HEAT TRANSFER ENHANCEMENT IN HEAT EXCHANGER USING PASSIVE ENHANCEMENT TECHNIQUE

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Abstract:- The main this project is to analyze the heat transfer in turbulent flow to horizontal tube using different types of inserts. The Reynolds number ranged from 6000 to 14000. The five different types of inserts used. 1) Plain rod 2) Spiral over rod 3) Spiral and square blocks over rod 4) Spiral and rectangle blocks over rod 5) Spiral and pyramid blocks over rod. The data from ANSYS is used to calculate Friction factor and Nusselt number in the presence of inserts. The theoretical values are compared with the analysis values. The analysis is done to know which type of insert among the five inserts gives the maximum heat transfer. 3D models of the horizontal tube with inserts are done in Pro/Engineer and analysis is done in Ansys. Different types of inserts Heat transfer rate at Reynolds number Maximum; spiral rod Minimum; spiral on square When compared the results for different Reynolds number, Nusselt number is more at Reynolds number 14000 and decreasing with decrease of Reynolds number. Friction number, mass flow rate, pressureare more at Reynolds number 14000 and it is increase of Reynolds number. The heat transfer rate is more at Reynolds number 14000.

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. Heat transfer augmentation techniques are generally classified into three categories namely: active techniques, passive techniques and compound techniques. Passive heat transfer techniques (ex: tube inserts) do not require any direct input of external power. 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 relatively easy to take out for cleaning operations too.

Performance Evaluation Criteria

Besides the relative thermal–hydraulic performance improvements brought about by the Enhancement devices, there are many factors that should be considered to evaluate the Performance of particular heat transfer equipment. They include economic (engineering Development, capital, installation, operating, maintenance, and other such costs), Manufacturability (machining, forming, bonding, and other production processes), reliability (material compatibility, integrity, and long-term performance), and safety, among others. The Assessment of these factors, as well as the enhanced convection performance, is usually.

II. LITERATURE SURVEY

Prabhakar Ray, Dr. Pradeep Kumar Jhinge, "A review paper on heat transfer rate enhancement by wire coil inserts in the tube", International journal of engineering sciences & research technology (2014), Vol.3(6) pp. 238- 243.

The heat exchanger is an important device in almost all of the mechanical industries as in case of process industries it is key element. Thus from long time many researchers in this area are working to improve the performance of these heat exchangers in terms of heat transfer rate, keeping pressure drop in limit. This paper is a review of such techniques keeping focus on passive augmentation techniques used in heat exchangers. The thermal performance behavior for tube in tube heat exchanger is studies for wire coil inserts, twisted tape inserts and their combination. The research was carried for constant/periodically varying wire coil pitch ratio. Some of them have varied three coil pitch ratios. The twisted tapes were also been tested by many of them for different twist ratios. These inserts are tested individually and in combine form and results were compared. The wide range of Reynolds number is selected for allowing the inserts to be tested for different flow conditions from laminar to turbulent. The improved performance was found in the increasing order for wire coil inserts, twisted tapes and combined inserts. Also few of researchers have developed correlations for these inserts for Nusselt number as a function of Reynolds number.

III. DESIGN AND ANALYSIS

INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products. Customer requirements may change and time pressures may continue to mount, but your product design needs remain the same - regardless of your project's scope, you need the powerful, easy-to-use, affordable solution that Pro/ENGINEER provides.

IV. OBJIECTIVE INTRODUCTION

Many FEA programs also are equipped with the capability to use multiple materials within the structure such as:

1. Isotropic, identical throughout
2. Orthotropic, identical at 90 degrees
3. General anisotropic, different throughout

METHODOLOGY

In all of these approaches the same basic procedure is followed.

1. During preprocessing

   a) The geometry (physical bounds) of the problem is defined.
   b) The volume occupied by the fluid is divided into discrete cells (the mesh). The mesh may be uniform or non-uniform.
   c) The physical modeling is defined – for example, the equations of motion + enthalpy + radiation + species conservation
   d) Boundary conditions are defined. This involves specifying the fluid behaviour and properties at the boundaries of the problem. For transient problems, the initial conditions are also defined.

2. The simulation is started and the equations are solved iteratively as a steady-state or transient.
3. Finally a postprocessor is used for the analysis and visualization of the resulting solution.

VELOCITY CALCULATIONS FOR REYNOLDS NUMBER 10000 – 14000

Reynolds number - 12000

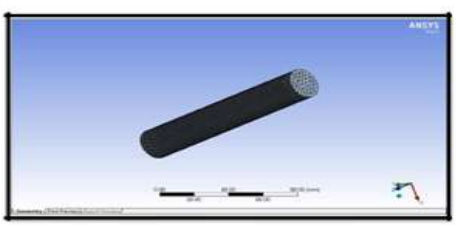
= density of fluid
v = velocity
= inner diameter
= viscosity

V. MODELING AND MESHING CFD ANALYSIS ON HEAT TRANSFER ENHANCEMENT IN HORIZONTAL TUBE WITH INSERTS

PLAIN ROD

Meshed model

Meshed model



Select faces → right click → create named section → enter name → air inlet & outlet

Compare the value types of insert : heat transfer rate(W);

S.no. Reynold number	Plain rod	Spiral over on rod	Spiral over on rectangle	Spiral on square	Spiral over on pyramid
10000	3.600821	0.37166672	-1.5105124	-1.0056232	1.452586
12000	-0.58058844	0.084730413	3.9696711	-1.01123658	1.9830686
14000	5.535928	0.438259365	6.8288705	-1.0898772	-0.043541745

Heat transfer rate at Reynolds number

Maximum; spiral rod

Minimum; spiral on square

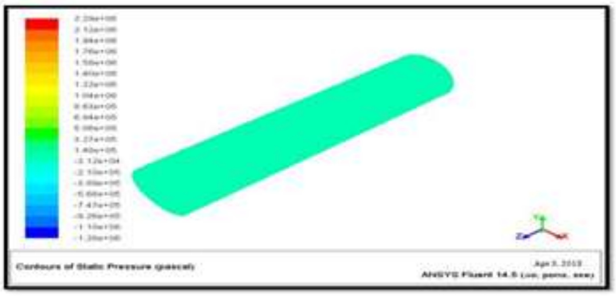
REYNOLD'S NUMBER – 10000

BOUNDARY CONDITIONS

inlet temperatures(t)	*331 k*
inlet pressure(p)	*101325 pa*
inlet velocity(v)	73.036

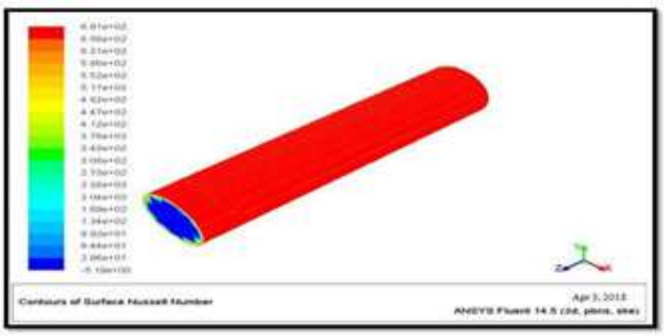
PLAIN ROD

Pressure



From above figure shown Reynolds number 1000014 with respect to static pressure will increases 1.48 Pa to 3.27Pa

Nusselt number

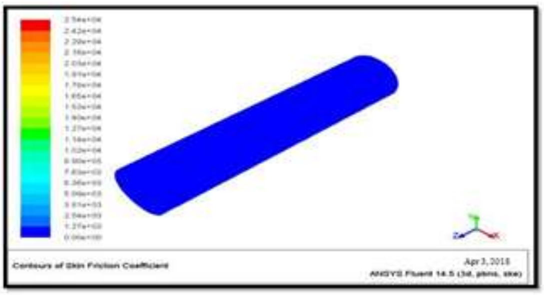


From above figure shown Reynolds number 10000 with respect to Contours of surface Nusselt number will increases6.21e to 6.91e

Reynolds number

From above figure shown Reynolds number 10000 with respect to Contours of surface Nusselt number will increases6.21e to 6.91e

Friction coefficient



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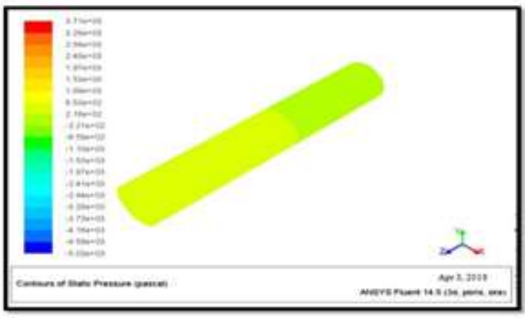
SPIRAL OVER ON ROD

Pressure



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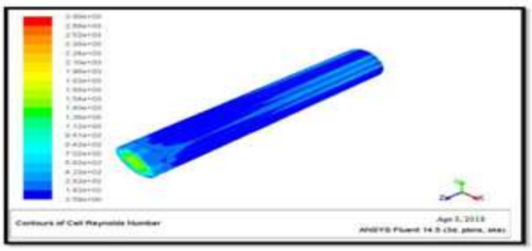
Reynolds number



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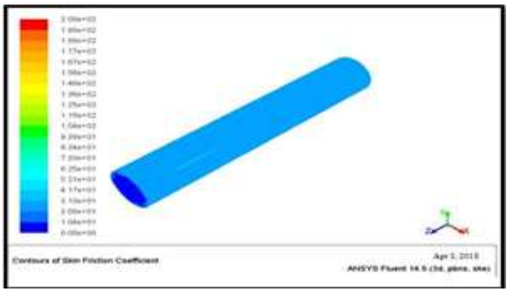
Skin friction coefficient



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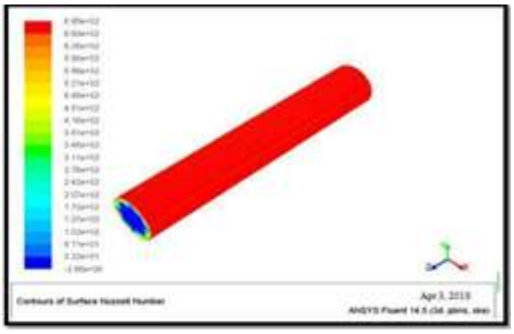
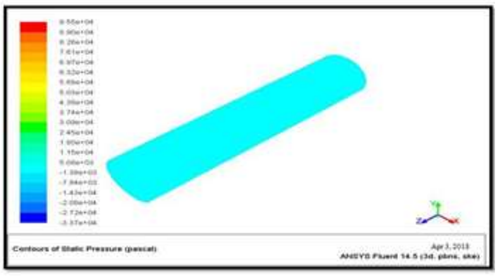
Nusselts number



From above figure shown Reynolds number 10000 with respect to Contours of surface Nusselt number will increases6.21e to 6.91e

SPIRAL AND RECTANGLE BLOCKS OVER ON ROD

Pressure



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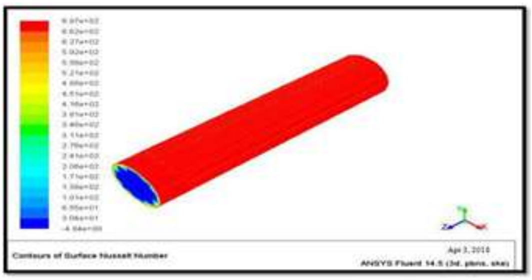
NusseltNumber



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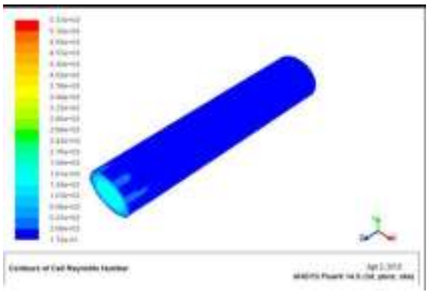
Reynolds number



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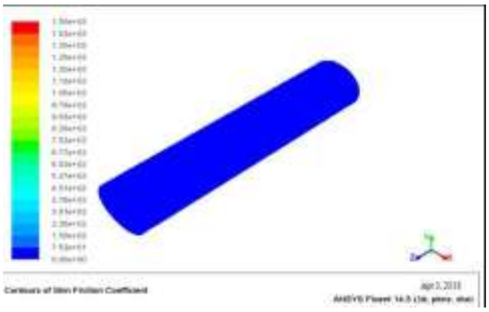
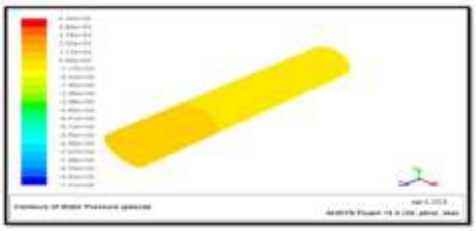
Friction coefficient



From above figure shown Reynolds number 10000 with respect to Contours of surface Nusselt number will increases6.21e to 6.91e

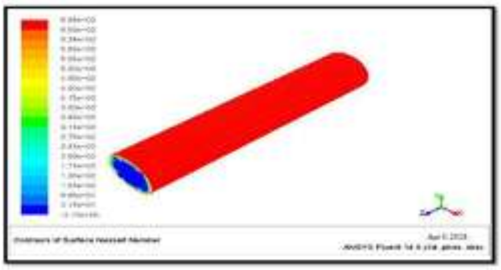
SPIRAL AND SQUARE BLOCKS OVER ON ROD

Pressure



From above figure shown Reynolds number 10000 .14 with respect to static pressure .will increases 1.31 Pa to 5.99Pa

Nusselt number



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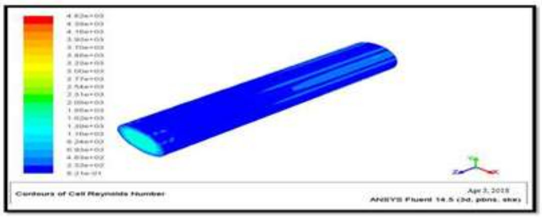
Reynolds number



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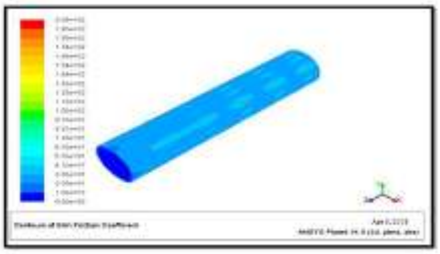
Friction coefficient



From above figure shown Reynolds number 10000 with respect to Contours of surface Nusselt number will increases6.21e to 6.91e

REYNOLD'S NUMBER - 12000

BOUNDARY CONDITIONS

inlet temperatures(t)	*331 k*
inlet pressure(p)	*101325 pa*
inlet velocity(v)	*87.64 m/s*

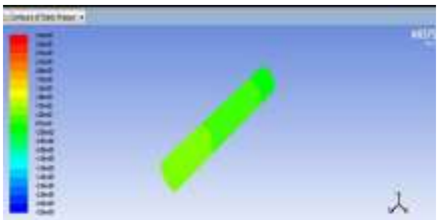
Solution > Solution Initialization > Hybrid Initialization >done

Run calculations > no of iterations = 10> calculate > calculation complete>ok

Results>edit>select contours>ok>select location (inlet, outlet, wall.etc)>select pressure>apply

PLAIN ROD

Pressure



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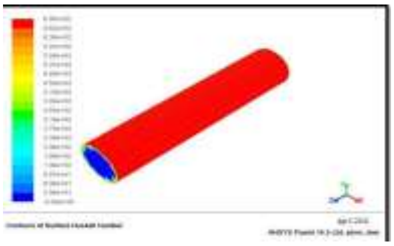
Nusselt number



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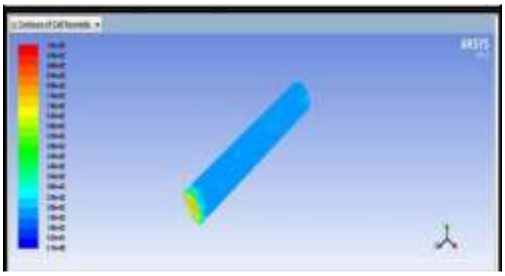
Reynolds number



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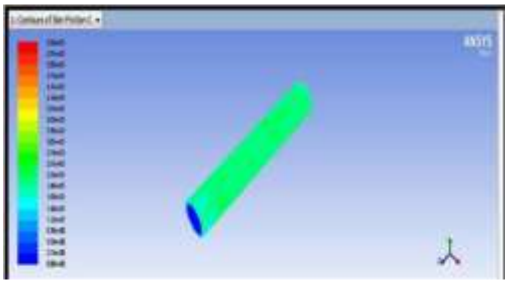
Friction coefficient



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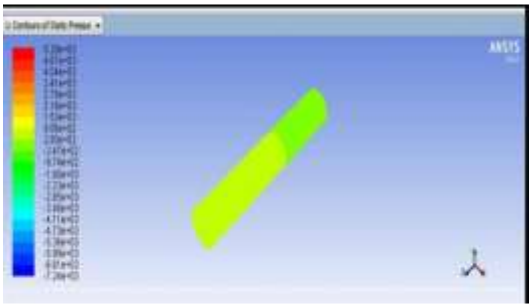
SPIRAL OVER ON ROD

Pressure



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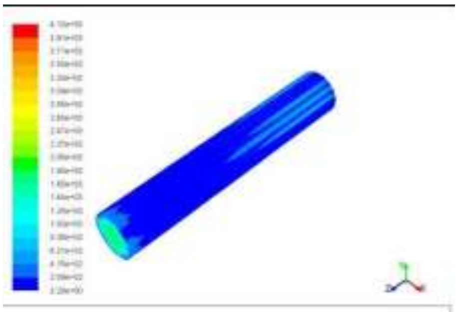
Reynolds number



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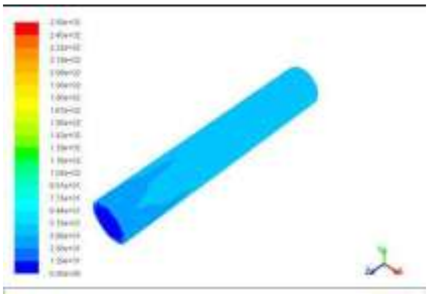
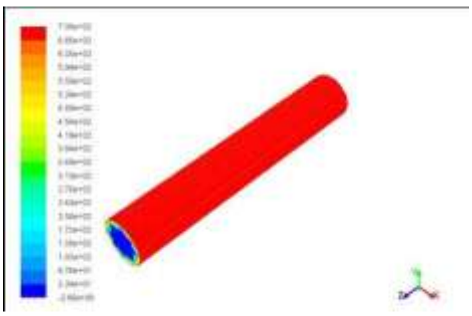
Skin friction coefficient



From above figure shown Reynolds number 10000 with respect to Contours of surface Nusselt number will increases6.21e to 6.91e

Nusselts number



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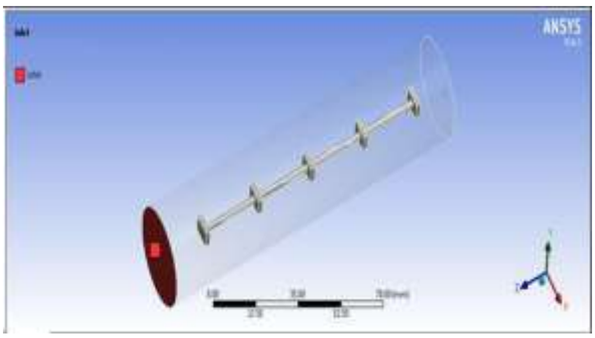
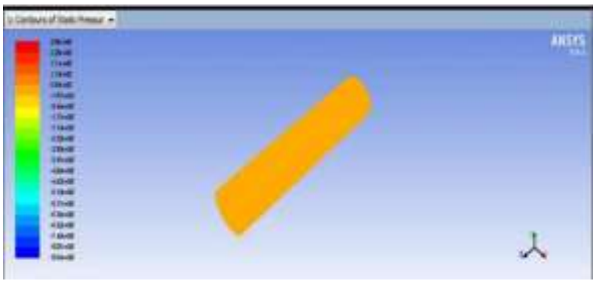
SPIRAL AND RECTANGLE BLOCKS OVER ON ROD



PRESSURE



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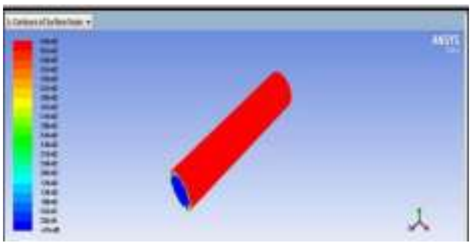
NUSSSELT NUMBER



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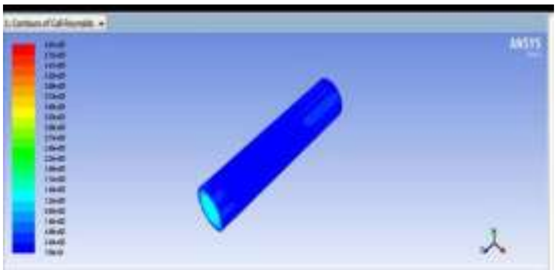
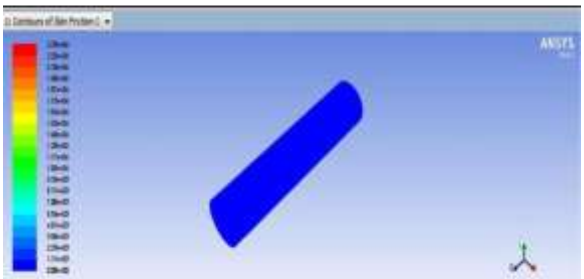
Reynolds number



From above figure shown Reynolds number 12000With respect to Contours of cell Reynold number Will increases 1.25e to 2.29e

FRICTION COEFFICIENT



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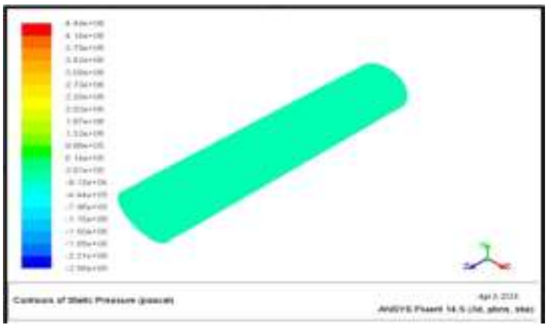
REYNOLD'S NUMBER – 14000

BOUNDARY CONDITIONS

inlet temperatures(t)	*331 k*
inlet pressure(p)	*101325 pa*
inlet velocity(v)	102.2514

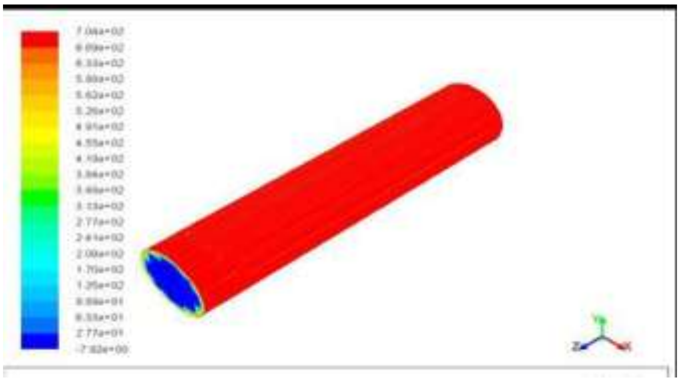
PLAIN ROD

Pressure



From above figure shown Reynolds number 10000 with respect to Contours of

NUSSELT NUMBER

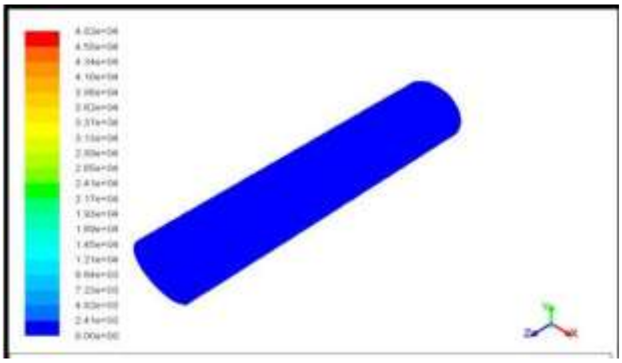


surface Nusselt number will increases6.21e to 6.91e From above figure shown Reynolds number 10000 with respect to Contours of surface Nusselt number will increases6.21e to 6.91e

REYNOLDS NUMBER

From above figure shown Reynolds number 10000 with respect to Contours of surface Nusselt number will increases6.21e to 6.91e

Friction coefficient



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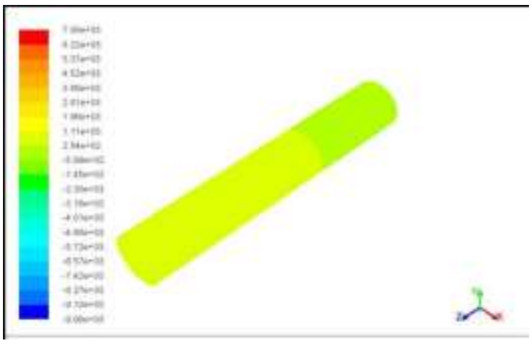
SPIRAL OVER ON ROD

Pressure



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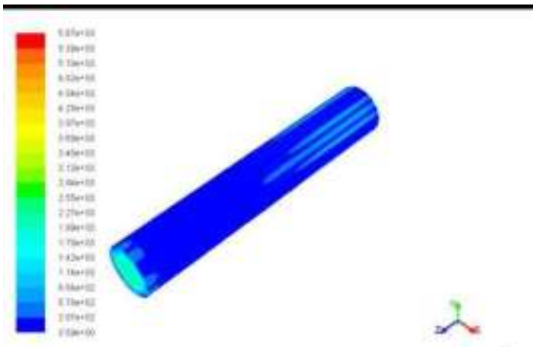
Reynolds number



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Skin friction coefficient

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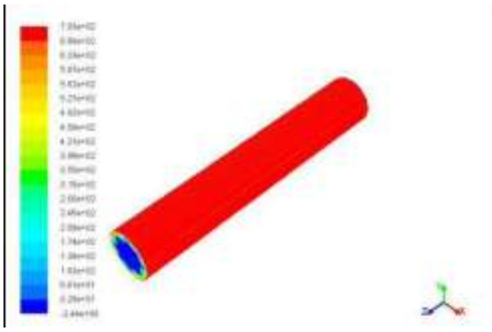
Nusselts number



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SPIRAL AND RECTANGLE BLOCKS OVER ON ROD

Pressure

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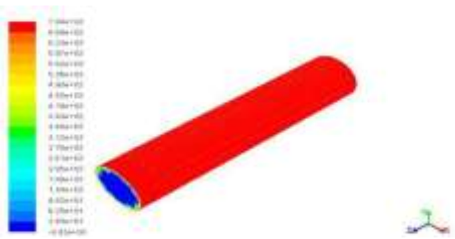
NusseltNumber



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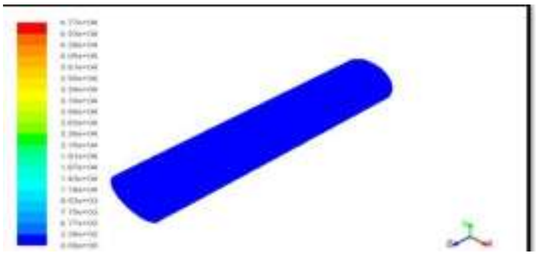
Friction coefficient



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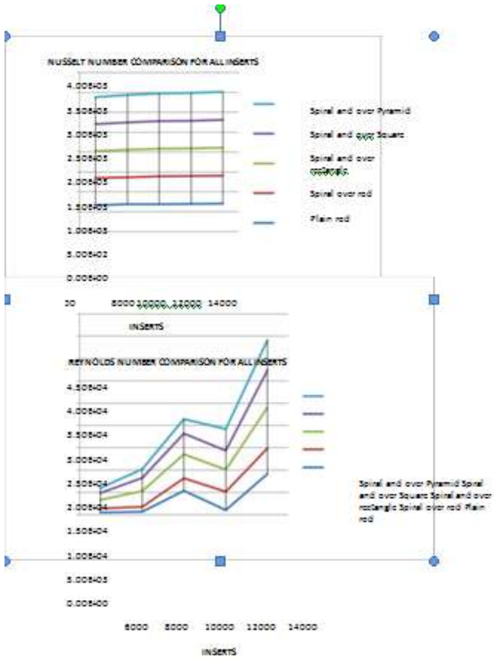
RESULTS AND CONCLUSION

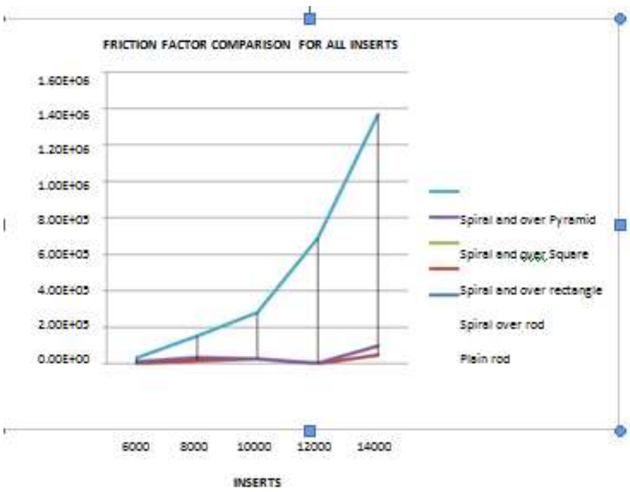
THEORETICAL RESULTS

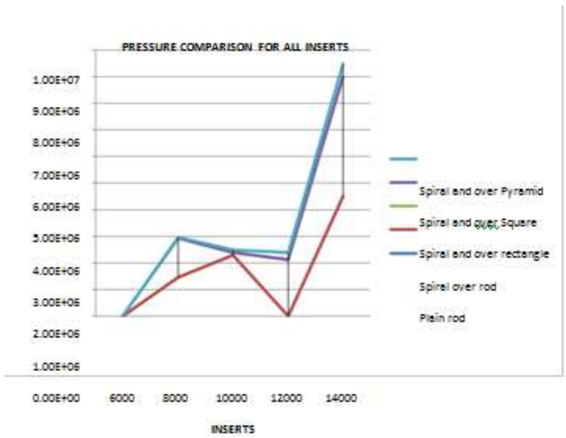
Reynolds number	Nusselt's number	Friction factor
5999.7	20.171	473.98
7999.7	25.391	631.98
9999.8	30.35	789.98
11999.44	35.119	947.98
13999.7	39.73	1105.98

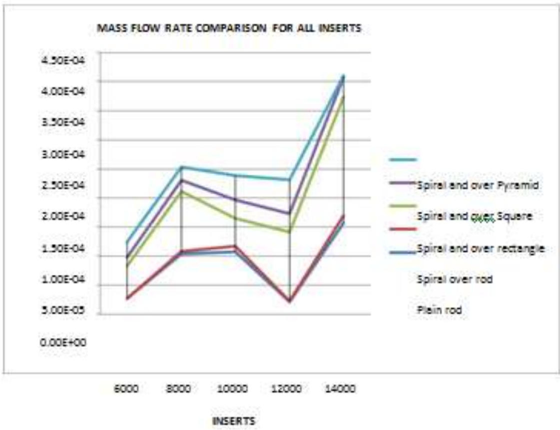
Pipe Type	Pressure (Pa)	Nusselt Number	Reynolds Number	Friction factor	Mass flow rate(Kg/s)	Heat transfer rate(W)
Plain rod	2.29e+06	6.91e+02	5.36e+03	2.54e+04	0.000107437 37	3.600821
Spiral over on rod	3.71e+03	6.95e+02	2.80e+03	2.08e+02	1.0047108e-05	0.37166672
Spiral over on rectangle	9.55e+04	6.97e+02	5.37e+03	1.50e+03	-4.7400594e-05	-1.5165124

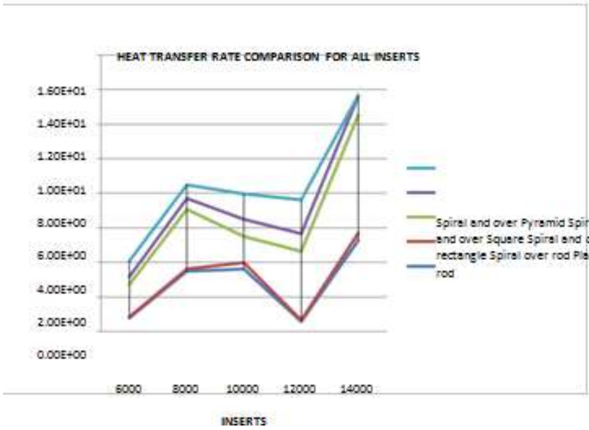
COMPARISON GRAPHS FOR DIFFERENT INSERTS AT DIFFERENT REYNOLDS NUMBER











VI. CONCLUTIONS

- The five different types of inserts used 1) Plain rod 2) Spiral over rod 3) Spiral and square blocks over rod 4) Spiral and rectangle blocks over rod 5) Spiral and pyramid blocks over rod
- CFD analysis is done for different Reynold's number varying from 6000, 8000, 10000, 12000 and 14000. Finite element analysis is done in Ansys to determine Nusselt number, Reynolds number, friction factor, heat transfer rate and mass flow rate and comparison is done between the inserts.
- The Nusselt number is more for spiral over on pyramid than other inserts, friction factor, heat transfer rate, mass flow rate and Reynolds number are more for spiral and pyramid over rod. When compared the results for different Reynolds number, Nusselt number is more at Reynolds number 14000 and decreasing with decrease of Reynolds number. Friction number, mass flow rate, pressure are more at Reynolds number 14000 and it is increase of Reynolds number. The heat transfer rate is more at Reynolds number 14000.
- By observing the above inserts the value of Reynold number and nusselt number and friction factor and mass flow and pressure value is increase maximum in "spiral rod" so I concluded that theat the inserts of spiral rod is better heat transfer enhancement in heat exchanger

S.no. Reynold number	Plain rod	Spiral over on rod	Spiral over on rectangle	Spiral on square	Spiral over on pyramid
10000	3.600821	0.37166672	-1.5105124	-1.0056232	1.452586
12000	- 0.58058844	0.084730413	3.9696711	- 1.01123658	1.9830686
14000	5.535928	0.438259365	6.8288705	-1.0898772	- 0.043541745

Compare the value types of insert : heat transfer rate(W);

Heat transfer rate at Reynolds number

Maximum; spiral rod

Minimum; spiral on square

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