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"A Review of Heat Transfer Enhancement in a Shell and Tube Heat Exchanger Using Different Nano Fluids"

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Abstract

In this paper a brief review on application of nanofluids in heat exchangers has been addressed. Heat exchangers can improve industrial production efficiency and ensure equipment safety. Among various types of heat exchanges, shell and tube heat exchangers have been widely used in various industrial applications, such as power systems, energy industry, refrigeration, heating ventilation and air conditioning (HVAC), and food processing. Due to their compact structure, small pressure loss and high heat transfer coefficient, the helically coiled tube heat exchangers have been extensively studied as one of the passive heat transfer enhancement. The various researchers have been studying the cooling performance of shell and tube heat exchangers. This paper provides the review regarding the heat exchangers and nanofluid utilization for heat transfer applications.

The aim of present paper is to review "The various nanofluids which affect the heat transfer rate of Shell and Tube heat exchanger." on the basis of previous study.

Keywords; Shell and tube Heat exchanger, nanofluids, NTU analysis, heat transfer rate etc.

INTRODUCTION

Heat exchangers are devices that provide the flow of thermal energy between two or more fluids at different temperatures, and therefore, are heat transferring device. heat exchangers are used in both cooling and heating processes. they are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. the fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. In most heat exchangers, the fluids are serarated by a heat transfer surface, and ideally they do not mix. such heat exchangers are referred to as the direct heat transfer type.

Types of Heat Exchangers

A heat exchanger is a device used to transfer heat between hot and cold fluids. there are several different variants of heat exchangers available:

1) Shell and tube heat exchangers
2) Double pipe heat exchangers
3) Plate heat exchangers
4) Condensers, evaporators, and boilers

Shell and Tube Heat Exchangers

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. Two fluids, of different starting temperatures, flow through the heat exchanger. One flows through the tubes (the tube side) and the 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 be either liquids or gases on either the shell or the tube side. In order to transfer heat efficiently, a large heat transfer area should be used, leading to the use of many tubes. In this way, waste heat can be put to use. This is an efficient way to conserve energy.

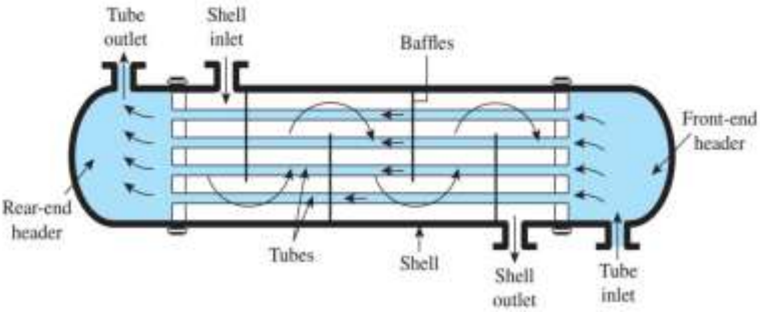


Fig.1. Shell and tube counter-flow heat exchanger.

Applications and uses

The simple design of a shell and tube heat exchanger makes it an ideal cooling solution for a wide variety of applications. One of the most common applications is the cooling of hydraulic fluid and oil in engines, transmissions and hydraulic power packs. with the right choice of materials they can also be used to cool or heat other mediums, such as swimming pool water or charge air. One of the big advantages of using a shell and tube heat exchangers have the ability to transfer large amounts of heat in relatively low cost, serviceable designs. They can provide large amounts of effective tube surface while minimizing the requirements of floor space, liquid volume and weight.

LITERATURE REVIEW

Alhassan Salami Tijani et al**;** aims to evaluate the performance of the heat transfer characteristics of water/anti-freezing based nanofluid as a coolant for car radiator. For the based fluid, a mixture of water and Ethylene Glycol were used with concentration of 50% for each of the fluid. Al_2O_3 and CuO nano particles of concentration 0.05%, 0.15% and 0.3% were added to the base fluid and then evaluate the heat transfer characteristics of the nanofluid. The mass flow rate of nanofluids in the flat tube was kept constant. The heat transfer models are simulated using ANSYS fluent solver. The performance of the heat transfer characteristics was evaluated based on certain parameters which are the heat transfer coefficient, thermal conductivity, Nusselt number, and rate of heat transfer of the nanofluids. It was found that the nanofluid that exhibited the highest heat transfer performance was the CuO nanofluid. The heat transfer coefficient was recorded at 36384.41 W/m^2 K, the thermal conductivity was 1.241 W/m K, Nusselt number was 208.71 and the rate of heat transfer was at 28.45 W. The Al_2O_3 nanofluid had a heat transfer coefficient of 31005.9 W/m2 K, thermal conductivity of 1.287 W/m K, Nusselt number was 173.19 and the rate of heat transfer was at 28.25 W [1].

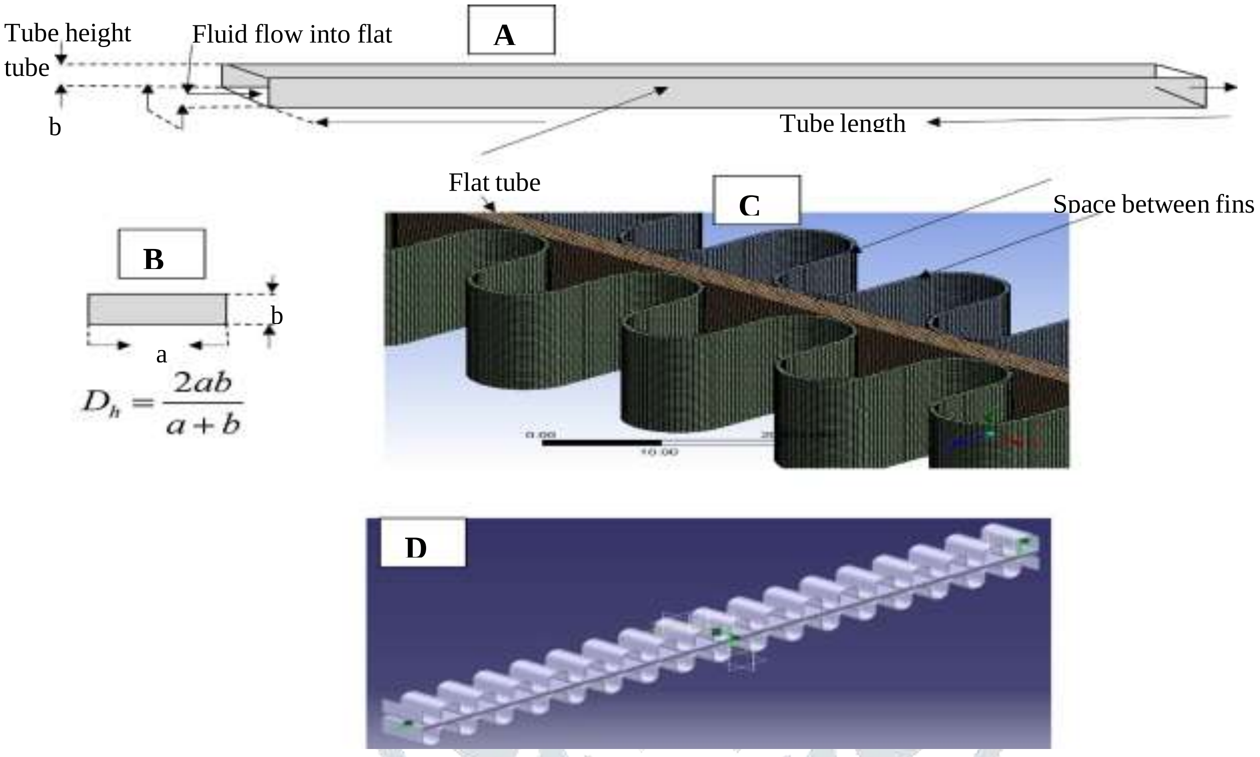


Fig.2. (a) Schematic of flat tube (b) Flat tube hydraulic diameter D_h (c) Geometry of Meshed model (d) Catia model.

Jaafar Albadr et al; reports in this article an experimental study on the forced convective heat transfer and flow characteristics of a nanofluid consisting of water and different volume concentrations of Al_2O_3 nanofluid (0.3–2) % flowing in a horizontal shell and tube heat exchanger counter flow under turbulent flow conditions are investigated. The Al_2O_3 nanoparticles of about 30 nm diameter are used in the present study. The results show that the convective heat transfer coefficient of nanofluid is slightly higher than that of the base liquid at same mass flow rate and at same inlet temperature. The heat transfer coefficient of the nanofluid increases with an increase in the mass flow rate, also the heat transfer coefficient increases with the increase of the volume concentration of the Al_2O_3 nanofluid, however increasing the volume concentration cause increase in the viscosity of the nanofluid leading to increase in friction factor [2].

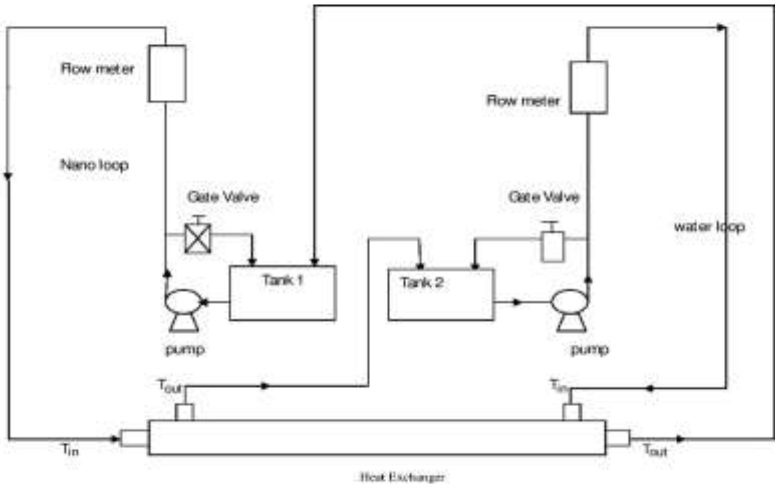


Fig.3. System diagram of the experimental setup.

Arun Kumar Tiwari et.al; presents this paper an attempt has been made to optimize different nanofluid particle volume fractions based on a maximum heat transfer rate, convective heat transfer coefficient, overall heat transfer coefficient, effectiveness and performance index. The novelty of the present study is the optimization of particle volume fraction of various nanofluids based on experimentation in the commercial plate heat exchanger for wide range of nanoparticle volume fraction (0–3%). Effects of other operating conditions on the optimization have been discussed as well. Results show that for maximum enhancement of heat transfer characteristics, different nanofluids work at different optimum volume concentrations. For CeO_2/water, Al_2O_3/water, TiO_2/water and SiO_2/water nanofluids, the optimum volume concentrations are 0.75%, 1%, 0.75% and 1.25%, respectively, at the flow rate of 3 lpm. The corresponding maximum heat transfer enhancements are about 35.9%, 26.3%, 24.1%, and 13.9%, respectively. Present study indicates that the optimum concentration for maximum performance index is lower than that for maximum heat transfer rate. Moreover the effect of nanomaterials is more predominant than that of heat transfer fluid

temperature or volume flow rate [3].

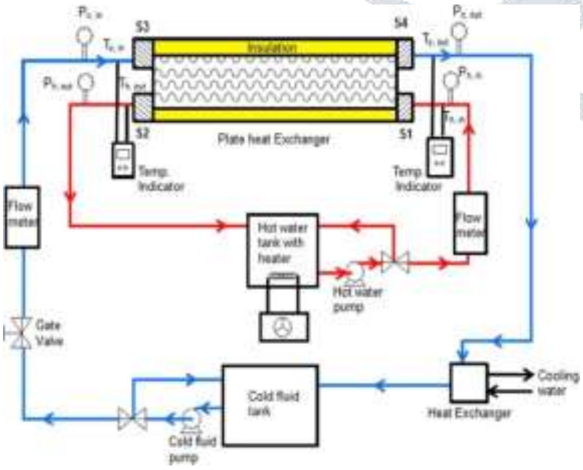


Fig.4. (a) Schematic diagram of the experimental setup.

Fig.4. (b) Fully-instrumented experimental setup.

B. Farajollahi et al; reports in this paper an experimental investigation were calculated the heat transfer characteristics of c-Al_2O_3/water and TiO_2/water nanofluids were measured in a shell and tube heat exchanger under turbulent flow condition. The effects of Peclet number, volume concentration of suspended nanoparticles, and particle type on the heat characteristics were investigated. Based on the results, adding of nanoparticles to the base fluid causes the significant enhancement of heat transfer characteristics. For both nanofluids, two different optimum nanoparticle concentrations exist. Comparison of the heat transfer behaviour of two nanofluids indicates that at a certain Peclet number, heat transfer characteristics of TiO_2/water nanofluid at its optimum nanoparticle concentration are greater than those of c-Al_2O_3/water nanofluids while c-Al_2O_3/water nanofluids possesses better heat transfer behaviour at higher nanoparticle concentrations [4].

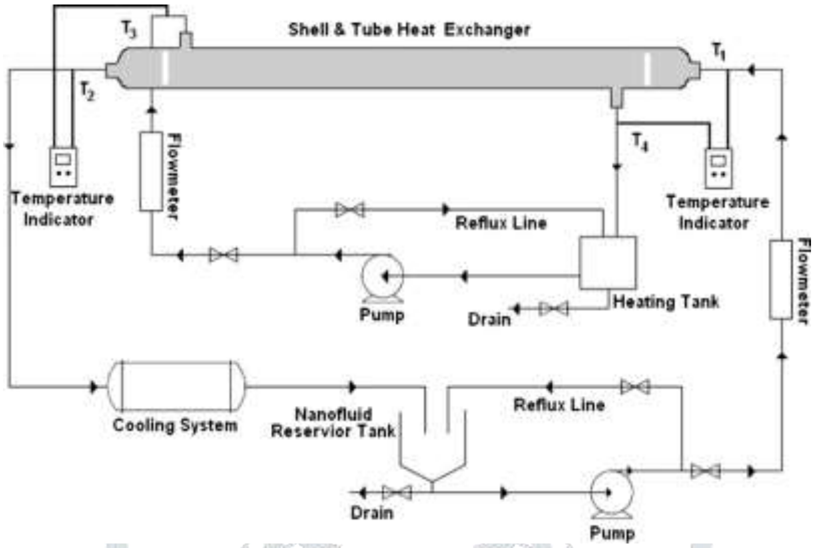
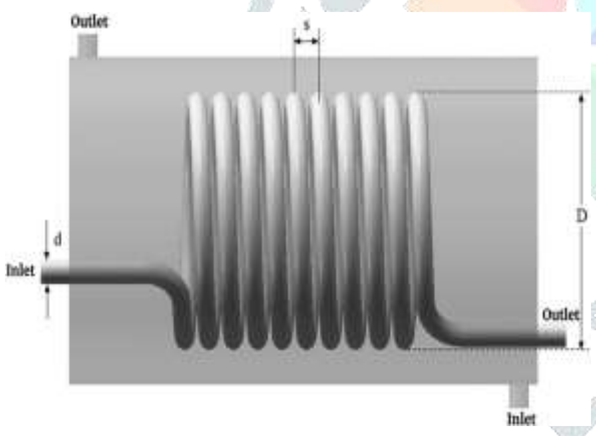


Fig.5. Experimental setup..

M.M. Sarafraz et. Al. presents of this work is to investigate the heat transfer coefficient and pressure drop characteristics of carbon nanotube water-based nanofluids inside the double pipe heat exchanger. Diameters of inner and outer copper tubes (ID and OD) were 6.35 and 12.7 mm, respectively (in accordance with ANSI/ ASME/API 5L). Nanofluids were prepared using two-step method at mass concentrations of 0.1–0.3% by dispersing the COOH functionalized multi-walled carbon nanotubes, (FCNTs as purchased) into the deionized water. Since this work can technically be important, thermal conductivity of nanofluids were experimentally measured using KD2 Decagon instrument at different mass concentrations and temperatures. To assess the thermal performance of nanofluids, forced convection experiments were conducted at laminar and turbulent flow regimes ($900 < Re < 10{,}500$). Influence of different operating parameters including: flow rate, mass concentration of nanofluid, inlet temperature of nanofluid on the heat transfer coefficient and pressure drop is studied. Results demonstrated that presence of carbon nanotube can enhance the thermal conductivity up to 56% at wt.% = 0.3. Likewise, CNT/water nanofluids have higher convective heat transfer coefficient in comparison with water, which is due to internal thermal conduction of CNTs. Longer stability was seen due to the COOH group attached to the CNTs. Small penalty is reported for pressure drop and friction factor as well, which is due to the presence of carbon nanotube inside the bulk of base fluid. Considering the influence of CNTs on heat transfer and pressure drop, it was found that carbon nanotube nanofluids can drastically enhance the thermal performance of heat exchanger in comparison with water up to 44% at maximum mass concentration (wt.% = 0.3) [5].

M.M. Elias et. al. aims to study the effect of different particle shapes (cylindrical, bricks, blades, and platelets) on the overall heat transfer coefficient, heat transfer rate and entropy generation of shell and tube heat exchanger with different baffle angles and segmental baffle. Established correlations were used to determine the abovementioned parameters of the heat exchanger by using nanofluids. Cylindrical shape nanoparticles showed best performance in respect to overall heat transfer coefficient and heat transfer rate among the other shapes for different baffle angles along with segmental baffle. An enhancement of overall heat transfer coefficient for cylindrical shape particles with 20˚ baffle angle is found 12%, 19.9%, 28.23% and 17.85% higher than 30˚, 40˚, 50˚ baffle angles and segmental baffle, respectively in corresponding to 1 vol.% concentration of Boehmite alumina (c-AlOOH). Heat transfer rate is also found higher for cylindrical shape at 20˚ baffle angle than other baffle angles as well as segmental baffle. However, entropy generation decreases with the increase of volume concentration for all baffle angles and segmental baffle [6].

Cong Wang et al; presents the intelligent optimization design of shell and helically coiled tube heat exchanger is proposed. The structural design, meshing, and numerical calculations are integrated into the genetic algorithm to perform intelligent optimization in selecting the structural and thermodynamic parameters. Compared with the experimental results, the heat flux and heat transfer rate of the heat exchanger with the optimal structure increase by 110% and 101%, respectively, which can be proved by the decrease of the average intersection angle between the velocity vector and temperature gradient on both the shell side and tube side. Considering the pressure drop constraint, the maximum heat flux increases by 12% compared with the value obtained from the optimization criterion when the total heat transfer rate is maximized, indicating its potentials in reducing the financial cost. Finally, this method provides an automatic solution to the optimization design of a diversity of heat exchangers [7].



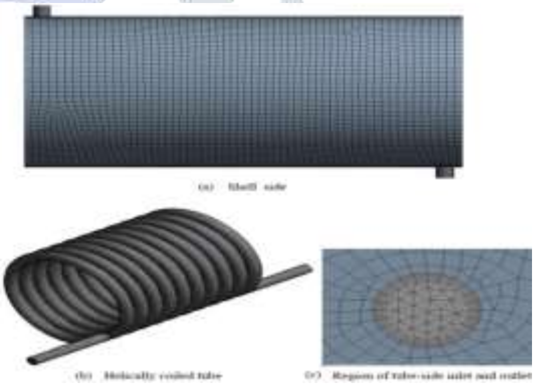


Fig.6. (a) Physical model of helically coiled tube heat exchanger. Fig.6. (b) Grid of the shell-side and tube-side.

K.Y. Leong et. al. Studies in this paper focused on the application of ethylene glycol based copper nanofluids in an automotive cooling system. Relevant input data, nanofluid properties and empirical correlations were obtained from literatures to investigate the heat transfer enhancement of an automotive car radiator operated with nanofluid-based coolants. water and ethylene glycol as conventional coolants have been widely used in an automotive car radiator. These heat transfer fluids offer low thermal conductivity. With the advancement of nanotechnology, the new generation of heat transfer fluids called, “nanofluids” have been developed and researchers found that these fluids offer higher thermal conductivity compared to that of conventional coolants. It was observed that, overall heat transfer coefficient and heat transfer rate in engine cooling system increased with the usage of nanofluids (with ethylene glycol the basefluid) compared to ethylene glycol (i.e. basefluid) alone. It is observed that, about 3.8% of heat transfer enhancement could be achieved with the addition of 2% copper particles in a basefluid at the Reynolds number of 6000 and 5000 for air and coolant respectively. In addition, the reduction of air frontal area was estimated [8].

K. Goudarzi et. al. Presents this paper an experimental study for Aluminium's Oxide (Al_2O_3) in Ethylene Glycol (EG) as nanofluid was used for heat transfer enhancement in car radiator together with wire coil inserts. Two wire coils insert with different geometry and nanofluids with volume concentrations of 0.08%, 0.5% and 1% were investigated. The results indicated that the use of coils inserts enhanced heat transfer rates up to 9 %. In addition, the simultaneous use of the coils inserts with the nanofluid with concentration of 0.08%, 0.5% and 1% resulted the thermal performance enhancement up to 5% as compared to the use of coils inserts alone [9].

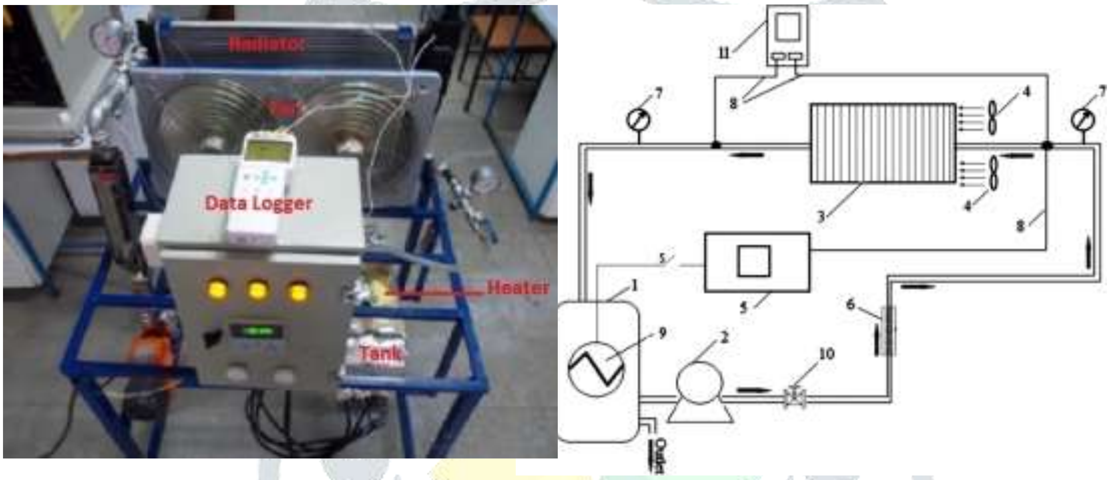


Fig.7. (a) The experimental setup.

Fig.7. (b) Schematic of the experimental apparatus.

Hasan Kücük et al; reports this study investigated experimentally the shell side heat transfer and pressure drop of a mini-channel shell and tube heat exchanger (MC-STHE) designed and manufactured using Kern's method. A shell with an inner diameter of 30 mm and four horizontally oriented transverse baffles with a 25% baffle cut were used in the mini-channel heat exchanger. Using rotated triangular layout, the tube bundle was composed of 13 mini-channel copper tubes with an outer diameter of 3 mm and a length of 240 mm. The shell-side Reynolds numbers ranged from 250 to 2500 while the tube-side Reynolds number was kept constant at 5900 based on the experimental surface flow area goodness factor (j/f) results. The shell side convective heat transfer coefficients and total pressure drop results were compared with correlations for macro tubes commonly used in the literature. The experimental convective heat transfer coefficients were in good agreement with the Kern design, VDI-HA and McAdam's correlations within the Reynolds numbers ranging from 250 to 2500. The experimental total pressure drop of the MC-STHE was 2.3 times higher than that of macro tube heat exchangers. In addition, the Nusselt number and Colburn factor correlations were proposed for the estimation of shell side convective heat transfer coefficient in MC-STHEs. The optimum working range for shell side is Re < 1000 according to surface flow area goodness factor by which heat transfer and hydrodynamic effects in MC-STHE are evaluated together [10].

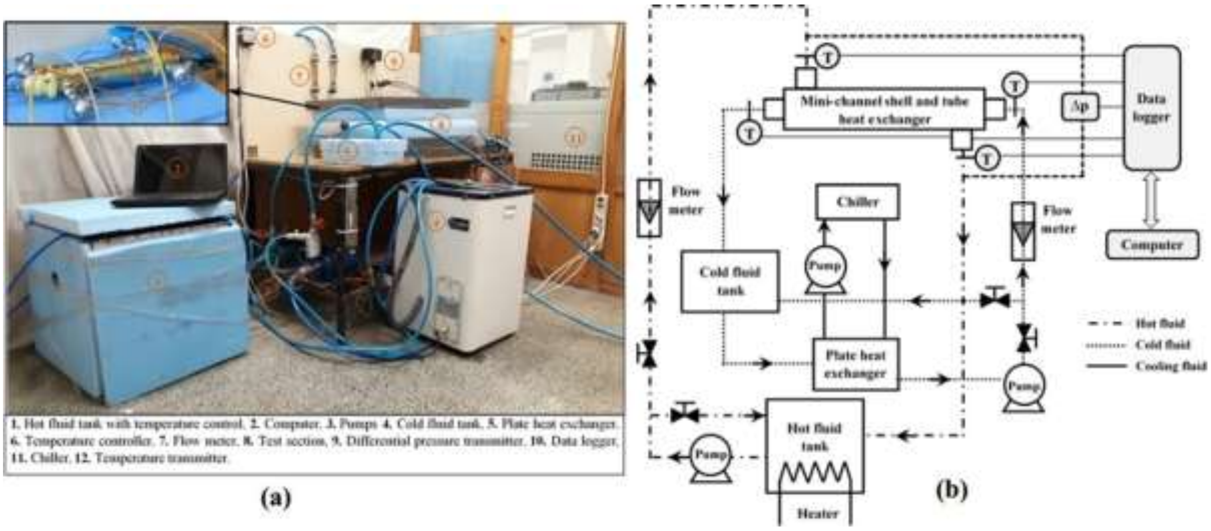


Fig.8. (a) Photo of experimental setup.

Fig.8. (b) schematic of experimental setup.

G. Jamuna Rani et al; presents this study focuses on the specialist's improvement in experimental and analysis of cross-flow heat exchanger which incorporates structure, experimental outcomes with different fluids like air, water, Nano fluids and further more numerical analysis (CFD, COMSOL and ANN). Various investigations have revealed enhancements in heat transfer by a heat exchanger by means of the utilization of nanofluids acquired by suspending X_2O_3 type oxides, for example, Al_2O_3, TiO_2 and SiO_2 in water. the main objective of moderation in the heat transfer equipment is to utilize the vitality and capital cost. The Cooling system's thermal performance is mainly based on the Performance of the heat exchanger. The cross-flow heat exchanger works more efficiently with a high rate of heat transfer when compared with shell and tube heat exchanger, spiral heat exchanger, and plate type heat exchanger. One method of enhancement of heat transfer rate in different types of heat exchangers is possible with the use of nano fluids instead of plain fluids. cross flow heat exchanger mostly used for hygienic standards at large canteens, hospitals, food industries and they will not exchange humidity like a rotary heat exchanger [11].

CONCLUSION

On the basis of previous research study, this study review outline involves crucial thoughts applicable to the shell and tube heat exchanger. A nanofluid seems the principle possible plan right now for the cooling challenge in the smaller than normal and nanotechnology period. Numerous specialists were examining the shell and tube heat exchangers by leading different examinations for as far back as a couple of many years. However, mathematical techniques or offers the feasibility to dismember the shell and tube heat exchangers in different applications. Throughout the previous few years, analysts are moving towards mathematical procedures to contemplate different blends of boundaries to improve the presentation of warmth exchangers. Adjusting to the non-regular strategies like mathematical recreation utilizing CFD, creating various relationships, Artificial Neural Networks and so forth can be savvy and are attainable. This examined a portion of the non-traditional strategies used to improving the heat transfer and increasing the efficiency are very important. In this case, it is a research gap to carry out the investigate the heat transfer rate of shell and tube heat exchanger. And the heat transfer phenomena can enhance by using the various nano fluids. The further research can be gone in this direction. the more exploration is required in the field of non-customary strategies to configuration heat exchangers in a powerful way.

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