A Review on Experimental Investigation of Shell and Tube Heat Exchanger using Nano-fluids

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***Abstract*—Heat exchangers are most widely used for heat transfer applications in industries. Shell and Tube heat exchanger is one such heat exchanger, provides more area for heat transfer between two fluids in comparison with other type of heat exchanger. Shell and Tube heat exchangers are widely used for liquid-to-liquid heat transfer applications with high density working fluids. This study is focused on use of shell and tube heat exchanger for nano-fluid as a working fluid. A nano-fluid is a mixture of nano sized particles of size up to 100 nm and a base fluid. Typical nanoparticles are made of metals, oxides or carbides, while base fluids may be water, ethylene glycol or oil. The effect of nano-fluid to enhance the heat transfer rate in various heat exchangers is experimentally evaluated recently. The heat transfer enhancement using nano-fluid mainly depends on type of nanoparticles, size of nanoparticles and concentration of nanoparticles in base fluid. This research work deals with experimental investigation of shell and tube heat exchanger with evaluation of convective heat transfer coefficient, overall heat transfer coefficient, exchanger effectiveness. The main objective of this work is to find effects of these parameters on performance of plate heat exchanger with parallel flow arrangement.**

***IndexTerms*—heat transfer rate, Shell and tube heat exchanger, Nano-fluid, flow arrangement..**

I. INTRODUCTION (HEADING 1)

Heat exchanger is a device in which transfer of thermal energy takes place between two of more fluids across a solid surface. These exchangers are classified according to construction, flow arrangement; number of fluids, compactness, etc. The use of heat exchanger gives higher thermal efficiency to the system. In many applications like power plants, petrochemical industries, air conditioning etc. heat exchangers are used. The key role of the heat exchanger is to transfer heat at maximum rate. Although today a set of common types of heat exchangers (such as: double-pipe, spiral, plate and frame, plate-fin,compact heat exchangers) are used in heat transfer applications, the shell and tube heat exchangers (STHXs) are still the most common type in use. The STHX provides a comparatively large ratio of heat transfer area to volume and weight. STHXs are widely used in manyindustrial areas such as chemical process, power generation, petroleum refining, refrigeration, air-conditioning and etc [1-12]. The main objective in any heat exchanger design is the estimation of the minimum heat transfer area required for a given heat duty, as it governs the overall cost of the heat exchanger. The baffles are of primary importance in improving mixing levels and consequently enhancing heat transfer of STHXs. Segmental baffles are most commonly used in STHXs. The most-commonly used baffle is the segmental baffle, which forces the shell side fluid going through in a zigzag manner, hence, improves the heat transfer with a large pressure drop penalty. Baffles are provided for heat transfer purposes and are used to support tubes, enable a desirable velocity to be maintained for the shell side fluid and prevent vibration of the tubes.

To enhance the thermal efficiency of the shell and tube heat exchangers (STHXs), the thermal capability of the working fluid must be increase. Addition of small amount of high thermal conductivity solid nanoparticles in base fluid increases the thermal conductivity, thus increasing the heat transfer rate in the heat exchangers. A nano-fluid is a mixture of nano sized particles and a base fluid. Typical nanoparticles are made of metals, oxides or carbides, while base fluids may be water, ethylene glycol or oil. The nano-fluid exhibits different thermo physical properties than the base fluid. Generally thermal conductivity of nanofluids is higher than the base fluid which increases the heat transfer rate. The heat transfer enhancement using nano-fluid mainly depends on type of nanoparticles, size of nanoparticles and concentration of nanoparticles in base fluid.

Nano-fluid is the name conceived by Argonne National Laboratory (ANL), USA, to describe a fluid in which nanometer-sized particles are suspended. Nanofluids are a class of heat transfer fluids created by dispersing solid nanoparticles in traditional heat transfer fluids. Research results show that nanofluids have thermal properties that are very different from those of conventional heat transfer fluids such as water or ethylene glycol.

The ANL performed nano-fluid experiment, where it was found a 20% increase in the thermal conductivity. Theoretically the thermal conductivity increases are based on the volume fraction and shape of the particles. The increase of the thermal conductivity leads to an increase in heat transfer performance. In fact the reduction of the thermal boundary layer thickness due to the presence of the nanoparticles and the random motion within the base fluid may have important contributions to such heat transfer improvement as well.

II. LITERATURE REVIEW

Masoud Haghshenas Fard, Mohammad Reza Talaie, and Somaye Nasr [1] "Numerical and Experimental Investigation of Heat Transfer of Zno/Water Nano-fluid in the Concentric Tube and Plate Heat Exchangers" In this research paper the plate and concentric tube heat exchangers are tested by using the water- -water and nano-fluid-water streams. The ZnO/water (0.5 v/v%) nano-fluid has been used as the hot stream. The heat transfer rate omitted of hot stream and overall heat transfer coefficients in both heat exchangers are measured as a function of hot and cold streams mass flow rates. The experimental results show that the heat transfer rate and heat transfer coefficients of the nano-fluid in both of the heat exchangers is higher than that of the base liquid (i. e. water) and the efficiency of plate heat exchange is higher than concentric tube heat exchanger. In the plate heat exchanger the heat transfer coefficient of nano-fluid at =10g/s is about 20% higher than the base fluid and under the same conditions in the concentric heat exchanger is 14% higher than the base fluid. The heat transfer rate and heat transfer coefficients increases with increase in mass flow rates of hot and cold streams. Also the computational fluid dynamics code is used to simulate the performance of the mentioned heat exchangers. The results are compared to the experimental data and showed good agreement. It is shown that the computational fluid dynamics is a reliable tool for investigation of heat transfer of nanofluids in the various heat exchangers.

N. K. Chavda, Jay R. Patel, Hardik H. Patel, Atul P. Parmar [2] "Effect of Nano-fluid on Heat Transfer Characteristics of Double Pipe Heat Exchanger: Part-I: Effect Of Aluminum Oxide Nano-fluid" In this research paper a nano-fluid is a mixture of nano sized particles of size up to 100 nm and a base fluid. Typical nanoparticles are made of metals, oxides or carbides, while base fluids may be water, ethylene glycol or oil. The effect of nano-fluid to enhance the heat transfer rate in various heat exchangers is experimentally evaluated recently. The heat transfer enhancement using nano-fluid mainly depends on type of nanoparticles, size of nanoparticles and concentration of nanoparticles in base fluid. In the present paper, an experimental investigation is carried out to determine the effect of various concentration of Al2O3 nano-dispersion mixed in water as base fluid on heat transfer characteristics of double pipe heat exchanger for parallel flow and counter flow arrangement. The volume concentrations of Al2O3 nano-fluid prepared are 0.001 % to 0.01 %. The conclusion derived for the study is that overall heat transfer coefficient increases with increase in volume concentration of Al2O3 nano-dispersion compared to water up to volume concentration of 0.008 % and then decreases.

FIGURE 2 : Experimental Setup of Double Pipe Heat ExchangerApparatus

Tambe Shahanwaj K, Pandhare Nitin T, Bardeskar Santosh J, Khandekar S.B [3] " Experimental Investigation of Performance of Plate Heat Exchanger for Water as Working Fluid"Compact heat exchangers are most widely used for heat transfer applications in industries. Plate heat exchanger is one such compact heat exchanger, provides more area for heat transfer between two fluids in comparison with shell and tube heat exchanger. Plate type heat exchangers are widely used for liquid-to-liquid heat transfer applications with high density working fluids. This study is focused on use of plate type heat exchanger for water as a working fluid. This research work deals with experimental investigation of plate type heat exchanger with evaluation of convective heat transfer coefficient, overall heat transfer coefficient, exchanger effectiveness. The heat exchanger used for carrying out this work consists of thin metal welded plates of stainless steel with 1mm thickness, rectangular geometry and distance between two plates is 7mm. This test setup consists of total 16 numbers of plates and it is designed to withstand with 850C temperature, pressure drop is neglected. Tests are conducted by varying operating parameters like mass flow rate, inlet temperatures of hot water. The main objective of this work is to find effects of these parameters on performance of plate heat exchanger with parallel flow arrangement. Results show that, overall heat transfer coefficient and convective heat transfer coefficient increases with increase in mass flow rate and Reynolds number. Also the effectiveness varies slightly with heat capacity ratio. In this study, maximum effectiveness achieved for plate heat exchanger with water as a working fluid is 0.48. Use of plate heat exchanger is more advantageous than the tube type heat exchanger with same effectiveness, as it occupies less space.

Arun KumarTiwari [4] "Thermal Performance of Shell and Tube Heat Exchanger usingNanofluids "in this paper, an attempt is made to experimentally investigate the thermal performance of a shell and tube heat exchanger using nanofluids. The cold water based nanofluids flow in tube side and water as hot fluid flows on shell side. Use of nanoparticles in water based nanofluid as coolant in shell and tube heat exchanger improves the effectiveness by a considerable amount,whiletheconvectiveandoverallheat transfer coefficient increases even further with the addition of 3% Al_2O_3 nanoparticlesin waterbasedfluid.

S.G.h. Etemad* , B.Farajollahi[5] "Heat Transfer of Nano-fluid in a shell and tube heat exchanger "The objective of this paper is An experimental system was designed and constructed to investigate heat transfer behavior of γ-Al_2O_3 nano-fluid 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 nanoparticles 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 nano-fluid has an optimum volume concentration in which the heat transfer characteristics show the maximumenhancement.

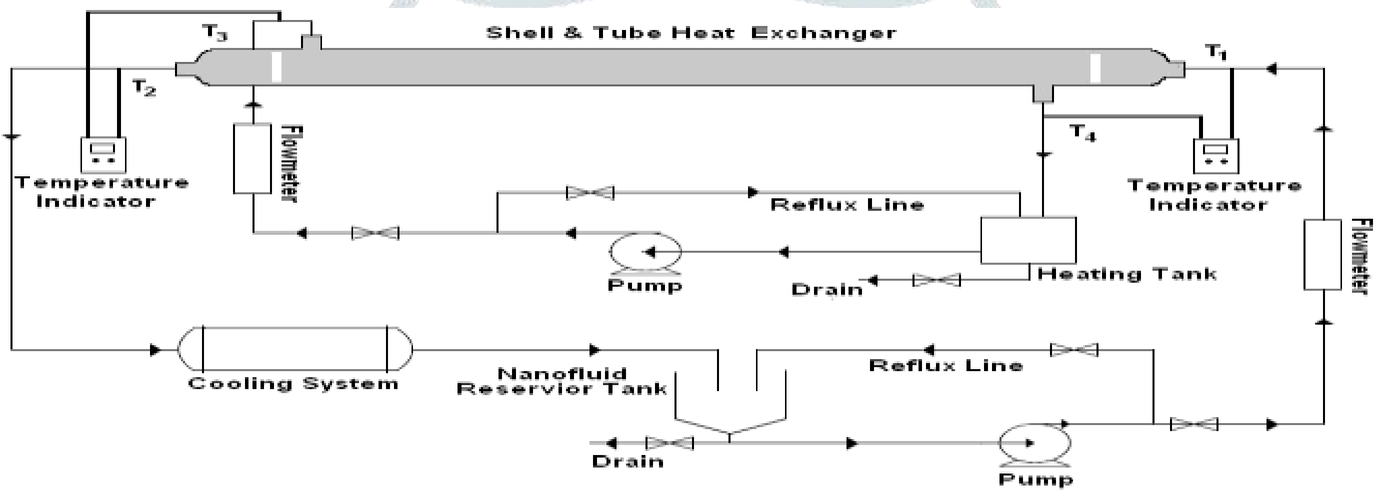

FIGURE 2: Experimentalsetup

Ramesh R, Dr.R.Vivekananthan[6] "Application of Al_2O_3 Nanofluid for Enhance Heat Transfer Rate in Shell and Tube HeatExchanger" This project is to enhance the heat transfer rate of shell and tube heat exchanger in temperature process station by using Al_2O_3 nanofluid and Ethylene glycol. Al_2O_3 and copper nano particles are found to have good thermal conductivity for the heat transfer in shell and tube heat exchanger in Temperature process station. The presence of nano particles changes the flow structure so that besides of thermal conductivity increment in a temperature process station of heat exchanger. Al_2O_3 has been mixed with water as a base fluid to increase the heat transfer rate. The experimental and numerical investigation has to be performed and the results have been compared to validate the performance of the hx.

FIGURE 3: MODEL OF SHTX

Vinodkumar, Kiran Voonna, T.K.Tharakeshwar [7] "Improvement of Heat Transfer Coefficients in a Shell and HelicalTube Heat Exchanger Using Water/Al_2o_3 Nano-fluid"In this research paper improving heat transfer in helical tube heat exchanger is studied, experimented and analyzed by many research peoples, it's because the fluid passing through the helical tube offers certain better advantages then straight tubes. in this paper we are concentrating on improving shell side heat transfer coefficients and net heat transfer in given experimented model, without much pressure loss is our main aim of project. So we are referring some journals for correlations of AL_2O_3 nanofluids properties and designing the model in ANSYS WORKBENCH 15 then it is meshed and solved in STARCCM+ solver for various concentrations of nanofluids. The hot fluid passes through the helical coil and cold fluid passes through the shell in a counter flow manner, water is used as a base fluid in both cases. The copper is chosen as a material of tube, where as the physics monitoring equations like mass momentum and energy are solved using turbulence of k-e two equation models. The results of temperatures are validated for experimented values that are referred and heat transfer values are plotted.

III. CONCLUSION

An experimental investigation is carried out to determine the effect of various concentration of nano-dispersion mixed in water as base fluid on heat transfer characteristics of shell and tube heat exchanger for parallel and counter flow arrangement. The volume concentrations of nano-fluid prepared are 0.001 % to 0.01 %. The conclusion derived for the study is that overall heat transfer coefficient increase with increase in volume concentration of nano- dispersion compared to water up to volume concentrationof 0.008 % and then decreases. After analyzing the results the net heat transfer increases with the addition of nano particle i.e. from 0.5 to 2% and shell side heat transfer coefficient also increases as in turn net heat transfer improves hence the objective is achieved.

REFERENCES

[1] Masoud Haghshenas Fard, Mohammad Reza Talaie, and Somaye Nasr [1] "Numerical and Experimental Investigation of Heat Transfer of Zno/Water Nano-fluid in the Concentric Tube and Plate Heat Exchangers" Numerical and Experimental Investigation of THERMAL SCIENCE, Year 2011, Vol. 15, No. 1, pp. 183-194)

[2] N. K. Chavda, Jay R. Patel, Hardik H. Patel, Atul P. Parmar [2] "Effect of Nano-fluid on Heat Transfer Characteristics of Double Pipe Heat Exchanger: Part-I: Effect Of Aluminum Oxide Nano-fluid" International Journal of Research in Engineering and Technology Vols 03, eISSN: 2319-1163.

[3] Tambe Shahanwaj K, Pandhare Nitin T, Bardeskar Santosh J, Khandekar S.B [3] " Experimental Investigation of Performance of Plate Heat Exchanger for Water as Working Fluid"International Journal of Research in Engineering and Technology Vols 4, eISSN: 2319-1163.

[4] Arun KumarTiwari [4] "Thermal Performance of Shell and Tube Heat Exchanger usingNanofluids " INDIAN TECHNICAL RESEARCH ORGANISATION, volume 1, issue 1, July 2015 ISSN 2394-6202.

[5] S.G.h. Etemad*, B.Farajollahi[5] "Heat Transfer of Nano-fluid in a shell and tube heat exchanger "International Journal of Heat and mass transfer, January 2010.

[6] Ramesh R, Dr.R.Vivekananthan[6] " Application of Al_2O_3 Nanofluid for Enhance Heat Transfer Rate in Shell and Tube HeatExchanger"IOSR Journal of Mechanical and Civil Engineering(IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 2 .