Manufacturing and testing of shell and tube heat exchanger using nanopartical for increasing heat transfer rate

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Abstract: In India people's corner will be a web based application which will help the citizen of a municipal corporation to register their complaints about day to day problems in their ward through a web application. People's corner will provide a common man to register his complaints and problems to municipal authority as well as let the municipal authorities to address the issue as soon as possible. This application provides an interface to register one's complaint and follow it up. This interface provide a which help clicking up a picture of any generalized problem that people are facing and will help in uploading the photo along with the complaint. This complaint, once registered, will be redirected to specific department of Municipal Corporation for example; a complaint about damaged road will be redirected to Public Work Department. Once the complaint sent to the respective ward the officers can take the necessary actions as soon as possible.

Keywords: shell and tube, heat exchanger, nanopartical, heat transfer rate.

I. INTRODUCTION

Heat exchangers are used for transferring thermal energy between two or more fluids, at different temperature and in thermal contact. The essential principle of a heat exchanger is that it transfers the heat without transferring the fluid that carries the heat. In heat exchangers, there are no external thermal energy and work interactions.

The heat transfer occurs mainly due to conduction and convection. The heat exchangers are classified according to transfer processes, number of fluids, and degree of surface compactness, construction features, flow arrangements, and heat transfer mechanisms. Heat exchangers are extensively used in many engineering applications such as chemical engineering processes, power generation, petroleum refining, refrigeration, air conditioning, food industry and so on. Among different types of heat exchangers, shell and tube heat exchangers are relatively easy to manufacture and have multipurpose application possibilities for gaseous as well as liquid media in large temperature and pressure ranges. In shell and tube heat exchanger, two fluids of different temperature flow through the heat exchanger.

One flows through the tubes (the tube side) and other flows outside the tubes but inside the shell (the shell side). Heat is transferred from one fluid to the other through the tube walls, either from tube side to shell side or vice versa. The fluids can either be liquids or gases on either the shell or the tube side. In order to transfer heat efficiently, a large heat transfer area is used, leading to the use of many tubes. This is an efficient way to use energy and avoid wastage of thermal energy. Found that more than 30% heat exchangers are used of shell and tube type. Shell and tube heat exchangers can be custom designed by considering its operability, maintainability, flexibility and safety.

This makes it very robust and serves major reason to be used widely in industries. For efficient heat transfer process, heat exchanger should have low pressure drop, high shell side mass flow velocity, high heat transfer coefficient, and no or very low fouling and so on. Heat transfer also depends on the amount of turbulence created in shell side. This turbulence can be created by using baffles.

Various types of baffles are enlisted in literature. Some of the commonly used are segmental, double segmental, triple segmental.

When traditional segmental baffles are used in shell and tube heat exchanger, higher pumping power is often needed to offset higher pressure drop under same heat load. The problems of SG-STHX mentioned above were improved or solved by helical baffles.

The shell and tube heat exchanger with discontinuous helical baffle was firstly proposed and commercially produced carried out a numerical investigation to study the impact of various baffle inclination angles on fluid flow and heat transfer of continuous helical shell and tube heat exchangers by using periodic model. From the results computed, it was observed that the best-integrated performance occurs approximately 45° helix angle Performance of heat exchanger also depends on pressure drop Leakage can reduce pressure drop and thus per compartment average heat transfer coefficient.

A procedure to evaluate pressure drop and its comparison with experimental data. Based on flow arrangement, shell and heat exchangers are classified into parallel (co-current) and counter (concurrent). In a counter-flow or counter-current exchanger, the two fluids flow parallel to each other but in opposite directions within the core (The temperature variation of the two fluids in such an exchanger may be idealized as one dimensional). As shown later, the counter-flow arrangement is thermodynamically superior to any other flow arrangement.

It is the most efficient flow arrangement, producing the highest temperature change in each fluid compared to any other two fluid flow arrangements for a given overall thermal conductance (UA), fluid flow rates (actually, fluid heat capacity rates), and fluid inlet temperatures.

Moreover, use of helical; baffles has proved better heat transfer efficiency than original segmental shell and tube heat exchanger in same shell structure and same mass flow rate. proposed maximal velocity design method for continuous helical shell and tube heat exchanger.

A shell and tube heat exchanger is a class of heat exchanger designs. It is the most common type of heat exchanger in oil refineries and other large chemical processes, and is suited for higher-pressure applications. As its name implies, this type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids. The set of tubes is called a tube bundle, and may be composed of several types of tubes: plain, longitudinally finned, etc.

In this paper we are concerned about the performance analysis of shell and tube type heat exchanger under different loading conditions. To do the same we have first designed a shell and tube type heat exchanger to get the dimensions of the parts involved and thereafter fabrication and testing of the actual working model has been done to see the effects of various parameters on the performance of the heat exchanger.

A heat exchanger is the equipment built to efficiently transfer heat from one medium to another without actually mixing the two. The two media may be separated by a solid conducting structure to prevent mixing the two. It is widely used in appliances such as air conditioning, refrigeration, power plants, chemical plants, space heating, natural gas processing, petrochemical plants, petroleum refineries and sewage treatment.

The ultimate example of a heat exchanger is found in an internal combustion engine in which a fluid known as engine coolant flows through radiator coils and air flows which past the coils cools the coolant and heats the incoming air Heat exchangers are devices that facilitate the exchange of heat between two fluids that are at different temperatures while keeping them from mixing with each other.

Heat exchangers are commonly used in practice in a wide variety of applications, from air conditioning systems in a house to power production applications in large plants.

II. LITERATURE SURVEY

[1] S.Gh. Etemad, B. Farajollahi , this paper concluded that an experimental system was designed and constructed to investigate heat transfer behavior of γ-Al_2O_3 nanofluid in a shell and tube heat exchanger. Heat transfer characteristics were measured under the turbulent flow condition. The experiments were done for wide ranges of Peclet numbers, and volume concentrations of suspended nanoparticles. Based on the results, the heat transfer characteristics of nanofluids improve with Peclet number significantly. Addition of naoparticles to the base fluid causes the significant enhancement of heat transfer characteristics and results in larger heat transfer coefficient than that of the base fluid at the same Peclet number. The nanofluid has an optimum volume concentration in which the heat transfer characteristics show the maximum enhancement.In the present experimental study heat transfer behavior of γ-Al_2O_3/water nanofluid in a shell and tube heat exchanger was investigated. The experiments were done for The results obtained for a range of Peclet number and nanoparticle concentrations. The experimental results indicate that the heat transfer characteristics of nanofluid enhance significantly with increasing Peclet number. For example nanofluid with 0.5% nanoparticle volume concentration possesses about 20%, 56%, and 54% higher overall heat transfer coefficient, convective heat transfer coefficient and Nusselt number, respectively. Also there is an optimum for volume concentration in which the nanofluid shows the maximum heat enhancement.

[2] Kallalu Harika, Tummala Likhitha , Karnati Hema and Penumala Pavani , this paper concluded that shell and tube heat exchanger is a class of heat exchanger. Heat exchanger is a device used to transfer heat between a solid and a fluid or between two or more fluids. This paper is concerned with the study of shell and tube heat exchanger. Also the main components of shell and tube type heat exchanger are shown in drawing and its detail discussion is given. Moreover the constructional details and design methods of shell and tube heat exchangers are given from which kern's method for design is described in detail with step inside the paper. Also other research papers are studied and the review from those papers is also describes in this paper with some of the review work in detail After this study it is said that the shell and tube heat exchanger has given the respect among all the classes f heat exchanger due to their virtues like comparatively large ratios of heat transfer area to volume and weight and many more.

[3] Amarjit Singh and Satbir S. Sehgal , this paper concluded that the experimental analysis was performed on the shell-and-tube type heat exchanger containing segmental baffles at different orientations. In the current work, three angular orientations (θ) 0∘, 30∘, and 60∘ of the baffles were analyzed for laminar flow having the Reynolds number range 303–1516. It was observed that, with increase of Reynolds number from 303 to 1516, there was a 94.8% increase in Nusselt number and 282.9% increase in pressure drop. Due to increase of Reynolds number from 303 to 1516, there is a decrease in nondimensional temperature factor for cold water (ω) by 57.7% and hot water (ξ) by 57.1%, respectively.experimental study of shell-and-tube heat exchanger is conducted to calculate the heat transfer coefficient, LMTD, Nusselt number, and pressure drop at different Reynolds numbers (303 1516). It is concluded that the increase in Reynolds number has a significant impact on different parameters of shell-and-tube type heat exchange

[4] Dr.Hiregoudar Yerrennagoudaru, Manjunatha.k , B.Vishnu Prasad , Sandeep .k ,S.Veeresh Kumar , this paper concluded that ultrahigh performance cooling is one of the important needs of many industries. However, low thermal conductivity is a primary limitation in developing energy-efficient heat transfer fluids that are required for cooling purposes. Nanofluids are engineered by suspending nano particles with average sizes below 100 nm in heat transfer fluids such as water, oil, diesel, ethylene glycol, etc. Innovative heat transfer fluids are produced by suspending metallic or non-metallic nanometer-sized solid particles. Experiments have shown that nanofluids have substantial higher thermal conductivities compared to the base fluids. These suspended nanoparticles can change the transport and thermal properties of the base fluid. The aim of this project is to summarize recent developments in research on nanofluids, and to carry out cfd analysis for four different nano fluids and the result is analysed, two fluids are selected for experimentation work and finally the experimented result is compared with the cfd results to draw out the conclusion. The different nano fluids used for cfd analysis are Magnesium oxide-water, copper oxide-water, Titanium oxide-water, and Iron oxide-water. For experimentation nanoparticle's sizes are varied in the range of 70 to 230 nm for preparing nanofluids, and to observe enhancement in the thermal conductivity.

[5] A.GopiChand, A. V. N. L. Sharma, G. Vijay Kumar, A.Srividya , this paper concluded that a simplified model for the study of thermal analysis [1] of shell-and-tubes heat exchangers of water and oil type is proposed. Shell and Tube heat exchangers are having special importance in boilers, oil coolers, condensers, pre-heaters. They are also widely used in process applications as well as the refrigeration and air conditioning industry. The robustness and medium weighted shape of Shell and Tube heat exchangers make them well suited for high pressure operations. In this paper we have shown how to done the thermal analysis by using theoretical

formulae for this we have chosen a practical problem of counter flow shell and tube heat exchanger of water and oil type, by using the data that come from theoretical formulae we have design [2] a model of shell and tube heat exchanger using Pro-e and done the thermal analysis by using Floefd software and comparing the result that obtained from Floefd software and theoretical formulae. For simplification of theoretical calculations we have also done a Mat lab code which is useful for calculating the thermal analysis of a counter flow of water-oil type shell and tube heat exchanger

[6] Bharat B. Bhosle, Prof.D.N.Hatkar , this paper concluded that achieve high heat transfer rate, different techniques have been used. One of the advanced techniques among them is suspension of nanoparticle in the base fluids as water, ethylene glycol, oil. In the present work Al2O3 nanoparticle of diameter size 50 nm is suspended in water. The present work has been carried out on double pipe heat exchanger for water to water and Nano fluid to water heat transfer investigation with counter flow arrangement under turbulent flow condition. The computational fluid dynamic code is used to simulated different concentrations of Nano fluid (0.01% to 0.19%) in ANSYS FLUENT 14 software. The overall heat transfer coefficients for all concentrations are measured as a function of hot and cold streams mass flow rates. Considering friction factor, one appropriate concentration (0.1%) is taken into account experimentally. The study is done at different mass flow rates and inlet fluid temperatures. It is observed that for high Reynolds number low concentration of Nano fluid is useful. The work concludes that there is promising enhancement in heat transfer rate using Nano fluid.

[7] Dawit Bogale, this paper concluded that a heat exchanger is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at different temperatures and in thermal contact .From different types of heat exchangers the shell and tube heat exchangers with straight tubes and single pass is to be under study. Here the redesign takes place because of temperature fluctuation at the 9th zone of the pasteurizer in the Harar Brewery Company. Thermal and mechanical design is run in order to optimize the output temperature of the cold fluid at the last heat exchanger in which it is sprayed on the beer ready for customer use. In thermal design part geometry optimization is done through trial and error. And for Mechanical design part the natural frequency& vortex shedding of different components of heat exchangers are investigated through governing equations of vibrations under dynamic fluid with in tubes. Using computational fluid dynamics (CFD) the heat transfer of the two fluid is investigated using FEM simulation software's Gambit1.3 and Fluent 6.1and the performance of the STHEx determined in terms of variables such as pressure, temperature, flow rate, energy input/output, mass flow rate and mass transfer rate that are of particular interest in STHEx analysis.

[8] Sven Olaf Danielsen , this paper concluded that the thesis investigates twisted tube type shell-and-tube heat exchangers with emphasis on thermal-hydraulic characteristics, fouling and vibration properties. An extensive literature study has been carried out in order to map all published research reports written on the topic. The mapping of performed research shows that the available information is limited. Mathematical correlations for twisted tube thermal-hydraulic characteristics are extracted from the research reports found in the literature study. Correlations for convective heat transfer coefficients and pressure loss for both shell side and tube side are presented. The enhancement of heat transfer by swirl flow in a twisted tube bundle is also discussed.

[9] Vindhya Vasiny Prasad Dubey, Raj Rajat Verma, Piyush Shanker Verma, A.K. Srivastava , this paper concluded that the study of shell & tube type heat exchangers along with its applications and also refers to several scholars who have given the contribution in this regard. Moreover the constructional details, design methods and the reasons for the wide acceptance of shell and tube type heat exchangers has been described in details inside the paper. After the above discussion it is easy to say that the shell & tube type heat exchangers has been given a great respect among all the classes of heat exchangers due to their virtues like comparatively large ratios of heat transfer area to volume and weight and many more.

Moreover well designed as well as described methods are available for its designing and analysis. The literature survey also shows the importance of this class of heat exchangers. It is also shown by the literature survey that the Computational Fluid Dynamics and other software's like ANSYS etc. have been successfully used and implemented to secure the economy of time, materials and efforts.

III. DESIGN AND SPECIFICATION

A. Design

A cylindrical shell with multiple tube running inside the shell One fluid passes through the tubes and then exits the heat exchanger; the other fluid circulates on the outside of the tubes within the cylindrical shell. Heat is transferred from one fluid to the other through the walls of the tubes. The flow path of the fluid within the cylindrical shell is directed through the vessel by means of double segment baffles, which has the effect of increasing the flow path and thus contact time of the fluid heat transfer interchange.

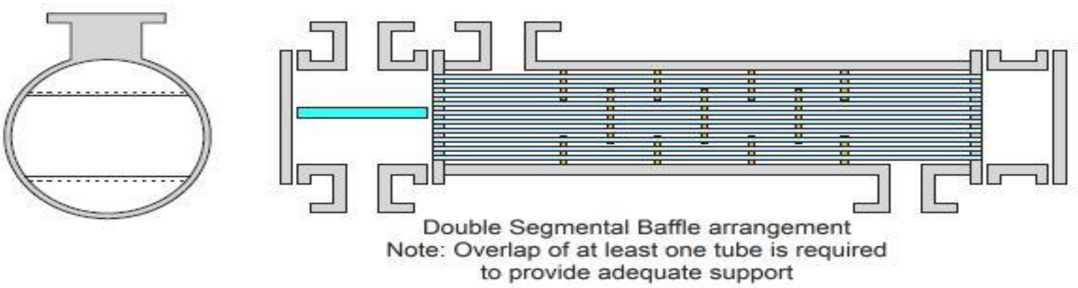

Fig 3.1 shell and tube heat exchanger

B. Material specifications

Heat Exchanger type: Shell and Tube
Nano Fluid used- SiO_2
Outer shell diameter: 300 mm
Inner copper pipe diameter: 25.4 mm
Aluminum Baffle type: Double segments
Heat Exchanger length: 1.2 m (1200mm)
Piping – ½ inch UPVC
Temperature Indicator - Digital indicator
Temperature Sensor type: P K-Type PT100 (Range)
Water pump: ¼ HP
Rotameter: 0 to 10 LPM
Water heater: 2 KW

C. Catia Model

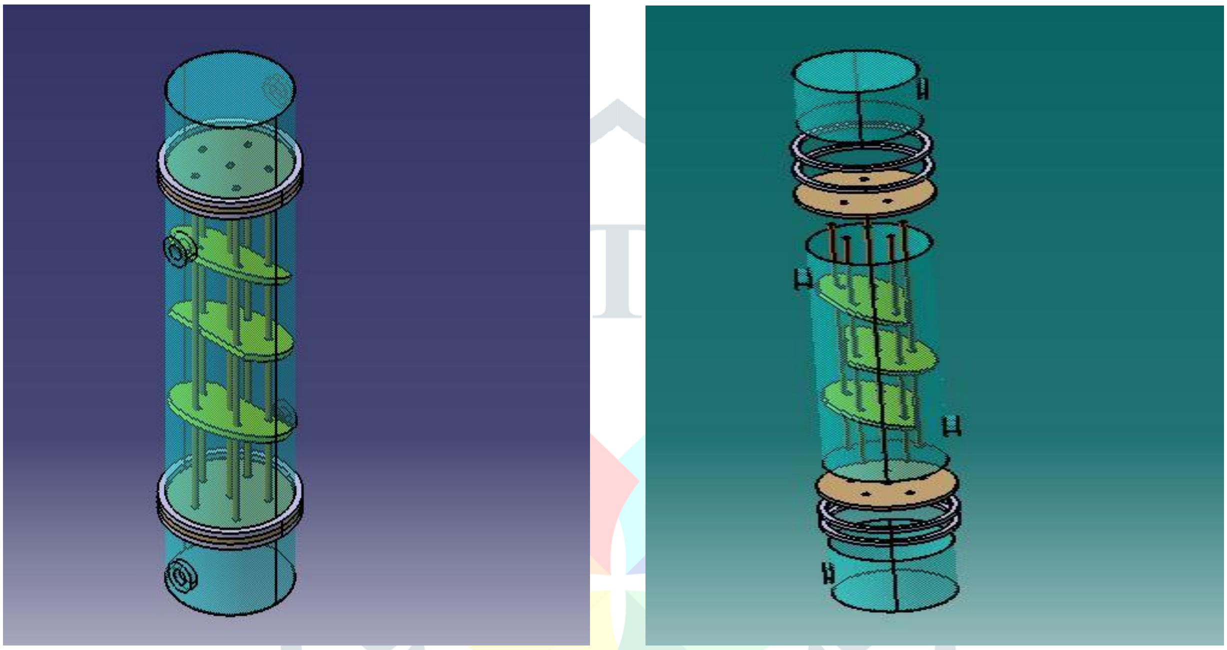

Fig 3.2 Catia Model Design

IV. CONCLUSION

It is concluded that nanofluids are having better heat transfer rate as compared to other coolants and they can be considered as a potential candidate for numerous applications involving heat transfer and their use will continue to grow. It is also found that the use of nanofluids appears promising, but the development of the field faces several challenges. Nanofluid stability and its production cost are major factors in using nanofluids. The problems of nanoparticle aggregation, settling, and erosion all need to be examined in detail in the applications. We can say that once the science and engineering of nanofluids are fully understood and their full potential researched, they can be reproduced on a large scale and used in many applications.

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