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Augmentation Of Heat Transfer In A Cirucalar Tube With Inserts

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Abstract: **Present research is going on augmentation of Heat Transfer in Heat Exchangers by using Passive techniques than the Active techniques, because they do not require direct input of External power. Inserts fitted inside the tubes come under passive technique. In this Study Heat transfer augmentation with mass in a circular tubes has been investigated without inserts and with inserts which are rectangular inserts of 5mm thickness are being fitted across the flow direction at equal distances from each other along the length at following inlet velocities of 0.04m/s, 0.08 m/s, 0.12 m/s. The Combinations are composed of without insert, and two inserts. An 800mm long pipe with 26mm inner diameter 30mm outer diameter considered in our simulation. A constant heat flux is generated at the boundary layer of the tube close to the flowing fluid around the boundary layer. The purpose of using inserts is to scatter the fluid particles in laminar flow which increases the heat transfer with Reynolds number.**

Keywords: **CFD Analysis; Pro-E; ANSYS; Velocity**

I. INTRODUCTION

Conventional resources of energy are depleting at an alarming rate, which makes future sustainable development of energy use very difficult. As a result, considerable emphasis has been placed on the development of various augmented heat transfer surfaces and devices. The process of improving the performance of a heat transfer system is referred as the heat transfer enhancement technique .In recent years, the high cost of energy and material has resulted in an increased effort aimed at producing more efficient heat exchange equipment .The major challenge in designing a heat transfer is to make the equipment compact and achieve a high heat transfer rate using minimum pumping power. The subject of heat transfer growth in heat exchanger is serious interest in the design of effective and economical heat exchanger. Augmentation techniques increase convective heat transfer by reducing thermal resistance in a heat exchanger. A decrease in heat transfer surface area, size, and hence weight of heat exchanger for a given heat duty and pressure drop. The heat transfer can be increased by the following different augmentation techniques. They are classified as (i) Passive Techniques (ii) Active Techniques (iii) Compound Techniques.

Passive techniques do not require direct input of external power, unlike active techniques. They generally use surface or geometrical modifications to the flow channel, or incorporate an insert, material, or additional device. Except for extended surfaces, which increase the effective heat transfer surface area, these passive schemes promote higher heat transfer coefficients by disturbing or altering the existing flow behavior. This, however, is accompanied by an increase in the pressure drop. In the case of active techniques, the addition of external power essentially facilitates the desired flow modification and improvement in the rate of heat transfer. The use of two or more techniques (passive and/or active) in conjunction constitutes compound augmentation techniques. Hence many researchers preferred passive heat transfer enhancement techniques for their simplicity and applicability for many applications. Tube inserts present some advantages over other enhancement techniques, such as they can be installed in existing smooth tube that exchanger, and they maintain the mechanical strength of the smooth tube. Their installation is easy and cost is low. It has relatively easy to take out for cleaning operations too.

II. PASSIVE TECHNIQUES

Treated surfaces are heat transfer surfaces that have a fine-scale alteration to their finish or coating. The alteration could be continuous or discontinuous, where the roughness is much smaller than what affects single-phase heat transfer, and they are used primarily for Boiling and condensing duties.

Rough surfaces are generally surface modifications that promote turbulence in the flow field, primarily in single-phase flows, and do not increase the heat transfer surface area.

Their geometric features range from random sand-grain roughness to discrete three dimensional surface protuberances.

Extended surfaces, more commonly referred to as finned surfaces, provide an effective heat transfer surface area enlargement. Plain fins have been used routinely in many heat exchangers. The newer developments, however, have led to modified finned surfaces that also tend to improve the heat transfer coefficients by disturbing the flow field in addition to increasing the surface area.

Displaced enhancement devices are inserts that are used primarily in confined forced convection, and they improve energy transport indirectly at the heat exchange surface by “displacing” the fluid from the heated or cooled surface of the duct with bulk fluid from the core flow.

Swirl flow devices produce and superimpose swirl or secondary recirculation on the axial flow in a channel. They include helical strip or cored screw-type tube inserts, twisted ducts, and various forms of altered (tangential to axial direction) flow arrangements, and they can be used for single-phase as well as two-phase flows.

Coiled tubes are what the name suggests, and they lead to relatively more compact heat exchangers. The tube curvature due to coiling produces secondary flows, which promote higher heat transfer coefficients in single-phase flows as well as in most regions of boiling.

Surface tension devices consist of wicking or grooved surfaces, which direct and improve the flow of liquid to boiling surfaces and from condensing surfaces.

Additives for liquids include the addition of solid particles, soluble trace additives, and gas bubbles in single-phase flows, and trace additives, which usually depress the surface tension of the liquid, for boiling systems.

Additives for gases include liquid droplets or solid particles, which are introduced in single-phase gas flows in either a dilute phase (gas–solid suspensions) or dense phase (fluidized beds).

III. LITERATURE SURVEY

[1] Saber Husain: “The enhancement of heat transfer in a circular tube with insert and without insert by using the finite element method procedia engineering 105 (2015) 81 – 88.

Enhanced heat transfer with water as fluid in a tube has been investigated without inserts and with inserts. Inserts are 5 mm thick are being fitted in perpendicular to the flow direction. The composed combinations are without insert, two inserts, four inserts, six inserts, eight inserts, ten inserts. Dimensions of tube 800 mm, inner and outer diameter are 26 mm and 30 mm respectively considered in simulation and analyzed at constant heat flux is generated at the boundary layer of the tube. Comparison done between outlet temperatures of different inserts at different combinations and arrangement. They concluded that highest outlet temperature is found with four inserts and six, eight inserts domain shows greater outlet temperature after changing inserts position.

[2] Bodius Salam: ‘’Heat transfer enhancement in a tube using rectangular-cut twisted tape insert’’ procedia engineering 56 (2013) 96 – 103.

He was a carried experimental investigation for measuring tube-side heat transfer coefficient, friction factor, heat transfer enhancement efficiency of water for turbulent flow in a circular tube fitted with rectangular-cut twisted tape insert. A copper tube of 26.6 mm internal diameter and 30 mm outer diameter and 900 mm test length was used. A stainless steel rectangular-cut twisted tape insert of 5.25 twist ratio was inserted into the smooth tube. The rectangular cut had 8 mm depth and 14 mm width. A uniform heat flux condition was created by wrapping nichrome wire around the test section and fiber glass over the wire. At 5 different points surface temperatures of the tube were measured. The Reynolds numbers were varied in the range 10000-19000 with heat flux variation 14 to 22kW/m2 for smooth tube, and 23 to 40kW/m2 for tube with insert. Heat transfer enhancement efficiencies were found to be in the range of 1.9 to 2.3 and increased with the increase of Reynolds number. They concluded that an average of 68% enhancement of heat flux was observed for tube with rectangular-cut twisted tape insert (qe) than that of smooth tube (qs).

IV. INTRODUCTION TO CREO

PTC CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself. It has many advantages like Optimized for model-based enterprises, Increased engineer productivity, Better enabled concept design, Increased engineering capabilities, Increased manufacturing capabilities, Better simulation, Design capabilities for additive manufacturing.

INTRODUCTION TO FINITE ELEMENT METHOD

Finite Element Method (FEM) is also called as Finite Element Analysis (FEA). Finite Element Method is a basic analysis technique for resolving and substituting complicated problems by simpler ones, obtaining approximate solutions Finite element method being a flexible tool is used in various industries to solve several practical engineering problems. In finite element method it is feasible to generate the relative results.

ANSYS Software:

ANSYS is an Engineering Simulation Software (computer aided Engineering). Its tools cover Thermal, Static, Dynamic, and Fatigue finite element analysis along with other tools all designed to help with the development of the product. The company was founded in 1970 by Dr. John A. Swanson as Swanson Analysis Systems, Inc. SASI. Its primary purpose was to develop and market finite element analysis software for structural physics that could simulate static (stationary), dynamic (moving) and heat transfer (thermal) problems. SASI developed its business in parallel with the growth in computer technology and engineering needs. The company grew by 10 percent to 20 percent each year, and in 1994 it was sold. The new owners took SASI's leading software, called ANSYS®, as their flagship product and designated ANSYS, Inc. as the new company name.

V. THEORETICAL FORMULATION

- 4.1 Determination of heat transfer coefficient:

According to Dittus Boelter Equation,

For laminar flow Pr >0.7; Re<2300

1. Nusselt number, Nu: It is the ratio of convective to conductive heat transfer.

Nu = $\frac{hL}{k}$

2. Reynolds number, Re: A dimensionless number to indicate whether a fluid flow is laminar or turbulent.

Re = $\frac{vD}{\upsilon}$

3. Prandtl number, Pr: It is the ratio of momentum diffusivity to thermal diffusivity.

Pr = $\frac{cp\ \mu}{k}$

h is heat transfer coefficient in Wm^2/K

L is characteristic length in m

K is thermal conductivity in W/mK

v Is the Velocity of air in m/sec

υ Is the Kinematic viscosity of air in m^2/sec

μ Is the Absolute viscosity Ns/m^2

C_p is the Specific heat of air in J/kg K

D is the diameter in m

We have Nu = $\frac{hL}{k}$

Therefore, Heat transfer coefficient h = $\frac{Nu\ k}{L}$

- 4.2 Determination of Mass Flow rate:

M=ρAV

Where $\rho\ (density\ of\ water) = 1000 kg/m3$

M=Mass flow rate(kg/sec)

A= Cross sectional area of tube

V= Inlet velocity

- 4.3 Determination of Friction factor:

F=64/ Re

Re=Reynolds number

Laminar flow:

-Fluid layers flow over one another with virtually no mixing

- Great for fluid transport systems

- Lower flow and less head loss

- Large difference between "max" velocity and "average" velocity

- Since laminar flow velocity profile cross-section has a parabolic shape, the "max" velocity is about twice the "average" velocity

- Actual velocity profile depends on surface condition of pipe wall

- Laminar flow occurs for Reynolds numbers < 2000

Turbulent flow:

- Great for heat transfer systems due to mixing of fluid
- Irregular motion of fluid molecules
- Velocity profile is flattened at centerline
- Average velocity is only slightly less than "max" velocity
- Turbulent flow occurs for Reynolds numbers > 3500.

Transition flow:

- Transition flow occurs between 2000 and 3500

4.4 Determination of Pressure drop:

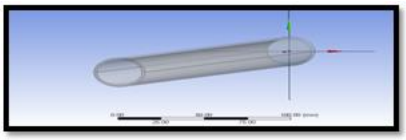
$$\Delta p = 2f * \frac{l}{d} * \rho * v^2$$

Where:
Δ p - pressure drop due to friction in the pipe;
ρ - Density;
f - Friction coefficient;
l - Pipe length;
v - Velocity;
D_i - Internal pipe diameter;
Q - Volumetric flow

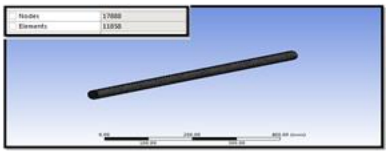
VI. CFD ANALYSIS

ANALYSIS OF PLAIN TUBE

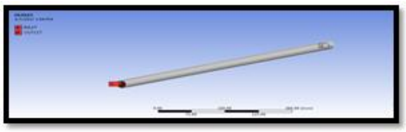
IMPORTED MODEL



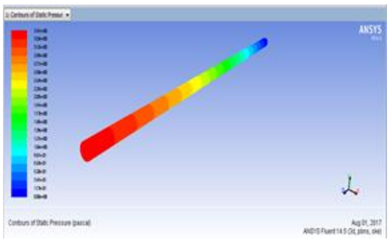
MESHED MODEL



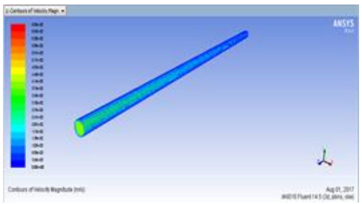
BOUNDARY CONDITIONS



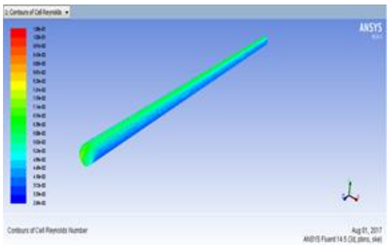
Pressure



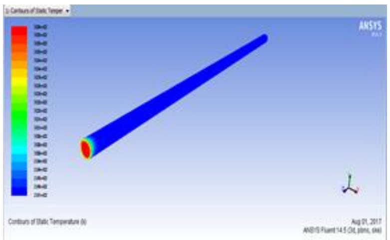
velocity



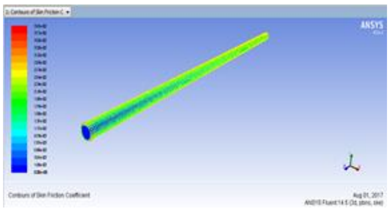
cell reloynd number



temperature

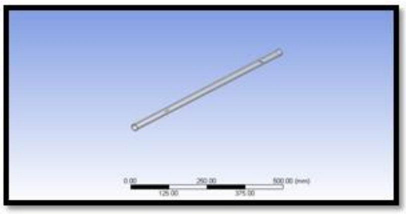


friction coefficient

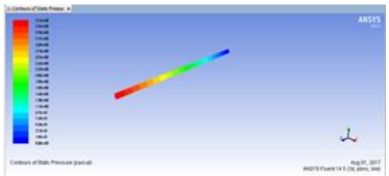


ANALYSIS OF TWO INSERTS

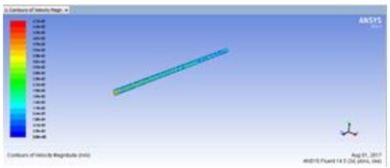
IMPORTED MODEL



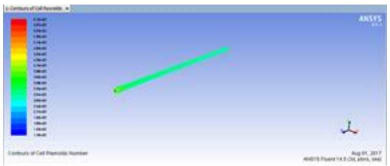
Pressure



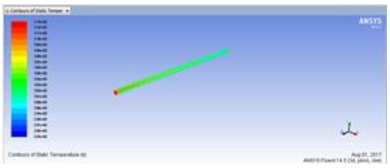
velocity



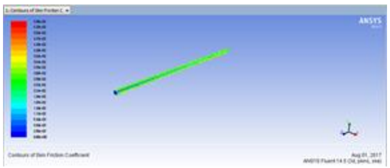
cell reloynd number



temperature



friction coefficient



VII. CFD ANALYSIS RESULTS TABLES

Analytical results of Plain tube

Sl. No	Input velocity (m/s)	Velocity (m/s)	Pressure (Pa)	Cell Reynolds number	Temperature (K)	Friction Factor	Heat Flux (w/m^2)
1.	**0.04**	0.0689	3.47	0.10	306	0.039	32087
2.	**0.08**	0.0976	7.82	0.19	308	0.014	32087
3.	**0.12**	0.205	10.6	0.3	310	0.121	32087

Analysis results of tube with two inserts

Sl. No	Input velocity (m/s)	Velocity (m/s)	Pressure (Pa)	Cell Reynolds number	Temperature (K)	Friction Factor	Heat Flux (w/m^2)
1.	**0.04**	0.047	3.72	61.2	313	0.06	32087
2.	**0.08**	0.088	7.81	71.6	317	0.11	32087
3.	**0.12**	0.129	14.6	83.7	321	0.17	32087

VIII. CONCLUSION

A CFD simulation study on heat transfer characteristics of fluid in a tube without inserts and with inserts under constant boundary heat flux condition for non- isothermal laminar flow has been presented. The salient conclusions that can be drawn from the Theoretical study are

1. The experimental data indicate an increase in heat transfer co-efficient for two inserts.

2. With the increase in Reynolds number, Nusselt number increases and friction factor decreases.

3. We found that higher heat transfer co-efficient is obtained for two inserts compared to without inserts and temperature is low for two inserts compared to without inserts.

4. Mass flow rate increases with increase of velocities.

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