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# Experimental investigation of corrugated copper tube double pipe heat exchanger using TiO2 and CNT Nano fluids

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**ABSTRACT**: In this paper, the performance of double pipe heat exchanger was studied experimentally with counter flow arrangement along with nanofluids TIO2 and CNT. These nanoparticles were mixed along with base fluid water in concentrations 0.25%,0.5%,1.0% for 40 litres of water. The fluid was passed through corrugated copper tubes instead of plain copper tubes in order to increase the heat transfer rate . The enhanced performance of heat exchanger is due to high value of thermo physical properties of fluid when dispersing nanoparticles in the base fluid and the swirl motion created by the corrugated copper tubes in the heat exchanger. This reduces the time required for the heat transfer, and thereby increasing the productivity and reducing the operating costs, wherever applied. Heat exchanger have vast applications in various industrial fields such as Thermal power plant, Nuclear power plant, Petroleum industry, Chemical industry, Food industry, etc.

**KEYWORDS :** Nanofluids (TIO2 and CNT), Thermal conductivity, Double Pipe Heat Exchanger, Corrugated Tubes.

## 1. INTRODUCTION:-

Heat exchanger is nothing but a device which transfers the energy from a hot fluid medium to a cold fluid medium with maximum rate, minimum investment and low running costs .The heat transfer in a heat exchanger involves convection on each side of fluid and conduction taking place through the wall which is separating the two fluids. In a heat exchanger, the temperature of fluid keeps on changing as it passes through the tubes and also the temperature of the dividing wall located between the fluids varies along the length of heat exchanger. Nano fluids are dilute liquid suspended nano particles which have only one critical dimension smaller than ~100nm. Much research work has been made in the past decade to this new type of material because of its high rated properties and behaviour associated with heat transfer

(Masuda et al. 1993; Choi 1995), mass transfer (Krishnamurthy et al. 2006, Olle et al. 2006). The thermal behaviour of nano fluids could provide a basis for an huge innovation for heat transfer, which is a major importance to number of industrial sectors including transportation, power generation, micromanufacturing, thermal therapy for cancer treatment, chemical and metallurgical sectors, as well as heating, cooling, ventilation and air-conditioning.

## 2. LITERATURE REVIEW:-

[1]Here we are using heat exchanger of counter flow direction type .Tuckerman and Pease are the first to introduce this idea by using micro channel heat sink (MCHS) as a source for cooling of electronic devices in the year 1981. They experimentally narrated the MCHS capability and claimed that they were able to dissipate heat flux at a rate of 790 W/cm2 . They showed that the convective heat transfer of single phase flows could be improved by decreasing the width of the heat sink channels and increasing wetted area by the heat transfer fluid. The experimental and analytical studies by Wang et al. , Lee et al. , Wang et al. and Koo and Kleinstreuer showed that nanofluid have a higher thermal conductivity than that of pure fluids and therefore has great affinity for heat transfer enhancement. Li and Xuan , Xuan and Li and Pak and Cho experimentally showed the convection heat transfer and pressure dropping for nano fluid tube flows. Their results show that heat transfer coefficient was greatly incremented and it depends upon factors like Reynolds number, particle size and shape, and particle volume fraction. They also found that nano particles did not cause an extra pressure drop. Another scientist named Donsheng and Yulog studied practically the convective heat transfer of nanofluid made up of ã-Al2O3- water, flowing through a tube made up of copper in the laminar flow region and showed a considerable enhancement of convective heat transfer using the nanofluids. The enhancement was particularly significant in the entrance region as it was higher than that obtained solely due to the enhancement on thermal conduction.

[2] Corrugated tubes are used in double pipe heat exchanger because a corrugated tube has an increase heat transfer rate compared to a smooth tube of the same length, the heat exchanger can be made smaller. Copper has many desirable properties for thermally efficient and durable heat exchangers. First and foremost, copper is an excellent conductor of heat. This means that copper's high thermal conductivity.

[3] Nguyen et al. investigated the heat transfer coefficient and fluid flow characteristic of Al2O3 nanoparticles dispersed in water flowing through a liquid cooling system of microprocessors under turbulent flow condition. The results revealed that the nanofluid gave a higher heat transfer coefficient than the base liquid and the nanofluid with a 36 nm particle diameter gave higher heat transfer coefficient compared to the nanofluid with a 47 nm particle diameter. He et al. reported an experimental study that investigated the heat transfer performance and flow characteristic of TiO2-distilled water nanofluids flowing through a vertical pipe in an upward direction under a constant heat flux boundary condition in both a laminar and a turbulent flow regime. Their results showed that at a given Reynolds number and

particle size, the heat transfer coefficient is raised with increasing nanoparticle concentration in both laminar and turbulent flow regimes. Similarly, heat transfer coefficient was not sensitive to nanoparticle size at a given Reynolds number and particle size. Moreover, the results indicated that the pressure drop of the nanofluids was very close to that of the base fluid.

[4] TiO2 nanoparticles are used most commonly due to the stability of its chemical structure, electrical, optical, biocompatibility, and physical properties. Titanium dioxide (TiO2) has been used extensively because of its unique thermal and electric properties. Different techniques have been used for the preparation of TiO2 Nano fluids which include single-step and two- step methods. In the natural world, TiO2 exists in three different crystalline forms as anatase, brookite, and rutile. Nanoparticles are not used directly in many heat transfer applications, and this provides a major challenge to researchers to advance towards stable Nano fluid preparation methods.

[5] The primary step involved in the preparation of Nano fluid is the production of Nano-sized solid particles by using a suitable technique, and then these particles are dispersed into base fluids like oil, water, paraffin oil or ethylene glycol. However, Nano fluid can also be prepared directly by using a liquid chemical method or vapor deposition technique (VDT). Nano fluids are mostly used in heat transfer applications and the size and cost of the heat transfer device depend upon the working fluid properties, thus, in the past decade scientists have made great efforts to formulate stable and cost-effective Nano fluids with enhanced thermos-physical properties. This review focuses on the different synthesis techniques and important physical properties (thermal conductivity and viscosity) that need to be considered very carefully during the preparation of TiO2 Nano fluids for desired applications.

[6] Ding et al. studied rheology of CNT-based nanofluids and observed non-Newtonian behaviour. The rheological behaviours of the functionalised CNTs/1-butyl-3-methylimidazolium hexafluorophosphate ([Bmim][PF6]) nanofluids were also studied by Wang et al. Viscosity of CNT/water nanofluids stabilised by chitosan was studied by Phuoc et al. for different concentration of CNTs and chitosan.

## 3. EXPERIMENTAL VALIDATION :-

Our goal is to enhance the heat transfer rate in a double pipe heat exchanger by employing Titanium dioxide (TiO2) And Carbon Nanotube (CNT) Nano particles and using corrugated copper tubes in the heat exchanger. The corrugated copper tube gives a swirl flow to the Nano-fluid and thus increases the heat transfer rates. The Nano particles on the other hand, when mixed with a base fluid increases the heat transfer rates.

## 3.1 Experimental setup:

1) Three Double tube heat exchangers were constructed by using corrugated copper tubes as the inner pipe and M.S. pipe as the outer pipe and other two pipes consisted of plain steel and plain copper inner tubes. M.S. nozzles were used as fittings on the M.S. pipe. The tubes were sealed by welding and by using M-seal in case of minor leakages.
2) Two hot fluid and two cold fluid tanks were fabricated to the main frame of the setup for supplying the respective fluids.
3) Two pumps were used for running both the fluids throughout the system.
4) Two bypass circuits were created for controlling the flow and the pressure of the fluids.
5) A tank with ice was setup for cooling the fluid
6) Heaters were employed for heating of the fluids.
7) A manometer was used for monitoring the pressure in the system.
8) Two flow meters were used for monitoring the flow of the fluids.
9) Four digital thermometers were used for monitoring the temperature of the fluids.
10) A mechanical stirrer was used for mixing the nano particles and the base fluid.
11) An electronic weigh was for measurement of the nano particles.
12) Tanks were attached to the bypass system with help of flexible pipes and rubber nozzles.

## *4.* CONCLUSION

This experiment shows the effect on thermal efficiency of nanofluid and corrugated tubes. The outcomes for current experiment can be referred as follows:

- The corrugations on the copper pipe increase the heat transfer rate due to the swirl flow created by them.
- Lower pitch gives higher heat transfer rates.
- Adding Nano particle to the base fluid improves heat transfer rates i.e. the efficiency of the heat exchanger.
- Heat transfer rates increase with an increase in the concentration of Nano particles.
- It seen that with help of Nano fluid thermal properties like viscosity, density, surface tension & thermal conductivity of base fluid increased.
- Effectiveness and overall heat transfer coefficient of the heat exchangers increase considerably when Nano fluids are used for heat transfer along with corrugated copper tube heat exchanger.

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