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CFD ANALYSIS OF RADIATOR BY USING GRAPHENE/WATER NANO-FLUID PROPERTIES

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Abstract - The Radiator is important part of Vehicles. For its better efficiency cooling liquid or coolant is important factor. Such liquids improve day by day because of high performance vehicle need effective dissipation of heat. Nano-fluid is good substitute for that and research with different nano material is the need of the today's automotive sector. Graphene is newly introduced two dimensional one atom thick nano material and here properties of Graphene are much useful. By using water as a base fluid in Nano-fluid, Graphene/Water nano-fluid is prepared for simulation of Radiator. ANSYS fluent is the best simulation software to simulate thermal and fluid related simulations. And by using that software here simulation results are achieved.

***Key Words*: Radiator, Nano-fluid, Graphene, CFD, ANSYS.**

1. INTRODUCTION

Radiator is a heat transferring device which is essential part of vehicles. For controlling temperature of engine cooling liquid, coolants are used. But high performance vehicle needs rather faster heat dissipation. For that high performing liquids are needed.

Nano-fluids are the solution for that. Its exceptional properties, for high performance vehicle, are the best resource to control engine temperature faster than other liquids. These nano-fluids are nothing but fluids containing nano particles of a material. These are prepared by using a base liquid and nano particles.

In nano-fluid research some common materials like Al_2O_3, CuO, $CuTiO_2$, AgMgO, SiO_2, TiO_2, ZnO etc. are used. Here Graphene can also be used but with Alumina. So here we go with Graphene nano particles and water as a base fluid.

Analysis can be carried by two different ways. One conventional way is experimentation and another by Simulation. This simulation is recently developed. In simulation, prototype is developed in Software. These simulations are carried by using different numerical methods. For CFD analysis here ANSYS FLUENT is best option for making any fluid related simulations. With that simulation software, the work is completed, by using Graphene/Water Nano-fluid properties.

2. EXPERIMENTAL SETUP

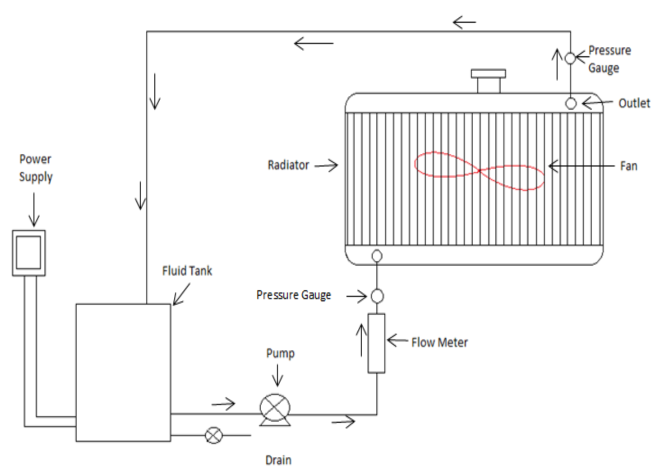

Fig -1: Experiment Block Diagram

The above figure is a block diagram of the setup. It shows the working and direction of liquid flow. After switching on, all electrical equipments start except fan. It has a separate switch on board. The fluid comes in Radiator by pumping fluid from fluid tank. In radiator heat will removed and passed it to fluid tank and it is a continuous cycle. But because of this COVID-19 pandemic situation, couldn't conduct physical experimentation on Setup.

2.1 Specification of Experimental Setup and Materials

Radiator

- Type of Radiator:- Single Panel Radiator
- Used for:- Maruti 800 Material :- Aluminum
- No. of Tubes:- 33
- Heater with thermostat:- It gives us 90^{0}C continuous temperature of the fluid which we pass from the radiator. Heater works on AC power supply. Thermostat works on DC supply. This helps to maintain temperature at same.
- Motor:- Sameer i-Flo 0.5 Cetrifugal water pump , Single phase water Pump, 0.5kW, 220V, 0.5 HP
- Fluid tank:- Steel , 10 ltr capacity

Table -1: Radiator Dimensions

Radiator	Height (mm)	Length (mm)	Width (mm)
For Body	400	320	40
For Pipe	320	25	3

- Preferred material

Table -2: Properties of Materials

Properties → / Materials ↓	Density (Kg/m^3)	Viscosity (Kg/m-s)	Specific Heat (j/Kg-k)	Thermal Conductivity (w/m-k)
Water	998.2	0.001003	4182	0.6
Ethylene Glycol	1111.4	0.0157	2415	0.252

- Graphene:-

Graphene is a nano-material which comes in the form of sheet. It is two dimensional and material with thickness of one atom.

3. CALCULATION for DIFFERENT FLOW RATE

Here we consider different flow rates for checking heat transfer rate at a different flow rates as well as the velocity of outlet with an inlet velocity difference. For this we take 300, 240, 180 LPH mass flow rate. With this mass flow rates following calculations are carried,

$\frac{1}{\mu} = \frac{1}{hi} + \frac{L}{KA} + \frac{1}{ho}$

μ= Dynamic viscosity, hi = Internal heat transfer coefficient, ho = External heat transfer coefficient, For 5 LPM = 0.0000833 m^3/sec

Area of Pipe = A= l×w (Rectangular area) = 4.5× 10^{-5} m^2

Height of Pipe is 0.32m, Thermal Conductivity K= 0.5918 w/m-K

Equivalent Resistance = $\frac{L}{KA}$ = 12016.07 Discharge = A × V = 1.85 m/sec.

Nusselt number = Nu = $\frac{hL}{K}$, Hydraulic dia. = Dh = $\frac{2A}{P}$ = 5×10^{-3}

Re = $\frac{\varrho \times v \times Dh}{\mu}$ = 10362, Pr = $\frac{\mu \times Cp}{k}$ = 6.31, Nu = 78.36

h = $\frac{Nu \times k}{L}$ = 144.47, Nu = $\frac{hL}{K}$ = 78.48

4. NUMERICAL ANALYSIS of RADIATOR by ANSYS

This part gives the Analysis of Radiator by using ANSYS. That ANSYS is worked on governing equations. That governing equations are given below,

Continuity Equation:-

$$\frac{D\rho}{Dt} + \rho\,(\nabla . v) = 0 \quad 1$$

Momentum Equation:-

$$\frac{\partial}{\partial t}(\rho u) + \nabla.(\rho u \times u) = -\nabla p + \nabla.\tau + \rho g \quad 2$$

Energy Equation:-

$$\rho Cp \frac{DT}{Dt} = -\left(\frac{d\dot{q}_x}{dx} + \frac{d\dot{q}_y}{dx} + \frac{d\dot{q}_z}{dx}\right) + q_h \quad 3$$

4.2 Geometry and Meshing of Radiator

As per physically measurable dimensions, create model in design modular of ANSYS FLUENT.

The Meshing of radiator in flow domain is calculated in ANSYS fluent meshing module. Here the unstructured tetrahydral mesh is used for meshing. The following table shows the quality of different aspect values of meshing technique.

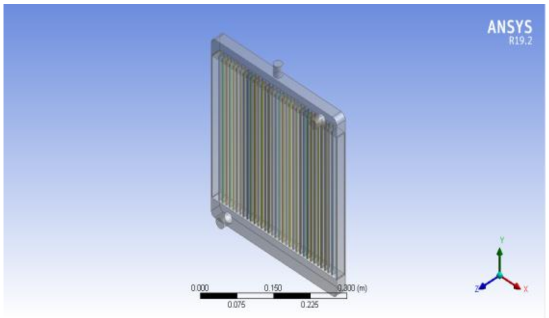

Fig -2: Geometry of Radiator

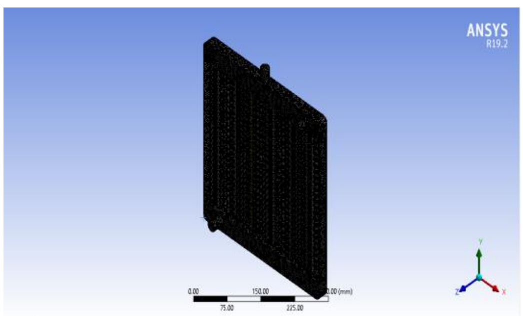

Fig -3: Meshing of Radiator

Table -3: Mesh Quality Aspects

Nodes	Element	Aspect Ratio	Skewness
482186	120780	9.108	0.4908

4.3 Boundary Conditions

Table -4: Boundary Conditions for Water, Ethylene Glycol

No.	Face	Type of boundary condition	Velocity magnitude (m/sec)	Temperature (K)
1	Inlet	Velocity Inlet	5	363
2	Outlet	Exit Pressure	-	-
3	Wall Solid	-	No slip condition	Heat Transfer rate 15

Table -4: Boundary Conditions Water based Graphene Nano-fluid

No.	Face	Type of boundary condition	Velocity magnitude (m/sec)	Temperature (K)
1	Inlet	Velocity Inlet	4	363
2	Outlet	Exit Pressure	-	-
3	Wall Solid	-	No slip condition	Heat Transfer rate 15

4.4 Solver Setting

Solver setting used for Analysis in 3D Pressure based solver with standard K-ω and then energy equation is activated. Here we consider heat transfer. So energy equation must start with calculation of that. After this fluid properties and boundary conditions are given to solver. The SIMPLE algorithm for coupling velocity was used. The higher order upwind stream scheme was used for pressure, momentum, turbulent kinetic energy, specific heat dissipating rate and energy.

5. RESULTS and DISCUSSION

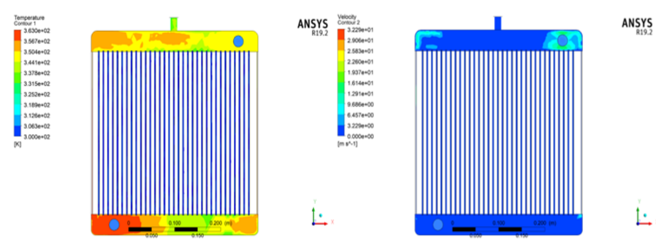

Fig -4: Temperature and Velocity Contour of Water

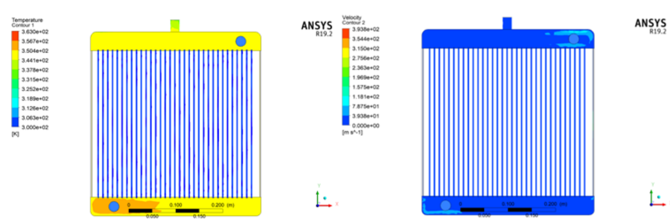

Fig -5: Temperature and Velocity Contour of Ethylene Glycol

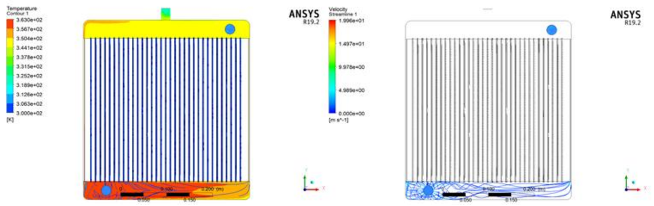

Fig -6: Temperature and Velocity Contour of Graphene/Water Nano-fluid

Above figures represent the simulation result in the form of Contour plot. As per use of a radiator it works like that temperature will decrease with increasing velocity. It is because of area of pipes compared to inlet and outlet. Velocity of water is comparatively higher than Nano-fluid because of its density and viscosity. In following table values are given as per simulation result:

Table -6: Result Table

Radiator Properties →	Temperature (K)		Velocity (m/Sec)	
Radiator Material ↓	Inlet	Outlet	Inlet	Outlet
Water	363	348.678	5	7.27
Ethylene Glycol	363	352.678	5	6.50
Nano-fluid	363	345.287	4	5.1638

6. CONCLUSION

This paper reports the simulation work on Radiator. And as per simulation result 15°C to 17°C temperature drop is achieved by Nano-fluid and velocity increase from 1 to 1.5m/sec. Increasing velocity is natural because of an area of radiator pipes. This result of Nano-fluid is compared with water and Ethylene Glycol and its shows positive effect.

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