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Highlights on Improvement of Performance Characteristics of Nanofluids by Enhanced Heat Transfer Process

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INTRODUCTION

Nanofluids are prospective heat transfer fluids with higher thermophysical properties and heat transfer performance. It can be applied in many devices for better performances (i.e. energy, heat transfer and other performances). In the present paper, highlights are made on different problems that occur with the use of Nano fluids and how their performance characteristics can be improved by enhancing heat transfer process.

Nanofluids

Nanofluids consist of a base fluid enriched with nano size particles (less than 100 nm). Nanofluids are characterized by an enrichment of a base fluid like Water, Ethylene glycol or oil with nanoparticles in variety of types like Oxides ,Metals, Carbides, Carbon. Mostly commonly recalled Nanofluids could be typified as TiO_2 in water, CuO in water, Al_2O_3 in water, ZnO in Ethylene glycol.

Today Nanofluids are widely used in transportation, power generation, solar water heating, nuclear, space, microelectronics, fuel cells, biomedical, industrial cooling and many areas where heat removal is involved.
All the applications of nanofluids are largely because of enhanced thermal conductivity.

Production of Nanofluids

There are mainly two methods of nanofluid production, described in the following:

a) **Two-step technique** – In the two-step technique, the first step is the production of nanoparticles and the second step is the distribution of the nanoparticles in a base fluid. Two-step technique is advantageous when mass production of Nano fluids is considered, because at present, nanoparticles can be produced in large quantities by utilizing the technique of inert gas condensation. The main disadvantage of the two-step technique is that the nanoparticles form clusters during the preparation of the nanofluid precludes the proper dispersion of nanoparticles inside the base fluid.

b) **One-Step Technique** – One-step technique combines the production of nanoparticles and dispersion of nanoparticles in the base fluid into a single step. There are some variations of this technique. In direct evaporation one-step method, the nanofluid is formed by the solidification of the nanoparticles, which are in initial gas phase, inside the base fluid. The dispersal features of nanofluids produced with one-step techniques are improved than those formed by two-step technique. The main drawback of one- step techniques is that they are not suitable for mass production, limiting their commercialization.

The study of nanofluids is important for the practical application of nanofluids in heat transfer devices. The recent experimentations showed that heat transfer improvement of Nano fluids exceed the thermal conductivity limit of Nano fluids. This extra enhancement can be explained by thermal dispersion, occurring due to the random motion of nanoparticles in the flow.

According to studies related to the thermal conductivity of Nano fluids displayed that improvements in thermal conductivity can be achieved by using Nano fluids. It is likely to obtain thermal conductivity enhancements larger than 20% at a particle volume fraction smaller than 5%. Such enhancement values surpass the predictions of theoretical models developed for suspensions with larger particles. This is a signal of the presence of additional thermal transport enhancement property of Nano fluids. There are many experimental and theoretical studies in the literature regarding the thermal conductivity of Nano fluids.

LITERATURE SURVEY ON HEAT TRANSFER MECHANISM IN NANOFLUIDS

The technology of nanofluids can be traced back to 9th century AD in Mesopotamia however, its conceptual birth of nanotechnology can be found in the teachings of the legendary scientist Richard P Feynman. The word nanotechnology was first coined by a Japanese scientist norio Taniguchi in 1974. And initial theoretical development was credited in the name of K. Eric Drexler in 1986. As a result of experiments, nanofluids intended to increase the thermal conductivityof liquids.

V. I. Terekhov et al. gave a detailed analysis of results corresponding to the past researches made on forced and free convection in laminar, and turbulent flows. Experimental data on heat conductivity of nanofluids with different concentrations, sizes, and material of nanoparticles are presented.

Sandeep Pal et al. discussed a major problem before commercialization of nanofluids in his paper, lying in their short term stability, disagreements between the results of various researchers, increased cost due to increased pumping power His paper mainly concentrated on disperse experimental data obtained by various researchers in their study on nanofluids and summarizes various models used by them to calculate the various thermophysical properties of the nanofluids.

Sezer Özerinç has well-documented in his research work about unavoidable discrepancy in thermal conductivity data of nanofluids. For the practical application of nanofluids in heat transfer devices, these discrepancies should be eliminated by systematically investigating the effects of some parameters on thermal conductivity of nanofluids. It is seen that nanofluid thermal conductivity increases with increasing particle volume fraction and temperature. On the other hand, most of the experimental results indicate increasing thermal conductivity with decreasing particle size but contradictory results are also present. There are several mechanisms proposed to explain the thermal conductivity enhancement of nanofluids, such as Brownian motion of nanoparticles, clustering of nanoparticles and liquid layering around nanoparticles.

PROBLEMS WITH NANOFLUIDS

Apart from the long range of applications, nanofluids also possess a few physical and chemical limitations. This is to be noted that, nanofluids may not be physically or chemically stable for a long period of time. Its homogeneity is greatly limited by agglomeration of nanoparticles. When the concentration of nanoparticles increases, their boiling performance gets degraded causing an increase in the surface temperature which may impose a severe limitation on the design of cooling system with nanofluids. Thus, this can cause overheating.

The complications related to the technology of nanofluid production, experimental setup, and features of measurement methods can be accounted on the basis of past researches. The normal fluid has some major disadvantage regarding heat transfer:

1. Quicks setting of the particle, formation of a layer on the surface and reduction in the heat transfer capacity.
2. Reduced sedimentation due to increase in the circulation rate of the fluid, with the erosion of the heat transfer device, pipe line etc. increased rapidly.
3. Clogging the flow due to the large size of the particle, particularly if the cooling channels are narrow.
4. Drop in the pressure as fluid increases considerably.

FUTURE AND SCOPE OF NANOFLUIDS

Nanofluids have a wide scope for research as well as it gives numerous industrial applications such as - Nano drug delivery, cancer therapeutics, smart fluids, nuclear reactors, nanofluid detergent, automotive and electronic Applications. So the crucial area of concern in extending the scope for nanofluids is towards developing efficient energy transport methods, efficiency of cooling system employed by nuclear reactors as well as safety techniques for its use and production activities. The rate of heat transfer is mainly depended on the thermal conductivity of nanofluids. The effect of particle shape, particle agglomeration on the thermal conductivity should be thoroughly worked out to invent microchips of smaller size, efficient energy transport mechanisms such as drug delivery. Also important area of research is found to produce non-toxic or biodegradable nanoparticles in order to harness nanofluid technology.

The enhanced thermal conductivity of nanofluids makes them a very promising invention of all times since they are more opted than the base fluids. The mobility of nanoparticles in the fluid due to their small size help in increasing micro convection of fluids greatly leading to enhanced heat transfer. Also, thermal conductivity of nanofluids can be enhanced by increasing the temperature which in turn increases the Brownian motion. This leads to increased stability and reduces the erosion of components like pipeline, pumps and heat exchangers. In other words, nanoparticles dispersed in liquids reduce friction and wear.

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