

Enhancement of Engine Cooling System through Design and Analysis of Thermostat

Anish Save¹, Abhay Kakirde², Dr. Suman Sharma³

¹Mr. Anish D Save, Student, Sagar Institute of Research and Technology, Madhya Pradesh, India

²Mr. Abhay Kakirde, Professor Mechanical Engineering Dept., Sagar Institute of Research and Technology, Madhya Pradesh, India

³Dr. Suman Sharma, Head of Department, Mechanical Engineering Dept., Sagar Institute of Research and Technology, Madhya Pradesh, India

Abstract - We maintain engine temperature by the engine cooling system which consist of radiator, water pump, thermostat, pipe assembly and many other parts. Engine cooling system performance depends upon so many factors but the most important factor is thermostat failure, if thermostat is not in a proper operation, engine cooling system cannot work properly due to this engine performance will be creased or engine parts will get damaged because of overheating. Parts like piston ring, connecting rod, crank shaft and cam shaft may also get affected.



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

1. Introduction - Thermostat Is a component which sense the temperature and takes action accordingly, this component is used in any device or system that is related to heating and cooling, for example HVAC units, automobile cooling system, air conditioners, water heaters, refrigerators etc. The word thermostat is derived from Greek word thermos and statos. The thermostat is a kind of check valve which open and close according to temperature limit and it is located at water outlet in the engine cooling system. When the Engine is started in the warm condition the thermostat remains closed and water pump is used to circulate the coolant inside the engine block. When engine temperature reaches its limit the thermostat valves is in open condition and allows hot coolant to flow towards the radiator to release heat energy and get cooled. The standard thermostats are designed to start opening the valve at 84C, and the fully opening temperature is around 95C.

2. Problem identification - Thermostat is the most important part of the engine cooling system, but some time thermostat will fail due to some reason listed below.

Overheating- The engine may overheat due to any reasons. This overheating also impacts on internal parts of the thermostat, because they are designed for normal working temperature only.

Sludge- A common problem is the congealing of the coolant is a thick sludge-like material. This sludge can get inside the thermostat and restrict the flow or even cut-off altogether.

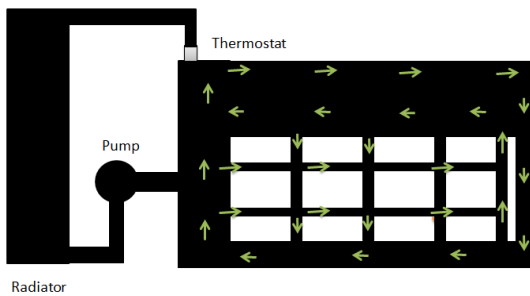
Defect- Just like other manufacturing parts thermostat is also produced in mass scaling some minor defects can lead thermostat to get defective straight from the box, or may fail shortly after installation.

Age- Age is another common reason for failure. The thermostat is constantly heated and cooled, and after a while the internal components can simply wear out. This occurs slowly and almost unnoticed, but the temperature in which the thermostat opens begins to get higher and higher, until one day a complete overheats occurs.

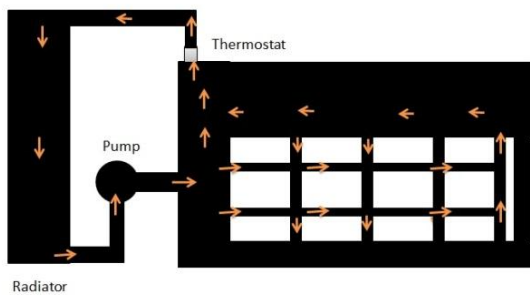
If the thermostat becomes stuck in the open position, there is continuous flow of coolant into the radiator causing the engine to run cold. Overcooled engines run inefficiently, which leads to increase fuel consumption and higher emission levels. In addition, the car interior will not heat up properly, if the thermostat becomes stuck in the closed position. The circulation of the coolant is blocked and the coolant cannot reach the radiator, which causes the engine to overheat.

3. Working - Thermostat is a device combined with valve mechanism and temperature sensor, that is used to circulate coolant, when engine temperature is above the limit. In simple words a thermostat work by responding to the change in temperature of coolant. If the engine coolant is cold, Thermostat maintain their closed position by not allowing cold fluid to go outside, and return back to the engine again as shown in case 1. Once the engine coolant gets heated, thermostat allow this hot coolant to go towards the radiator and transfer its heat on open atmosphere. The thermostat contains a cylinder filled with wax. This cylinder

lies on the sides of the thermostat so it will maintain contact with coolant inside the engine. This cylinder contains one valve connected by rod, the rod press in to wax at the center of cylinder. When the coolant temperature rise, the wax starts melting, this melting wax expand and push the rod outward, this movement of the rod helps to open the connected valve, once the valve opens this hot coolant is allowed to pass from it, as shown in case 2.



(a)



(b)

4. Methodology – In this research methodology we first study the previous research work to understand the topic, and then we need to find the failures in design, 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 need to perform the CFD analysis. According to the results we have to modify our traditional design as per current requirements and again perform the analysis, at last we have to conclude the result.

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

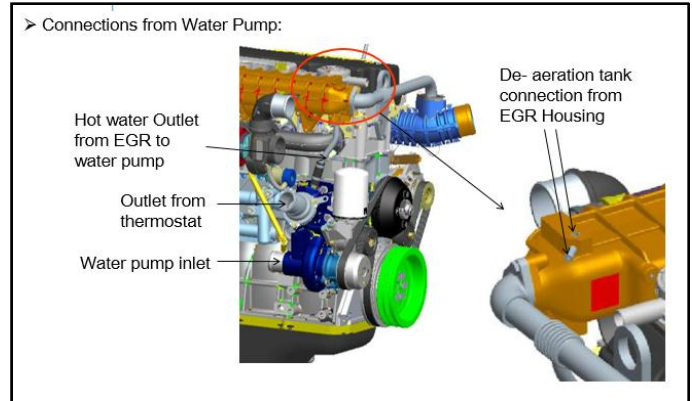


Fig.4.1 Engine cooling system Design

6. CAE Modeling - CAE modeling and analysis is the most important technology in automobile industries. We used ANSYS as a preprocessor and FLUENT as a solver for preparation of our model.

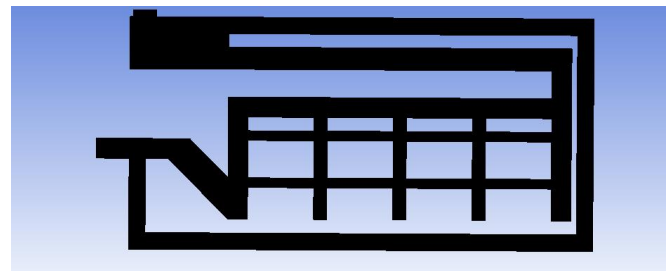


Fig.6.1 FEA model

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

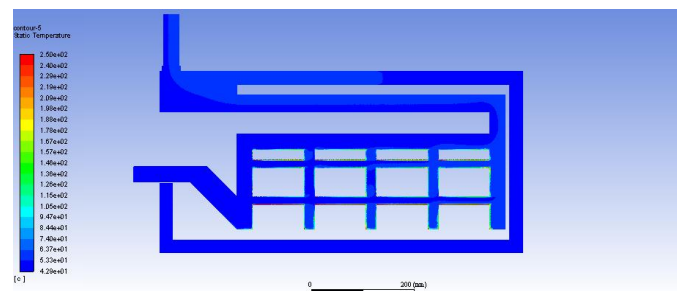


Fig.7.1 Temperature result

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

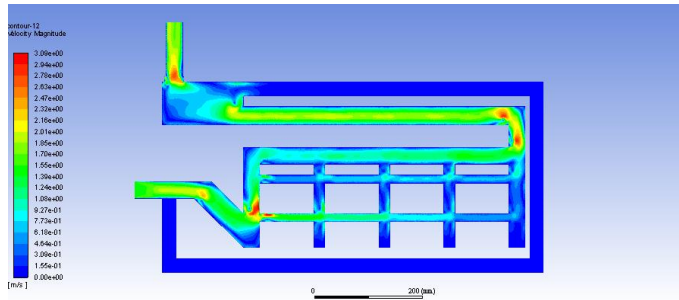


Fig.7.2 Velocity result

In the same condition when the thermostat is not in working condition the velocity of the coolant is 2.73m/s.

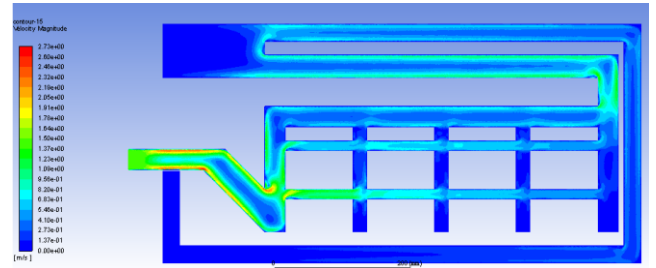


Fig.7.6 Velocity result

If the velocity increases the pressure of the coolant will also increase and this value is going up to 2.91e+04 Pascal.

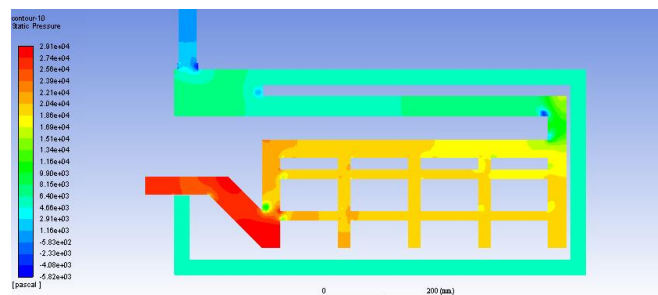


Fig.7.3 Pressure results

On that condition the pressure value will be 2.66E+04

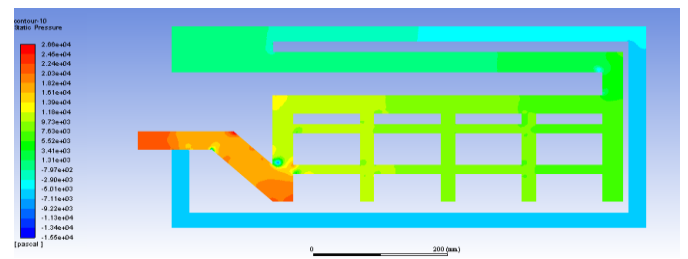


Fig.7.7 Pressure results

the density of the coolant will remain same in the whole engine and the value of the density is 1.11e+03.

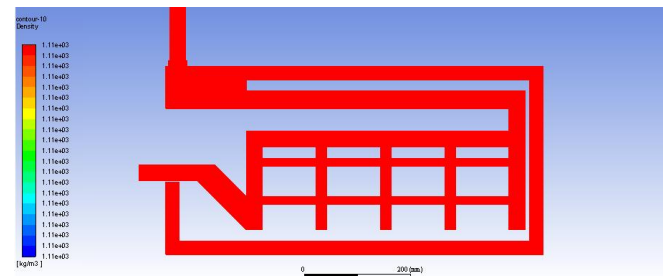


Fig.7.4 Density results

As the previous discussed the density of the coolant will be same in the engine internal area.

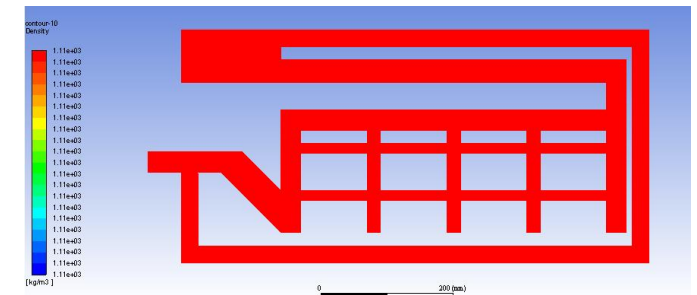


Fig.7.8 Density results

A condition assumed when mechanical thermostat fail. In that condition engine may get heated, or may shut down due to overheat. It may cause damage in the engine piston ring, may break the crank shaft, connecting rod etc.



Fig.7.5 Temperature result

8. Design Modification- In case the mechanical thermostats fail due to any reason; engine component may get damaged. For this we update engine cooling system by introducing one electronic thermostat with the existing thermostat.

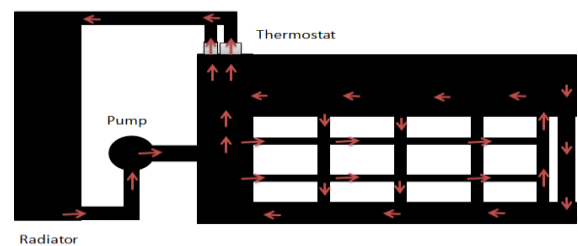


Fig.8.1 Design Modification

Condition assumed when mechanical thermostat fail and only electronic thermostat will be in full open position at the highest temperature of coolant.

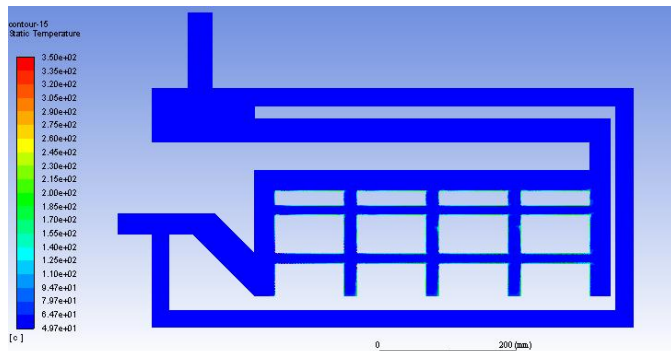


Fig.8.2 Temperature result

On same condition when the electrical thermostat is in open position and the velocity of the mechanical thermostat coolant will increase with previous cases.

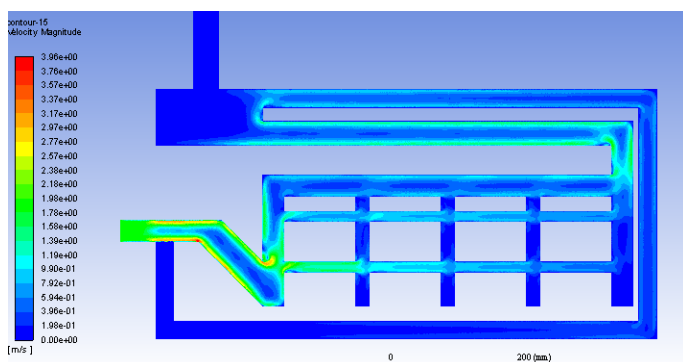


Fig.8.3 Velocity result

When the velocity and temperature of coolant increased, the pressure valve will also increase.

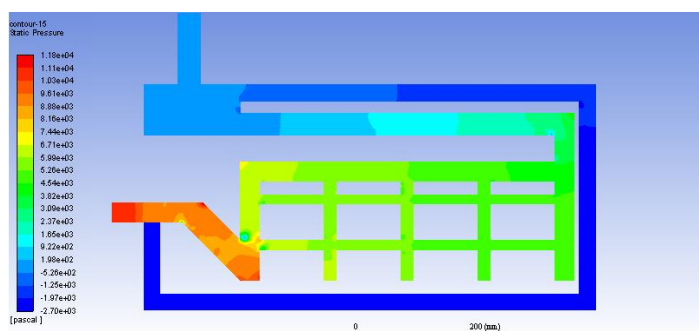


Fig.8.4 Pressure results

As discussed the density of the coolant will be same in the engine internal area.

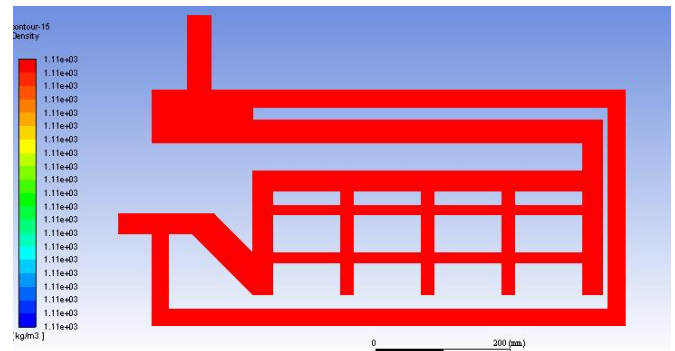


Fig.8.5 Density results

9. Conclusion- The aim of this research is to prevent engine from failure due to overheating and maintaining optimum temperature by changing the engine cooling system design, we have used two thermostat in our design, first one is traditional thermostat and second thermostat is electronic thermostat which is larger in diameter along with different working temperature.

10. References-

1. Cooled by air and water by John H. Lienhard
2. Vehicle for hot weather
3. High temperature engines by Lloyd Kamo, Ardy Kleyman, Walter Bryzik, Ernest Schwarz-
4. Katrina C. Arabe (April 11, 2003). ""Dummy" Thermostats Cool Down Tempers, Not Temperatures". Retrieved February 13, 2010.
5. James E. Brumbaugh, AudelHVAC Fundamentals: Volume 2: Heating System Components, Gas and Oil Burners, and Automatic Controls, John Wiley & Sons, 2004 ISBN 0764542079 pp. 109-119
6. "An Early History Of Comfort Heating". The NEWS Magazine. Troy, Michigan: BNP Media. November 6, 2001. Retrieved November 2, 2014.
7. "Smart PID temperature control". smartpid.com. Retrieved October 10, 2018
8. Automotive Thermostat Valve Configurations: Enhanced Warm-Up Performance Journal of Dynamic Systems Measurement and Control 131(4) · July 2009
9. High performance thermostat , Tridon.com
10. Sawyer, "Doc". "Thermostat Wire Color Codes". dr-fix-it.com. Retrieved March 7,2015.
11. Transtronics, Inc. "Thermostat signals and wiring". wiki.xtronics.com. Retrieved March 7, 2015.

12. "Honeywell smart response technology". manualslib.com. Retrieved October 10,2018.
13. "Temperature Controllers Using Hysteresis". panasonic.com. Retrieved October 10, 2018.