Heat Transfer Enhancement by Twisted Tube Inserts and Water Al_2o_3 Nano Fluid.

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Abstract-The aim of this present work is to enhance thermal performance characteristics in a heat exchanger tube by studying: (i) multiple twisted tapes in different arrangements; (ii) Al_2O_3 nano particles with different concentrations as the working fluid. The tube inserted with twisted tapes showed superior thermal performance factor when compared with plain tube, due to continuous multiple swirling flow and multi-longitudinal vortices flow along the test tube. The higher number of twisted tape inserts led to an enhancement of thermal performance that resulted from increasing contact surface area, residence time, swirl intensity and fluid mixing with multi-longitudinal vortices flow. Moreover, arrangement of twisted tapes in counter current was superior energy saving devices for the practical use, particularly at low Reynolds number. Experiments were conducted within range of 2200<Re <700.Investigation was carried out for the fully developed laminar convective heat transfer and friction factor characteristics in a plain tube and fitted with twist tubes . Using water with Al_2O_3 nano particle as a working fluid yielded a higher thermal performance than using pure water. The tube inserted Al_2O_3/water nano fluid at concentration of 0.3% by volume provided the highest thermal performance factor 1.59, where heat transfer rate and friction factor increased to 3.52 times and 11.7 times of those in the plain tube with water as the working fluid.

Index Terms- Laminar convective heat transfer, Multi longitudinal vortices, Nano Particles ,Twisted Tapes.

I. INTRODUCTION

Heating and cooling are two important processes in thermal engineering and play a vital role in industries such as power plants, chemical process plants, manufacturing processes, automotives and electronics. To dissipate heat at faster rate, different heat transfer enhancement methods have been suggested in literature. Active and passive heat transfer techniques are commonly employed for heat transfer augmentation in fluids. Conventional heat transfer fluids like water, oil, and glycols have poor heat transport capabilities and they hardly meet the present day requirements of high heat dissipation rates in compact heat exchangers. Design of Compact heat exchanger and miniaturizing of high energy devices are possible only with the fluids having better heat transfer performance. The nanofluids are considered to be new generation fluids characterized by better heat transfer capabilities over traditional heat transfer fluids. The nanofluid is an emerging area of research and has lot of potential in heat transfer applications. A nanofluid is a two phase fluid of solid-liquid mixture and heat transfer performance of nanofluids are expected to be significantly higher than the conventional single phase fluids. The common problems like channel clogging, tube abrasion and sedimentation formation which are very often associated with suspensions of micro particles are minimized to a great extent with use of nano particles in the base fluids. Heat transfer coefficient and friction factor are two important parameters to be studied before judging the suitability of any fluids for transport of heat energy in heat exchangers.

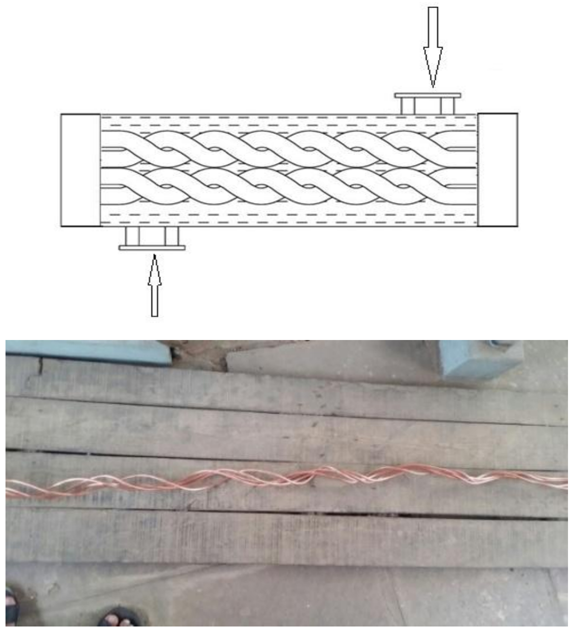

Fig.1: Twisted Tube floaw

A twisted tube is a passive heat transfer enhancement device, generally classified in a swirl-flow device category. Swirl-flow devices consist of variety of geometrical flow arrangement that produce forced vortex fluid motion in confined flows. The enhancement of all the cases occurs primarily due to fluid agitation and mixing induced by swirl flow.

II. EXPERIMENTATION & TESTING

Fig.2: Experimental setup

Experimental apparatus for twisted tube water heat exchanger: A double pipe heat exchanger with provision to permit cold water in the annulus in opposite directions is available. Hot water from the geyser flow through the inner tubes, the heat transfer takes place across the wall of the inner tube. The cold water in the annulus is made to flow in the direction of the hot fluid, which is the parallel flow.

Nu = {(f/8) * (Re – 1000) * Pr / [1+ 12.7 (f/8)^0.5 * {(Pr^0.67 – 1)}]

Nu = 0.023 * Re^0.8* Pr^0.4

Qh = mh*Cp*(Thi-Tho)

U = Q / (A*LMTD)

III. RESULTS FOR TWISTED TUBES.

Experiment was performed to investigate heat transfer characteristics with twisted copper tube. Use of twisted tube causes high heat transfer augmentation. In present investigation, effectiveness is 0.37 to 0.64.

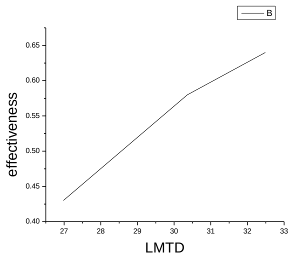

Fig.3: Graph representing effectiveness of heat transfer without twisted tube

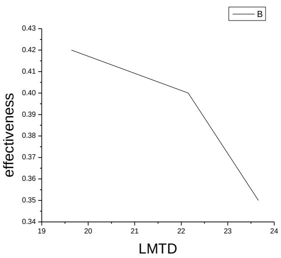

Fig.4: Graph representing effectiveness of heat transfer with twisted tube

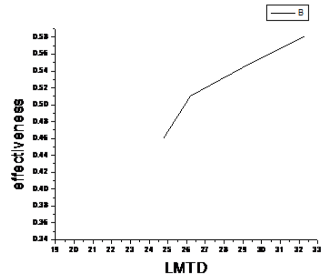

Fig.5: effectiveness

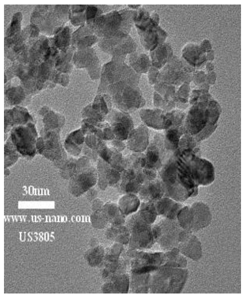

Fig.6: microstructure of nanofluids

Preparation of nano fluid: Nano fluid made in three different concentrations 0.1%,0.25%,0.4%.In0.1% concentration,0.608 grams of Al_2O_3 nano particles are added in base fluid(Water) ,0.25 %concentration, 1.5 grams added and for 0.4% concentration, 2.44 grams. The amount of nano particles are added after weighing on weighing machine, then these are mixed with water and start stirring by stirrer manually .In this method can be mixed but the manual preparation cannot be done for a period and the nano particles will not be disperse in the base fluid properly, in running conditions the particles should disperse in water should not come down to bottom or precipitate are inhomogeneous periodically to overcome these issues automatic/mechanical stirring has used.

In Automatic / Mechanical stirring the device is attached to dimmerstat so that rotational speed can vary under the conditions, the device is clamped between the two poles and then the device is kept in to collecting tank in center, then power is supplied and the voltage is set so that one speed is put to constant, and it kept on for half an hour, to avoid precipitation it will remain on in the experiment in running condition

Fig.7: Automatic stirring

Re=ρVD/μ=mD/Aμ

For Re>2300 => turbulent flow

$Pr = \mu c_p / K$

$Nu = 0.023 x Re_D^{0.8} x Pr^n$

$Nu_h = 0.023 x Re_h^{0.8} x Pr^{0.3}$

$K_{nf} = Kf * \frac{Knp + 2Kf - 2\phi(Kf - Knp)}{K + 2Kf + \phi(Kf + Knp)}$

The use of Al_2O_3 Nano particles as the dispersed phase can significantly enhance the convective heat transfer and its increases with increase in Reynolds number and also with increase in nano particle concentration. The convective heat transfer performance and flow characteristics of Al_2O_3 Nano fluid flowing in a double pipe heat exchanger has been experimentally investigated. Experiments have been carried out under turbulent conditions. The effect of particle concentration and the Reynolds number on the heat transfer performance and flow behavior of the Nano fluid has been determined. Important conclusions have been obtained and are summarized as following. At a particle volume concentration of 0.1%,0.25%, 0.4% the use of Al_2O_3/water (and 0.1% of Cuo/water) Nano fluid gives significantly higher heat transfer characteristics. For example, at the particle volume concentration of 0.1% Al_2O_3 heat transfer coefficient is 182.7 w/m^{2}k and for water is 140 W/m^{2}k for a mass flow rate of 0.102 kg/s so the enhancement ratio of the overall heat transfer coefficient is 1.305 this means the amount of the overall heat transfer coefficient of the nano fluid is 30% greater than that of base fluid.

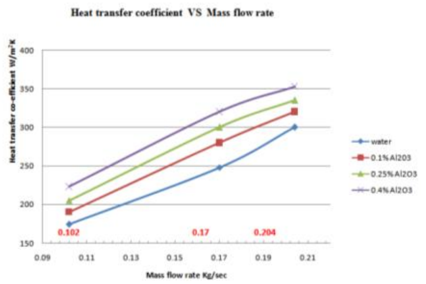

Fig.8: Graph HTC vs MFR

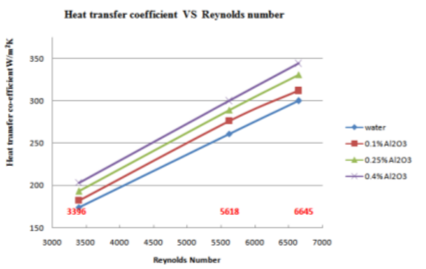

Fig.9: graph HTC vs Re

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