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Review for The Heat Transfer Enhancement of Heat Exchanger Using Nanofluids

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Abstract:
Heat exchanger is used to exchange heat in high heat flux area. A solid-liquid emulsion of nanoparticles in base fluid in the heat exchanger called nanofluids, which is used to enhance the heat transfer characteristics of the base fluid. This review paper give details of recent researchers in heat exchanger using nanofluids both numerical and experimental investigation has to be examined. Factors that included in heat exchanger like heat transfer coefficient, turbulence, pressure drop, Reynold's Number, Nusslet Number, Peclet number, etc. are to be examined here.
Keywords: Heat exchanger, Heat transfer coefficient, Nanoparticle.

I. INTRODUCTION

In the recent days for improving the technology, number of process has to be carried out in a single machine which produce large amount of heat. Heat removal and its control are the demanding challenges in high heat flux area. Heat exchangers are used to remove heat. The increased heat removal rate by decreasing size of the heat exchanger is calling as innovative cooling technology. The cooling rate can be increased either by varying the design of the heat exchanger or modify properties of fluid used for cooling. The nanofluids are used to enhance the base fluid properties to increase heat transfer rate. M. Akbari et al[14] said that the fluid used in heat exchanger such as water, ethylene glycol and engine oil has low thermal conductivity which limits the performance of engineering equipments such as heat exchanger, electronic devices, etc. Ehsan B. Hagihighi et al[6] explained that the need for compact heat exchangers has been drastically increasing due to reduction in size of electronic components and also need to focus the use of cooling fluid with high heat transfer capacity. S. ZeinaliHeris at al[25] noted the methods of heat transfer enhancement by structural variation such as heat transfer area addition, vibration of heated surface, injection or suction of fluid and applying electrical or magnetic fields. Further [11] mentioned that improvement of thermal properties of base fluid become a key idea for increasing the heat transfer.

II.NANOFLUIDS

For the dispersion of large amount of heat with the help of conventional fluid in the heat exchanger such as water, ethylene glycol and mineral oil have series of disadvantages. To overcome that the dispersion of nanometer size particles in the base fluid called nanofluids has been developed, which has higher thermal conductivity than base fluid said by Massimo Corcione[19].Taofik H. Nassan et al[27] told that the number of researcher examined that the addition of small amount of nanoparticles in base fluid can increase thermal conductivity and heat transfer properties could lead to a revolution in heat transfer applications in the next few years.

2.1 Preparation of Nanofluids

R. Sureshkumar et al[23] said that for conducting the experiments, the nanofluids preparation is the preliminary step. The nanofluids can be produced by two different processes. They are single step process and two step process. The main requirements for the nanofluids are stable suspension, adequate durability, negligible agglomeration of particulates, no chemicals change of the particulates or fluid, uniformdistribution, etc. A.K. Singh [1] explained that nanofluid preparation techniques. In the single step process the nanofluids is prepared by discharging the nanoparticles in the base fluid but in the two step process, primarily nanoparticles are prepared and then spread over the base fluid by any of the dispersion techniques in the presence of any of the surfactant. The difficult in nanofluid manufacturing is nanoparticles tend to agglomerate into larger particles, which limits the advantages of using nanoparticles by means of nanoparticles of high surface area. YiminXuan et al[32] explained that the effective method for preparation of suspensions are (1) to change the pH value of suspensions, (2) to use surface activators and/or dispersants, (3) to use ultrasonic vibration. Shriram. S. Sonawane et al[26] initially prepare Al_2O_3 nanoparticles by sol-gel method form aluminum chloride precursor without any further purification and then dispersed in water using ultrasonicattor for 2 hours for 2% and 3% nanoparticles volume concentration. Ahmed Azari et al[3] prepare the nanofluids by means Al_2O_3, SiO_2 and TiO_2 in water as a base fluid. In thisDe-ionized water was taken and nanoparticles was mixed. Stirrer and Sonicatorwas used for preparation in the absence of any surfactant. S. ZeinaliHeris et al[25] make the nanofluids of Al_2O_3/water by which powdered nanoparticles was taken and mixed with distilled water in a flask and then vibrated in ultrasonic mixer system for 8-16 hours. In that no sedimentation is observed after 24 hours for 0.2-2.5% volume concentration of nanoparticles. N.Kannadasan et al [20] was used Chemical precipitation method to produce CuO nanoparticles.Nanofluids were prepared by dispersing nanoparticles in the chemical measuring flask with distilled water. Ultrasonicpulses of 100W at 36 ± 3 kHz was switched on for 4 h to get the uniform dispersion and stable suspension.Lazarus Godson Asirvathama et al[12] produced the nanofluids by utilizing the silver nanoparticles manufactured by Sigma Aldrich where mixed with de-ionized water without any additive or stabilizer for 12 h under ultrasonic vibration with power density of 750 W at frequency of 20 kHz, to ensure complete dispersion of the nanoparticles in water. GianpieroColangelo et al[8] prepared by taking weighted both the liquid and the solidphases and mixed for 60 min with a magnetic stirrer at700 rpm. The suspension is therefore vibrated in an ultrasonichomogenizer at 20 kHz and 70W to break the clusters of thenanoparticles and to improve the stability of the suspension.

III. NUMERICAL INVESTIGATION

Shriram. S. Sonawane et al [26] investigate numerically that the overall maximum heat transfer coefficient of Al_2O_3/waternanofluids yields approximately 47.36%, which is at 3% volume concentration and Reynolds number of about 3992. Later compare with experimental results, which are very close to the assumed value of available correlation. Arun Kumar Tiwari et al[4] analyzed numerically that the simulated results have been validated with experimental data for various flow rates and particle volume concentrations.V. Bianco et al[29] carried out the single-phase and discrete phase models for two different concentration of 1% and 4%, with Reynolds number 250, 500, 750 and 1050 and q = 5000, 7500 and 10,000 W/m2 and predict that there is 11% increase in heat transfer rate for discrete phase models when compared to single phase models. Further explain that the heat transfer rate increase with increase in concentration. Vincenzo Bianco et al[30] investigated further in steady state turbulent convection ofWater/Al2O3 nanofluid inside a circular tube by means of finite volume method. From the investigation, in terms of wall and bulk temperature, given by thesingle phase model and mixture model were quite similar for1% concentration, while for higher concentration there is a significantdeviation.H. Demir et al[10] examined that nanofluids with higher volume concentration have higher heat transfer enhancement and pressure drop. In that proper decision need to be taken when selecting a nanofluid that will balance the heat transfer enhancement and the pressure drop creation. R. Lotfi et al[22] investigated numerically by means of two phase Eulerian model, the values obtained is more precise to the experimental value compared to all other models and also examined that the rate of heat transfer enhancement decreases with increase in volume concentration. Praveen K. Namburu et al[21] analyzed that the same concentration of CuO, Al2O3 and SiO2 nanofluids, at the certain Reynolds number, CuOnanofluids have higher heat transfer performance followed by Al2O3 and SiO2. Nusselt number and pressure loss increases with increase in the volume concentration of the nanofluids. ZouhaierMehrez et al[33] analyzed in a open cavity maximum enhancement of heat transfer with minimum entropy generation depends mainly on the aspect ratio of the cavity and Reynolds and Richardson numbers. K.Y. Leong et al[11] analyzed that entropy generation in a circular tube subjected to constant heat flux and predict that the entropy increased with increase in temperature difference, decrease with increase in mass flow rate, tube length and diameter and notified that Titanium Oxide nanofluid has less entropy generation when compared to Alumina nanofluids. M.M. Elias et al[17] studied that the effect of nanoparticle shape on the heat transfer enhancement of different shapes such as cylindrical, bricks, blades, platelets, and spherical in a shell and tube heat exchanger which showed the cylindrical shaped nanoparticles in base fluid enhance more heat transfer rate than all other shape and followed by bricks, blades, platelets and spherical shaped nanoparticles. M.Akbari et al[14] has been analyzed and compared the single and two phase model in CFD and predicted that the single-phase and two-phase models almost identicalhydrodynamic fields but very different thermal ones i.e.,the two-phase models give closer predictions of the convective heattransfer coefficient to the experimental data than the single-phase model.

IV. EXPERIMENTAL INVESTIGATION

YiminiXuan et al [32] studied that copper nanoparticles in base fluid (oil and water) and measures that the thermal conductivity of nanofluids increases with increase volume fraction of ultra fine particle. i.e., the ratio of the thermal conductivity of the nanofluid to that of base fluid varies from 1.24 to 1.78 if the volume fraction of the ultra fine particle increases from 2.5% to 7.5%. S. ZeinaliHeriset all [25] showed that Al_2O_3/ water nanofluid in concentric tube heat exchanger, heat transfer coefficient of nanofluids increases with peclet number as well as nanoparticle concentration. M.A. Khairul et all [15] analyzed that average of 34%, 22% and 12% enhanced energetic heat transfer effectiveness is found for 1.5 vol.%, 1.0 vol.% and 0.5 vol.% of CuO nanoparticles in CuO/water nanofluid when compared to water. Shriram. S. Sonawaneet all [26] studied that effect of surface area nanoparticle by using Al_2O_3/ water nanofluid in concentric tube heat exchanger, the nanoparticles suspended in a base fluid provide large surface area which allows for more heat transfer. GoutamSahaet et all [9] have studied the effects of Reynolds number and Prandtl number, two different nanofluids, nanoparticle volume concentration, diameter size and Brownian motion of nanoparticles on flow and heat transfer from this observation the friction factor of nanofluids has no significant effect compared to the base fluid and hence induce no extra pumping power. R.M. Mostafizuret all [24] investigated that values for thermal conductivity enhancement of Al_2O_3–methanol were approximately 6% and 5% higher compared to SiO_2 and TiO_2 nanoparticles for the same volume concentration and operating temperature. Taofik H. Nassanet all [27] analyzed square cross-section duct CuO/water nanofluid expresses more enhancements in convective heat transfer coefficient compared to Al_2O_3/water nanofluid at the same concentrations.Arun Kumar Tiwariet all [5] investigated that the optimum volume concentration of CeO_2, Al_2O_3, TiO_2 and SiO_2 nanoparticles in water are found to be 0.75, 1.0, 0.75 and 1.25% volume respectively. Ehsan B. Haghighiet all [6] investigated that nanofluids show no advantage over water in laminar flow when compared at equal pumping power, which would be the most relevant comparison for practical applications. Massimo Corcione[19] examined that the heat transfer enhancement increases as the nanoparticle diameter decreases and the average temperature of the nanofluid increases. M.N. Golubovic et al[18] was found that the increase of nanoparticle concentration in the nanofluid increases the peak heat flux up to a certain point, after which further increase does not affect critical heat flux. Gabriela Huminicet all [7] studied in the same flow conditions, flattened tubes enhance the heat transfer coefficients compared to that of the circular and elliptic tubes significantly. M.A.Khairulet all [16] investigated on the basis of second law of thermodynamics CuO/water nanofluids could increase the heat transfer coefficient and decrease the entropy generation about 7.14% and 6.14% respectively. Lazarus Godson Asirvathama et al[12] experimentally predicted that the addition of 0.3% and 0.9%volume silver particles in water enhances the heat transfer coefficientsby 28.7% and 69.3% respectively and explained that thermal conductivityplaysa important role in heat transfer enhancement.A correlation has been developed which makes deviation of about $\pm$10% from the experimental data.Wei Yu et al[31] experimentally investigated the heat transfer properties of Al_2O_3 nanofluids with 1and 2% volume of nanoparticles have been found to heat transfer coefficient increase up to 57% and 106% respectively. It has been explainedthat the enhancements of heat transfer for nanofluids not only dueto the increase of thermal conductivity, but also depends on particle–particle interaction, particle–liquidinteraction, and the micro convection in nanofluids. Lin Lu et al[13] experimentally analyzed with Cu-water and Cu-ethanol nanofluids in a small flat capillary pumped loop and predicted that the enhancement ratio of heat transfer co-efficient and heat removal rate depends on operating temperature. From this observation the heat transfer co-efficient has been enhanced up to 38% and 45% by using Cu-water and Cu-ethanol nanofluids instead of base fluid.ThierryMareet al[28] noticed that at the same Reynolds number the pressuredrop can be seven times superior to that of water for the carbon nano tube nanofluid due to its high viscosity and three times superior to that ofwater for the alumina nanofluid.It can be observed that the heat transfer enhancement can reaches 22% for alumina and 150% for carbon nano tube.

V. CONCLUSION

This review paper presents number of recent development in researches on heat transfer enhancement of nanofluids. From this some of the conclusions have to be made. For adding small amount of nanoparticle to the base fluid enhance thermal conductivity compared to base fluid. The ratio of thermal conductivity is more in optimum concentration of the nanofluids. The heat transfer enhancement rate depends on volume concentration of nanoparticles, particle size, types of nanoparticles used, etc. Number of models is available for prediction of thermal conductivity of nanofluids, but proper models are not available. Hence further investigation is needed. The heat transfer enhancement is not only due to thermal conductivity, it also depends of Brownian motion of nanoparticles in the base fluid, Reynolds number, Peclet number, chaotic movement of nanoparticles, particles fluctuation and interactions and so on.

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