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# EXPERIMENTAL STUDIES ON FLOW AND HEAT TRANSFER CHARACTERISTICS OF SECONDARY REFRIGERANT BASED CNT NANOFLUIDS FOR COOLING APPLICATIONS

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Abstract **-** The aim of the research work is explore the convective heat transfer coefficient characteristics of propanol based nano fluids for cooling applications. The stable suspension of the nano fluid with volume fraction of 0.15 and 0.3 are prepared and characterized. The measurement on the density shows that there is only negligible increase in the density of the nano fluid and the specific heat of the nano fluid increases with volumetric concentration of nano fluids. Further there is an enhancement in the convective heat transfer coefficient of 70% for the nano fluid containing 0.3% of CNT.

**Abbreviations**

| | |
|---|---|
| CNT | Carbon nanotubes |
| MWCNT | Multi walled carbon nanotubes |
| SDBS | Sodium dodecyl bensine sulphate |
| IPA | Isopropelene Alychol |

## I. Introduction

*In the development of energy – efficient heat transfer fluids, the thermal conductivity of the heat transfer fluids plays a vital role. Despite considerable previous research and development efforts on heat transfer enhancement, major improvements in cooling capabilities have been constrained because traditional heat transfer fluids used in various industrial sectors, such as water, oils and ethylene glycol [1], have inherently poor thermal conductivities, orders-of-magnitude smaller than those of most solids. Due to increasing global competition, a number of industries have a strong need to develop advanced heat transfer fluids with significantly higher thermal conductivities than which are presently available. It is well known that at room temperature, metals in solid form have orders-of-magnitude of higher thermal conductivities than those of fluids (Touloukian et al., 1970). In the fully developed convective heat transfer coefficient model for laminar flow in a heat exchanger pipe, is obtained. The effect of heat transfer rate varies with the trunk diameter. The rate of heat transfer increases with the increase of pressure drop, and change in temperature, whereas the rate of heat transfer decreases with the increase of the length of heat exchanger [13].*

*The various Concentrations of the nanofluids vary in the range of 0.1–1.8 vol-% and particle sizes between 8 and 58 nm. The convective heat transfer experiments setup* *are done by using an annular tube heat exchanger with the Reynolds numbers varying in the range of 1000–11000. The pressure losses are considered in the analysis in order to assess the feasibility of the nanofluids. The enhancement in convective heat transfer is noted based on comparison of the Nusselt numbers with Reynolds numbers [14].*

*The nanoparticle with various concentrations of 0.25% and 0.5% by volume concentration has been used at various inlet temperatures. The experimental consisted of concentric double tube heat exchanger. The nanofluids on the cold side used in turbulent regime with range of Reynolds number from 20000 to 60000. The study shows that the heat transfer increases with the increase in volume concentration of nano-particles and increase in temperature [15].*

## II. Secondary Refrigerants

The secondary refrigerant circuit is commonly used in all big commercial and industrial refrigeration plants. The secondary refrigerans are playing major role in cooling conditions. If base fluid as water used in heat transfer applications, we can't go to beyond $0^0$C due to freezing take into account. In order to avoid freezing problem, the secondary refrigerants are adding with base fluid in certain ratio. The refrigerants like propanol, ethylene glycol are directly used in the secondary refrigeration circuit without addition of the antifreeze medium [6].

## III. Nano fluid

The nano fluid technology coupled with heat transfer related study on various fields of flow applications has provided a new option of revisiting suspensions of nanoparticles. A substantial increase in liquid thermal conductivity, liquid viscosity and heat transfer coefficient, are the unique characteristics of nano fluids [2]. In the recent years, the carbon nanotubes receive much attention among the thermal engineers due to its excellent thermal and mechanical properties.

## IV. Experimentation

Fig. 4.1 shows the schematic diagram of the experimental setup, to investigate the heat transfer characteristics of nano fluids.

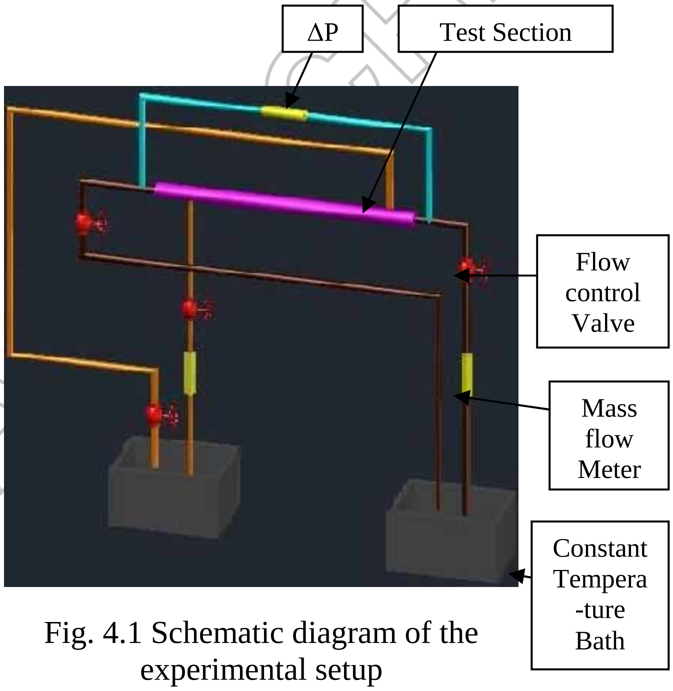
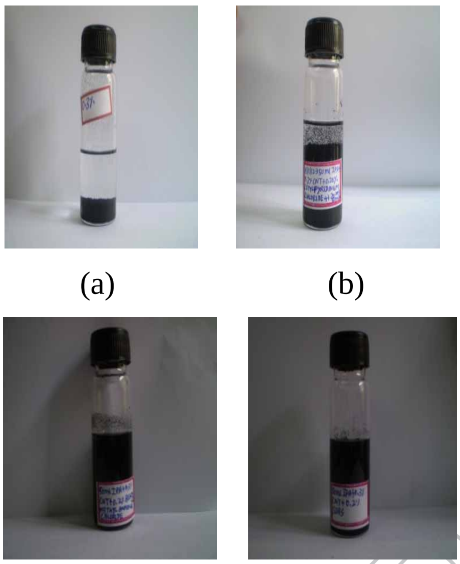



Fig. 4.1 Schematic diagram of the experimental setup

It consists of a test section, constant temperature baths, mass flow meter, mechanical stirrers, RTDs, pumps, air conditioning unit and a data acquisition system. The test section length is a 1.5 m concentric tube heat exchanger. The RTDs are inserted in the test section at various locations for measuring the temperature. A differential pressure transmitter is placed across the test section to measure the pressure drop of the nano fluid. Inner tube of test section the nano fluid is flowing and water is flowing in annular side of the counter flow concentric tube heat exchanger. The both fluids are flowing in counter flow direction for getting the more enhancement as compare to parallel flow arrangement. The both constant temperature bath is maintained the required temperature by air conditioning unit. In this work, the enhancement of convective heat transfer of proponal based water nano fluid flowing in a concentric-tube counter flow heat exchanger was experimentally studied.

4.1 Preparation of Nano fluid

The Stable nano fluids are prepared by two step method. The required quantity of base fluid, IPA and MWCNT with surfactant are taken and then stirred in a flask in well manner by the help of magnetic stirrer and then ultrasonicated. The various surfactants such as cetyl pyridinum chloride, benzyl trimethyl ammonia chloride and SDBS as shown in Fig. 4.2.




(c) (d)

Fig. 4.2 Photograph of the nanofluids with various surfactants of MWCNT

Among these the SDBS is found to be most suitable for the preparation of stable nano fluids by carrying out the stability test for more than 24 hrs.

**V. Results and Discussion**

5.1. Effect of Reynolds number on pressure drop

The Pressure drop is a function of Reynolds number. The experimental results show in Fig. 5.1 it clearly indicates that the variation of different concentration of nano fluids, the pressure drop increase with respect to Reynolds number. Finally it will conclude that as the flow rate and concentration increase the resulting pressure drop also increased.

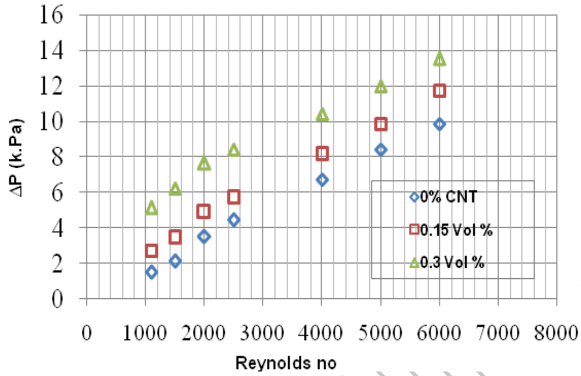



Fig. 5.1 Reynolds Number vs Pressure drop

5.2.Effect of temperature on thermal conductivity

Fig. 5.2 shows that the Temperature vs Thermal Conductivity. The thermal conductivity is a function of Temperature. If the temperature is increased the thermal conductivity also increased.

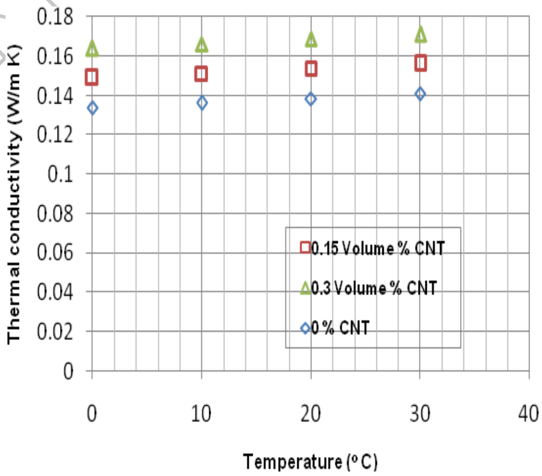



Fig. 5.2 Temperature vs Thermal Conductivity

From the graph we can infer that the thermal conductivity of nano fluid increase with increasing in concentration of the nano fluid as well as temperature also.

5.3. Effect of Reynolds number on heat transfer coefficient

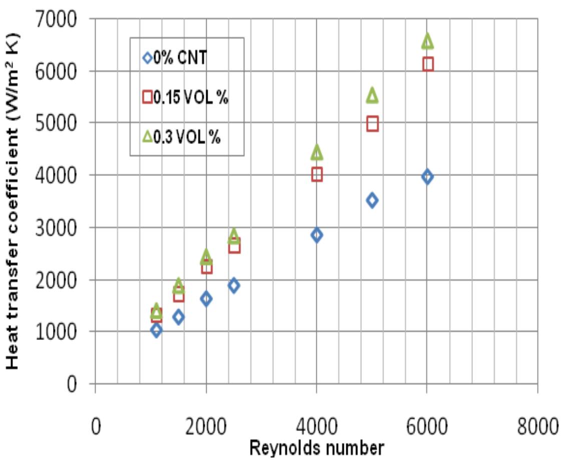



Fig. 5.3 Reynolds number vs Heat Transfer Coefficient

Fig. 5.3 shows that the Reynolds number vs Heat Transfer Coefficient. It shows the variation of heat transfer coefficient with respect to the Reynolds number at different concentration of nanofluid. It is seen from the figure that the heat transfer coefficient is considerably enhanced with the increase in MWCNT concentration at various Reynolds number.

## VI. Conclusions

The convective heat transfer behavior of MWCNT nanofluid based secondary refrigerant is investigated for various flow conditions and concentrations. The following conclusions are arrived based on the experimental results. The increase in thermal conductivity of the nano fluids containing 0.15 %, 0.30 % are found to be 0.133 W/m K, and 0.163 W/m K respectively also ensured significant enhancement in heat transfer coefficient.

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