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DESIGN AND ANALYSIS OF HAIRPIN HEAT EXCHANGER AT DIFFERENT NANO FLUIDS

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ABSTRACT: In this thesis, different nano fluids mixed with base fluid water are analyzed for their performance in the hair pin heat exchanger. The nano fluids are Aluminium Oxide and Titanium carbide for two volume fractions 0.4, 0.5. Theoretical calculations are done determine the properties for nano fluids and those properties are used as inputs for analysis.

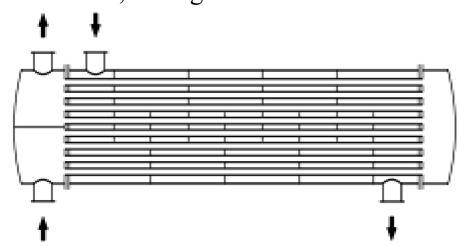
3D model of the hair pin heat exchanger is done in CREO parametric software. CFD analysis is done on the hair pin heat exchanger for all nano fluids and volume fraction and thermal analysis is done in Ansys for two materials Aluminum and Copper.

INTRODUCTION TO HEAT EXCHANGERS

Heat exchangers are one of the mostly used equipment in the process industries. Heat Exchangers are used to transfer heat between two process streams. One can realize their usage that any process which involve cooling, heating, condensation, boiling or evaporation will require a heat exchanger for these purpose. Process fluids, usually are heated or cooled before the process or undergo a phase change. Different heat exchangers are named according to their application. For example, heat exchangers being used to condense are known as condensers, similarly heat exchanger for boiling purposes are called boilers. Performance and efficiency of heat exchangers are measured through the amount of heat transfer using least area of heat transfer and pressure drop. A better presentation of its efficiency is done by calculating over all heat transfer coefficient. Pressure drop and area required for a certain amount of heat transfer, provides an insight about the capital cost and power requirements (Running cost) of a heat exchanger. Usually, there is lots of literature and theories to design a heat exchanger according to the requirements.

Heat exchangers are of two types:-

Where both media between which heat is exchanged are in direct contact with each other is Direct contact heat exchanger, Where both media are separated by a wall through which heat is transferred so that they never mix, Indirect contact heatexchanger.A typical heat exchanger, usually for higher pressure applications up to 552 bars, is the shell and tube heat exchanger. Shell and tube type heat exchanger, indirect contact type heat exchanger. It consists of a series of tubes, through which one of the fluids runs.



The shell is the container for the shell fluid. Generally, it is cylindrical in shape with a circular cross section, although shells of different shape are used in specific applications. For this particular study shell is considered, which a one pass shell is generally. A shell is the most commonly used due to its low cost and simplicity, and has the highest log-mean temperature-difference (LMTD) correctionfactor.

LITERATURE SURVEY

DESIGN AND ANAYSIS OF DOUBLE PIPE HEAT EXCHANGER USING COMPUTATIONALMETHOD

Heat transfer equipment is defined by the function it fulfills in a process. On the similar path, Heat exchangers are the equipment used in industrial processes to recover heat between two process fluids. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, and natural gas processing. The operating efficiency of these exchangers plays a very key role in the overall running cost of a plant. So the designers are on a trend of developing heat exchangers which are highly efficient compact, and cost effective. A common problem in industries is to extract maximum heat from a utility stream coming out of a particular process, and to heat a process stream. Therefore the objective of present work involves study of refinery process and applies phenomena of heat transfer to a double pipe heatexchanger.

Keywords— Thermal, Heat transfer, Computational Flow Dynamics (CFD), Modeling, Heat Flux, Heat transfer Coefficient

Pipe in pipe heat exchanger are used in industrial process to recover heat between two process fluids. The project carried out design of pipe in pipe heat exchanger having tube with fin and without fin. The fins were taken in the form of semi-circular type arranged in alternating way with spacing of 50mm.The fins were only provided on the inner tube for creating turbulence of cold water. The number of fin were 18 and its height and thickness 10 and 1.6mm respectively. Experiment were performed for heat exchanger with fins and without fins. The experiment were performed for different flow rates of hot and cold fluid Differentparameters like Overall heat transfer, Nussult number, Convective heat transfer coefficient, Pressure drop, friction factor were obtained and compared for simple inner tube and finned tube.Keywords: Heat Exchanger, Pipe in Pipe, Semi-circular fins, Heat transfer, Effectiveness

INTRODUCTION TO CAD

Computer-aided design (CAD) is that the use of pc systems (or workstations) to help within the creation, modification, analysis, or improvement of a style. CAD package is employed to extend the productivity of the designer, improve the standard of style, improve communications through documentation, and to form an info for producing. CAD output is usually within the type of electronic files for print, machining, or alternative producing operations. The term CADD (for pc assisted style and Drafting) is additionally used.

INTRODUCTION TO CREO

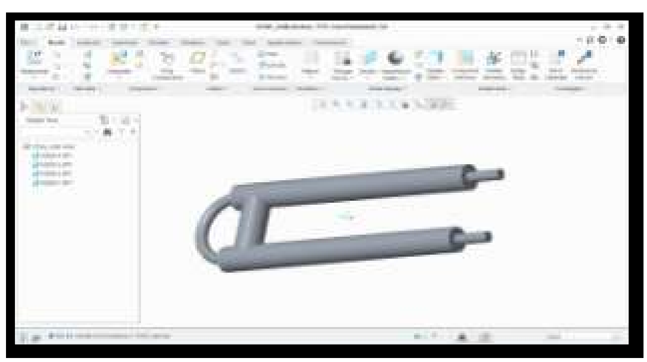
PTC CREO, earliest called Pro/ENGINEER, is 3D modeling package utilized in engineering science, design, producing, and in CAD drafting service companies. It had been one among the primary 3D CAD modeling applications that used a rule-based constant quantity system. Parameters, dimensions and options to capture the behavior of the merchandise, it will optimize the event product in addition because the style itself.

3D MODEL OF HAIR PIN HEAT EXCHANGER

Dimensions of designed double tube Hair-pin heat exchanger: Outer pipe specification Inner tube specification

Copper tube of Ubends

I.D. of shell= 19.05mm I.D. of tube = 8.4 mm Copper tube of UbendsI.D. of shell= 19.05mm I.D. of tube = 8.4 mm O.D. of shell = 22 mm O.D. of tube = 9.5 mm Center to center distance is takenWall thickness=



0.55 mm 1.5 - 1.8 times of outer dia. ofshell. Thermal conductivity of wall= 385 w/m2K Length of each

IJMTARC – VOLUME – V – ISSUE – 23, JULY-SEP, 2018

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G.I. pipe =22.86cmEffective length of copper tube through which heat transfer could take place= 45cm Total length of the copper tube = straight part (51cm) + U-shaped bend part (9cm) =60cm

INTRODUCTION TO FEA

Finite Element Analysis may be a technique of finding, sometimes roughly, sure issues in engineering and science. It's used primarily for issues that no precise resolution is required. Mainly used in some mathematical modeling of a structure or member in design or thermal analysis. Strategies of this kind area unit required as a result of analytical strategies, sophisticated issue that are used in engineering. For instance, in engineering strength of materials or the mathematical theory of snap are often want to calculate analytically the stresses and strains during a bent beam.

ANSYS Mechanical

ANSYS Mechanical may be a finite part analysis tool for structural analysis, as well as linear, nonlinear and dynamic studies. This framework product provides finite parts to model behavior, and supports material models and equation solvers for a good vary of mechanical style issues. ANSYS Mechanical conjointly includes thermal analysis and coupled-physics capabilities involving acoustics, electricity, thermal–structural and thermo-electric analysis.

Fluid Dynamics

ANSYS Fluent, CFD, CFX, FENSAP-ICE and connected package area unit procedure Fluid Dynamics package tools employed by engineers for style and analysis. These tools will simulate fluid flows during a virtual setting — for instance, the fluid dynamics of ship hulls; turbine engines (including the compressors, combustion chamber, turbines and afterburners); craft aerodynamics; pumps, fans, HVAC systems, combining vessels, hydro cyclones, vacuum cleaners, etc.

Calculations

FLUID PROPERTIES

FLUID	Volume fraction	Thermal conductivity (w/m-k)	Specific heat (J/kg-k)	Density (kg/m^3)	Viscosity (kg/m-s)
ALUMINUM OXIDE	0.4	2.647	1809	2150.92	0.002006
	0.5	4.17	1570.9	2439.1	0.002256
TITANIUM CARBIDE	0.4	2.625	5357.01	2570.92	0.002006
	0.5	4.12	4069.1	2964.1	0.002256

Base fluid properties

Quantity fraction= 0.Four & 0.5(taken from journal paper)

fabric houses

ALUMINUM OXIDE

Density = 3880 kg/m3

Thermal conductivity =40 W/m-k Specific heat = 910J/kg-k

TITANIUM CARBIDE

Density = 4930 kg/m3

Thermal conductivity =330 W/m-k

special warmth = 711 J/kg-k

WATER

Density = 998.2 kg/m3

Thermal conductivity = 0.6 W/m-ok

certain heat = 4182 J/kg-k

Viscosity = 0.001003kg/m-**s**

FORMULAS

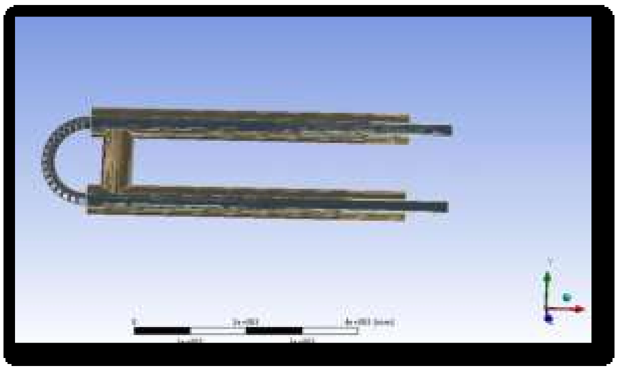
PROPERTIES	FORMULA

IJMTARC – VOLUME – V – ISSUE – 23, JULY-SEP, 2018

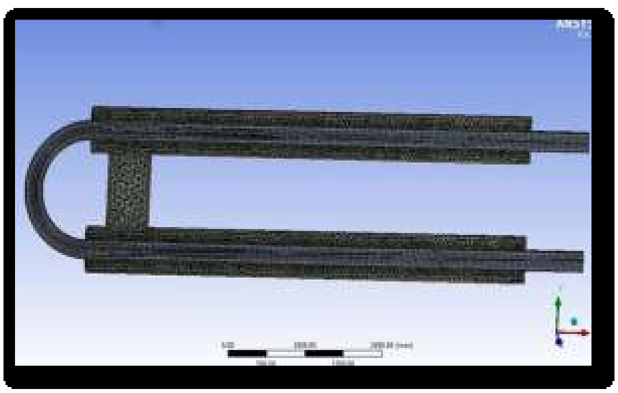
ISSN: 2320-1363

DENSITY	$\rho_{mix} = \phi \times \rho_{R160} + [(1-\phi) \times \rho_{R30}]$
SPECIFIC HEAT	$C_{pmix} = \frac{\phi \times \rho R160 \times CpR160 + (1-\phi)(\rho R30 \times CpR30)}{\phi \times \rho R160 + (1-\phi) \times \rho R30}$
THERMAL CONDUCTIVITY	$K_{mix} = \frac{K1+2K2+2(K1-K2)(1+\beta)^3 \times \phi}{K1+2K2-(K1-K2)(1+\beta)^3 \times \phi} \times k_2$
VISCOSITY	$\mu_{mix} = \mu_{R160}\ (1+2.5\phi)$

IMPORTED MODEL



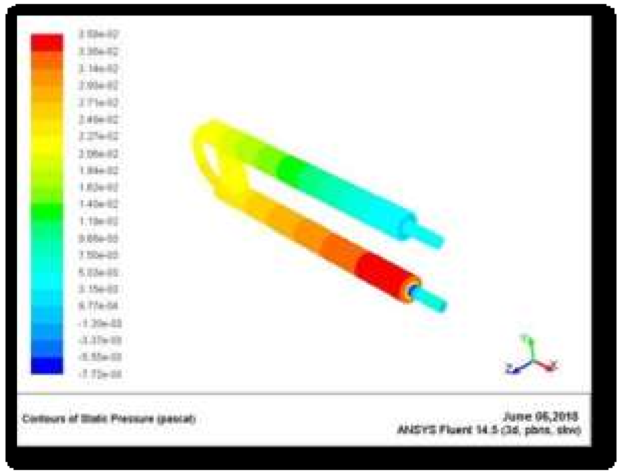
MESHED MODEL



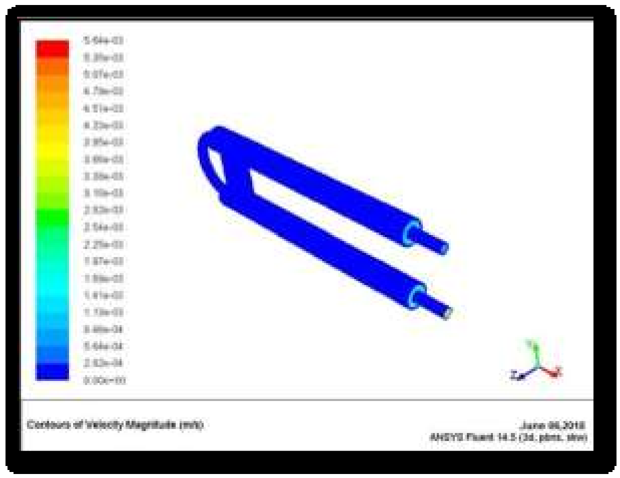
Fluid –Al2O3

At volume fraction-0.5

PRESSURE



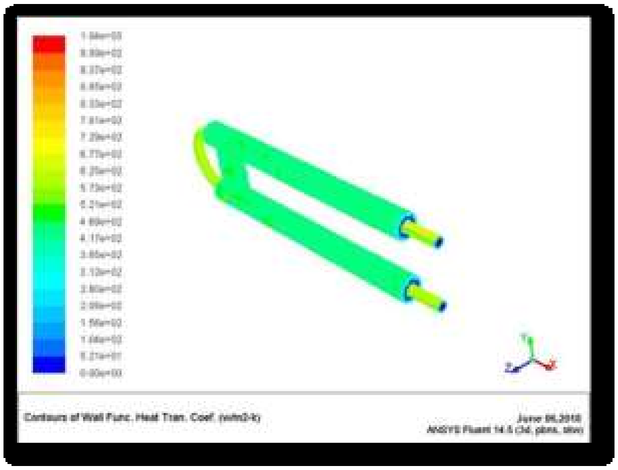
Velocity



HEAT TRANSFER COEFFICIENT

IJMTARC – VOLUME – V – ISSUE – 23, JULY-SEP, 2018

ISSN: 2320-1363



MASS FLOW RATE

```
                  Mass Flow Rate                (kg/s)
-------------------------------- --------------------
                      cold_inlet           0.049999997
                     cold_outlet          -0.34936157
:ontact_region-contact_region_3-contact_region_2-contact_region_3-src          -0.5796594
:ontact_region-contact_region_3-contact_region_2-contact_region_3-trg           0.579659
             contact_region_4-src          0.017812613
             contact_region_4-trg         -0.017812585
                       hot_inlet           0.69999987
                      hot_outlet          -0.45220888
                     interior-16          -0.57966024
                      interior-5           0.017812405
                interior-___msbr          -16.229658
                         wall-14                    0
                         wall-15                    0
                         wall-17                    0
                         wall-18                    0
                    wall-___msbr                    0
                ---------------- --------------------
                             Net          -0.051570909
```

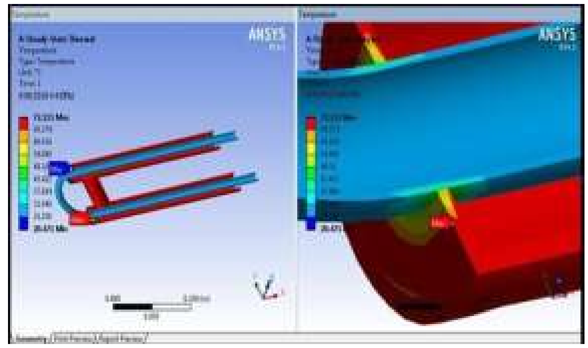
HEAT TRANSFER RATE

```
        Total Heat Transfer Rate                   (w)
-------------------------------- --------------------
                      cold_inlet            1166.3931
                     cold_outlet           -30182.238
contact_region-contact_region_3-contact_region_2-contact_region_3-src            0
contact_region-contact_region_3-contact_region_2-contact_region_3-trg            0
            contact_region_4-src                    0
            contact_region_4-trg                    0
                       hot_inlet            60314.602
                      hot_outlet           -35457.238
                         wall-14                    0
                         wall-15                    0
                         wall-17                    0
                         wall-18                    0
                    wall-___msbr                    0
                ---------------- --------------------
                             Net           -4078.4819
```

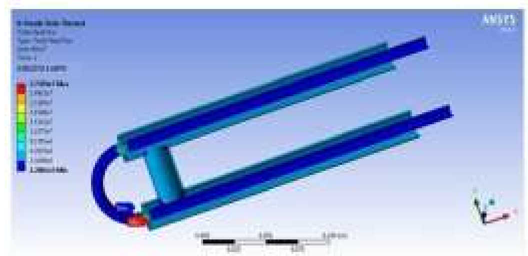
THERMAL ANALYSIS OF MICRO TUBE

Material- copper

Temperature distribution



Heat flux



RESULT TABLE: Analytical Investigation

Cfd analysis results

Fluid	Pressure (Pa)	Velocity (m/s)	Heat transfer coefficient (w/m2-k)	Mass flow rate(kg/s)	Heat transfer rate(W)
Water	6.46e-02	1.32e-02	1.50e+02	0.035707	7178.0925
Al2o3(ϕ=0.4)	3.79e-02	6.31e-03	6.61e+02	0.05145	4613.6967
Al2o3(ϕ=0.5)	3.58e-02	5.64e-03	1.04e+03	0.0515709	4078.4819
TiC (ϕ=0.4)	3.29e-02	5.30e-03	6.56e+02	0.0525819	14320.233
TiC(ϕ=0.5)	3.05e-02	4.62e-03	1.03e+03	0.058124	11510.686

Thermal analysis results

ISSN: 2320-1363

Material	Temperature (°C)		Heat flux(w/m^2)
	Min.	Max.	
Aluminum alloy	20.471	72.111	2.4941e7
copper	19.28	72.316	2.7459e7

CONCLUSION

In this thesis, different nano fluids mixed with base fluid water are analyzed for their performance in the hair pin heat exchanger. The nano fluids are Aluminium Oxide and Titanium carbide for two volume fractions 0.4, 0.5. Theoretical calculations are done determine the properties for nano fluids and those properties are used as inputs foranalysis.

Hairpin Exchangers are available in single tube (Double Pipe) or multiple tubes within a hairpin shell (Multitude), bare tubes, finned tubes, U-tubes, straight tubes (with rod-thru capability), fixed tube sheets and removable bundle.

By observing the CFD analysis results the heat transfer rate value more at titanium carbide volume fraction 0.4.

By observing the thermal analysis results the heat flux value more for copper material compare with aluminum alloy.

So it can be concluded the titanium carbide nano fluid at volume fraction 0.5 fluid is the better fluid for hair pin heat exchanger and material is copper.

REFERENCES

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