Review Paper on Enhancement of Heat Transfer by Using Binary Nanofluids

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Abstract - *There is increasing interest in the heat transfer enhancement by using different types of nanofluids. This paper covers the advances research in convection boiling and pool boiling, the working fluid used as nanofluids. The data available in the literature review in terms of CHF enhancements and degradations in the nucleate pool boiling. The all researcher are focus on the measuring a CHF enhancement by using different nanofluids in the base fluid. An experiment has conducted at various concentrations and different temperature ranges with different nanofluids, for the calculating a heat transfer rate and critical heat flux factor for water-based nanofluids. The entire researcher has confirmed the increasing a concentration of nanofluids in base fluids to enhancement of the heat transfer coefficient. The effects of nanofluids on size, shape and other parameter of boiling heat transfer and critical heat flux. The resents study of nanofluids, such as the preparation methods, stability of nanofluids, bubble dynamics in flow boiling with the aim of identifying the reasons for its enhancement and the demerits of nanofluids.*

Key Words: critical heat transfer, boiling heat transfer.

1. INTRODUCTION

Boiling heat transfer (BHT) is used in several applications are heat exchangers, refrigeration, power generation, for cooling purpose such as nuclear reactors and high-power electronics components and industrial process. To enhance the BHT processes are essential for typical industrial application and previously more energy saving. To increasing, a heat-transfer processes and the reduction in energy losses are important work, particular with regarding to the prevailing energy crisis.

Boiling is a very capable and accomplished mode of heat transfer, and it is use in various engineering application. One of them the most important application of boiling and evaporation is in distillation of seawater, which is becoming essential in some arid regions. Boiling with surfactant additives is generally an exceedingly complex process, and it is influence by a larger set of variables than the phase-change process of pure water. [7]

Heat transfer enhancement is method to save energy in different engineering field processes. To use of surfactants or solid particles because of their higher thermal conductivity so it can use in conventional fluids, it has been consider for last some decades to enhancement in the heat transfer. There are some practical problems like sedimentation; pressure drop and fouling to increase research in industry for this technique is never really pick uped.

In last some recent years the important advances research in nano-technology to overcome or reduce this problem by using different nanoparticles and producing nanoparticles in nanometer size ranges. Nanoparticles are in form of solid to make a different category of fluids, called nanofluids. Nanofluids are in the form of liquid position containing nanoparticles, which are smaller size such as a 100 nm. Thermal conductivity of nanofluids is significantly higher than that of the base liquids. These kinds of fluids are now of great development or research is not only improving the characteristics such as flow and deformation (rheological properties) and mass transfer but also modify the Boiling Heat Transfer rate of fluid. [10]

2. CHF ENHANCEMENT

Several techniques discussed below to enhancement the Critical Heat Flux (CHF) and Boiling Heat Transfer (BHT) can be divide in the two different types are:

1. Active Method
2. Passive Method

In the Active Method they can required a external changes in the heater surface and the Passive Method has not required any external changes in the heater surface. In the Active Method they can providing a vibration to the heater surface because to removing the bubble from the heated surface of the heater so that ways the Active Method required an external energy. In the Passive Method they cannot required an external energy because they can be providing a coating of a porous layer because to increase the oxidization of heated surface. [8]

A recent passive approach that has increased attraction worldwide is to create or generate a new fluid to mix solid nanoparticles in base fluid, distilled, or pure water called nanofluids. There are several materials available for the choice of the dispersed chemically stable nanoparticles metals such as Au, Ag and Cu and metal oxides such as ZrO_2, Al_2O_3 and SiO_2 and in the different form availability of a carbon such as graphite, fullerene and diamond. In the boiling test show, that the engineer used nanofluids as coolants to have a higher Critical Heat Flux (CHF) is generally an enhancement range 20% to from more than 300% as compared to water.

Over the past decade, a considerable lot of research carried out in the specific area of Nucleate Pool Boiling and Critical Heat Flux in different nanofluids. In the present review paper study the different parameter to enhance the Critical Heat Flux in Pool Boiling Heat Transfer by using different nanofluids as below are:

1. Effect of Nanoparticle material
2. Effect of Nanoparticle size
3. Effect of Concentrations
4. Effect of Stabilizer
5. Effect of heater size and geometry
6. Effect of heater surface orientation

The articles shown in the bar chart in Fig. 1 are shows that, the paper published in a different journal between 2003 from to 2010 and there no published journal articles on the boiling and nanofluids before 2003. In the resent last some year attention increase in nanofluids boiling this is most likely due to the enhancement thermal conductivity of the nanofluids and the relatively large gap in the knowledge that exists, concerning the mechanisms involved in nanofluids boiling enhancement.

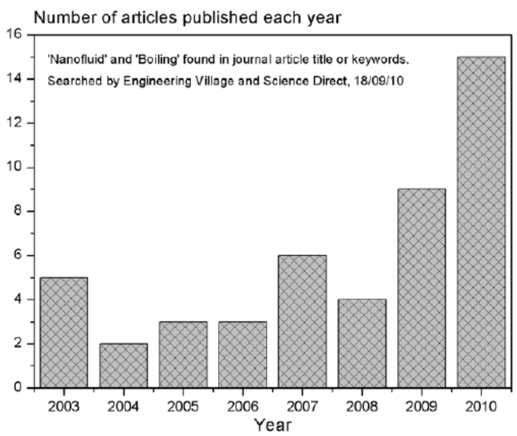

Fig. 1 Bar chart to illustrate the increasing treads in journal articles dedicate to nanofluids boiling in last few year

2.1 CONVECTIVE FLOW BOILING

In convective flow, boiling has become most popular in the last few years, because possibilities of the demand for the high heat flux for cooling of microelectronics components and many other compact cooling processes. An experimental study was conducted explore the advantage by using Alumina nanoparticles (Al2O3) with a water as a base fluid for cooling application such as micro channel. It can found the enhance heat transfer in a single phase laminar flow and the two phase region, the nanofluids in heater surface deposition in from of agglomerates and micro-channels, large clusters of nanoparticles have been formed. The investigated aqueous nanofluids with a 0.01% concentration of nanoparticles, the Critical Heat Flux was enhance under the forced convective flow and compare with the condition of with pure water.

2.2 CONVECTIVE FLOW BOILING

In pool-boiling heat transfer, enhancement experiments with using different nanoparticles with water-based nanofluids containing were conduct by Kim et al. Again, nanoparticle deposition observed on the heater surface soon after nanofluids boiling was initiate; an irregular porous structure was form at the surface. This is very similar as to the one that was observing during the convective flow boiling of nanofluids presented in the previous section. Kim et al. investigated this surface deposition further and noted an enhancement in wettability. They analyses the modified Young's equation and concluded that wettability.

Enhancement in the CHF due to the two combined reasons

1. The first effect they can be an increase the adhesion tension.
2. The second effect they can be an increase the surface roughness value.

The micro cavities is activation the heater surface to prevent the nanoparticles on heater surface so there decrease in contact angle of bubble, so which leads to a reduce the bubble nucleation in the nanofluids. So there effect of surface wettability on the Critical Heat Flux, the effects occurs at high heat fluxes transfer when hot spots or dry patches are developed on the heater surface; due to these dry spots can be irreversibly overheating or rewetted, causing Critical Heat Flux. [8]

3. LITERATURE REVIEW

J. Jung, E. S. Kim, Y. Nam, Y. T. Kang has conducted experiments to measure the CHF and BHT coefficient of LiBr / H2O based binary nanofluids. He used the Polyvinyl Alcohol as a stabilizer to stable dispersion of Al2O3 nanoparticles in LiBr / H2O. The plate copper heater (10 X 10 mm2) was use as the boiling surface. He varied the concentration of nanoparticles from 0 to 0.1 vol%, dispersed in H2O/LiBr solutions. The result showed that the BHT coefficient is lower than the base fluid as concentration of nanoparticles while CHF of it becomes higher. [1]

M. R. Raveshi, A. Keshavarz, M. S. Mojarrad, S. Amiri, described one of the most recent techniques to improving the boiling process is using nanofluids. He experimentally investigated the nucleate boiling heat transfer of Alumina – Water –Ethylene Glycol nanofluids. For understanding the boiling heat transfer mechanisms of binary mixture based nanofluids, experiments was done for the effect of alumina nanoparticles on the boiling heat transfer coefficient of alumina–water–ethylene glycol. The results showed a critical enhancement of HTC up to 64% for the 0.75% nanoparticles volume concentration. [2]

O. S. Prajapati, N. Rohatgi they are measured the effect of ZnO - water nanofluids on heat transfer characteristics in convection. Heat transfer rate increasing by 126% of water with applied pressure and nanoparticle volume of ZnO - water nanofluid within the given range of heat flux adopted. There is no pressure drop change with water only it was observe with low concentrations of nanofluid but pressure drop increases 23% with concentration of 0.1% nanoparticlesis in the nanofluid. [3]

A. Kumar, U. K. Nayak, R. S. Prasad has focused on the effect of mass resistance on the heat transfer rate in pool boiling. The nucleate pool BHT coefficients for binary mixture (Propanol – Water and Ethanol - Water) were measure at different concentrations of the more volatile components. Critical heat flux (CHF) conditions were determined by boiling binary mixture of water with Propanol or Ethanol at atm. pressure. [4]

Dr. V. Ravi has conducted an experiment on study on characteristics of Carbon Nanotube (CNT) and Ethylene Glycol based nanofluids mixture in nucleate pool boiling. He measured the thermal conductivity of working fluid (Triethylene glycol, water and CNT mixture) with transient hot-wire (THW) method. He was studied the characteristics like Critical Heat Flux, behavior of nanotube with different heat inputs and visualizes the boiling phenomenon. [5]

S. J. Kim has conducted an experimental Study of pool boiling and critical heat flux enhancement in nanofluids dilute dispersions of silica, alumina and zirconia nanoparticles in water the Critical Heat Flux enhancement in Nucleate Pool Boiling experiments with wire heater. During nucleate pool boiling experiment some nanoparticles deposit on the heater surface form a porous layer. The higher wettability can produce CHF enhancement. [6]

G. A. Matre1, R. L. Karwande has focused on CHF enhancement in nucluate pool boiling with Al2o3 & Water nanofluid. Critical Heat Flux enhancement increases with nanoparticle concentration from 3 to from 12 gram/liter to increase maximum CHF and more than 12 gram/liter the value of CHF to get reduces but it can more than the Distilled Water. The surface roughness value can measure by using heater surface used in pool boiling of nanofluids. The surface roughness value increases 3 to from 12 gram/liter and more than 12 gram/liter nanofluids in pool boiling then roughness value are reduce in nanofluids. [9]

Dr. S. Kumarappa, Dr. R. K. Hegde has conducted experiment of Pool boiling CHF characteristics in nanofluids are study with the different concentrations of Graphene Oxide and Alumina nanofluid range 0.01 gram/liter to from 1 gram/liter and the effect of nanoparticles in pool boiling Critical Heat Flux for each concentration is increasing as concentration increasing as 0.01 gram/liter to from 1 gram/liter and the effect on heat transfer enhancement, was studies by using surface inspection and flow visualization of the heater surface. [11]

P. Atcha Rao, V.V.Ramakrishna, S. Rajasekhar in experimentation is conduct on Pool Boiling heat transfer with Ammonium Dodecyl Sulfate. The result in the maximum heat flux is 3628 KW/m2, to the ADS in amount of 2.5-gram can increases the heat flux about hundred times more. Therefore, increase the rate of heat transfer by using ADS in nucleate pool boiling. By using Ammonium Dodecyl Sulfate in power plants, we may get best rate of steam generation. [12]

H. Kim, J. Kim and M.H. Kim has conducted experiments with titania (TiO2) and alumina (Al2O3) ranging from 10-5 vol% to 10-1vol% concentrations. They found a ~100% CHF enhancement for pool boiling of titania and alumina nanofluids on nichrome wires and saw nanoparticle deposition on the wire heaters. They also studied pool boiling of pure water on nanoparticle-deposited wires and found that the CHF enhancements were high than those of nanofluids. [13]

I.C. Bang and S. Heung chang, has conducted experiment with 0.5vol% to 4vol% alumina nanofluid, and found ~50% and ~13% CHF enhancement for 1vol% alumina on a horizontal and vertical plate, respectively. [14]

S.J. Kim, I.C. Bang, J. Buongiorno and L.W. Hu, focous on employed alumina, zirconia (ZrO2), and silica (0.001vol% - 0.1vol%) nanofluids in pool boiling of wire heater and found CHF enhancements of 52%, 75%, and 80%, respectively. [15]

Wu W., Bostanci H., Chow L.C., Hong Y., Su M., Kizito J.P., has used a copper plate with 1μm-thick coatings of TiO2 nanoparticles and SiO2 nanoparticles of 10nm size. In water pool boiling experiments they found that the TiO2 coated surface showed a 50.4% CHF enhancement, and the SiO2 coated surface a 10.7% CHF enhancement. [16]

4. ADVANTAGES

1. The heat transfer between particles and fluids is very high.
2. The dispersion stability of particles with predominant motion of particle is very high.
3. To enhances the heat transfer rate as compare to base fluid.
4. To increases the concentration of nanoparticles to adjust the properties of nanoparticles.

5. LIMITATIONS

1. The cost of nanoparticles is very high.
2. The specific heat of some nanoparticles is very low.
3. It is difficult to produce a nanofluid.

6. APPLICATION

1. It is uses for cooling purpose in Industry.
2. It is use in space and defence.
3. It is use for cooling purpose such as microchip.
4. It is use for cooling an electronic application.
5. It is use for nuclear cooling purpose.

7. CONCLUSIONS

1. The review findings from the literature of heat transfer of nanofluids that, to enhance the heat

transfer rate by using different nanofluids as compare to its base fluid and increasing CHT factor by increasing concentration of nanoparticles, also increase Reynolds number.

2. The review of various experimental results for Nucleate Pool Boiling Heat Transfer, it can be conformed that the undisputed substantial increase in the boiling CHF of nanofluids.
3. This papers various advantages and limitations nanofluids.
4. There are some results for CHF enhancement observed during pool boiling by using different nanofluids.
5. We need different nanofluids that maintain their stability over increased CHF and BHT.

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