shell direct the shell-side fluid flow, increasing turbulence and enhancing heat transfer.

Key Methodological Aspects:

Design Considerations:

- Fluid Properties: Understanding the thermal conductivity, viscosity, and density of the fluids is crucial. Temperature and Pressure: Operating temperatures and pressures dictate material selection and structural design.
- Heat Transfer Requirements: The desired heat transfer rate determines the size and configuration of the heat exchanger. Fouling: Potential fouling (accumulation of deposits) must be considered, as it reduces heat transfer efficiency.
- Pressure Drop: Minimizing pressure drop while maximizing heat transfer is a key design objective

FIG.1.2 Shell & Tube Heat Exchanger

VI. CONCLUSION

A study was done on flow and heat transfer analysis using CFD. The modeling was done using Autodesk Inventor Professional 2015 and the simulation was carried out using Autodesk Simulation CFD 2015. Based on the experimental and CFD results it can be concluded as follows:

The heat transfer rate was better this is due to the corrugated copper tubes that were used to improve the contact surface of the tube.

Compared to the other types of shell & tube heat exchangers the fouling is very less this was achieved due to the clearance between the baffles and the PVC pipe which causes shear stress on shell wall. This stress reduces fouling.

Low pressure drops and high potential heat transfer rate were achieved. This was due to the single segmental baffles which was used to regulate the flow of the fluid and they are very easy to replace.

The shell & tube heat exchanger cost was reduced this was due to the design and materials used in the heat exchanger.

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