A REPORT ON HEAT TRANSFER OPTIMIZATION OFSHELL AND TUBE HEAT EXCHANGER USING DIFFERENT FLUIDS USING THROUGH CFD ANALYSIS

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Abstract - *There are many models to characterize the behavior of the heat exchangers encountered in many industries. Shell and Tube heat exchangers are having special importance in boilers, oil coolers, condensers, and 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 present work, three types of fluids are considered such as water, SiO_2 and Al_2O_3 nano particles. Thermal properties of different volume of concentration of nano particles are calculated theoretically to run the analysis. CATIA software is used to create the model and analysis have been performed in solid works flow simulation software. From the CFD results, overall heat transfer, effectiveness and friction factor are calculated and compared with respect to the velocity.*

Key Words: Water, sio_2, Al_2o_3, CATIA software, CFD

1. INTRODUCTION

Using passive techniques in order to enhance heat transfer characteristics in heat exchanger as been an interesting topic for scientists and researchers during recent decades. Numerical and experimental studies have been conducted in order to improve heat transferred by these techniques. The demand of reduction of the cost and dimensions of heat exchanger has motivated the searchers to investigate different ways of heat transfer enhancement. Passive heat transfer enhancement techniques are mostly preferred due to their simplicity and applicability in many applications. Furthermore, in passive techniques, there is no need of any external power input except to move the fluid.

1.1 The passive techniques are as follows

Treated surfaces are heat transfer surfaces that have a fine scale altercation to their finish or coating. The altercation could be continuous or discontinuous, where the roughness is much smaller than what affects single-phase heat transfer and they are primarily used for boiling and condensation duties

Rough surfaces are generally surface modifications that promote turbulence in the flow field, primary in single phase flows and do not increase the heat transfer surface area. Their geometric features range from random sand-grain roughness to discrete three dimensional surface protuberances.

Extended surfaces more commonly referred to as finned surfaces provide an effective heat transfer surface area enlargement. Plain fins have been used routinely in many heat exchangers. The newer developments, however have led to modified finned surfacesthat also tend to improve the heat transfer coefficients by disturbing the flow field in addition to increasing the surface area.

- Displaced enhancements devices are inserts that are used primarily in confined forced convection and they improve energy transport indirectly at the heat exchange surface by displacing the fluid from the heated or cooled surface of the duct with bulk fluid from the core flow.
- Swirl flow devices produce and superimpose swirl or secondary recirculation on the axial flow in a channel. They include helical strip or cored screw-type tube inserts ,ducts, and various forms of altered (tangential to axial direction) flow arrangements , and they can be used for single –phase as well as two- phase flows Coiled tubes are what the name suggests, and they lead to relatively more compact heat flows in either a dilute phase (gas-solid suspensions) or dense phase(fluidized beds). Vortices, which promote higher heat transfer heat coefficients in single phase flows as well as in most regions of boiling.
- Surface tension devices consist of wicking or grooved surfaces, which direct and improve the flow of liquid to boiling surfaces and from condensing surfaces.
- Additives for liquids include the addition of solid particles, soluble trace additives, and gas bubbles in single–phase flows, and gas bubbles in single –phase flows, and trace additives ,which usually depress the surface tension of liquid, for boiling systems.
- Additives for gases include liquid droplets or solid particles, which are introduced in single-phase gas flows in either a

dilute phase (gas-solid suspensions) or dense phase(fluidized beds).

1.2 Descriptions for the various active techniques are as follows

- Mechanical aids are those that stir the fluid by mechanical means or by rotating the surface. The more prominent examples include rotating tube heat exchangers and scraped-surface heat and mass exchangers.
- Surface vibration has been applied primarily, at either low or high frequency, in single phase flows to obtain higher convective heat transfer coefficients.
- Fluid vibration or fluid pulsation, with vibrations ranging from 1.0 Hz to ultrasound (~1.0MHz), used primarily in single–phase flows, is considered to be perhaps the most practical type of vibration enhancement technique.
- Electrostatic fields which could be in the form of electric or magnetic fields, or a combination of the two, from dc or ac sources, can be applied in heat applied in heat exchange systems involving dielectric fluids. Depending on the application, they can promote greater bulk fluid mixing and induce forced convection (corona "wind") or electro-magnetic pumping to enhance heat transfer.
- Injection, used only in single–phase flow, pertains to the method of injecting the same or a different fluid into the main bulk fluid either through a porous heat transfer interface or Upstream of the heat transfer section.

2. LITERATURE REVIEW

Daniel Flórez-Orrego, Walter Arias, Diego Lopez and Hector Velasquez[1] have worked on the helical coil heat exchanger. The study showed the flow and the heat transfer in the heat exchanger. An empirical correlation was proposed from the experimental data for the average Nusselt number and a deviation of 23% was found. For the helical coils an appreciable velocity vector components in the secondary flow was seen, even though the contours of velocity were similar. The study showed that some of the deviations and errors were due to the non-uniform flame radiation and condensed combustion products which modified the conditions of the constant wall heat flux assumptions. The correlations for the Nusselt number values were not totally reliable. There was no proper data available for the effect of the taper in the local Nusselt number and also the effect of curvature ratio, vertical position and the pitch of the heat exchanger's. S. Jayakumar:[2] observed that the use of constant values for the transfer and thermal properties of the fluid resulted in inaccurate heat transfer coefficients. Based on the CFD analysis results a correlation was developed in order to evaluate the heat transfer coefficient of the coil. In this study, analysis was done for both the constant wall temperature and constant wall heat flux boundary conditions. The Nusselt numbers that were obtained were found to be highest on the outer coil and lowest in the inner side. Various numerical analyses were done so as to relate thecoil parameters to heat transfer. The coil parameters like the diameters of the pipes, the Pitch Circle Diameters have significant effect on the heat transfer and the effect of the pitch is negligible.

J. S. Jayakumar, S. M. Mahajani, J. C. Mandal, Rohidas Bhoi[3] studied the constant thermal and transport properties of the heat transfer medium and their effect on the prediction ofheat transfer coefficients. Arbitrary boundary conditions were not Applicable for the determination of heat transfer for a fluid-to-fluid heat exchanger. An experimental setup was made for studying the heat transfer and also CFD was used for the simulation of the heat transfer. The CFD simulation results were reasonably well within the range of the experimental results. Based on both the experimental and simulation results a correlate on was established for the inner heat transfer coefficient Leong et al., [4] attempted to investigate the heat transfer characteristics of an automotive car radiator using ethylene glycol based copper nano fluid numerically. Thermal performance ofan automotive car radiator operated with nano fluid has been compared with a radiator using conventional coolants. Vajjha et al., [5] have been numerically studied a three-dimensional laminar flow and heat transfer with two different nano fluid, Al_2O_3 and CuO, in the ethylene glycol/water mixture circulating through the flat tubes of an automobile radiator to evaluate their superiority over thebase fluid. Convective heat transfer coefficient along the flat tubes with the nano fluid flow showed considerable improvement over the base fluid. Peyghambarzadeh et al., [6] have recently investigated the application of Al_2O_3/water nano fluids in the car radiator by calculating the tube side heat transfer coefficient. They have recorded the interesting enhancement of 45% comparing with the pure water application under highly turbulent flow condition. In the other study, Peyghambarzadeh et al. have used different base fluids including pure water, pure ethylene glycol, and their binary mixtures with Al_2O_3nanoparticles and once again it was proved that nano fluids improves the cooling performance of the car radiator extensively. Eastman et al., [7] found that a "nano fluid" consisting of copper nanometer-sized particles dispersed in ethylene glycol has a much higher effective thermal conductivity than either pure ethylene glycol or ethylene glycol containing the same volume fraction of dispersed oxide nanoparticles. Thermal conductivity of ethylene glycol can be increased by 40 % for a nano fluid consisting of ethylene glycol containing approximately 0.3 vol. % Cu nano particles of mean diameter <10 nm. Eastman et al., [10] found that a "nano fluid" consisting of copper nanometer-sized particles dispersed in ethylene glycol has a much higher effective thermal conductivity than either pure ethylene glycol or ethylene glycol containing the same volume fraction of dispersed oxide nanoparticles. Thermal conductivity of ethylene glycol can be increased by 40 % for a nano fluid consisting of ethylene glycol containing approximately 0.3 vol. % Cu nanoparticles of mean diameter <10 nm.Peyghambarzadeh et al., [11] have used two different water based (CuO and Fe_2O_3) nanofluid at different air and liquid velocities and liquid inlet temperatures to measure overall heat transfer coefficients in the automobile radiator. They have concluded that overall heat transfer coefficient increases while the liquid inlet temperature decreases and enhances with increasing the liquid flow rate and the air flow rate. Also, found that increasing the concentration of nanoparticles enhances the overall heat transfer coefficient especially for Fe2O3/ water nano fluid. Naraki et al., [12] found that thermal conductivity of CuO/water nano fluids much higher than that of base fluid water. He found that the overall heat transfer coefficient increases with the enhancement in the nano fluid concentration from 0 to 0.4 vol. %. Conversely, the implementation of nano fluid increases the overall heat transfer coefficient up to 8% at nano fluid concentration of0.4 vol. % in comparison with the base fluid. Singh et al., [13], have determined that the use of high-thermal conductive nano fluid in radiators can lead to a reduction in the frontal area of the radiator by up to 10%. This reduction in aerodynamic drag can lead to a fuel savings of up to 5%. The application of nano fluid also contributed to a reduction of friction and wear, reducing parasitic losses, operation of components such as pumps and compressors, and subsequently leading to more than 6% fuel savings

3. MODELLING

3.1 MODELLING OF SHELL AND TUBE HEAT EXCHANGER

To create the heat exchanger CATIA V5-6R 2015 software is used. Here the heat exchanger mainly consists of two parts, they are, one is pipes, second one shell, All these are individual components

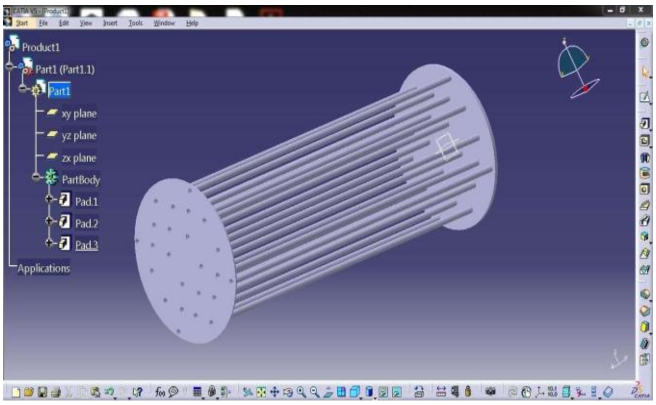

Fig.1 :Extruded part of circular pipes

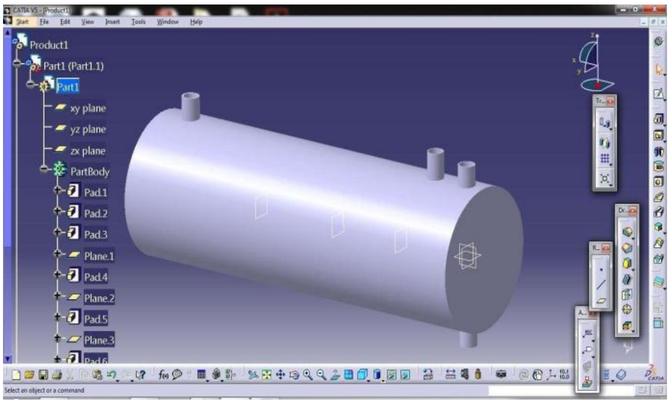

Fig.2 :cold and hot fluid separate plate

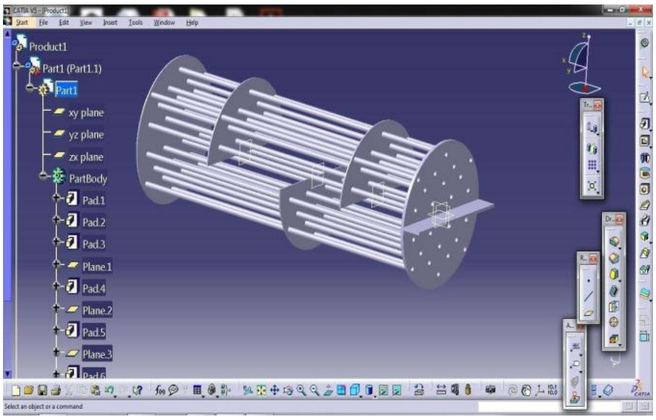

Fig.3.3 : shell and pipe assembly created in CATIA

4. SOLID WORKS FLOW SIMULATION

The total assembly for in line arrangement of tubes is imported to SOLIDWORKS Flowsimulation from CATIA as shown in fig

Part number	Part name	State of part
1	shell	solid
2	pipes	solid
3	Fluid in shell	Fluid
4	Fluid in pipes	Fluid

5. RESULTS & DISCUSSIONS

Some presumptions have been considered during the course of calculations, such as the shell inlet water temperature is assumed to be constant value of 55ºC and speed taken as 0.116m/sec, respectively, expect for the part in which the effect of changes in the conditions of the inlet air has been investigated. Mass flow rate of the coolant (nano fluid) is assumed to be differentspeeds such as 0.2, 0.4, 0.6, 0.8 and

1m/sec and its input temperature has been considered 30ºC. All the investigations have been carried out in the domain of 0 to 5% of volume fraction of nanoparticles.

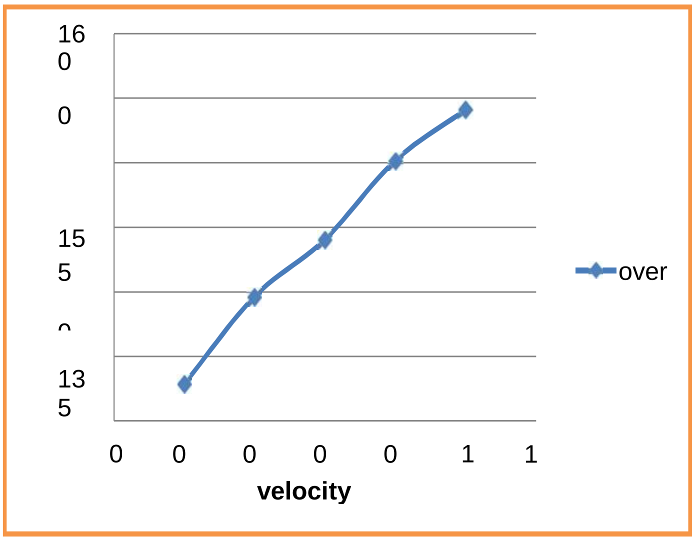

FIG 5.1 CFD SIMULATION RESULTS FOR WATER

The above graph shows between velocity and effectiveness. The velocity is shown in x- direction and effectiveness in y-direction. In the graph the velocity starts from 0.2 and the effectiveness starts from 0.75 and started to increase on 0.4 of velocity and 0.2 of effectiveness. When there is an effectiveness of 0.21 it has the velocity of 0.6. With of increase of velocity increase of 0.8 there is a gradual increase of 0.22 of effectiveness. With the increase of 0.23 of effectiveness the increase of velocity will be The graph shown in the above is about overall heat transfer in related to the velocity. The overall heat transfer is shown the above graph is in y- direction and the velocity is in x- direction. The graph here shows the gradual increase of overall heat transfer with respect to that of the velocity. With the velocity of 0.2 the overall heat transfer is 1320. When the velocity is increased to 0.4 the overall heat transfer is 1400. With the overall heat transfer of 1445 the velocity will be 0.6. Under the velocity of 0.8 the overall heat transfer is 1500. If the velocity is increase to 1 the overall heat factor is 1548.

6. CONCLUSIONS

In this present work, shell and tube exchanger analysis has been performed using different fluids with respect to various velocities. Initially total geometric model is created in CATIA software by considering all dimensions from previous reviewed article. Here 55 degree centigrade temperature has taken as inlet of shell and 30 degrees centigrade for tubes. In this work, inside fluid velocity is taken as a constant i.e. 1m/sec and outer fluid velocity is changing from 0.16 m/secto 1m/sec.

If we increase the velocity of the fluid, outer pipe outlet temperature also deceases. As wellas effectiveness, overall heat transfer of heat exchanger increases linearly and friction factor reduces continuously. Three volumes of concentrations, Al_2O_3, SiO_2 nano particles are mixed with water and sent through outer pipe.

Effectiveness and overall heat transfer has increased if we used the nano particles. Friction factor is slightly decreased in nano particles. If we increase the volume of concentration, performance of heat transfer also increases. When we compare $Al_2O_3$and SiO_2 nano particles, effectiveness and overall heat transfer in Al_2O_3 is more to that of SiO_2. In Al_2O_3, when volume of concentration is increased from 1% to 3%, 22% overall heat transfer is improved, likewise; from 3%, 33% of heat transfer is increased.

comparing with SiO_2, Al_2O_3 has56more overall heat transfer and effectiveness. From the above results, water with Al_2O_3 nano particles is preferred as optimum fluids to improve the performance of tube in tube helical coil heat exchangers.

There are different nano particles available in the market, using those, we can improve the performance. By increasing the coil diameter, we can analyze the performance. Pitch valueand outer diameter of coil are varied and these type of heat exchanger performance can be increased.

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