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# CFD and Heat Transfer Analysis of Automobile Radiator Using Helical Tubes

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**ABSTRACT:** In cooling system of automobile engine the water is evaporate at high temperature, so we need to add water and also water is low capacity of absorb heat. Cooling system plays important roles to control the temperature of car's engine. One of the important elements in the car cooling system is cooling fluid. The usage of wrong cooling fluid can give negatives impact to the car's engine and shorten engine life. An efficient cooling system can prevent engine from overheating and assists the vehicle running at its optimal performance. In this thesis, different nano fluids mixed with base fluid water are analyzed for their performance in the helical type tube and straight type tube radiator. In this project the different types of fluids are applied in radiator. The fluids are water, air and aluminum oxide nano fluid. 3D model of the radiator is done in CREO parametric software. CFD analysis is done on the radiator for all fluids and thermal analysis is done in Ansys.

## I. INTRODUCTION TO AUTOMOBILE RADIATOR

Radiators are heat exchangers used to transfer thermal energy from one medium to another for the purpose of cooling and heating. The majority of radiators are constructed to function in automobiles, buildings, and electronics. The radiator is always a source of heat to its environment, although this may be for either the purpose of heating this environment, or for cooling the fluid or coolant supplied to it, as for engine cooling. Despite the name, radiators generally transfer the bulk of their heat via convection, not by thermal radiation, though the term "convector" is used more narrowly; see radiation and convection, below. The Roman hypocaust, a type of radiator for building space heating, was described in 15 AD. The heating radiator was invented by Franz San Galli, a Polish-born Russian businessman living in St. Petersburg, between 1855 and 1857.



Water-air convective cooling radiator

## RADIATION AND CONVECTION

One might expect the term "radiator" to apply to devices that transfer heat primarily by thermal radiation (see: infrared heating), while a device which relied primarily on natural or forced convection would be called a "convector". In practice, the term "radiator" refers to any of a number of devices in which a liquid circulates through exposed pipes (often with fins or other means of increasing surface area), notwithstanding that such devices tend to transfer heat

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mainly by convection and might logically be called convectors. The term "convector" refers to a class of devices in which the source of heat is not directly exposed.

## Heating



Radiator typical of a convective central heating system

Radiators are commonly used to heat buildings. In a central heating system, hot water or sometimes steam is generated in a central boiler, and circulated by pumps through radiators within the building. There are two types: Single-pipe and double-pipe. The single-pipe radiators work with steam, while the double-pipe radiators work with steam or hot water.

## Engine cooling

Auto radiators with a double grid tubes, staggered grids with left, right with parallel grids

Radiators are used for cooling internal combustion engines, mainly in automobiles but also in piston-engined aircraft, railway locomotives, motorcycles, stationary generating plants and other places where such engines are used.

To cool down the engine, a coolant is passed through the engine block, where it absorbs heat from the engine. The hot coolant is then fed into the inlet tank of the radiator and distributed across the radiator core. As the coolant circulates through the radiator tubes on its way to the opposite tank, it cools again. The cold coolant is fed back to the engine, and the cycle repeats.

This coolant is usually water-based, with the addition of glycols to prevent freezing and other additives to limit corrosion, erosion and cavitation. However, the coolant may also be an oil. The first engines used thermosiphons to circulate the coolant; today, however, all but the smallest engines use pumps.

As it circulates through the tubes, the coolant transfers its heat to the tubes which, in turn, transfer the heat to the fins that are lodged between each row of tubes. The fins then release the heat to the ambient air. Fins are used to greatly increase the contact surface of the tubes to the air, thus increasing the exchange efficiency.

Up to the 1980s, radiator cores were often made of a copper (for fins) and brass (for tubes, headers, side-plates, while tanks could be made also of brass or of plastic, often a polyamide). Starting in the 1970s, use of aluminium increased to take over the vast majority of vehicular applications. The main drivers for aluminum are reduced weight and cost. However, the superior cooling properties of Copper-Brass over Aluminium makes it preferential for high performance vehicles or stationary applications. In particular MW-class installations, copper-brass constructions are still dominant (See: Copper in heat exchangers). CuproBraz is a copper-alloy heat exchanger technology for harsh temperature and pressure environments such as those in the latest generations of cleaner diesel engines mandated by environmental regulations.[3][4] Its performance advantages over radiators made with other materials include better thermal performance, heat transfer, size, strength, durability, emissions, corrosion resistance, repairability, and antimicrobial benefits.

Since air has a lower heat capacity and density than liquid coolants, a fairly large volume flow rate (relative to the coolant's) must be blown through the radiator core to capture the heat from the coolant. Radiators often have one or more fans that blow air through the radiator. To save fan power consumption in vehicles, radiators are often behind the grille at the front end of a vehicle. Ram air can give a portion or all of the necessary cooling air flow, and the fan remains disengaged.

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## Electronics



A passive heatsink on a motherboard

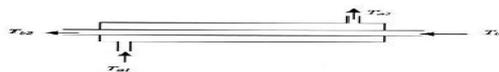
As electronic devices become smaller, the problem of dispersing waste heat becomes more difficult. Tiny radiators known as heat sinks are used to convey heat from the electronic components into a cooling air stream. Heat is transferred to the air by conduction and convection; a relatively small proportion of heat is transferred by radiation owing to the low temperature of semiconductor devices compared to their surroundings.



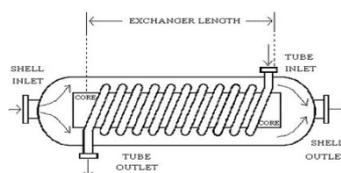
Large oil-filled power transformers will have radiators to cool the insulating oil (left side of this photo); some units rely on natural circulation of oil through the radiator, others use pumps. Often transformer radiators will have fans to increase air flow and transformer power rating. Radiators are found in fluid power systems and air compressors to cool working fluids.

## HEAT EXCHANGERS

A steady-state heat exchanger consists of a fluid flowing through a pipe or system of pipes, where heat is transferred from one fluid to another. Heat exchangers are very common in everyday life and can be found almost anywhere. Some common examples of heat exchangers are air conditioners, automobile radiators, and a hot water heater. A schematic of a simple heat exchanger is shown in Figure below. Fluid flows through a system of pipes and takes heat from a hotter fluid and carries it away. Essentially it is exchanging heat from the hotter fluid to the cooler fluid.



## II. SIMPLE HEAT EXCHANGER HELICAL-COIL HEAT EXCHANGERS



Helical-Coil Heat Exchanger sketch, which consists of a shell, core, and tubes (Scott S. Haraburda design).

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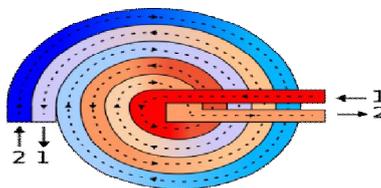
Although double-pipe heat exchangers are the simplest to design, the better choice in the following cases would be the helical-coil heat exchanger (HCHE):

- The main advantage of the HCHE, like that for the SHE, is its highly efficient use of space, especially when it's limited and not enough straight pipe can be laid
- than its shell and tube counterpart; however the helical coil unit would require cleaning less often.

These have been used in the nuclear industry as a method for exchanging heat in a sodium system for large liquid metal fast breeder reactors since the early 1970s, using an HCHE device invented by Charles E. Boardman and John H. Germer. There are several simple methods for designing HCHE for all types of manufacturing industries, such as using the Ramachandra K. Patil (et al.) method from India and the Scott S. Haraburda method from the United States.

However, these are based upon assumptions of estimating inside heat transfer coefficient, predicting flow around the outside of the coil, and upon constant heat flux. Yet, recent experimental data revealed that the empirical correlations are quite in agreement for designing circular and square pattern HCHes. During studies published in 2015, several researchers found that the boundary conditions of the outer wall of exchangers were essentially constant heat flux conditions in power plant boilers, condensers and evaporators; while convective heat transfer conditions were more appropriate in food, automobile and process industries.<sup>1</sup>

## SPIRAL HEAT EXCHANGERS



Schematic drawing of a spiral heat exchanger.

A modification to the perpendicular flow of the typical HCHE involves the replacement of shell with another coiled tube, allowing the two fluids to flow parallel to one another, and which requires the use of different design calculations.<sup>[26]</sup> These are the [Spiral](#) Heat Exchangers (SHE), which may refer to a [helical](#) (coiled) tube configuration, more generally, the term refers to a pair of flat surfaces that are coiled to form the two channels in a counter-flow arrangement. Each of the two channels has one long curved path. A pair of fluid ports are connected [tangentially](#) to the outer arms of the spiral, and axial ports are common, but optional.

The main advantage of the SHE is its highly efficient use of space. This attribute is often leveraged and partially reallocated to gain other improvements in performance, according to well known tradeoffs in heat exchanger design. (A notable tradeoff is capital cost vs operating cost.) A compact SHE may be used to have a smaller footprint and thus lower all-around capital costs, or an oversized SHE may be used to have less [pressure](#) drop, less pumping [energy](#), higher [thermal efficiency](#), and lower energy costs.

### Construction

The distance between the sheets in the spiral channels is maintained by using spacer studs that were welded prior to rolling. Once the main spiral pack has been rolled, alternate top and bottom edges are welded and each end closed by a gasketed flat or conical cover bolted to the body. This ensures no mixing of the two fluids occurs. Any leakage is from the periphery cover to the atmosphere, or to a passage that contains the same fluid.

### Self cleaning

Spiral heat exchangers are often used in the heating of fluids that contain solids and thus tend to foul the inside of the heat exchanger. The low pressure drop lets the SHE handle fouling more easily. The SHE uses a "self cleaning" mechanism, whereby fouled surfaces cause a localized increase in fluid velocity, thus increasing the [drag](#) (or

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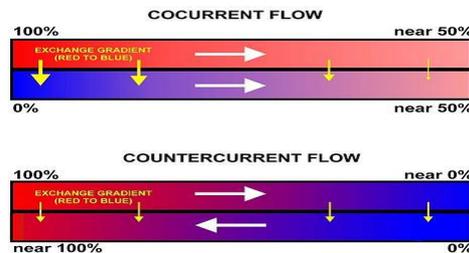
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fluid [friction](#)) on the fouled surface, thus helping to dislodge the blockage and keep the heat exchanger clean. "The internal walls that make up the heat transfer surface are often rather thick, which makes the SHE very robust, and able to last a long time in demanding environments. They are also easily cleaned, opening out like an [oven](#) where any buildup of foulant can be removed by [pressure washing](#). Self-Cleaning Water filters are used to keep the system clean and running without the need to shut down or replace cartridges and bag

Flow arrangements



A comparison between the operations and effects of a **cocurrent and a countercurrent flow exchange system** is depicted by the upper and lower diagrams respectively. In both it is assumed (and indicated) that red has a higher value (e.g. of temperature) than blue and that the property being transported in the channels therefore flows from red to blue. Note that channels are contiguous if effective exchange is to occur (i.e. there can be no gap between the channels).

There are three main types of flows in a spiral heat exchanger:

- **Counter-current Flow:** Fluids flow in opposite directions. These are used for liquid-liquid, condensing and gas cooling applications. Units are usually mounted vertically when condensing vapour and mounted horizontally when handling high concentrations of solids.
- **Spiral Flow/Cross Flow:** One fluid is in spiral flow and the other in a cross flow. Spiral flow passages are welded at each side for this type of spiral heat exchanger. This type of flow is suitable for handling low density gas, which passes through the cross flow, avoiding pressure loss. It can be used for liquid-liquid applications if one liquid has a considerably greater flow rate than the other.
- **Distributed Vapour/Spiral flow:** This design is that of a condenser, and is usually mounted vertically. It is designed to cater for the sub-cooling of both condensate and non-condensables. The coolant moves in a spiral and leaves via the top. Hot gases that enter leave as condensate via the bottom outlet.

Applications

The Spiral heat exchanger is good for applications such as pasteurization, digester heating, heat recovery, pre-heating (see: [recuperator](#)), and effluent cooling. For sludge treatment, SHEs are generally smaller than other types of heat exchangers<sup>1</sup> These are used to transfer the heat.

Selection

Due to the many variables involved, selecting optimal heat exchangers is challenging. Hand calculations are possible, but many iterations are typically needed. As such, heat exchangers are most often selected via computer programs, either by system designers, who are typically [engineers](#), or by equipment vendors.

To select an appropriate heat exchanger, the system designers (or equipment vendors) would firstly consider the design limitations for each heat exchanger type. Though cost is often the primary criterion, several other selection criteria are important:

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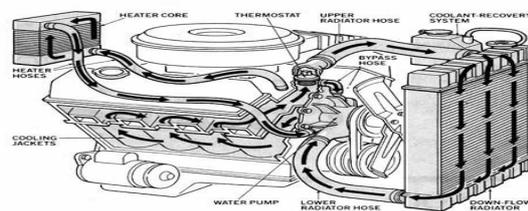
- High/low pressure limits
- Thermal performance
- Temperature ranges
- Product mix (liquid/liquid, particulates or high-solids liquid)
- Pressure drops across the exchanger
- Fluid flow capacity
- Cleanability, maintenance and repair
- Materials required for construction
- Ability and ease of future expansion
- Material selection, such as [copper](#), [aluminum](#), [carbon steel](#), [stainless steel](#), [nickel alloys](#), [ceramic](#), [polymer](#), and [titanium](#).

Small-diameter coil technologies are becoming more popular in modern air conditioning and refrigeration systems because they have better rates of heat transfer than conventional sized condenser and evaporator coils with round copper tubes and aluminum or copper fin that have been the standard in the HVAC industry. Small diameter coils can withstand the higher pressures required by the new generation of environmentally friendlier refrigerants. Two small diameter coil technologies are currently available for air conditioning and refrigeration products: [copper microgroove<sup>\[29\]</sup>](#) and brazed aluminum microchannel.

Choosing the right heat exchanger (HX) requires some knowledge of the different heat exchanger types, as well as the environment where the unit must operate. Typically in the manufacturing industry, several differing types of heat exchangers are used for just one process or system to derive the final product. For example, a kettle HX for pre-heating, a double pipe HX for the ‘carrier’ fluid and a plate and frame HX for final cooling. With sufficient knowledge of heat exchanger types and operating requirements, an appropriate selection can be made to optimise the process.

### III. WORKING OF AUTOMOBILE RADIATORS

Almost all automobiles in the market today have a type of heat exchanger called a radiator. The radiator is part of the cooling system of the engine as shown in Figure below. As you can see in the figure, the radiator is just one of the many components of the complex cooling system.



Coolant path and Components of an Automobile Engine Cooling System Most modern cars use aluminum radiators. These radiators are made by brazing thin aluminum fins to flattened aluminum tubes. The coolant flows from the inlet to the outlet through many tubes mounted in a parallel arrangement. The fins conduct the heat from the tubes and transfer it to the air flowing through the radiator.

The tubes sometimes have a type of fin inserted into them called a **turbulator**, which increases the turbulence of the fluid flowing through the tubes. If the fluid flowed very smoothly through the tubes, only the fluid actually touching the tubes would be cooled directly. The amount of heat transferred to the tubes from the fluid running through them depends on the difference in temperature between the tube and the fluid touching it. So if the fluid that is in contact with the tube cools down quickly, less heat will be transferred. By creating turbulence inside the tube, all of the fluid

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mixes together, keeping the temperature of the fluid touching the tubes up so that more heat can be extracted, and all of the fluid inside the tube is used effectively. Radiators usually have a tank on each side, and inside the tank is a transmission cooler. In the picture above, you can see the inlet and outlet where the oil from the transmission enters the cooler. The transmission cooler is like a radiator within a radiator, except instead of exchanging heat with the air, the oil exchanges heat with the coolant in the radiator. Your car radiator keeps your engine cool. When a car's engine is switched on and running, it generates a great amount of heat, most of which is expelled through the exhaust system. The rest of it sits stagnant in the engine area, and although engines need heat to operate at an optimum level, too much heat will destroy the inner mechanics of your engine. Once those pistons and cylinders start melting together, it'll mean the end of your engine – indefinitely. The radiator is the main part of the car's cooling system, and its primary function is to ensure exactly the right temperature for the car's engine to operate at maximum potential. In other words, the engine needs to be just hot enough, but not too hot. The quicker fuel is converted to a vapor in the combustion chamber, the more efficient the whole combustion process and the fewer harmful emissions are released into the atmosphere. An engine running at the right temperature also means that the oil lubricating the engine is of the perfect consistency to keep the parts turning over smoothly, ensuring a longer lifespan.

Usually fashioned from aluminum, a car radiator is comprised of an arrangement of tubes which pass through the engine. The tubes carry a liquid coolant throughout the engine bay to provide relief to the car parts that heat up. The engine's overall temperature is monitored by a thermostat which opens up once the normal operating temperature is surpassed. A water pump, along with a series of belts and hoses, helps the coolant circulate the engine while fan belt keeps the fan spinning. A radiator's job is to facilitate the transfer of heat from the cooling liquid to the air blown in from the radiator fan, or exchanger. Older cars are cooled by means of an air cooling system that directs hot air away from the engine's cylinder and cool air towards the engine bay via a strong fan. One of most common radiator-related problems is the overheating that occurs when the thermostat malfunctions. This will seriously compromise your vehicle's performance and emission levels, so if you're stuck with an overheated engine plus clouds emanating from the exhaust pipe, the thermostat probably needs attention. Overheating can also be caused by leaking coolant. It's best to check the whole cooling system, including all the hoses, the radiator itself, as well as the radiator cap and all the plugs. Besides overheating, the radiator can also become blocked or clogged with dirt particles and severely restrict its ability to dispel heat in the engine bay. The cooling process itself might also be hampered by a clogged exhaust system or constant aggressive driving. Pushing your car unnecessarily hard will begin to take its toll on the whole car and render the engine prone to overheating and lackluster performance. No matter the year or the make of your car, it's still a giant hunk of machinery that needs to be maintained. All cars generate heat, and all cars have cooling systems that work hard to keep the inner mechanics cool. Of course the radiator doesn't work alone, but it's best kept in good working order if you like driving a car that starts first time every time. Most commonly made out of aluminum, automobile radiators utilize a cross-flow heat exchanger design. The two working fluids are generally air and coolant (50-50 mix of water and ethyleneglycol). As the air flows through the radiator, the heat is transferred from the coolant to the air. The purpose of the air is to remove heat from the coolant, which causes the coolant to exit the radiator at a lower temperature than it entered at. The benchmark for heat transfer of current radiators is 140 kW of heat at an inlet temperature of 95 °C. The basic radiator has a width of 0.5-0.6 m (20-23"), a height of 0.4-0.7 m (16-27"), and a depth of 0.025-0.038 m (1-1.5"). These dimensions vary depending on the make and model of the automobile. For current radiator designs, a common configuration is to use parallel tubes which have aluminum fins attached to them. In these designs, there are basically three modes of heat transfer: conduction between tube walls and fins, and two modes of convection. One mode of convection is due to the coolant flowing in the tubes and the second is caused by the air flowing through the radiator. Associated with each type of heat transfer is a thermal resistance which obstructs the heat transfer rate. These resistances are summarized in Figure below.

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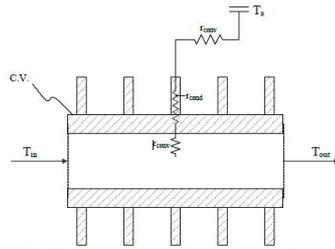


Figure : A control volume thermal circuit diagram

$$r_{cond} = \frac{R_{cond}}{L_{pipe}} \quad (\text{Eq. 1})$$

$$R_{cond} = \frac{L_{fin}}{k_{fin} A_{fin}} \quad (\text{Eq. 2})$$

$$r_{conv} = \frac{R_{conv}}{L_{pipe}} \quad (\text{Eq. 3})$$

$$R_{conv} = \frac{1}{h A_{S.A.}} \quad (\text{Eq. 4})$$

Here,  $T_{in}$  represents the inlet fluid temperature,  $T_{out}$  represents the outlet fluid temperature, and  $T_a$  represents the ambient air temperature. As shown by Eq. 1, thermal resistance due to conduction per unit length ( $r_{cond}$ ) is equal to the total resistance due to conduction ( $R_{cond}$ ) divided by the length of the pipe ( $L_{pipe}$ ). Eq. 2 provides the definition for  $R_{cond}$ . In this equation,  $L_{fin}$  is the length of the fin,  $k_{fin}$  is the thermal conductivity associated with the fin material, and  $A_{fin}$  is surface area associated with conduction. In this case, it would represent the bottom surface area of the fin. In Eq. 3,  $r_{conv}$  is equal to the total resistance due to convection ( $R_{conv}$ ) divided by the length of the pipe. Here,  $R_{conv}$  is equal to 1 divided by product of the convective coefficient associated with the air ( $h$ ) and the surface area exposed to the air ( $A_{S.A.}$ ). This can be seen by Eq. 4.

In current radiator designs, the largest thermal resistance is caused by the convective heat transfer ( $R_{conv}$ ) that is associated with the air. This comprises of over 75% of the total thermal resistance. The second largest thermal resistance is caused by the convection that is associated with the fluid. Together, these resistances comprise of over 97% of the total thermal resistance [3]. Since there is a large thermal resistance associated with the air, the increased heat transfer cannot be observed. Therefore, there is a need to design a radiator that reduces the percentage of thermal resistance associated with the air.

**Limitations** Current radiator designs are extremely limited and have not experienced any major advancements in recent years. As described above, the main problem is that current radiators experience a large resistance to heat transfer caused by air flowing over the radiator. Current radiators also experiences head resistance, are very bulky, and impose limitations on the design of the vehicle.

## IV. LITERATURE SURVEY

The literature review in this thesis is taken from paper done by Junjanna G.C<sup>[1]</sup> in which the study uses the computational analysis tool ANSYS Fluent 13.0 to perform a numerical study on a compact heat exchanger. The computational domain is identified from literature and validation of present numerical approach is established first. Later the numerical analysis is extended by modifying chosen geometrical and flow parameters like louver pitch, air flow rate, water flow rate, fin and louver thickness, by varying one parameter at a time and the results are compared. Recommendations has been made on the optimal values and settings based on the variables tested, for the chosen compact heat exchanger. In another paper by JP Yadav and Bharat Raj Singh<sup>[2]</sup> 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 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<sup>[3]</sup> 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. Five different concentrations of nanofluids in the range of 0–1.0 vol. % have been prepared by the addition of  $Al_2O_3$  nanoparticles into the water. The test fluid flows through the automobile radiator consisted of 33 vertical tubes with elliptical cross section and air makes a cross flow inside the tube bank with constant speed. The test

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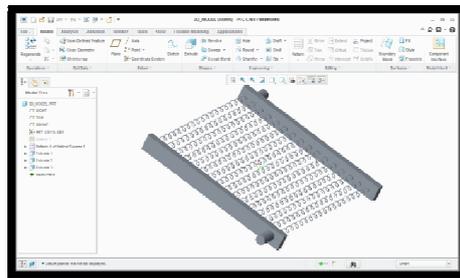
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fluid flow rate has been changed in the range of 3 l/min to 8 l/min to have fully turbulent regime. Obtained results demonstrate that increasing the fluid circulating rate can improve the heat transfer performance. The application of the nanofluid with low concentration can enhance heat transfer efficiency up to 40–45% in comparison with pure water. In the paper by Paresch Machhar, Falgun Adroja<sup>[4]</sup>, forced convective heat transfer in a water based nanofluid will experimentally be compared to that of pure water in an automobile radiator. Five different concentrations of nanofluids in the range of 0.1 - 1 vol. % will be prepared by the addition of TiO<sub>2</sub> nanoparticles into the water. The test liquid flows through the radiator consisted of 34 vertical tubes with elliptical cross section and air makes a cross flow inside the tube bank with constant speed. Liquid flow rate will be changed in the range of 2 - 5 l/min. Additionally the effect of fluid inlet temperature to the radiator on heat transfer coefficient will also be analyzed by varying the temperature in the range of 37 - 49 °C. Results will demonstrate that increasing the fluid circulating rate can improve the heat transfer performance while the fluid inlet temperature to the radiator has trivial effects. Meanwhile it was observed from investigators, application of nanofluid with low concentrations can enhance heat transfer efficiency up to 45% in comparison with pure water.

### V. MODEL OF RADIATOR



#### Radiator Specification for Helical type tubes:

Number of tubes: 29

Helical type tube mean diameter: 30mm

Inner diameter of tube: 2 mm

Outer diameter of tube: 4 mm

#### INTRODUCTION TO FEA

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L. J. Top established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures". By the early 70's, FEA was limited to expensive mainframe computers generally owned by the aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters. 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

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condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition. There are generally two types of analysis that are used in industry: 2-D modeling, and 3-D modeling. While 2-D modeling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results. 3-D modeling, however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively. Within each of these modeling schemes, the programmer can insert numerous algorithms (functions) which may make the system behave linearly or non-linearly. Linear systems are far less complex and generally do not take into account plastic deformation. Non-linear systems do account for plastic deformation, and many also are capable of testing a material all the way to fracture. FEA uses a complex system of points called nodes which make a grid called a mesh. This mesh is programmed to contain the material and structural properties which define how the structure will react to certain loading conditions. Nodes are assigned at a certain density throughout the material depending on the anticipated stress levels of a particular area. Regions which will receive large amounts of stress usually have a higher node density than those which experience little or no stress. Points of interest may consist of: fracture point of previously tested material, fillets, corners, complex detail, and high stress areas. The mesh acts like a spider web in that from each node, there extends a mesh element to each of the adjacent nodes. This web of vectors is what carries the material properties to the object, creating many elements.

**Types of Engineering Analysis Structural** analysis consists of linear and non-linear models. Linear models use simple parameters and assume that the material is not plastically deformed. Non-linear models consist of stressing the material past its elastic capabilities. The stresses in the material then vary with the amount of deformation as in.

**Vibrational** analysis is used to test a material against random vibrations, shock, and impact. Each of these incidences may act on the natural vibrational frequency of the material which, in turn, may cause resonance and subsequent failure.

Fatigue analysis helps designers to predict the life of a material or structure by showing the effects of cyclic loading on the specimen. Such analysis can show the areas where crack propagation is most likely to occur. Failure due to fatigue may also show the damage tolerance of the material.

**Heat Transfer** analysis models the conductivity or thermal fluid dynamics of the material or structure. This may consist of a steady-state or transient transfer. Steady-state transfer refers to constant thermo properties in the material that yield linear heat diffusion.

1. **Preprocessing:** The user constructs a model of the part to be analyzed in which the geometry is divided into a number of discrete sub regions, or elements, "connected at discrete points called nodes." Certain of these nodes will have fixed displacements, and others will have prescribed loads. These models can be extremely time consuming to prepare, and commercial codes vie with one another to have the most user-friendly graphical "preprocessor" to assist in this rather tedious chore. Some of these preprocessors can overlay a mesh on a preexisting CAD file, so that finite element analysis can be done conveniently as part of the computerized drafting-and-design process.
2. **Analysis:** The dataset prepared by the preprocessor is used as input to the finite element code itself, which constructs and solves a system of linear or nonlinear algebraic equations

$$K_{ij}u_j = f_i$$

where  $u$  and  $f$  are the displacements and externally applied forces at the nodal points. One of FEA's principal advantages is that many problem types can be addressed with the same code, merely by specifying the appropriate element types from the library.

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3. **Postprocessing:** In the earlier days of finite element analysis, the user would pore through reams of numbers generated by the code, listing displacements and stresses at discrete positions within the model. It is easy to miss important trends and hot spots this way, and modern codes use graphical displays to assist in visualizing the results. A typical postprocessor display overlays colored contours representing stress levels on the model, showing a full field picture similar to that of photo elastic or moiré experimental results.

## 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 is the standard FEA teaching tool within the Mechanical Engineering Department at many colleges. ANSYS is also used in Civil and Electrical Engineering, as well as the Physics and Chemistry departments.

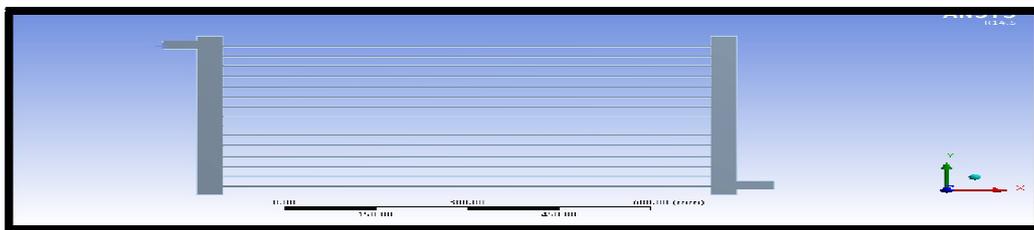
ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping.

With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of a design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc.

## CFD ANALYSIS OF RADIATORCASE -1 STRAIGHT TUBEAT MASS FLOW RATE-2.8 KG/SEC

**FLUID-AIR** → → Ansys → workbench → select analysis system → fluid flow fluent → double click

→ → Select geometry → right click → import geometry → select browse → open part → ok



→ → select mesh on work bench → right click → edit → select mesh on left side part tree → right click → generate mesh →

The model is designed with the help of CREO and then import on ANSYS for Meshing and analysis. The analysis by CFD is used in order to calculating pressure profile and temperature distribution. For meshing, the fluid ring is divided into two connected volumes. Then all thickness edges are meshed with 360 intervals. A tetrahedral structure mesh is used. So the total number of nodes and elements is 6576 and 3344

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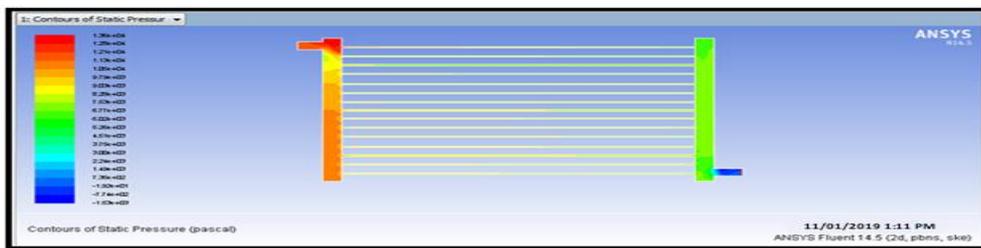
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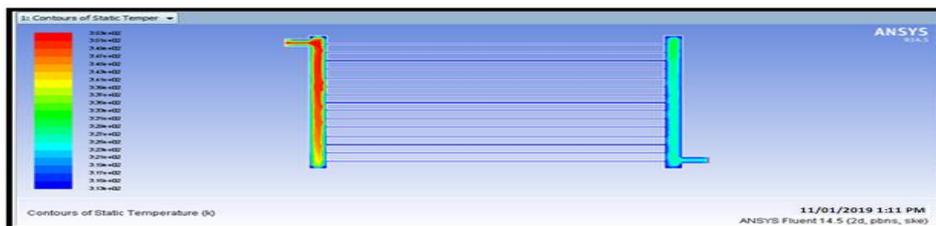
Select faces → right click → create named section → enter name → air inlet Select faces → right click → create named section → enter name → air outlet

## STATIC PRESSURE



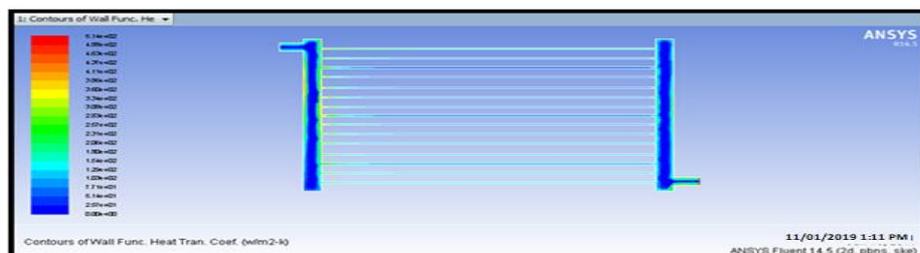
According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent sides of the narrow plate. According to the above contour plot, the maximum pressure is  $2.50e+04$ Pa and minimum static pressure is  $-2.14e+04$ Pa.

## STATIC TEMPERATURE



According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $3.22e+02$ m/s and minimum static temperature is  $3.11e+01$ m/s.

## HEATTRANSFER COEFFICIENT



According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $3.14e+02$ w/m<sup>2</sup>-k and minimum heat transfer coefficient is  $1.57e+01$ w/m<sup>2</sup>-k.

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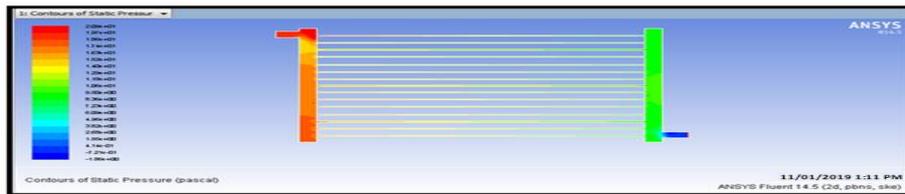
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## REPORTS MASS FLOW RATE

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)**

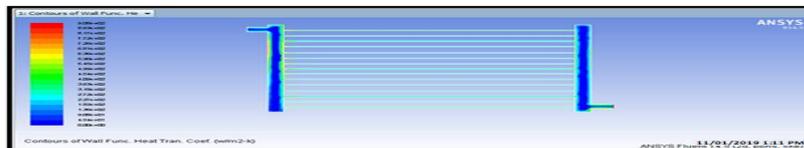
## FLUID-WATER STATIC PRESSURE



According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent sides of the narrow plate. According to the above contour plot, the maximum pressure is  $1.03e+05\text{Pa}$  and minimum static pressure is  $-8.57e+04\text{Pa}$ .

**STATIC TEMPERATURE** According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $4.44e+02\text{m/s}$  and minimum static temperature is  $2.22e+01\text{m/s}$ .

## HEAT TRANSFER CO-EFFICIENT



According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $5.52e+02\text{w/m}^2\text{-k}$  and minimum heat transfer coefficient is  $2.76e+01\text{w/m}^2\text{-k}$ .

Mass Flow Rate	(kg/s)
inlet	2.8
interior_trm_srf	41.862038
outlet	-2.7996235
wall_trm_srf	0
Net	0.00037646294

**Total Heat Transfer Rate (w)**

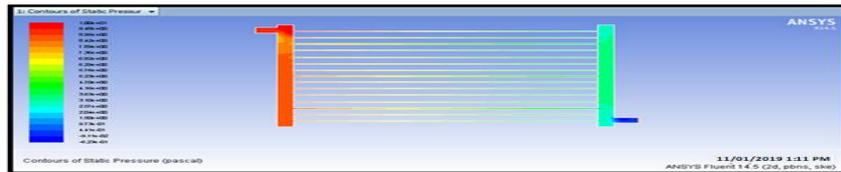
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## FLUID- $Al_2O_3$ STATIC PRESSURE



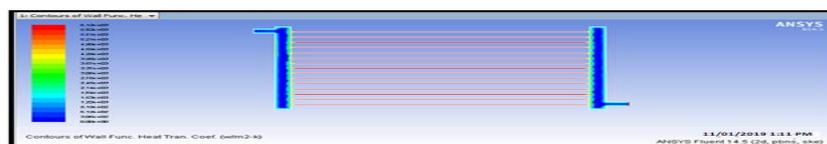
According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent sides of the narrow plate. According to the above contour plot, the maximum pressure is  $3.25e+04Pa$  and minimum static pressure is  $-5.05e+04Pa$ .

## STATIC TEMPERATURE



According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $2.80e+02m/s$  and minimum static temperature is  $1.40e+01m/s$ .

## HEAT TRANSFER CO-EFFICIENT



According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $3.39e+02w/m^2-k$  and minimum heat transfer coefficient is  $1.70e+01w/m^2-k$ .

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

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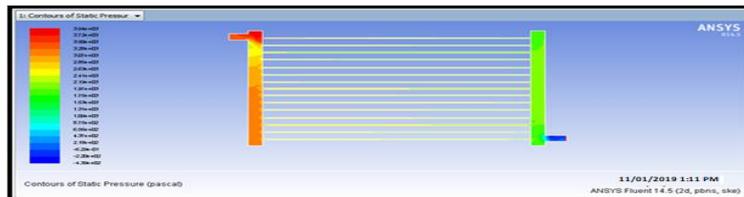
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## HEAT TRANSFER RATE

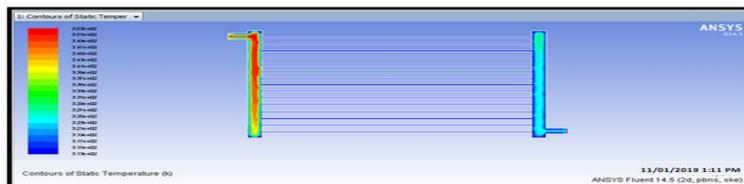
Total Heat Transfer Rate	(w)
inlet	250451.97
outlet	-67785.891
wall_trn_srf	-182665.75
Net	0.328125

## AT MASS FLOW RATE-1.5 Kg/sec FLUID-AIRSTATIC PRESSURE



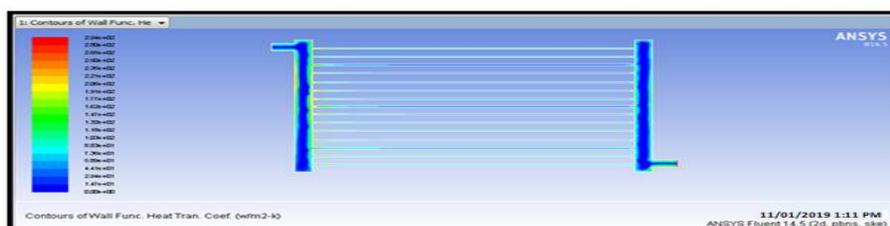
According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent sides of the narrow plate. According to the above contour plot, the maximum pressure is  $1.31 \times 10^5$  Pa and minimum static pressure is  $-2.03 \times 10^5$  Pa.

## STATIC TEMPERATURE



According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $5.60 \times 10^2$  K and minimum static temperature is  $2.80 \times 10^1$  K.

## HEAT TRANSFER CO-EFFICIENT



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According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $5.95 \times 10^2 \text{ W/m}^2\text{-K}$  and minimum heat transfer coefficient is  $2.97 \times 10^1 \text{ W/m}^2\text{-K}$ .

## MASS FLOW RATE

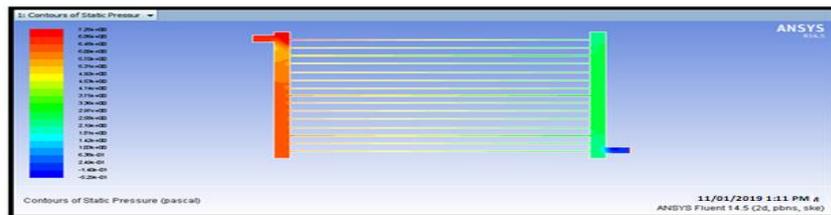
Mass Flow Rate	(kg/s)
inlet	1.5
interior_trm_srf	21.550976
outlet	-1.4997886
wall_trm_srf	0
<b>Net</b>	<b>0.00021135807</b>

## HEAT TRANSFER RATE

Total Heat Transfer Rate	(w)
inlet	82806.078
outlet	-38828.328
wall_trm_srf	-43970.742
<b>Net</b>	<b>7.0078125</b>

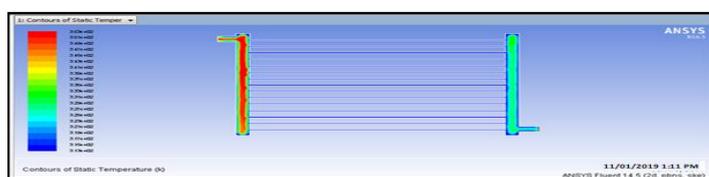
## FLUID-WATER

### STATIC PRESSURE



According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent sides of the narrow plate. According to the above contour plot, the maximum pressure is  $6.49 \times 10^4 \text{ Pa}$  and minimum static pressure is  $-6.45 \times 10^4 \text{ Pa}$ .

### STATIC TEMPERATURE



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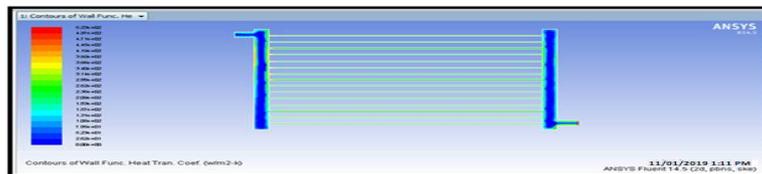
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According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $3.40 \times 10^2$  m/s and minimum static temperature is  $1.70 \times 10^1$  m/s.

## HEAT TRANSFER CO-EFFICIENT



According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $4.06 \times 10^2$  w/m<sup>2</sup>-k and minimum heat transfer coefficient is  $2.03 \times 10^1$  w/m<sup>2</sup>-k.

## MASS FLOW RATE

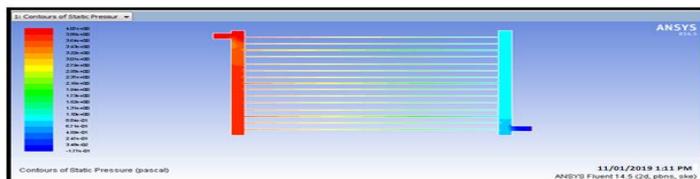
Mass Flow Rate	(kg/s)
inlet	1.5
interior_trm_srf	23.445898
outlet	-1.4997959
wall_trm_srf	0
<b>Net</b>	<b>0.0002040863</b>

## HEAT TRANSFER RATE

Total Heat Transfer Rate	(w)
inlet	344077.94
outlet	-184364.42
wall_trm_srf	-159681.11
<b>Net</b>	<b>32.40625</b>

## FLUID-Al<sub>2</sub>O<sub>3</sub>

## STATIC PRESSURE



According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent sides of the narrow plate.

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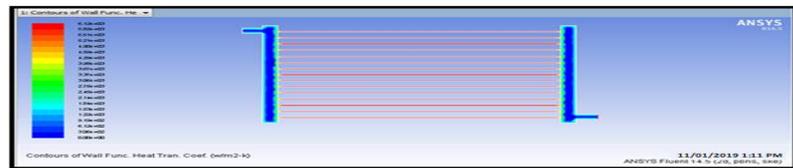
narrow plate. According to the above contour plot, the maximum pressure is  $2.57 \times 10^5$  Pa and minimum static pressure is  $-2.61 \times 10^5$  Pa

## STATIC TEMPERATURE



According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $6.80 \times 10^2$  m/s and minimum static temperature is  $3.40 \times 10^1$  m/s.

## HEAT TRANSFER CO-EFFICIENT



According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $7.09 \times 10^2$  w/m<sup>2</sup>-k and minimum heat transfer coefficient is  $3.55 \times 10^1$  w/m<sup>2</sup>-k.

## MASS FLOW RATE

Mass Flow Rate	(kg/s)
inlet	1.5
interior_trm_srf	24.826689
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

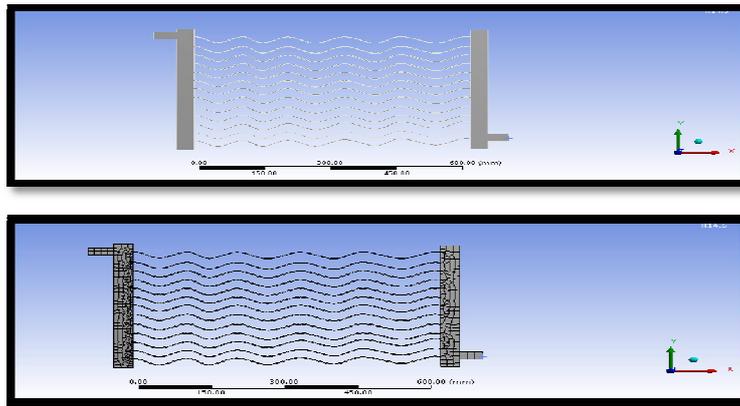
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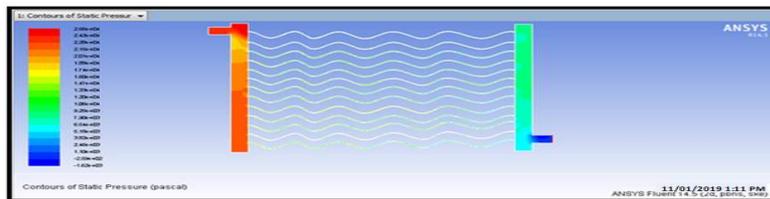
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## CFD ANALYSIS OF HELICAL TUBE RADIATOR CASE -2 HELICAL TUBE AT MASS FLOW RATE-2.8 KG/SEC FLUID-AIR



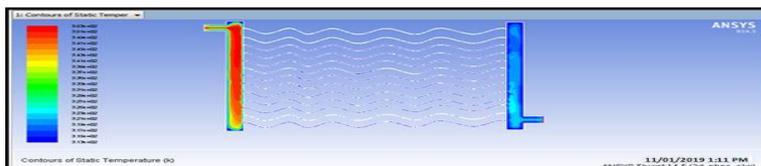
Select faces → right click → create named

### STATIC PRESSURE



According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent side of the narrow plate. According to the above contour plot, the maximum pressure is  $1.35e+05$ Pa and minimum static pressure is  $-8.68e+04$ Pa.

### STATIC TEMPERATURE



According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $5.01e+02$ m/s and minimum static temperature is  $2.50e+01$ m/s.

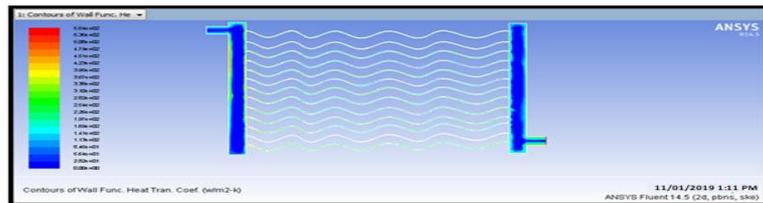
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## HEAT TRANSFER CO-EFFICIENT



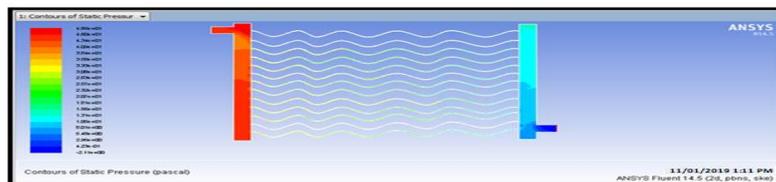
According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $4.93 \times 10^2 \text{ W/m}^2\text{-K}$  and minimum heat transfer coefficient is  $2.47 \times 10^1 \text{ W/m}^2\text{-K}$ .

## REPORTS

Total Heat Transfer Rate (w)		Mass Flow Rate (kg/s)	
inlet	154570.94	inlet	2.8
outlet	-68237.5	interior_trm_srf	139.43919
wall_trm_srf	-86606.688	outlet	-2.800086
Net	-273.25	wall_trm_srf	0
		Net	-8.6069107e-05

Total Heat Transfer Rate (w)

## FLUID-WATER STATIC PRESSURE



According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent sides of the narrow plate. According to the above contour plot, the maximum pressure is  $4.65 \times 10^5 \text{ Pa}$  and minimum static pressure is  $-3.47 \times 10^5 \text{ Pa}$ .

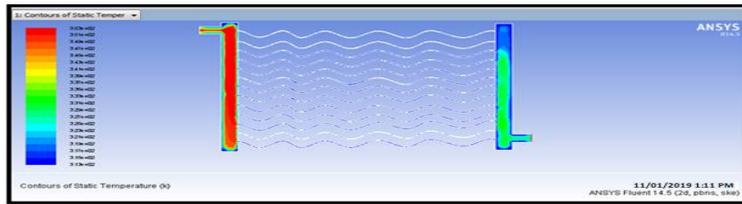
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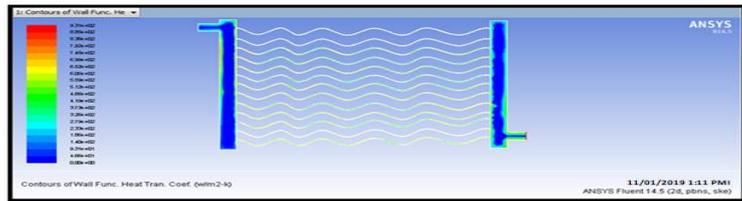
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## STATIC TEMPERATURE



According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $1.00e+03m/s$  and minimum static temperature is  $5.01e+01m/s$ .

## HEAT TRANSFER CO-EFFICIENT



According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $8.55e+02w/m^2-k$  and minimum heat transfer coefficient is  $4.28e+01w/m^2-k$ .

## REPORTS

Mass Flow Rate	(kg/s)
inlet	2.8
interior_trm_srf	145.7442
outlet	-2.8000216
wall_trm_srf	0
Net	-2.1696091e-05

Total Heat Transfer Rate (w)

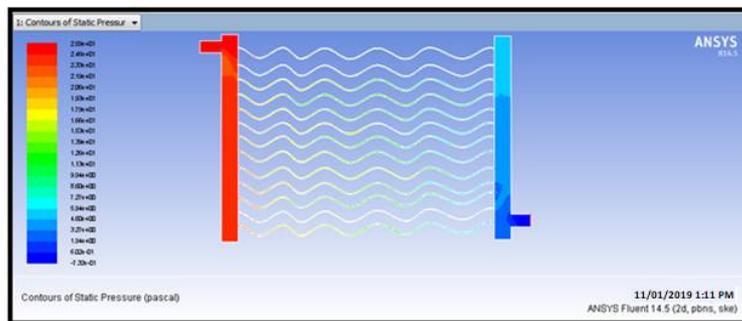
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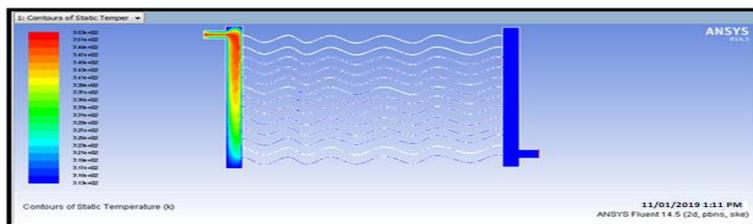
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## FLUID- $Al_2O_3$ STATIC PRESSURE



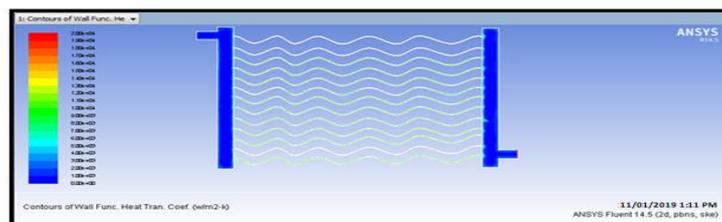
According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent side of the narrow plate. According to the above contour plot, the maximum pressure is  $1.35e+05$ Pa and minimum static pressure is  $-8.68e+04$ Pa.

## STATIC TEMPERATURE



According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $5.01e+02$ m/s and minimum static temperature is  $2.50e+01$ m/s.

## HEAT TRANSFER CO-EFFICIENT



According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $4.93e+02$ w/m<sup>2</sup>-k and minimum heat transfer coefficient is  $2.47e+01$ w/m<sup>2</sup>-k.

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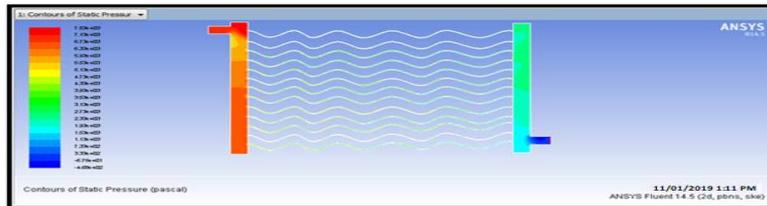
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Mass Flow Rate	(kg/s)
inlet	2.8
interior-trm_srf	150.78004
outlet	-2.800073
wall-trm_srf	0
<b>Net</b>	<b>-7.390976e-06</b>

## HEAT TRANSFER RATE

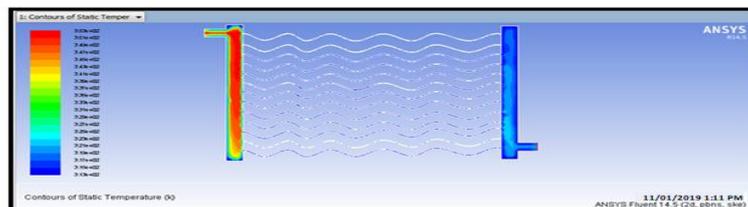
Total Heat Transfer Rate	(w)
inlet	250448.34
outlet	-67785.414
wall-trm_srf	-102663.77
<b>Net</b>	<b>-0.8359375</b>

## AT MASS FLOW RATE-1.5 Kg/sec FLUID-AIR STATIC PRESSURE



According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent sides of the narrow plate. According to the above contour plot, the maximum pressure is  $4.65 \times 10^5$  Pa and minimum static pressure is  $-3.47 \times 10^5$  Pa.

## STATIC TEMPERATURE



According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $1.00 \times 10^3$  K and minimum static temperature is  $5.01 \times 10^1$  K.

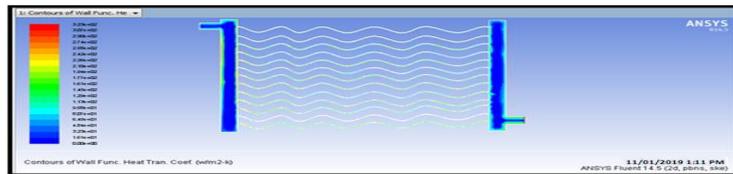
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## HEAT TRANSFER CO-EFFICIENT



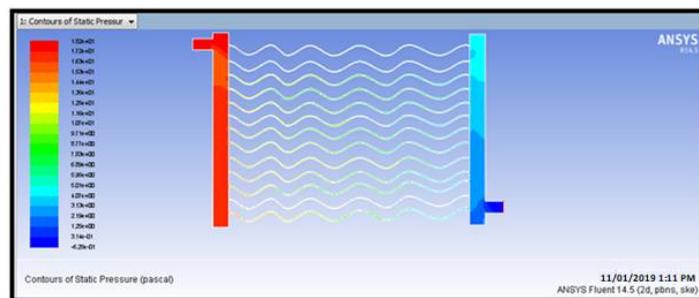
## MASS FLOW RATE

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

## FLUID-WATERSTATIC PRESSURE



According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent sides of the narrow plate. According to the above contour plot, the maximum pressure is  $4.65e+05$ Pa and minimum static pressure is  $-3.47e+05$ Pa.

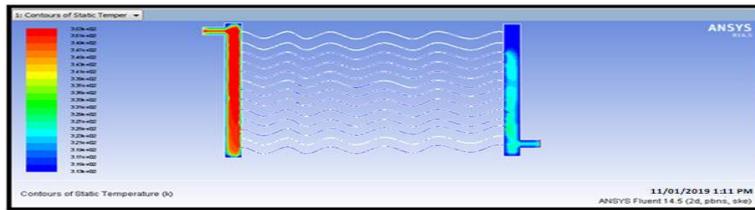
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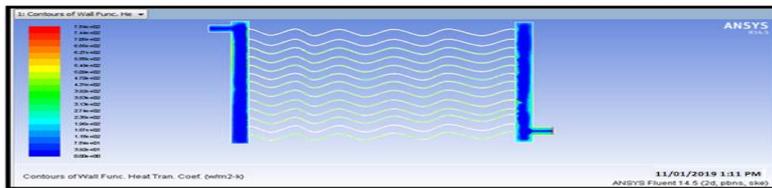
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## STATIC TEMPERATURE



According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $1.00e+03m/s$  and minimum static temperature is  $5.01e+01m/s$ .

## HEAT TRANSFER CO-EFFICIENT



According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $4.93e+02w/m^2-k$  and minimum heat transfer coefficient is  $2.47e+01w/m^2-k$ .

## MASS FLOW RATE

Mass Flow Rate	(kg/s)
inlet	1.4999999
interior_trm_srf	79.660637
outlet	-1.5000114
wall_trm_srf	0
Net	-1.1563301e-05

## HEAT TRANSFER RATE

Total Heat Transfer Rate	(w)
inlet	344077.63
outlet	-168404
wall_trm_srf	-175728.66
Net	-55.03125

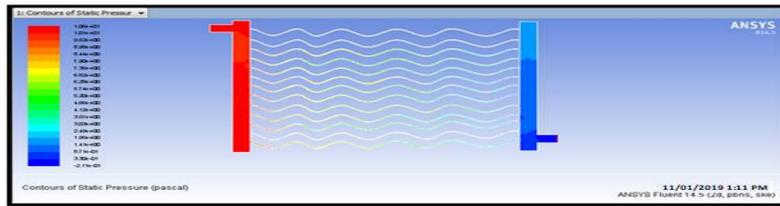
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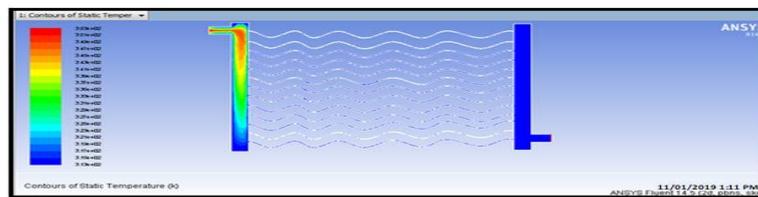
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## FLUID- $\text{Al}_2\text{O}_3$ STATIC PRESSURE



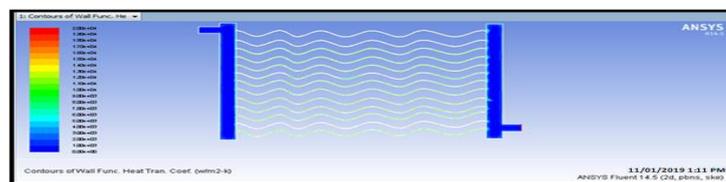
According to the above contour plot, the maximum static pressure at inlet of the radiator helical tubes because the applying the boundary conditions at inlet of the boundary and minimum static pressure at the adjacent sides of the narrow plate. According to the above contour plot, the maximum pressure is  $4.65\text{e}+05\text{Pa}$  and minimum static pressure is  $-3.47\text{e}+05\text{Pa}$ .

## STATIC TEMPERATURE



According to the above contour plot, the maximum static temperature magnitude of the air at corners of narrow plate, because the applying the boundary conditions at inlet of the boundary of the radiator helical tubes and minimum static temperature magnitude at around edges of the narrow plate. According to the above contour plot, the maximum static temperature is  $1.00\text{e}+03\text{m/s}$  and minimum static temperature is  $5.01\text{e}+01\text{m/s}$ .

## HEAT TRANSFER CO-EFFICIENT



According to the above contour plot, the maximum heat transfer coefficient of the air at edges of the radiator helical tubes and minimum heat transfer coefficient between around the boundary edges and radiator helical tubes edges. According to the above contour plot, the maximum heat transfer coefficient is  $4.93\text{e}+02\text{w/m}^2\text{-k}$  and minimum heat transfer coefficient is  $2.47\text{e}+01\text{w/m}^2\text{-k}$ .

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## MASS FLOW RATE

Mass Flow Rate	(kg/s)
inlet	1.4999999
interior_trn_srf	81.493301
outlet	-1.5000036
wall_trn_srf	0
Net	-3.695488e-06

## HEAT TRANSFER RATE

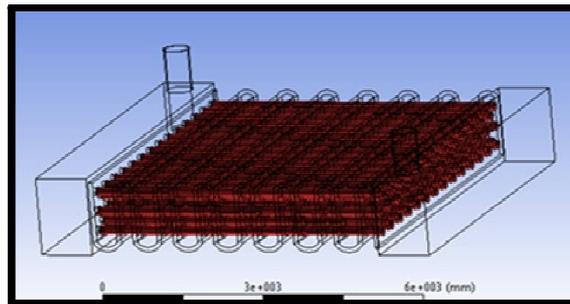
Total Heat Transfer Rate	(w)
inlet	134240.8
outlet	-36313.535
wall_trn_srf	-97927.539
Net	-0.27734375

## BOUNDARY CONDITIONS

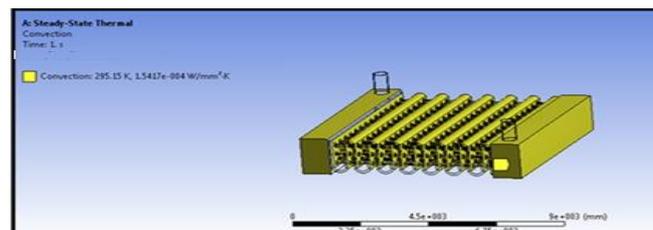
$$T_1 = 353K$$

Select steady state thermal >right click>insert>select convection> enter film coefficient value is 154.168 w/ m<sup>2</sup>k (from CFD analysis)

## THERMAL ANALYSIS APPLIED TEMPERATURE



## APPLIED CONVECTION



The model is designed with the help of CREO and then import on ANSYS for Meshing and analysis. The analysis by CFD is used in order to calculating pressure profile and temperature distribution. For meshing, the fluid ring is divided

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into two connected volumes. Then all thickness edges are meshed with 360 intervals. A tetrahedral structure mesh is used. So the total number of nodes and elements is 6576 and 3344. Select steady state thermal >right click>insert>select heat flux

Select steady state thermal >right click>solve Solution>right click on solution>insert>select temperature

## VI. RESULT TABLES 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 <sub>2</sub> O <sub>3</sub>	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 <sub>2</sub> O <sub>3</sub>	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 <sub>2</sub> O <sub>3</sub> 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 <sub>2</sub> O <sub>3</sub> nano fluid	1.06e+01	3.53e+02	1.97e+02	3.96e-06	0.277

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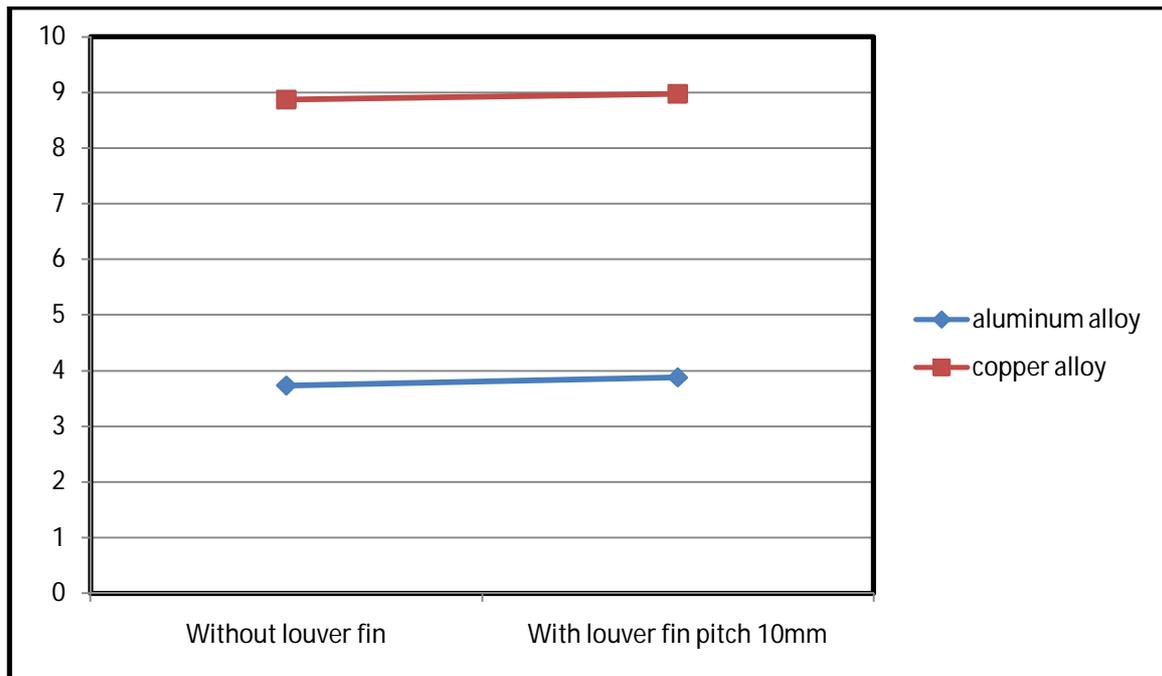
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## THERMAL ANALYSIS RESULTS TABLE

Models	Material	Temperature( <sup>0</sup> C)	Heat flux(w/mm2)
Radiator	Aluminum alloy	354.07	0.072436
	Copper alloy	353.58	0.098606

### Thermal analysis graphs

#### Heat flux plot



## VII. CONCLUSION

In this thesis, different nano fluids mixed with base fluid water are analyzed for their performance in the radiator. In this project the different types of fluids are applied in radiator. The fluids are water, air and aluminum oxide nano fluid. 3D model of the radiator is done in CREO parametric software. CFD analysis is done on the radiator for all fluids and thermal analysis is done in Ansys. By observing the CFD analysis the heat transfer coefficient values are increases by increasing the mass flow inlet. When we compare the fluids the aluminum oxide nano fluid fluid is the better fluid because the heat transfer rate value is more at fluid aluminum oxide nano fluid. Thermal analysis is done for two materials Aluminum and Copper taking heat transfer coefficient value of Aluminum oxide at 0.3 volume fractions from CFD analysis. By observing thermal analysis results, heat flux is more when Copper is used than Aluminum alloy. When we compare the different geometries of radiator the helical type tube is the better model because the heat transfer rate value is more for helical type tube radiator is better model.

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## REFERENCES

- [1]. A.Witry M.H. Al-Hajeri and Ali A. Bondac, "CFD analysis of fluid flow and heat transfer in patterned roll bonded aluminium radiator", 3rd International conference on CFD, CSIRO, Melbourne, Australia, pp. 12-19, 2003.
- [2]. Hilde Van Der Vyer, Jaco Dirker and Jousoa P Meyer, "Validation of a CFD model of a three dimensional tube-in-tube heat exchanger", Third International Conference on CFD in the Minerals and Process Industry, CSIRO, Melbourne, Australia, pp. 25-32, 2003.
- [3]. J A Chen, D F Wang and L Z Zheng, "Experimental study of operating performance of a tube-and-fin radiator for vehicles", Proceedings of Institution of Mechanical Engineers, Republic of China, 215: pp. 2-8, 2001.
- [4]. Changhua Lin and Jeffrey Saunders, "The Effect of Changes in Ambient and Coolant Radiator Inlet Temperatures and Coolant Flowrate on Specific Dissipation", SAE Technical Papers, 2000.
- [5]. Sridhar Maddipatla, "Coupling of CFD and shape optimization for radiator design", Oakland University. Ph.D. thesis, 2001
- [6]. J.P.Holman, Heat transfer, Tata-McGraw-Hill Publications, 2000.
- [7]. Seth Daniel Oduro, "Assessing the effect of dirt on the performance of an engine cooling system", Kwame Nkrumah University of Science and Technology, PG thesis, 2000.
- [8]. Beard, R. A. and Smith, G. J., "A Method of Calculating the Heat Dissipation from Radiators to Cool Vehicle Engines", SAE Technical Paper 710208, 1971.
- [9]. Salvio Chacko, "Numerical Simulation for Improving Radiator Efficiency by Air Flow Optimization" Engineering Automation Group, Tata Technologies Limited, Pune, India, Technical paper, 2003.
- [10]. S.N Sridhara, S.R. Shankapal and V Umesh Babu, (2005) "CFD analysis of Fluid Flow & Heat Transfer in a Single Tube-Fin Arrangement of an Automotive Radiator" International Conference on Mechanical Engineering 2005, Dhaka, Bangladesh, Conference Paper, 2005.