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Heat Transfer Enhancement in Vertical Helical Coiled Heat Exchanger by Using Nano Fluid-Tio_2 /Water

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1. ABSTRACT

In this project a comparison of heat transfer and pressure drop characteristics heat of Tio_2/water nano fluids in a helical coiled heat exchanger. In a helically coiled heat exchanger with attached pin fin arrangement in helical coil. Held in vertical position is presented.Experiments will be conducted in the turbulant flow region using Tio_2 / water Nano fluids of 0.1% and 0.2% volume concentration. Vertical arrangements in the enhancement of convective heat transfer coefficient and friction factors of Nano fluids compared to water. Vertical position of the helically coiled heat exchanger the enhancement internal nusselts number is high for concentration Nano fluids at turbulent flow. Reynolds number, nusselt number, friction factor values will be verified for both the application. Then will be compared which fluid offer maximum heat transfer efficiency

2. NOMENCLATURE

A_i	Inside heat transfer area m^2
b	Coil pitch –m
C_p	Specific heat capacity -J/kg K
D	Mean coil radius –m
D_e	Dean number = $Re_i (d_i/2R_c)^{0.5}$
d_i	Internal Diameter of the tube –m
f	Friction factor
h	Convective heat transfer co-efficient -W/m^2K
k	Thermal conductivity -W/m K
m	Mass flow rate -kg/s
M	Molecular weight
n	No. of turns
Nu	Nusselt number = $h\ d_i/k$
Pr	Prandtl number = Cp_l/k
Q	Heat transfer rate –W
R_c	Curvature radius –m
R_e	Reynolds number = $\rho_{nf} v_i\ d_i/\mu_{nf}$
T	Temperature –K
v_i	velocity -m/s
L_C	Length of coil in- m

Greek symbols

ρ	Density -kg/m^3
Φ	Volume concentration -%
μ	Dynamic viscosity -kg/m^2s
Δp	Pressure drop -N/m^2
δ	Internal tube radius d_i/mean coilradius D

Subscripts

eff	effective
i	inside condition
in	Inlet
out	Out outlet
f	Base fluids
n_f	Nanofluidss Surface
p	Particle
w	Water
m	Mean
r	Average radius of the coil

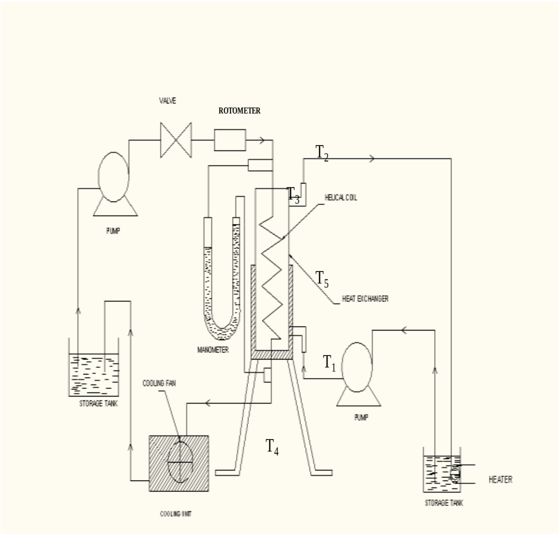
3. INTRODUCTION

Helical coil tubes are used in a variety of applications, e.g. Thermal oil heating, steam generation, thermal processing plants, food and dairy processing, refrigeration .Helical coil tubes are advantageous due to their high heat transfer coefficient and compactness compared to straight tubes.In this regard, Nano fluids containing nanometer-sized particles called nanoparticle show a significant potential to augment the heat transfer rate because of their enhanced thermo-physical properties. Important challenges faced by experts is the necessity to increase the heat fluxes and reduce the size of the heat exchangers. Conventional fluids such as water, oil and ethylene glycol which are called Nano fluids, have low thermal conductivity in comparison with metals and even metal oxides. Nano fluids have novel properties that render them potentially beneficial in a large number of heat transfer applications including microelectronics, heat exchangers, fuel cells, engine cooling, vehicle thermal management, hybrid-powered engines, chillers and nuclear reactors. The addition of nano-sizedsolid metal (Cu, Au, Fe) or metal oxide (CuO, Al2O3, TiO2) particles to the base fluids shows an increment in the thermal conductivity of resultant fluids

4.DESIGN OF EXPERIMENTAL SET-UP

The schematic of the experimental setup in vertical positions. The vertical set-ups have shell side loop and helical coiled tube side loop.Hot water flows through the shell side and nanofluid flows through the helical tube side. Shell side loop consists of storage vessel with heater of 1.75 kW capacity, magnetic pump and thermostat. Tube side loop consists of a mono bloc pump, valve to control the flow on tube side, test section, cooling unit and storage vessel of 5liter capacity.

SKEMATIC DIAGRAM OF EXPERIMENTAL SETUP



The coil was formed initially with a straight tube of copper. Helical tube is made up of copper and shell is made up of mild steel. Pump in shell side is operated once water reaches a prescribed temperature. Eight ktype thermocouples of 0.1^{o}C accuracy were used to measure inlet and outlet temperatures of shell and tube side as well as to measure the surface wall temperatures. A U-tube manometer is placed across the helical tube to measure the pressure drop. Mass flow rate on shell side is kept constant (0.15 kg/s) and flow on tube side loop is varied using the valve. A three-way valve is provided in the flow pipe connecting the cooler section and reservoir for mass flow rate measurements and cleaning the system between successive experimental runs.he mass flow rates were measured by collecting the fluid in the collecting station for a period of time with the help of a precise measuring jar and stop watch. The calming section is provided in helical tube to avoid the entrance effect. nternal diameter of helical tube (d_i) is 9 mm and external diameter of helical tube (d_o) is 10.5 mm, the shell external diameter (D) is 124 mm and effective length (L) is 370 mm, the coil pitch (b) and numbers of turns (n) are 17 mm and 13 respectively. The length of calming section is 270 mm and coil diameter (D_c) is 93 mm.

5.PREPARATION OF TIO$_2$/WATER NANOFLUIDS

Nanofluids -Tio$_2$ / water were prepared by dispersing the required particle volume concentration in the chemical measuring flask with distilled water. Ultrasonic bath generating Ultrasonic pulses of 100W at 36 ± 3 kHz was switched on for 3 hr to get the uniform dispersion and stable suspension. The nanofluids with TIO$_2$ nanoparticles of concentrations 0.1% and 0.2% by volume were prepared. No surfactant was added to maintain the stability of nanoparticles. It is observed that there was a very little settlement of nanoparticles even after 20 days of static condition of nanofluids.It shows that the nanoparticles are stable in base fluid.

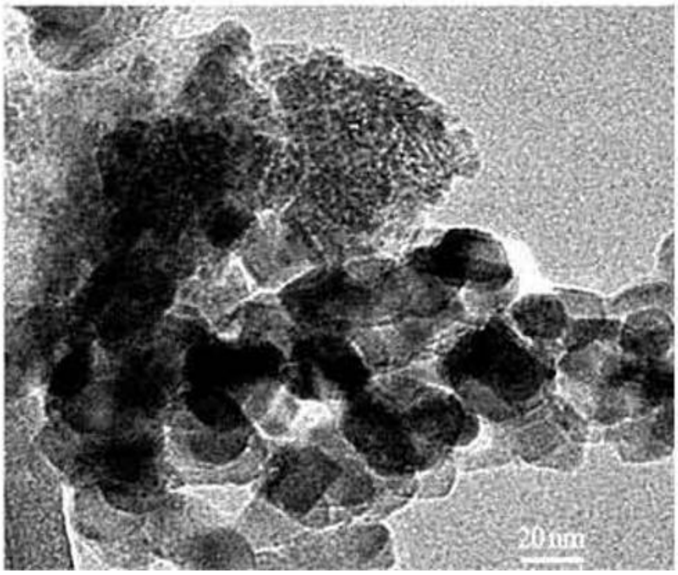


Fig-1

Estimatimation of nanofluid thermo-physical properties

The thermo physical properties of nano fluid such as specific heat,density,vicositythe below correlation were used in this investigation of nanofluid thermo-physical properties.

$\rho_{nf} = \Phi \rho_s + (1-\Phi)\rho_w$ ------------------(1)

$k_{nf} = k_f \, (125.62\Phi^2 + 4.82\Phi + 1)$—(2)

$C_{pnf} = (1-\Phi)C_{pf} + \Phi \, C_{ps}$-------------------(3)

Data reduction:

$Q_W = m_w C_{pw}(T_{in} - T_{out})$----------------(4)

$Q_{nf} = m_{nf} \, C_{pnf}(T_{out} - T_{in})_{nf}$ ------------(5)

$h_{nf} = Q_{nf}/(A_i \Delta T)$---------------------(6)

Friction factor obtained from pressure drop across the working length of coil and velocity of nano fluid

$f = [\Delta p/0.5\rho v^2]^* \delta^2 \, (4/n\prod)$----------(7)

$v = m/(\rho_{nf} {*} A)$---(8)

$\Delta P = (\rho_m - \rho_{nf}) \, \Delta hg$----------------------------------(9)

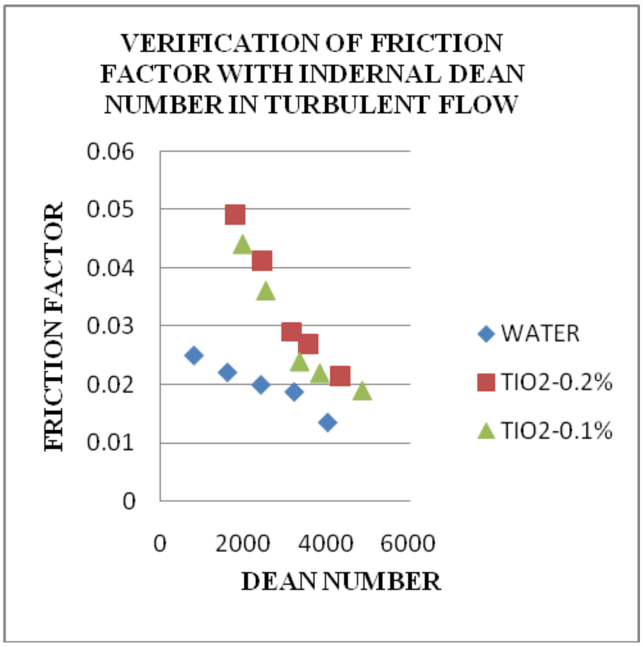
Length of coil to calculated From this relation

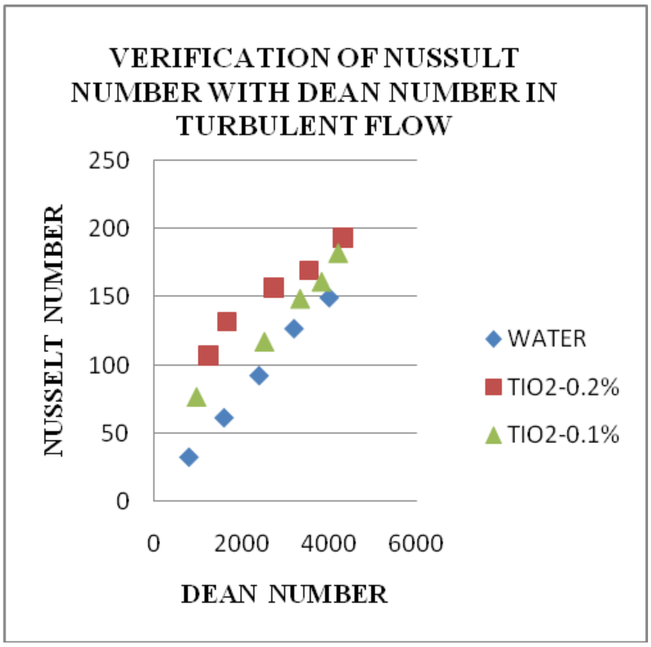
$L_C = \prod DN$ or $L_C = N\sqrt{((2\prod r)^2 + P^2)}$-------------(10)

THERMOPHYSICAL PROPERTIES

Material	Water	Tio$_2$
Density,ρ –kg/m^3	997.746	544.25
Specific heat capacity, c_p J/kgk	4180.2	544.25
Thermal conductivity,k w/mk	0.60192	7.44
Dynamic viscosity,μ kg/ms x10^{-3}	0.96172	-

Table-1





6. CORRELATIONS FOR NUSSELT NUMBERAND FRICTIONFACTOR.

SLNO	POSITION	RANGE OF DEAN NUMBER	NUSSELT NUMBER CORRELATION	FRICTION FACTOR CORRELATION
1	Horizontal	1600 < De < 4000	$Nu = 1.5D_e0.827_\delta0.0008_\varphi1.1694$ $Nu = 1.28D_e1.1\ _\delta 0.9617\ _\varphi 1.0985$	f = 0.559De0.0376d0.18u1.164 f = 0.034De0.412 d0.085u1.212
2	Vertical	1600 < De < 4000	$Nu = 3.67D_e0.67\ _\delta 0.009\ _\varphi 1.004$ $Nu = 0.48D_e1.23_\delta 0.99_\varphi 1.0721$	f = 0.602De0.0794d0.2u1.177 f = 0.0051De0.902 d1.001u1.15

Table-2

7. RESULT AND DISCUSION

Initially experiments were conducted with water which forms the basis for comparison of results with nanofluid. In this heat transfer result and discussion compare with dean number and nusselt number in above graph clearly to give heat transfer enhancement rate. Hear dean number increased nusselt number also increase clearly. In other discussion dean number vs friction factor hear dean number decrese friction factor also increased So TIO_2 /Water heat transfer enhancement rate proved by above graph values.

8.CONCLUSIONS

An experimental setup is fabricated to study fluid to fluid heat transfer in a helically coiled heat exchanger in laminar to turbulent regime under isothermal steady state and non-isothermal unsteady state conditions for Newtonian as well as non-Newtonian fluids. All physical properties of the Tio_2–water Nano fluids, i.e. the density, specific heat capacity, thermal conductivity, and dynamic viscosity, needed to calculate the pressure drop and the convective heat transfer coefficient have been measured over a temperature ranges and for the nanoparticle volume fractions of 0.1%, and0.2%, experimentally. Heat transfer and pressure drop studies of a helically coiled tube heat exchanger with Tio_2/water nanofluid were carried out in vertical positions under turbulent region. The Reynolds number , friction factor and Nusselt number at 0.1% and 0.2% Tio_2/water Nano fluid is to be found out for both the applications. The heat transfer enhancement is more in vertical position than in horizontal. This is because of rapid developments of secondary flow enhancing heat transfer due to increase in thermal conductivity of nanofluids when compared with water. Based on the experimental data, Nusselt number correlations were developed for helically coiled tube at turbulent flow. It is studied that the friction factor of nanofluid increases while increasing particle volume concentration in turbulent flow conditions.

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