International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
ISSN: 2457-0362

CFD ANALYSIS OF AN AIR COOLED CONDENSER BY THE COPPER AND ALUMINUM MATERIAL

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ABSTRACT: The evaporative cooling system principles for engine thermal control in automotive applications proposed in the last century are discussed and critically examined. The aim of this review is to identify obvious potential attacks and identify other research issues that are required to allow the vehicle manufacturers to implement this essential technology. Initially, it is possible to strengthen the advantages of evaporative cooling systems in terms of improving engine performance, reducing carbon dioxide emissions and enhancing the fuel economy. Cooling of fluids is one of the essential elements of the cooling system. The correct cooling fluid affects the engine of the car negatively and significantly reduces the driver's life. An efficient cooling system prevents an engine from being overheated and makes it possible to function optimally. The helical tube and tube thermostat analyses different Nano fluid mixed with specific fluid water to ensure their performance. The various fluid types are applied in the thermostat in this project. Fluids are water, air and aluminum oxide. The thermostat model was developed of CREO parametric software. 3D. Thermostat model. The thermostat analysis is performed by CFD and all fluids are analyzed.

Key words: Thermostat, Nano fluids, Cooling system, CREO, CFD analysis,

INTRODUCTION

Mechatronic components can be implemented in thermomechanical systems to increase engine performance using real-time control strategies. In a typic liquid-cooled internal combustion engine system, the coolant temperature is regulated by a thermostat that controls the fluid flow to the thermostat. The temperature of the coolant depends in general on the thermostat, thermostat, the flow rate of the coolant and the ambient temperature. As shown in Figure, a cooling system operates by transmitting a liquid coolant via engine block passes and heads. When the coolant moves in, heat is absorbed by the engine. The heated fluid then enters the thermo-state in front of the vehicle through a rubber tube. The hot liquid is cooled by the air stream entering the engine compartment from the grilled compartment as it flows through the fine tubes in the thermostat. When the fluid is changed, it comes back to the engine to take up more heat. This system is designed

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ISSN: 2457-0362

to keep the fluid flowing. A mould thermostat is placed between the engine and the thermostat to ensure the coolant is above a certain temperature. When the coolant temperature drops below this temperature, the coolant flow is blocked by the thermostat rather than by pushing the fluid back to the engine via restart. The coolant circulates like this until the design temperature is reached. At this moment a valve is opened by the thermostat and the coolant is released into the thermostat. The opening and close rate depends on the wax properties and temperatures of the coolant engine in a traditional mechanical wax thermostat. While for an electronic thermostat, it depends on PWM signals and its coolant temperature frequency.

In this analysis, an effort was made for the first time, in Indian conditions, to implement and evaluate the electronic thermostat technology for commercial vehicle use. This technology has been in a luxury passenger car to date. An electronically operated thermostat is used in regular service in the same way as a traditional thermostat. The electronic thermostat incorporates another heat source and receives PWM signals with various current values for heat production. Once the conditions of the ECU algorithm stored are fulfilled, a wax-integrated heating resistor is enabled. This external heat source enables the wax to expand further, supply energy in real time. This helps us to adjust the thermostat opening according to the device requirement.

Thermostat:

In this analysis, an effort was made for the first time, in Indian conditions, to implement and evaluate the electronic thermostat technology for commercial vehicle use. This technology has been in a luxury passenger car to date. An electronically operated thermostat is used in regular service in the same way as a traditional thermostat. The electronic thermostat incorporates another heat source and receives PWM signals with various current values for heat production. Once the conditions of the ECU algorithm stored are fulfilled, a wax-integrated heating resistor is enabled. This external heat source enables the wax to expand further, supply energy in real time. This helps us to adjust the thermostat opening according to the device requirement.

Cooling System: Typical 4-cylinder car cruising about 30 miles an hour along the highway, 4000 controlled explosions per minute will occur inside the engine as fuel is ignited by the spark plugs in each cylinder to propel the car along the lane.. Obviously, these explosions generate huge amount of heat and kill an engine in a matter of minutes if they aren't managed. It is the responsibility of the cooling system to regulate these high temperatures. The current cooling system did not change much in the 1920s compared to the cooling systems in the T model. It was always more powerful and effective, of course, but it's still the easiest refrigerator to pump coolant fluid through the engine and the thermostat that is refrigerated by the air through the front grill of the car. The cooling system today will keep the unit at a constant temperature of 110°F, or 10°F lower than 0°C. When the temperature of the engine is too low, it impairs fuel efficiency and raises emissions. The motor automatically destroys itself if its temperature can be overheated.

NECESSITY OF COOLING SYSTEM

The cooling system is provided in the IC engine for the following reasons:

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The melting gas temperature on the engine cylinder exceeds the melting point in the material of the cylinders body and head of the engine by up to 1500 to 2000°C. If the heat isn't dissipated, the substance of the cylinder will be ineffective (platinum, metal with one of the highest molten points, melts at 1,750 °C, iron at 1530 °C and aluminium at 657°C).

- The film of the lubricating oil would be ionised due to very high temperatures and thus produce on the surface carbon deposits. This leads to a piston convulsion.
- Large temperature differences due to overheating can cause a distortion of the components of the engine due to thermal stresses. The temperature variance must therefore be held to a minimum.
- High temperature also decreases the engine's volumetric effectiveness.

Requirements of efficient cooling system

The two main requirements of an efficient cooling system are:

- The combustion chamber shall only remove about 30% of the heat emitted. Too much heat removal decreases the engine's thermal efficiency.
- When the engine is heat, it can easily remove heat. The cooling should be very slow during the engine start, so that the individual working parts reach their operating temperatures within a short time.

TYPES OF COOLING SYSTEM

There are two types of cooling systems:

(i) Air cooling system and

(ii) Water-cooling system.

AIR COOLING SYSTEM:

In this cooling system, heat is radiated and led away from the air stream collected from the atmosphere to the outer parts of the engine. The supply of fins around the cylinders and cylinder heads improves the contact area to ensure adequate air cooling. The fins are metal cuts created when the cylinder and cylinders are cast, depending on the following factors: the amount of warmth brought by the air-cooling:

- The total area of the fin surfaces,
- The velocity and amount of the cooling air and
- The temperature of the fins and of the cooling air.

Figure: Air cooling system

Air cooling is primarily less efficient tractors, bikes, scooters, small cars and small aircrafts where the forward movement of the engine provides a reasonable speed to cool the engine. Some small industrial engines also have air cooling. Individual cylinders are normally employed in this system for providing a wide cooling area via fins.

Advantages of Air-Cooled Engines

Air cooled engines have the following advantages:

- Its design of air-cooled engine is simple.
- It is lighter in weight than water-refrigerated engines due to the lack of water jackets, thermostat, circulating pump and water weight.
- The production is cheaper.
- Less maintenance and care are required.
- In the case of conditions in the arctic or in conditions of water scarcity, this cooling system is particularly advantageous.
- No chance of frost damage, such as cylinder jackets cracking or water plumbing thermostat.

WATER COOLING SYSTEM:

In working an engine it serves two purposes:

a) Removal and prevent overheating of excessive heat produced in the engine. a)

B) it maintains an engine for effective and cost-effective operating at working temperature. There are four systems for this cooling system

- Direct or non-return system,
- Thermo-Syphone system,
- Hopper system and
- Pump/forced circulation system.

Although the new tractor has a device forced to circulate, the other three systems are still worth learning.

LITERATURE REVIEW

Below are some recommended characteristics as well as criteria mentioned in the literature.

Sharma et. al. [1]The air system gateway in the office building was designed and the value of a system design evaluated that would have the effect of system performance. Incorrect designs of the tubes caused problems including friction losses, uneven building cooling, increased casts, increased noise and energy consumption, etc. The problems above showed the need for an integrated conduit design and an efficient conduit layout. The authors used the measurement of hands and software tools to design the duct. The circular canal was found to be less pressure down than the rectangular channel.

Whalley et. al. [2] Considered modelling of HVAC for spatially distributed, large-scale structures. They addressed in this paper current techniques and suggestions for applying new research.

Xu et. al. [3] did field research on the efficiency in four large commercial buildings of five thermal distributed systems. They investigated the air leakage from ducts and concluded that the air leakage differed greatly from system to system in large commercial systems. The loss of energy due to the leak can be reduced by the insulation of the duct and ducts.

METHODOLOGY

In this research methodology, we first study the previous research to understand the topic and then find the design failures that can fail during operation. The key components of the whole assembly. After we have performed some analyses, we then begin our own design using cad software, according to specific engine dimensions, in our research work CFD analysis is required. We must

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change our traditional design to current requirements and carry out our analysis again, according to the results, and finally the result must be reached the conclusion.

In an automotive, combustion generates fuel and air energy within the engine. Only part of the total power generated actually powered the car — the rest wasted in the form of exhaust and heat. Unless such exceed heat is eliminated the engine temperature becomes too high and the lubricating oil overheats, the engine parts are weakened by metals, and the engine component stresses result in faster wear, and some others.

This heat energy is destroyed by a cooling system. Most automakers are cooled by thermostat, hydraulic pump, electrical cooling fan, thermostat pressure cap and thermostat. Thermostat is the most important part of the system of these components because heat is transferred. While coolant passes through the cylinder block of the engine, it builds up heat. As the temperature of the refrigerant rises above a threshold value the thermostat triggers a valve which forces the refrigerant to flow through the thermostat. The heat is transferred to the air through convective and convective fins and tube walls when the coolant is flowing through the tubes of the thermostat. Automotive thermostat is used to refresh the motor. If different problems have not happened like knock, deformation of the piston, deformation of the cylinder, etc. If Thermostat functions correctly cooling system, the engine's performance will increase in turn.

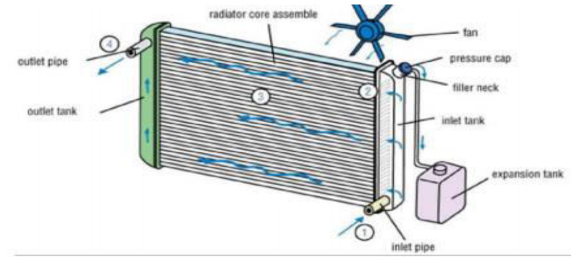

Fig. 1: Components within an Automotive Cooling System

Working of a Cooling System:

The cooling system is a component and fluid system that works together to control the operating temperature of the engine to achieve an optimum performance. This composite system is made up of passes inside the block and heads of the engine, a pump and drive belt to circulate the coolant, a coolant temperature control thermostat, a coolant cooling thermostat, a thermostat cap for control of the coolant pressurization in the system, and slides for the coolant to be transferred from the engine. The liquid flowing through a refrigerating system, anti-freeze, or usually called refrigerant, is extremely hot and cold and contains rust inhibitors and lubricants that keep the system running smoothly. Coolant follows a pathway which starts with the pump

The impeller of the water pump uses the centrifugal force to extract coolant from the thermostat into the motor block. Fan, serpentine timing belt or time chain pumps are typically driven. It can even be electrically driven nowadays. When the water pump experiences a seal leak, a cracked case, a ruptured spur or a failure to handle, the entire cooling system could be jeopardized, which causes the vehicle to overheat. As the heat from the motor is collected before the thermostat is reached, coolant runs through the systems. The heat

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valve measures the coolant temperature and opens so that heat can travel to the thermostat. The valve is an opening valve. If the thermostat is 'stuck' and stops working, the whole cooling system will be affected. Hot coolant is released by the thermostat to be cooled by the thermostat. Thin tubes in a thermostat pass through the antifreeze. It is refreshed as the air is flowing through the tubes outside. The movement of the car down the road (ram air effect) and/or cooling fans are provided with an airflow, according to the speed of the vehicle.. Thermostat constraints may jeopardize your heat transfer capacity. These can be restrictions on external air flow or internal flow of refrigerant. An electric cooling fan or fan clutch malfunctioning can limit airflow over the thermostat. Check/replace the fan clutch... the pumps and ventilator clutches live about the same life expectancy and share a shaft. Failed fan clutch may damage the water pump severely. The pressure in the cooling system increases as the cooling temperature rises. The thermostat cap regulates this pressure.

Traditional Thermostat Valve Fluid Control (Case 1): Three main components of the typical cooling system are designed to monitor the engine temperature: thermostat, water pump and thermostat fan. Conventional thermostats have a wax basis; the operation depends on the material characteristics of the thermostat housing and its coolant temperature Conventional water pumps and fans of the thermostat are typically mechanically powered by the crankshaft of the motor. The water pump is primarily driven as an accessory load while the thermostat fan is also directly connected to the crankshaft by a clutch. Usually, factory cooling systems have two problems

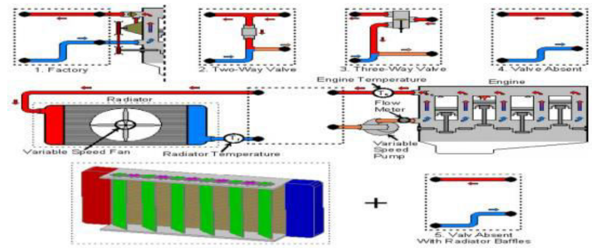

Figure: Five thermostat valve configurations to enhance fluid flow control; note the two thermocouples

Two-Way Valve Fluid Control (Case 2): The adequate protective valve controls the movement of coolants by blocking them. When the valve is driven by the bypass mode, a certain coolant often flows through the thermostat, which represents a major disadvantage in the attempt to warm the engine quickly to operating temp. Moreover, by geometry and position insides the cooling circuit the amount of coolant flow through the bypass and the heat status is determined. In several places, double-way valves can be mounted in an advanced cooling system which would adjust thermal dynamics.

Three-Way Valve Fluid Control (Case 3): The operations of an intelligent three-way valve are just like the two-way valve. But a three-way valve tracks the movement of coolant through passing and thermostat circuits. Contrary to the two-way Valve, the flux of the refrigerant cannot be fully prevented from entering or bypassing the heating or bypass, which helps to warm up the motor. While enhanced control has been achieved, it can be costly to install more usable hardware. Moreover, a three-way valve that proportionately controls coolant flux while reducing the pressure drop will make the valve geometries complicated.

No Valve Fluid Control ((Case 4): The thermostat Valve can be removed completely when a regulation over the coolant pump speed and thus flow rate can be achieved. As previously mentioned, the coolant flow rate and direction are the main task of the thermostat. Thus, because of the active pump speed control, the valve loses one of its primary purposes. This reduces the valve to the fluid flow regulation between the circumference and the thermostat loop, which only takes place under heating conditions. However, if the pump runs coolant as needed by the engine, the valve could be removed. Note that coolant must always circulate because hot spots will form, causing damage to the engine. A change in pump rate or flow rate is used for the temperature regulation. The pump speed is reduced to a minimum during warming conditions in order to maintain a fast-operating temperature. The pump speed will then be modified according to the thermal load until the engine reaches its operating temperature. If the pump alone can control the engine's thermal input, the thermostat fan becomes active and adjusts to match the amount of heat rejection required. With servo motor-driven thermostatic disturbances to monitor air-ram effects, more warm—up time can be increased without a thermostat.

Thermal Models and Operating Strategy:

In order to describe the thermal efficiency of an engine, detailed thermal parameters of the multi-node lumped parameters were proposed with application to the auto-coolant flow control by a smaller order mathematical model however can describe the transient response to the controls design needs of the engine.

$$C_e \dot{T}_e = Q_{in} - c_{pc}\dot{m}_r(T_e - T_r), \quad C_r \dot{T}_r = c_{pc}\dot{m}_r(T_e - T_r) - \varepsilon_r c_{pa}\dot{m}_a(T_r - T_\infty) - Q_o$$

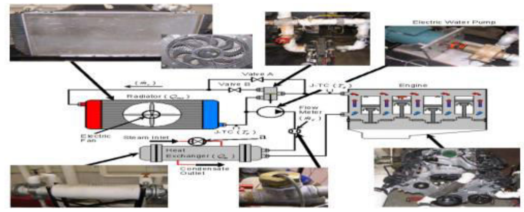

Fig: Schematic of thermal test bench with actual cooling system components, engine block, sensors

Design of new thermostat includes: Thermostat cover, fins, brain, grills and so forth which flow between the air flow paths from the atmosphere to the assembly of thermostat. The following parameters are used for designing a better automobile thermostat: the shape of the thermostat heart, the directional flow of work fluids, thermostat frontal field, space between fines, space between tuber size, fin & tube size, cooling mass fluid flow rate, fine material, fluid speed, air inlet percent respectively.

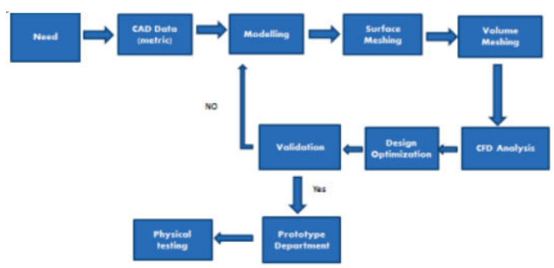

Fig. 2: Process Sequence of CFD Analysis

CFD's role today as a design tool is very significant. Different commercial software is available on the market for CFD simulation. Modelling is rendered by CAD and then the entire discretization model is dis assimilated into small cells. To use a discrete element to control the equation and to overcome these by a CFD solver. Digital solutions are obtained in terms of distribution of pressure, distribution of temperature, distribution of air flow, etc. The result is then optimised and validated by base data. If this model is

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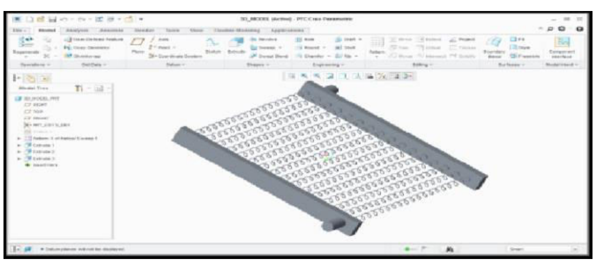
cast and tested in accordance with our requirements then it is generated in real world application.

The basics of CFD simulation:

Dynamics of computational fluids uses data analysis to solve fluid flow problems, including air and heat transport, as well as heat/air interaction with surrounding materials. CFD is also known as a virtual wind tunnel, flux bench and thermal test rig.In general, simulation and CFD in particular have become more important, since these CAD-centered tools allow designers to digitally test products using the latest product 3D CAD models in a variety of virtual environments. These simulations provide data which could hardly or not be collected by physical testing alone.However, simulation is more than the simulated test bed and a wind tunnel using a computer. Simulation may provide a valuable insight into the efficiency of a design and lead to detecting and resolving potential failures validity is the accuracy..

MODEL OF THERMOSTAT:

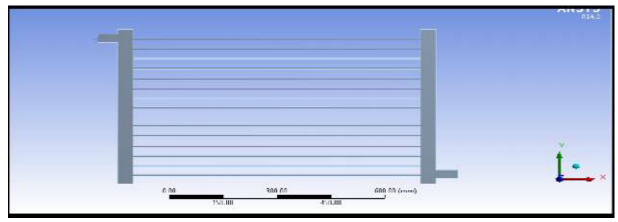


Thermostat Specification for Helical type tubes Number of tubes: 29, helical type tube mean diameter: 30mm, Inner diameter of tube: 2 mm, Outer diameter of tube: 4 mm

ANALYSIS
CFD ANALYSIS OF THERMOSTAT CASE -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 created using CREO and is imported on ANSYS to be meshed and analyzed. In order to calculate the pressure profile and the temperature distribution the CFD analysis is used. The ring is divided into two related volumes for meshing. The thickness of both boundaries is then meshed with 360 intervals. There is a mesh with tetrahedral form. There are 6576 and 3344 nodes and elements

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

RESULTS AND DISCUSSIONS

Automotive thermostats are a major component of a thermal device for cars. It is responsible for maintaining an optimal running temperature both to deter and preserve the performance of catastrophic failures. When cars and their cooling systems have become more sophisticated, thermostats have often become more complex. These sections are no longer as

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simple as a single flow path and flow through or the thermostat afterwards. Now it is easy to have at least three or four pathways and also many outlets for such components.

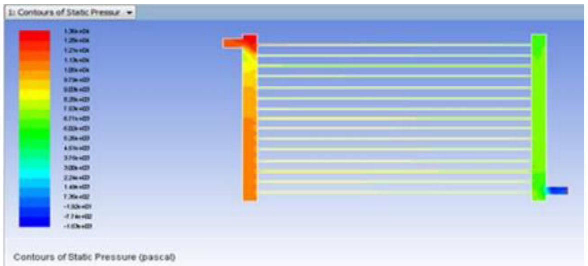

Figure: Static pressure

The above contour plot indicates the maximum static pressures on thermostat helical tubing inlets, because of the application on the neighboring sides of the narrow plate of boundary conditions at boundation and minimal static pressure inlet. The mean pressure is 2,50e+04Pa and the minimum static pressure is -2,14e+04Pa according to this material figure.

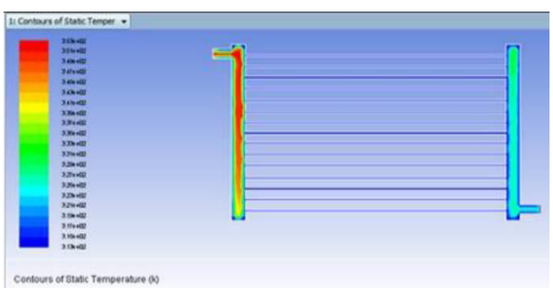

Figure: Static temperature

According to the above contour plot, the air at narrow plate angles has a high static temperature magnetic level when boundary conditions are introduced at the inlet boundary and the lowest static temperature at the narrow plate boundaries. The mean static temperature is 2,22e+02m/s, the minimum static temperature is 1,11e+01m/s, according to the contour analysis above.

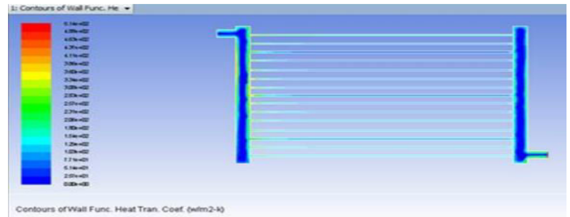

Figure: Heat transfer coefficient

The maximum coefficient of heat transfer of the air at the thermostatic helical tubes edges and minimum coefficient for heat transfer between the edges and the thermostat helical tube edges, according to the above contour plot. According to the contour plot above, maximum coefficient of heat transfer is 3.14e+02w/m2-k, minimum coefficient of heat transfer 1.57e+01w/m2-k.

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

BOUNDARY CONDITIONS:

T 1 =353K Select steady state thermal >right click>insert>select convection> enter film coefficient value is 154.168 w/ m2 k (from CFD analysis)

THERMAL ANALYSIS APPLIED TEMPERATURE

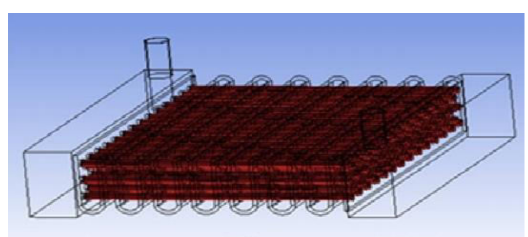

Figure: Applied temperature

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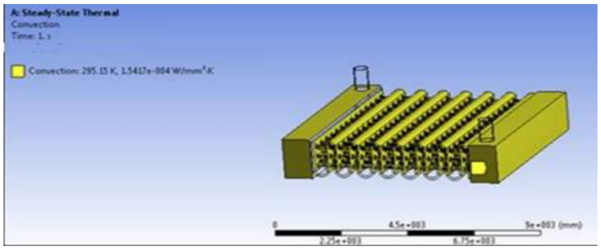


Figure: Applied convection

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. 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 3344Select steady state thermal >right click>insert>select heat flux Select steady state thermal >right click>solve Solution>right click on solution>insert>select temperature

MASSFLOW RATE(Kg/sec)	Fluid	Pressure (Pa)	Temperature (k)	Heat transfer coefficient	Mass flowrate (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

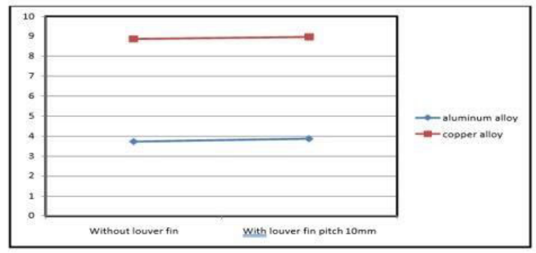
CASE 2 -HELICAL TUBE

MASS FLOW (Kg/sec)	Fluid	Pressure (Pa)	Temperature (k)	Heat transfer coefficient	Mass flowrate (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

Table: result tables case 1-straight tube

THERMAL ANALYSIS RESULTS TABLE

Models	Material	Temperature(°C)	Heat flux(w/mm2)
Thermostat	Aluminum alloy	354.07	0.072436
	Copper alloy	353.58	0.098606



CONCLUSION:

In this project concluded that different nano fluids mixed with base fluid water are analyzed for their performance in the thermostat applied to the different types of fluids.CREO parametric software uses water, air and aluminum oxide nano fluid.3D model radiator. For both fluids, CFD analysis is carried out on the heat sink and thermal analysis in Ansys is carried out. The CFD study would increase the value of the thermal transfer coefficient by increasing the mass flow intake. As compared with the fluids it is the stronger fluid for aluminium oxide Nano fluid, as the benefit of the thermal transfer rate is higher for fluids nano oxide. Thermal analysis is conducted for both aluminum and coffee products in 0.3 fractions of CFD analysis heat transfer coefficient of Aluminum oxide. When observing results of thermal analysis, heat flux is more significant when using copper than aluminium alloy. If we compare the various thermostat geometries, then the helical style tube is the better model, as the heat transfer rate is higher for the radiator of the helical type.

Future work:

A good thermostatic programmable will promote energy conservation and provide comfort and convenience for the persons using it. The goal of future thermostats is to overcome misconceptions about thermostatic activity and reduce the number of interface complaints.

Today, however, designers do not have basic investigations into which thermostat characteristics succeed or fail. Energy Star encourages usability measurement to be included in the next thermostat specification, hoping this initiative would lead to more quantitative usability research and build upon the success of the intuitive famous electronic products.

Finally, we remember that the thermostat is only one of the many devices in which human interaction is essential in the consumption of energy. We expect a similar talk in the future on renewable energy displays, lighting controls and domestic devices (e.g. televisions) aimed at making energy use more visible and more functional user interfaces.

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