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Numerical and Experimental Analysis of Heat Transfer in Automobile Radiator Using Helical Tubes

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ABSTRACT

Internal combustion engines are cooled by passing a liquid called as engine coolant through the engine block. The coolant gets heated as it absorbs the heat produced in the engine. It then passes through the radiator where it loses heat to the atmosphere. It is then circulated back to the engine in a closed loop. The engine's life, performance and overall safety are ensured due to effective engine cooling.

To ensure smooth running of an automotive vehicle under any variable load conditions, one of the major systems necessary is the cooling system. Automobile radiators are becoming highly power-packed with increasing power to weight or volume ratio.

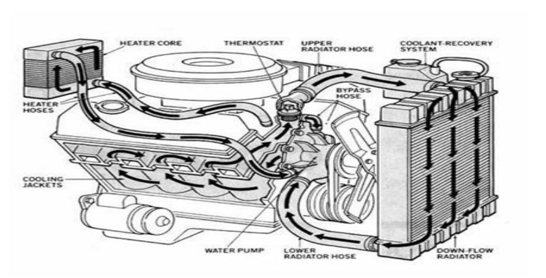
Computational Fluid Dynamics (CFD) is one of the important software tools to access preliminary design and the performance of the radiator. In this thesis, a 55 hp engine radiator data is taken for analysis in CFD. The model is done CREO parametric software and imported in ANSYS.

In this thesis consider both helical type tube and straight tube for the radiator. The comparison is done for helical and straight type tube at different mass flow rates like 2.8, 1.5 kg/sec. In this thesis the CFD analysis to determine the heat dissipate rate and mass flow rate, pressure drop, velocity and heat transfer rate for the both helical type and straight type tube.

Keywords:

1. INTRODUCTION

Radiators are warmth exchangers used to interchange thermal electricity from one medium to any other for the purpose of cooling and heating. The majority of radiators are built to characteristic in cars, houses, and electronics. The radiator is continuously a deliver of warmth to its surroundings, even though this can be for both the purpose of heating this environment, or for cooling the fluid or coolant furnished to it, as for engine cooling. Despite the decision, radiators typically switch the bulk in their heat thru convection, no longer via thermal radiation, although the term "convector" is used greater narrowly; see radiation and convection, underneath. Almost all motors inside the marketplace these days have a type of heat exchanger referred to as a radiator. The radiator is a part of the cooling system of the engine as proven in Figure under. As you may see in the discern, the radiator is simply one of the many components of the complex cooling system. The radiator is the principle a part of the auto's cooling system, and its number one feature is to make sure precisely the proper temperature for the auto's engine to perform at most potential. In other phrases, the engine desires to be simply warm enough, however now not too hot. The faster gasoline is converted to a vapor in the combustion chamber, the greater efficient the whole combustion process and the fewer harmful emissions are launched into the atmosphere. The Roman hypocaust, a form of radiator for constructing space heating, changed into described in 15 AD. The heating radiator become invented by means of way of Franz San Galli, a Polish-born Russian businessman dwelling in St. Petersburg, between 1855 and 1857



Coolant path and Components of an Automobile Engine Cooling System

Fig 1(a)Coolant path and Components of an Automobile Engine Cooling System

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Water-air convective cooling radiator

Fig 1(b)Water-air convective cooling radiator

1.1 INTRODUCTION TO CAD

Computers are being used increasingly for both design and detailing of engineering components in the drawing office. Computer-aided design (CAD) is defined as the application of computers and graphics software to aid or enhance the product design from conceptualization to documentation. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as a CAD system.

1.2 INTRODUCTION TO PRO/ENGINEER

Pro/ENGINEER, PTC's parametric,integrated3D CAD/CAM/CAE solution, is used by discrete manufacturers for mechanical engineering, design and manufacturing. This powerful and rich design approach is used by companies whose product strategy is family-based or platform-driven, where a prescriptive design strategy is critical to the success of the design process by embedding engineering constraints and relationships to quickly optimize the design, or where the resulting geometry may be complex or based upon equations. Pro/ENGINEER provides a complete set of design, analysis and manufacturing capabilities on one, integral, scalable platform.

1.3 INTRODUCTION TO FEA

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition.In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

1.4 INTRODUCTION TO ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated, or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyze by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations. ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping.

2. LITERATURE REVIEW

The literature overview on this thesis is taken from paper done by way of Junjanna G.C[1] wherein the look at makes use of the computational evaluation device ANSYS Fluent 13.Zero to carry out a numerical take a look at on a compact heat exchanger. The computational domain is identified from literature and validation of present numerical method is set up first. Later the numerical analysis is prolonged with the aid of modifying selected geometrical and drift parameters like louver pitch, air waft charge, water flow rate, fin and louver thickness, by various one parameter at a time and the consequences are as compared. Recommendations has been made on the optimum values and settings primarily based on the variables examined, for the selected compact warmness exchanger.In another paper by JP Yadav and Bharat Raj Singh[2] in which a complete set of numerical parametric studies on automotive radiator has been presented in detail in this study. The modeling of radiator has been described by two methods, one is finite difference method and the other is thermal resistance concept. In the performance evaluation, a radiator is installed into a test-setup and the various parameters including mass flow rate of coolant, inlet coolant temperature; etc. are varied. A comparative analysis between different coolants is also shown. One coolant as water and other as mixture of water in propylene glycol in a ratio of 40:60 is used. It is observed that that the water is still the best coolant but its limitation is that

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it is corrosive and contains dissolved salts that degrade the coolant flow passage. In the paper performed by Durgesh Kumar Chavan and Ashok T. Pise[3]experimental tests of forced convective heat transfer in an Al_2O_3/water nanofluid has experimentally been compared to that of pure water in automobile radiator.

3. CFD ANALYSIS OF RADIATOR

CASE -1 STRAIGHT TUBE

At Mass Flow Rate-2.8 Kg/Sec

3.1 FLUID-AIR

3.1.1 Static Pressure

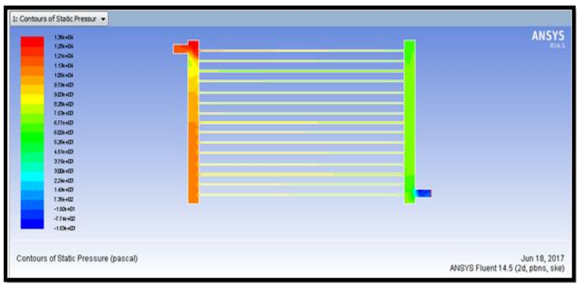


Fig 3.1.1 Static Pressure

3.1.2 Static Temperature

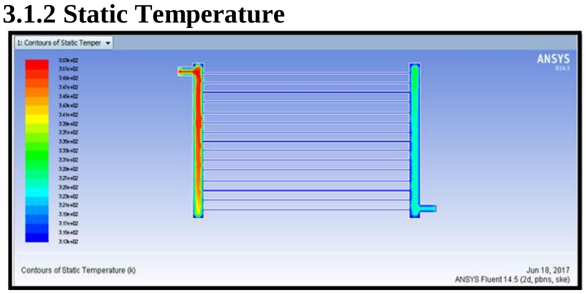
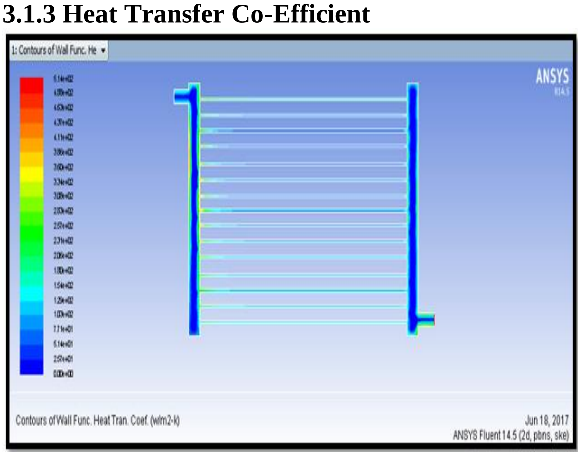


Fig 3.1.2 Static Temperature

3.1.3 Heat Transfer Co-Efficient



. Fig 3.1.3 Heat Transfer Co-EfficientReports

```
         Mass Flow Rate                  (kg/s)
-------------------------------- --------------------
                   inlet                       2.8
     interior-_trm_srf                  39.945717
                  outlet                 -2.799525
          wall-_trm_srf                          0
-------------------------------- --------------------
                     Net          0.00047492981
```

Total Heat Transfer Rate (w)

```
Total Heat Transfer Rate                        (w)
-------------------------------- --------------------
                   inlet                  154571.05
                  outlet                -77722.539
          wall-_trm_srf                 -76829.977
-------------------------------- --------------------
                     Net                  18.53125
```

3.2 FLUID-Al_2O_3

3.2.1 Static Pressure

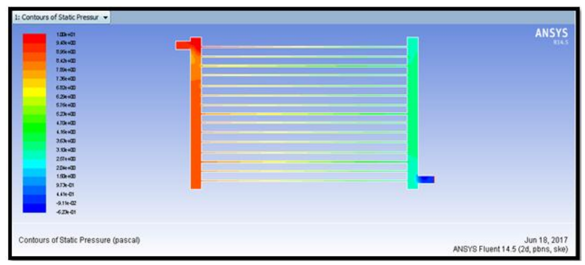


Fig 3.2.1 Static Pressure

3.2.2 Static Temperature

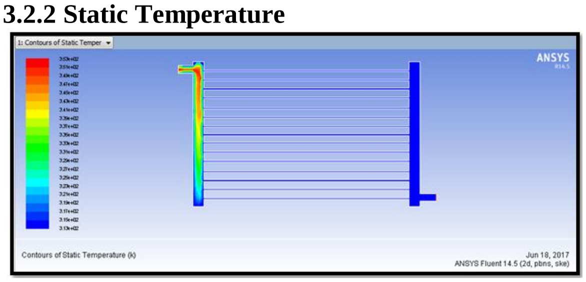


Fig 3.2.2 Static Temperature

3.2.3 Heat Transfer Co-Efficient

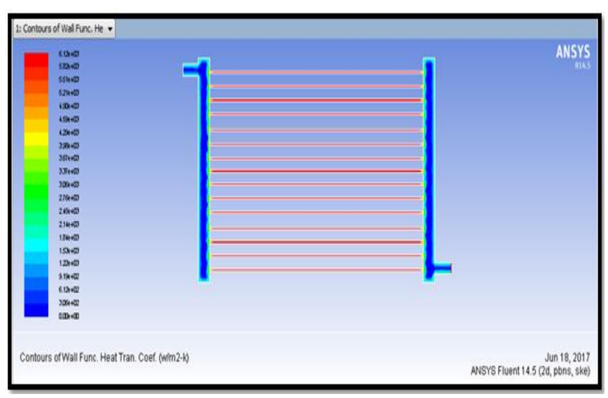


Fig 3.2.3 Heat Transfer Co-Efficient

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Reports

Mass Flow Rate	(kg/s)
inlet	2.8
interior-_trm_srf	45.036198
outlet	-2.8000147
wall-_trm_srf	0
Net	-1.4781952e-05

HEAT TRANSFER RATE

Total Heat Transfer Rate	(w)
inlet	250451.97
outlet	-67785.891
wall-_trm_srf	-182665.75
Net	0.328125

At Mass Flow Rate-1.5 Kg/Sec

3.3FLUID-AIR

3.3.1 Static Pressure

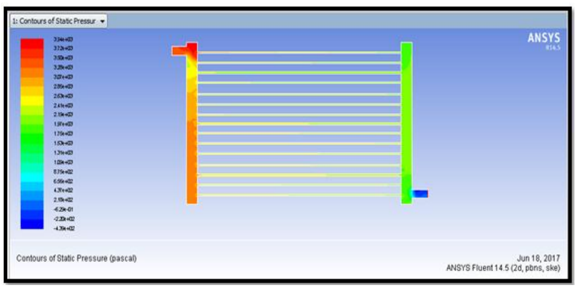

Fig 3.3.1 Static Pressure

3.3.2 Static Temperature

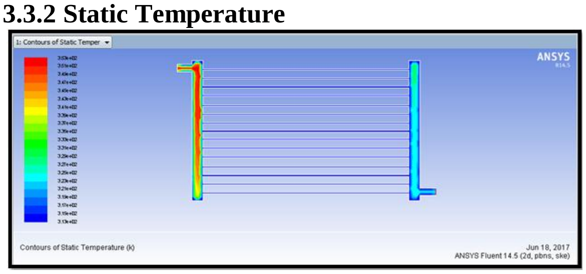

Fig 3.3.2 Static Temperature

3.3.3.Heat Transfer Co-Efficient

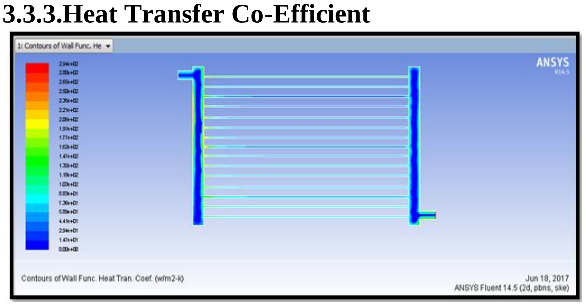

Fig 3.3.3 Heat Transfer Co-Efficient

Reports

MASS FLOW RATE

Mass Flow Rate	(kg/s)
inlet	1.5
interior-_trm_srf	21.550976
outlet	-1.4997886
wall-_trm_srf	0
Net	0.00021135807

HEAT TRANSFER RATE

Total Heat Transfer Rate	(w)
inlet	82806.078
outlet	-38828.328
wall-_trm_srf	-43970.742
Net	7.0078125

3.4FLUID-Al_2O_3

3.4.1 Static Pressure

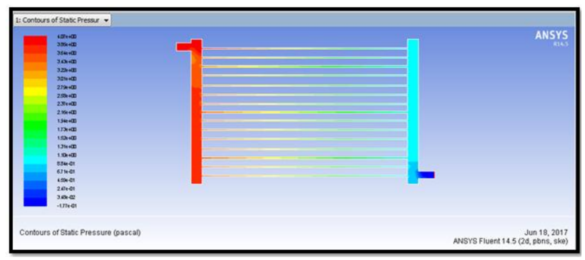

Fig 3.4.1 Static Pressure

3.4.2 Static Temperature

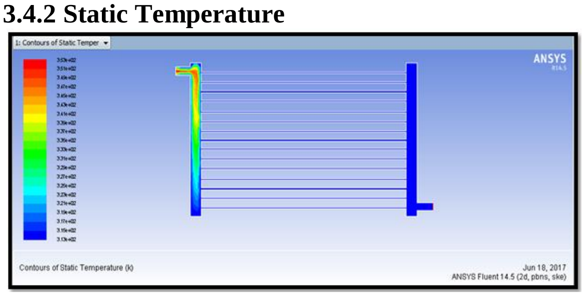

Fig 3.4.2 Static Temperature

3.4.3 Heat Transfer Co-Efficient

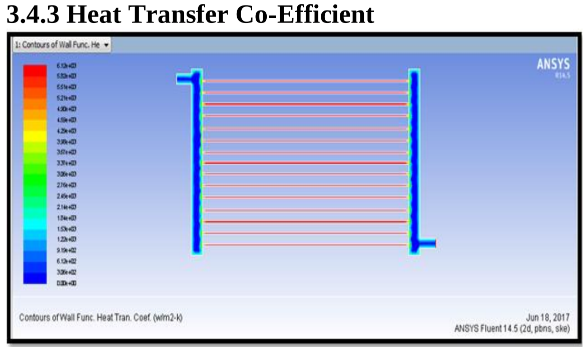

Fig 3.4.3 Heat Transfer Co-Efficient

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Reports

MASS FLOW RATE

Mass Flow Rate	(kg/s)
inlet	1.5
interior-_trm_srf	24.826609
outlet	-1.5000656
wall-_trm_srf	0
Net	-6.5565109e-05

HEAT TRANSFER RATE

Total Heat Transfer Rate	(w)
inlet	134245.33
outlet	-36315.246
wall-_trm_srf	-97930.805
Net	-0.72265625

4. CFD ANALYSIS OF HELICAL TUBE RADIATOR

CASE -2 HELICAL TUBE

At Mass Flow Rate-2.8 Kg/Sec

4.1FLUID-AIR

4.1.1 Static Pressure

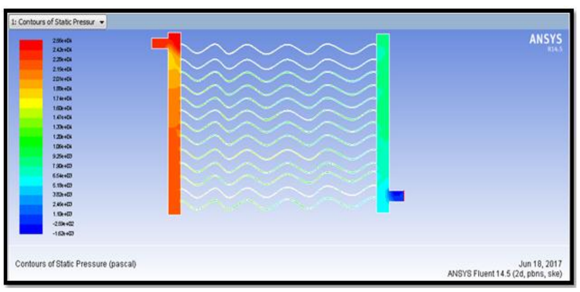

Fig 4.1.1 Static Pressure

4.1.2 Static Temperature

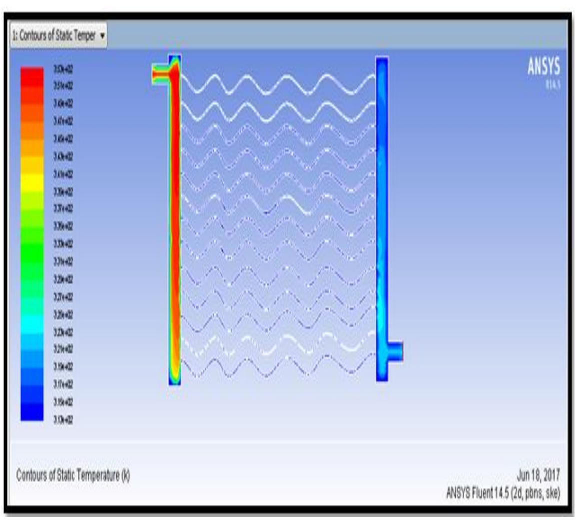

Fig 4.1.2 Static Temperature

4.1.3 Heat Transfer Co-Efficient

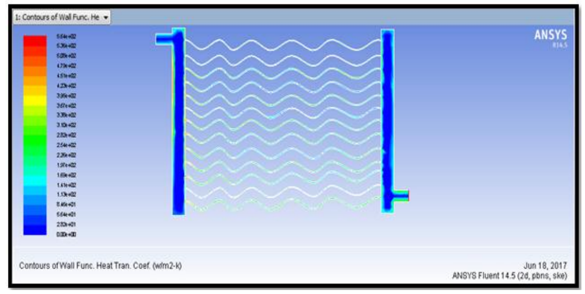

Fig 4.1.3 Heat Transfer Co-Efficient

Reports

Mass Flow Rate	(kg/s)
inlet	2.8
interior-_trm_srf	139.43919
outlet	-2.800086
wall-_trm_srf	0
Net	-8.6069107e-05

Total Heat Transfer Rate (w)

Total Heat Transfer Rate	(w)
inlet	154570.94
outlet	-68237.5
wall-_trm_srf	-86606.688
Net	-273.25

4.2FLUID-Al_2O_3

4.2.1 Static Pressure

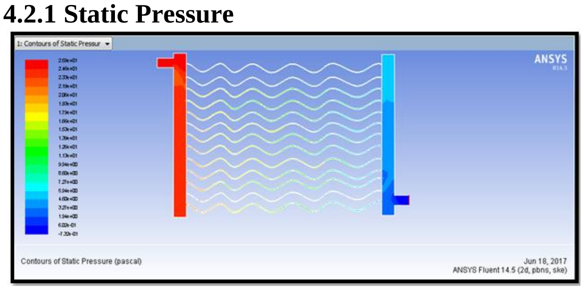

Fig 4.2.1 Static Pressure

4.2.2 Static Temperature

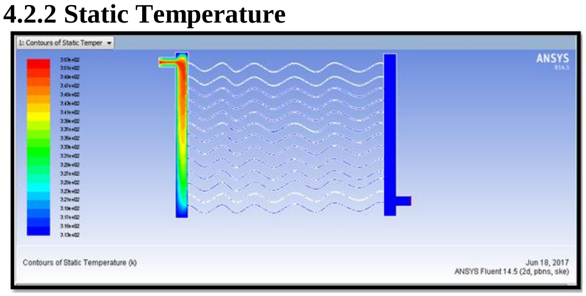

Fig 4.2.2 Static Temperature

4.2.3 Heat Transfer Co-Efficient

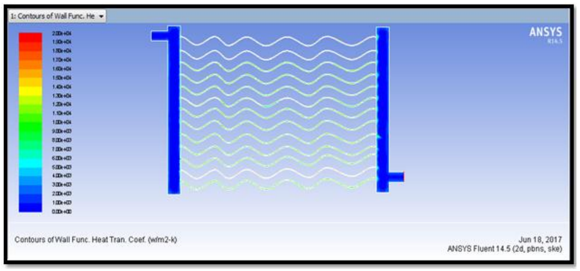

Fig 4.2.3 Heat Transfer Co-Efficient

Reports

Mass Flow Rate	(kg/s)
inlet	2.8
interior-_trm_srf	150.78084
outlet	-2.8000073
wall-_trm_srf	0
Net	-7.390976e-06

HEAT TRANSFER RATE

Total Heat Transfer Rate	(w)
inlet	250448.34
outlet	-67785.414
wall-_trm_srf	-182663.77
Net	-0.8359375

At Mass Flow Rate-1.5 Kg/Sec

4.3FLUID-AIR

4.3.1 Static Pressure

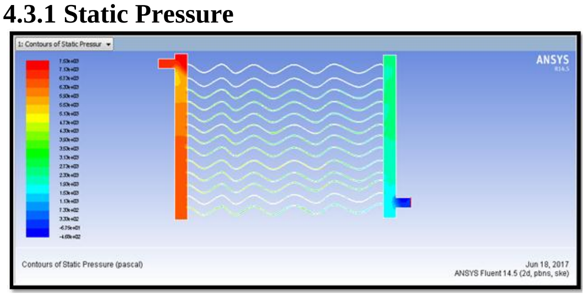

Fig 4.3.1 Static Pressure

4.3.2 Static Temperature

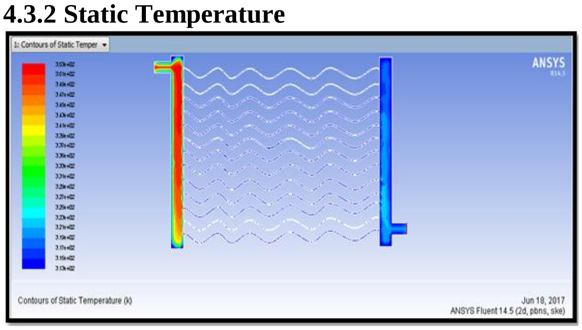

Fig 4.3.2 Static Temperature

4.3.3 Heat Transfer Co-Efficient

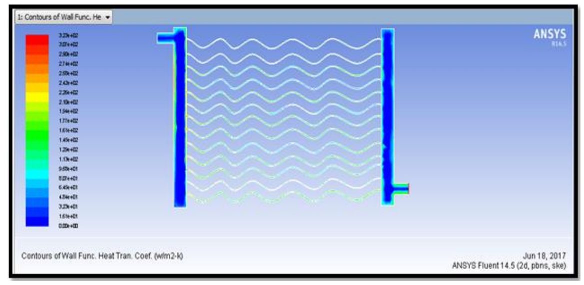

Fig 4.3.3 Heat Transfer Co-Efficient

Reports

MASS FLOW RATE

Mass Flow Rate	(kg/s)
inlet	1.4999999
interior-_trm_srf	75.010414
outlet	-1.5000232
wall-_trm_srf	0
Net	-2.3365021e-05

HEAT TRANSFER RATE

Total Heat Transfer Rate	(w)
inlet	82806.016
outlet	-34098.414
wall-_trm_srf	-48857.777
Net	-150.17578

4.4FLUID-Al_2O_3

4.4.1 Static Pressure

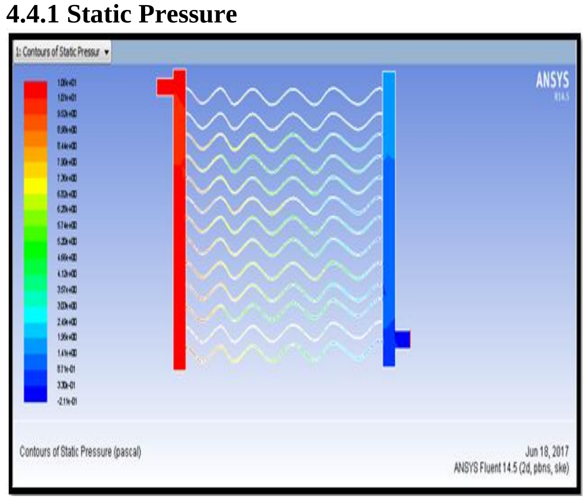

Fig 4.4.1 Static Pressure

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4.4.2 Static Temperature

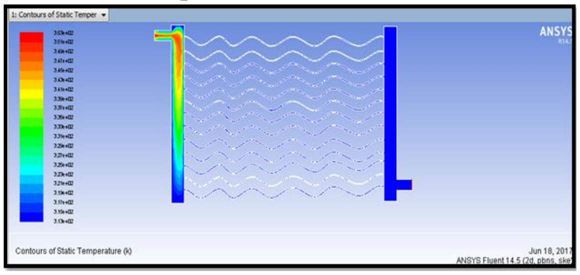

Fig 4.4.2 Static Temperature

4.4.3 Heat Transfer Co-Efficient

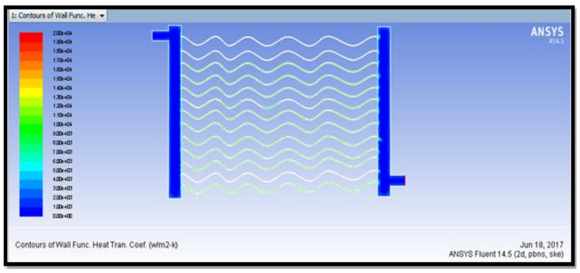

Fig 4.4.3 Heat Transfer Co-Efficient

Reports

MASS FLOW RATE

```
        Mass Flow Rate                          (kg/s)
-------------------- --------------------
                 inlet                       1.4999999
     interior-_trm_srf                       81.493301
                outlet                      -1.5000036
          wall-_trm_srf                               0
     ---------------- --------------------
                   Net                   -3.695488e-06
```

HEAT TRANSFER RATE

```
 Total Heat Transfer Rate                          (w)
-------------------------- --------------------
                     inlet                    134240.8
                    outlet                  -36313.535
             wall-_trm_srf                  -97927.539
         ---------------- --------------------
                       Net                 -0.27734375
```

5. RESULT TABELS

CASE 1-STRAIGHT TUBE

MASS FLOW RATE(Kg/sec)	Fluid	Pressure (Pa)	Temperature (k)	Heat transfer coefficient	Mass flow rate (Kg/sec)	Heat transfer rate (w)
2.8	Air	1.36e+04	3.53e+02	5.14e+02	0.000474	18.53125
	Water	2.09e+01	3.53e+02	9.08e+02	0.0003764	61.984
	Al_2O_3	1.00e+01	3.53e+02	6.09e+03	1.47e-05	0.32815
1.5	Air	3.94e+03	3.53e+02	2.94e+02	0.002113	7.007
	Water	7.25e+00	3.53e+02	5.23e+02	0.000204	32.406
	Al_2O_3	4.03e+00	3.53e+02	6.12e+03	6.55e-05	0.722

CASE 2 -HELICAL TUBE

MASS FLOW (Kg/sec)	Fluid	Pressure (Pa)	Temperature (k)	Heat transfer coefficient	Mass flow rate (Kg/sec)	Heat transfer rate (w)
2.8	Air	2.56E+04	3.53E+02	5.64E+02	8.60e-05	273.25
	Water	4.85e+01	3.53e+02	9.31e+02	2.16e-05	463.468
	Al_2O_3 nano fluid	2.59e+01	3.53e+02	2.00e+04	7.39e-06	0.83959
1.5	Air	7.53e+03	3.53e+02	3.23e+04	2.33e-05	150.17
	Water	1.82e+01	3.53e+02	7.84e+02	1.15e-05	55.031
	Al_2O_3 nano fluid	1.06e+01	3.53e+02	1.97e+02	3.96e-06	0.277

6. CONCLUSION

In this thesis, one of a kind nano fluids blended with base fluid water are analyzed for his or her overall performance in the radiator. In this mission the one-of-a-kind forms of fluids are carried out in radiator. The fluids are water, air and aluminum oxide nano fluid.

3-D version of the radiator is finished in CREO parametric software. CFD analysis is accomplished at the radiator for all fluids and thermal analysis is achieved in Ansys.

By observing the CFD analysis the heat transfer coefficient values are will increase through increasing the mass float inlet. When we examine the fluids the aluminum oxide nano fluid is the higher fluid because the warmth switch fee cost is extra at fluid aluminum oxide nano fluid.

When we compare the specific geometries of radiator the helical kind tube is the better model due to the fact the heat switch fee cost is extra for helical kind tube radiator is higher version.

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