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ADVANCED ENGINE COOLING SYSTEM DESIGN THROUGH ADDITION OF THERMOSTAT

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ABSTRACT

In the current scenario our engine technologies need to be modified to meet future emission standards or to increase fuel efficiency as well, the modern car engines worked at certain range of temperature, at which engine performance is very high, this temperature may be in range of 30C to 40C but sometimes due to surrounding atmosphere, weather condition and work load this temperature rises, and this not good for our engine performance. That's why we need a perfect cooling system, which can maintain engine temperature in range, it prevent the engine from getting too hot which lead damage to the engine itself. This can be achieved by coolant circulate through the engine and pick up excess heat and with the help of radiator release this excess heat outside and again circulate inside the engine walls and this circulation of coolant we can control by thermostat, this is situated between the engine and the radiator. Basically it will work as valves which maintain the coolant flow according to temperature of coolant. In our current research work we are going to design advance cooling system by the use of twin thermostat which work in an optimized way and help to increase the efficiency of engine.

KEYWORDS: IC engine, Temperature, Thermostat, Twin-thermostat, Valve, Cooling system etc.

1. INTRODUCTION

Internal combustion engine cooling uses Air or liquid to remove the extra heat from the engine. We can use this air or liquid cooling system according to surrounding atmosphere, location and purpose of engine. We use air cooling system in low capacity engine or when engine is located in open area like our bikes engines. And when we have a higher capacity engine we needs a liquid cooling system, the liquid put into the surrounding of the engine and its works in closed loop system. Liquid has higher heat capacity than Air, and it will help to remove heat quickly from the engine but in liquid cooling system we needed additional assembly like radiator, pump, piping system increase the weight and cost. Aircraft design required lower weight engine cooling system, that's why we use air-cooled designs in engine cooling system. In Automobiles like cars we generally use liquid cooling system as per requirements and we try to optimize the weight of the engine cooling system.

2. PROBLEM IDENTIFICATION

In India most of time mechanical thermostat will fail due to weather change or location change, means we design our vehicle for India considering a normal temperature or weather but this temperature is change according to Nature or location so that or thermostat will have to behave according to temperature, like if we have a winter and rain season, in that case thermostat help to maintain optimum working temperature. And if we are in summer season, in that case thermostat will help to maintain this optimum working temperature as well. We can see in both cases thermostat is in working condition. So the failure chances increase due to continuous uses.

3. METHODOLOGY

In this research methodology we firstly study the previous research work to deeply understand the topic, and then we need to find the failures in design, and the key components of the full assembly which may fail during operation. Then we start our own design using cad software according to particular engine dimensions after that we perform some analysis , in our research work we needed to perform the CFD analysis.

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According to results we have to modify our traditional design as per current requirements and again perform the analysis, in the last we have to conclude our results.

4. CAD MODELING

CAD stands for Computer-Aided Design; with the help of computer aided design software we can create new design, modified it or may analysis it also. There are so many cad software are used in industries currently like pro-e, cre-o, catia, solid works etc.

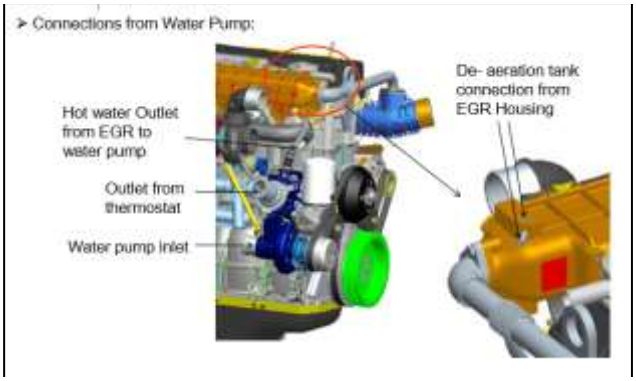

Figure 1.1 Engine cooling system Design

5. CAE MODELING

Generally we have three types of technique to solve any engineering problem, first one is Analytical method in which we reached to our solution through formulas and hand calculations, it is a classical approach , it is assumed to 100 % accurate , but this solution only applicable for simple problems . A second technique is numerical method; it is basically a mathematical presentation of a problem in which we use matrix to solve any engineering problem using CAE software, in this technique we does not need to make prototype , it is a simple technique in which we design and analysis our product using computer system. Using this technique we can easily test our product, or make changes according to requirements, but the results cannot be believed blindly, we need to verify our results by other any techniques. A third one technique is physical experiments, in this technique we need to make a real product prototype and test it, if the test will goes failed need to design and modify, and again test is so we can see it was very long term process and very costly also, along with that, we needed an experienced workers for this work. So finally we solved our problem through numerical method, the numerical method basically based on discretization to convert our model from infinite to finite one, assume we have a geometry have infinite number of points, so if we want to analysis it , we have to solve infinite number of equations means we can't achieve the exact solution of our problem. So with the help of discretization, divide our model into countable number of nodes and elements, at the end we got final and exact answer of our equation.

Meshing is process to generate elements in our model or in other term to replace surface or volume by element generation. Basically it is a process of subdivision of geometry in to discrete geometry. There are four types of elements used in mesh generation according to cad model geometry. The followings are described bellowed.

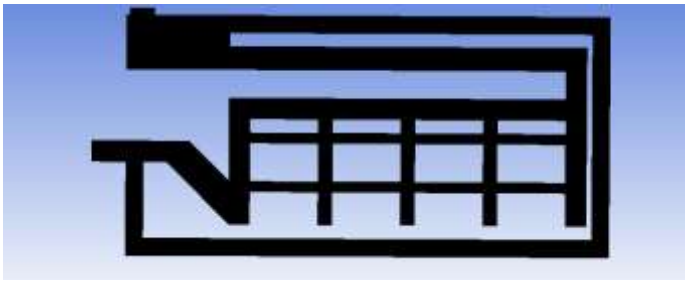

Figure 1.2 FEA model

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6. RESULTS

Results are showing in the contours, we have three cases in our research first results are showing condition when coolant temperature is below the limit so the thermostat is in close condition. As showing in figure the minimum temperature of the coolant is 26.8 degree centigrade, and maximum temperature is 250 degree centigrade at the end of engine cylinder wall.

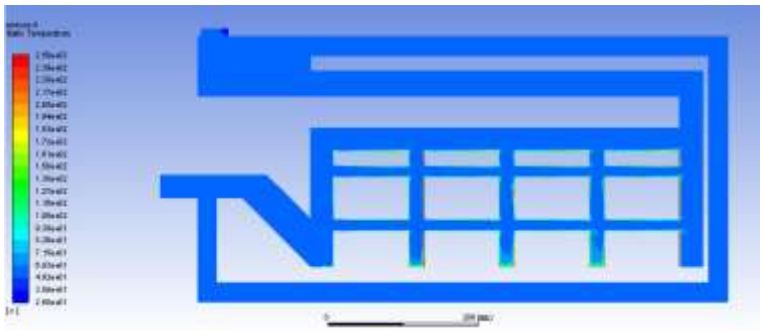

Figure 1.3 Temperature result

In the same case the maximum velocity of coolant is 2.23 m/s, but due to wall shape and flow path the value of velocity will change.

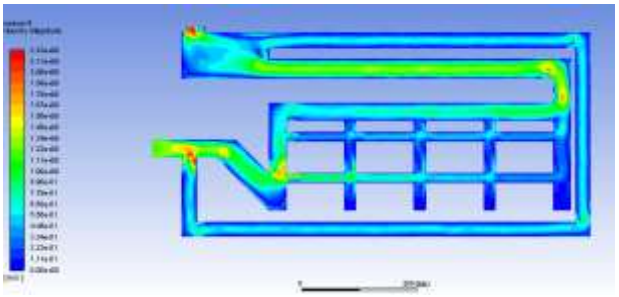

Figure 1.4 Velocity result

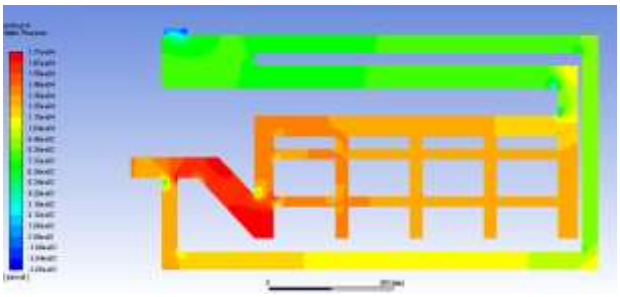

Figure 1.5 Pressure results

The internal coolant temperature will increase up to 84 degree centigrade due to increase the temperature of engine cylinder walls.in this condition the first thermostat will start to open the valve and allows the fluid to go outside.

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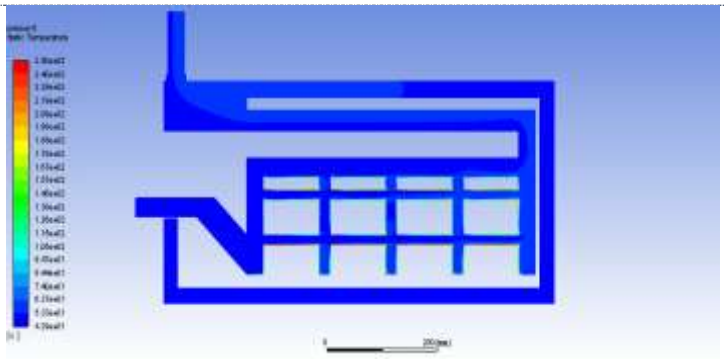

Figure 1.6 Temperature results

When the engine cylinder wall temperature increase up to 300 degree centigrade, the coolant temperature will also increase and this coolant temperature will increase up to 94 degree centigrade. In that condition first thermostat will open the full valve and allows the coolant to go outside in maximum volume like we have 30mm diameter tube in the first condition.

When the temperature increased, the thermostat will be in open condition and allows the fluid to go in to the radiator and release their heat to cool down and again come into engine at the inlet so that the velocity of the coolant will also increase as show in figure.

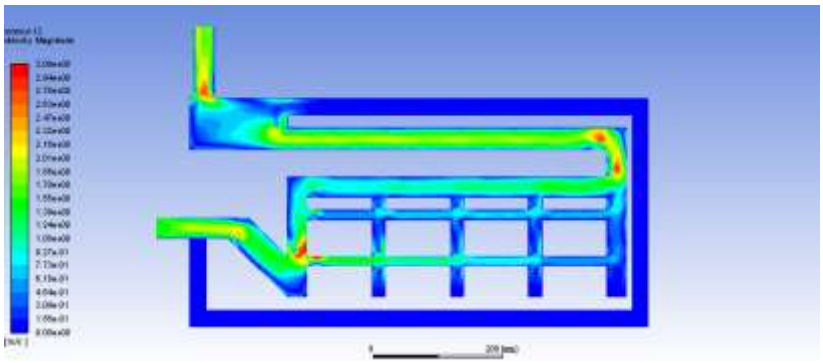

Figure 1.7 Velocity result

As discussed above the inlet and out let will be in open condition so the velocity will increased and when the velocity will increased the pressure of the coolant will also will increased and this value is going up to 2.91e+04 Pascal.

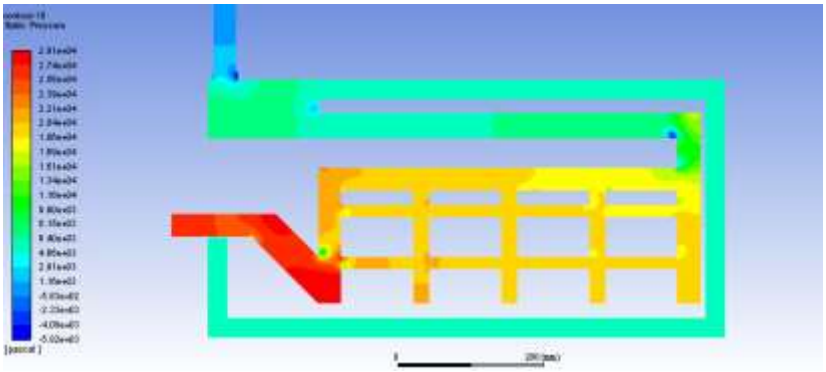

Figure 1.8 Pressure results

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As per our coolant flow path design we insure the density must be equal in the whole closed loop and there is only one inlet and one outlet and the cross section of the tube is also same so that the density of the coolant will remain same and the value of the density is 1.11e+03.

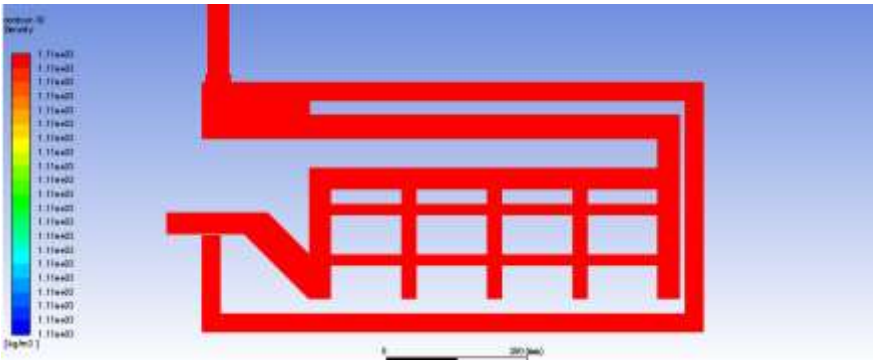

Figure 1.9 Density results

7. DESIGN MODIFICATION

when the engine temperature will increased too much due to any reason, the coolant temperature will also increase. And we need to cool the coolant in a faster and efficient way for that we modified our engine cooling system, in which we add one electronic thermostat at the same outlet place, but it will be in open condition only when the coolant temperature reaches above 94 degree centigrade. And we also made some modification in the dimension of the thermostat like traditional thermostat has 30mm diameter, but we need to increase the outlet size for that we used 35mm diameter in our new electronic thermostat.

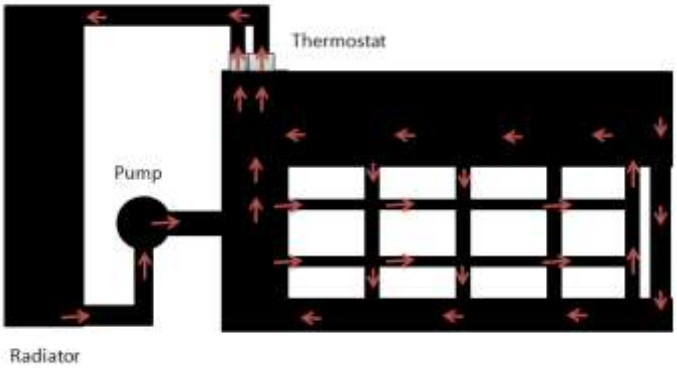

Figure 1.10 both thermostats open condition

When the coolant temperature reached above 94 degree centigrade, the both thermostat is in open condition, and allows the maximum coolant to go outside, and release their heat as soon as possible.

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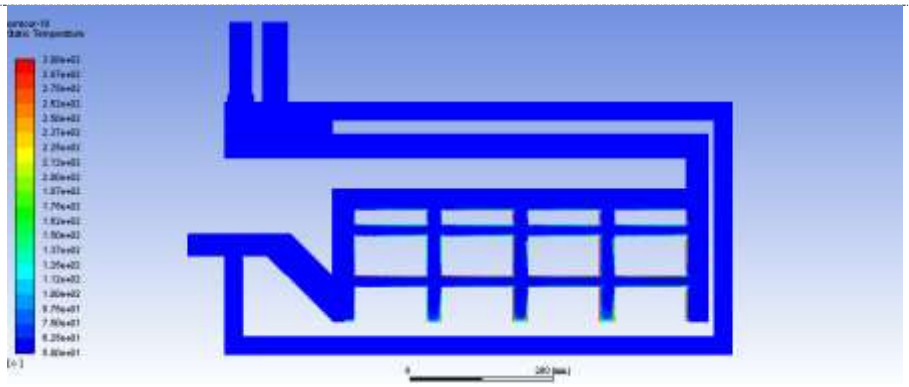

Figure 1.11 Temperature results

As discussed above when both thermostat valve is in open condition, but electronic thermostat only at just opening condition. So it will allow the coolant to go outside more than a previous condition as the same the velocity also increased.

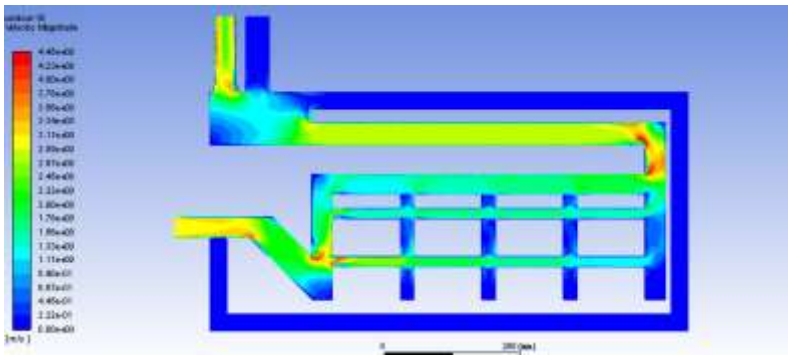

Figure 1.12 Velocity result

When the velocity of coolant is increased the pressure at inlet will also increase and this increased up to 2.95e+04. The increase in pressure and velocity is mainly due to the heating of the coolant.

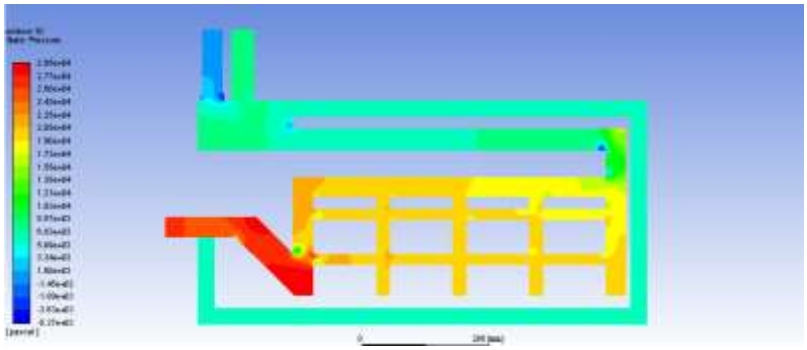

Figure 1.13 Pressure results

The value of the density in whole system will remain the same but at thermostat outlet it will more than a twice to a previous cases because outlet cross sectional area will increased.

When the coolant temperature reached above 98 degree centigrade, the electronic thermostat will be in full open condition.

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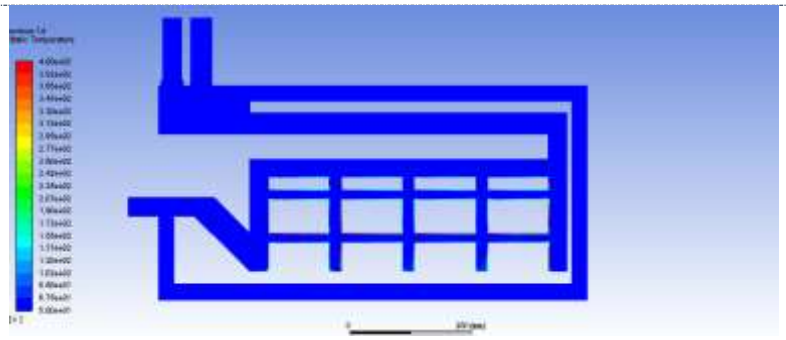

Figure 1.14 Temperature results

As discussed above when both thermostat valve is in full open condition, So it will allow the coolant to go outside more than a previous condition as the same the velocity also increased.

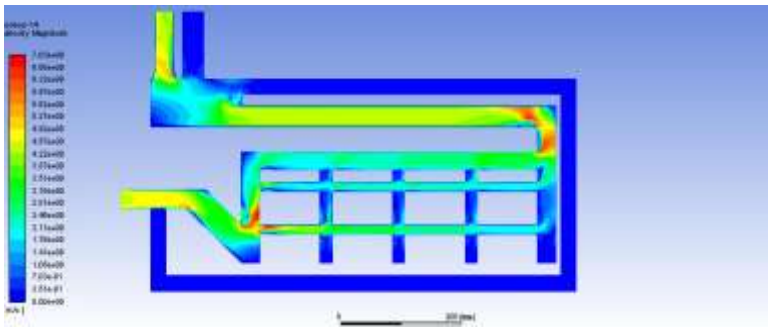

Figure 1.15 Velocity result

When the velocity of coolant increased the pressure at inlet will also increase and this increased up to 5.75e+04.

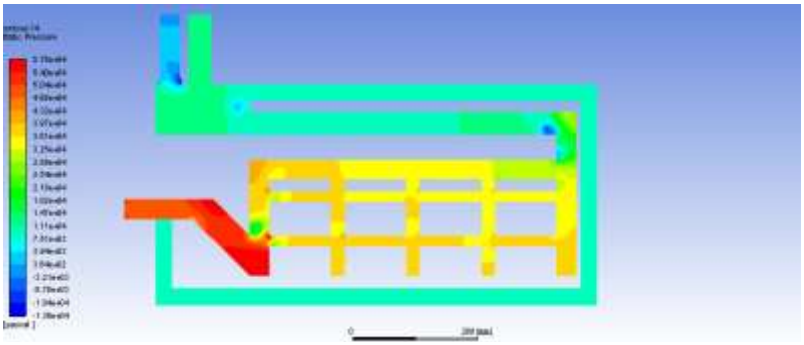

Figure 1.16 Pressure results

The value of the density in whole system will remain the same but at thermostat outlet it will more than a twice to a previous cases because outlet cross sectional area will increased.

8. CONCLUSION

The aim of this research is to improve engine performance by maintaining the optimum working temperature of engine cooling system. In engine cooling system we specifically worked on thermostat, without changing the design of thermostat we worked on size, type and working temperature of thermostat only. We studied some cases with different temperature according to the weather conditions in which we got results which are not satisfactory means in that condition thermostat may will fail due to continuous working or in some cases it will not in proper working condition which lead to decrease efficiency of engine. In that case we modified our design of engine cooling system, in which we use two thermostats, one is mechanical and second one is electrical. Both are different in dimensions, and working temperature. Mechanical thermostat will open above 84 degree

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centigrade, and electronic thermostat will open on above 94 degree centigrade. If one of the thermostats fails in operation second one can manage the operation. And this engine cooling system specially designed for a condition in which the temperature of engine is cross its limit and need to cool it urgently in that case our both thermostat are in open condition so the maximum hot coolant will escape from engine and cold coolant will maintain its optimum working temperature. And as shown in comparison table we can see as per the design change the velocity, pressure and flow rate will increase and that is beneficial for us.

Table.1.1 Results Comparison

Temperature	**Case**	**Velocity (m/s)**	**pressure (KPa)**	**Density(Kg/m3)**	**Flow rate (%)**
Below 84 C	Close thermostat condition	2.23	177	1110	NA
Above 84 C	Mechanical thermostat in opening condition	2.95	177	1110	65
Above 94 C	Mechanical thermostat in full open condition	3.09	291	1110	100
Above 94 C	Mechanical thermostat full open + Electrical thermostat in opening	4.45	295	1110	100 + 25
Above 98 C	Both full open condition	5.24	387	1110	100 + 100

.

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