Indigenous Development of Automobile Radiator using CFD

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Abstract- **The aim of this project is to design and optimize the existing automobile radiator. The entire analysis is carried out using CFD (Computational Fluid Dynamics) with FLUENT (6.0.) as software. The main objective is to design the automobile radiator with surface area density (SAD) greater than 1000 m^{2}/m^{3} with increased heat transfer coefficient, rate of Heat transfer, reduced cost and reduced weight using CFD. Suitable modifications are to be incorporated depending on the requirements.**

Key Words- CFD, FLUENT, SAD

I. INTRODUCTION

Car radiator is one of the most important operating components of our automobile. Responsible for keeping our automobile's engine at a safe operating temperature, a malfunctioning automotive radiator could mean big trouble for us if we do not seek professional mechanical attention immediately. Auto radiator and truck radiator problems can often develop without we even knowing it, with small particles of dirt and rust clogging up the essential elements, preventing our car radiator from being able to cool our engine properly. If this happens, our vehicle will over heat, potentially leaving us stranded.

A. *Chanracteristics*

Color is not always a reliable indicator of the coolant's family. There are green conventional and hybrid products, and we've even seen one green carboxylate. There are yellow coolants in all three families. So far, we haven't seen any orange conventional products but there are both carboxylates and hybrids in orange. All can be found in shades of red and blue. To make matters worse, most of the colors change with time, drawing closer together and making matching even more difficult.

II. DESIGN DETAILS

The automobile radiator is first designed using GAMBIT with following design specifications. Length (L) = 600 mm Width (B) = 750 mm Height (H) = 75 mm

With tube specification as follows:

Length of each tube = 1mm

Width of each tube = 3 mm

Total number of tubes= (24x12)

The inlet and outlet pipes through which water is flowing is designed with diameter of d= 70 mm and Length l = 200 mm

III. HEAT TRANSFER CALCULATIONS

A. *Heat transfer on air side*

1.Q=h a ΔT

For air heat transfer coefficient (h) = 20 w/m^2 k

Heat transfer area=(2x0.6x0.75)+(2x0.075x0.6)+(2x0.75x0.075)=1.1025m^2.

ΔT=40$^{\cdot}$c

Q=20x1.1025x40 = 882 w

B. *Heat transfer on water side*

2.Q=M C_P ΔT

882= M x 4187 x45

M = 0.00468kg/s

C. *Mass of water through each tube* (m) = ρA V

Area (A) = 3x1 = 3 mm^2

Density of water=1000 kg/ m^3

0.00468=1000x 3xe-6x V

V= 1.56 m/s

D. Reynolds number (Re) = VD/υ = 1.56x 3e-3/o.61225xe-6 =7644 Total volume (V)=lxbxw

= 0.6x0.75x0.075

= 0.03375m^3

E. Heat release rate per unit volume (Q/V) = 882/ 0.03375= 26133.33 w/m^3

Friction factor (f) =$0.079/Re^{0.25}$ = $0.079/7644^{0.25}$ = 0.0084

Pressure loss on tube side 4.(ΔT) = 4f L $V^2/2g$ D= 4x0.008x0.75xV^2/19.62x3e-3

= 0.43 V^2

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IV. DESIGN USING CFD

Fig.1 shows the static pressure drop of water with coolant from the inlet to outlet. The pressure decreases from 191 Pascal to nearly vacuum at the outlet. Fig 2 illustrates the velocity vector changes from 1.93e-3 to 1.83 e-7 of coolant .The very slow movement of coolant increases the time of contact between the two fluids resulting in increased heat transfer. In Fig.3 at inlet and outlet of the radiator, the velocity is different from at the porous media. To create turbulence, this increases the rate of heat transfer from water to air. In Fig 4 Using GAMBIT the given model is subjected to discretization using Hexa mesh type of Mesh Generation with interval count of 10. For fine mesh configurations copper mesh is preferred. The mesh is regenerated using above procedure. Fig 5. Shows the variation of water temperature from inlet to radiator to outlet. The tempmperature of water decreases from 353 k (80^{o}c) to 308 k (35^{0}c) in order to avoid the overheating problems.

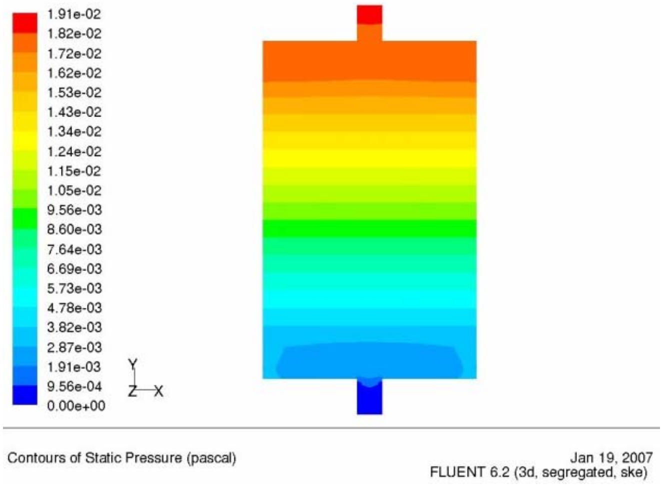

Figure.1Static Pressure drop of water

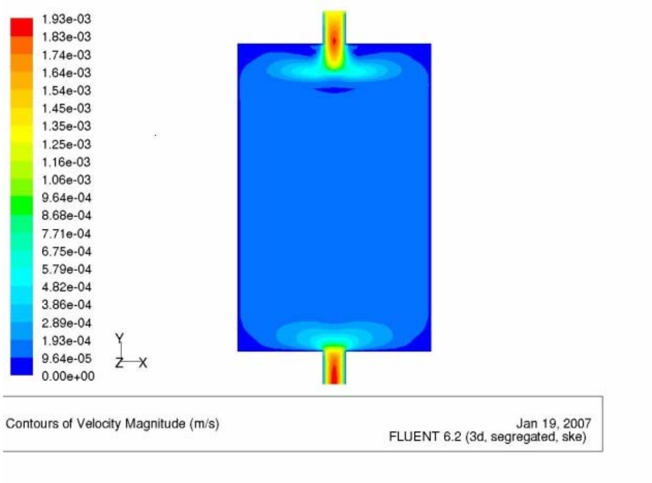

Figure.2Velocity magnitude on water side

Fig.3 Path line variation on water side

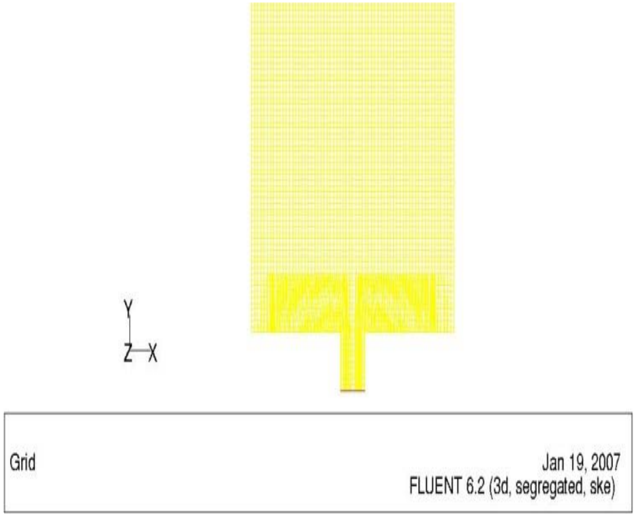

Figure.4 Grid generation ion water side

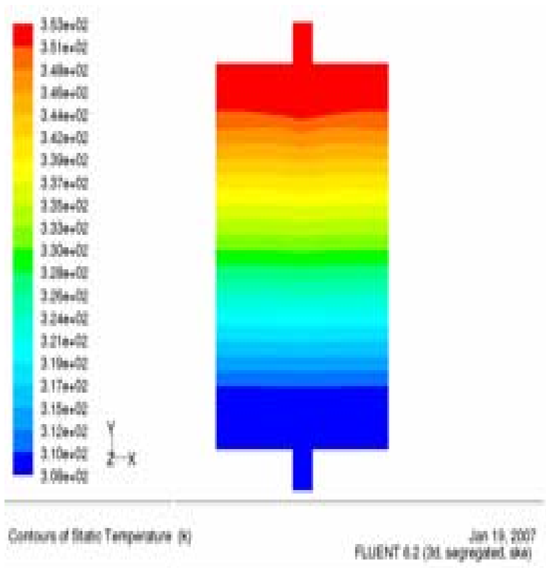

Figure.5 Static Temperature drop on water side

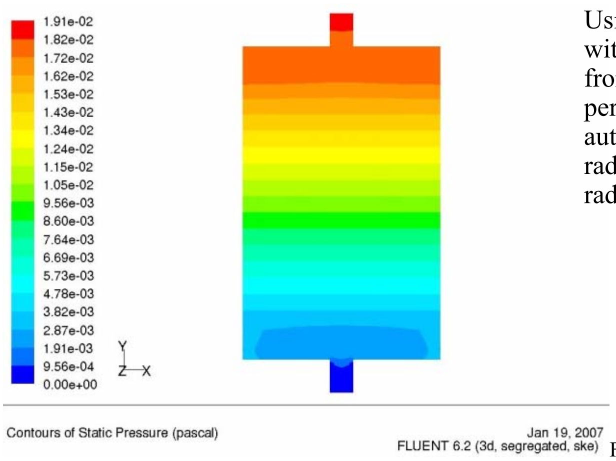

Figure.6 Static Pressure rise of air

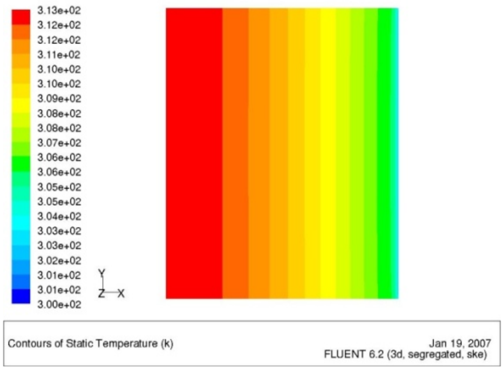

Figure.7 Static Temperature rise of air

Fig.7 shows the temperature of air increases from 302 k (29°c) to 313 k (40°c) from inlet to outlet with cross flow conditions.

V. D ESIGN SPECIFICATIONS

TABLE I

FLOW CONDITIONS

FLUID	*INLET TEMPERATURE °C*	*OUTLET TEMPERATURE °C*	*MASS FLOW RATE Kg/s*	*VELOSITY m/s*	*HEAT TRANSFER AREA m^2*
WATER BLENDED WITH COOLANT	80	35	0.046	------	0.86486

RESULTS AND DISCUSSIONS

Using FLUENT as a tool the Automobile radiator is designed withabove design specifications with surface area density increased fro from 1000 m^2 / m^3 to 1500 m^2/ m^3. Hence more heat is Tran transferred per unit volume thereby decreasing the size of exist existing automobile radiators with consequent reduction in the cost size of the radiator. This will be a improved solution for the problems faced by the radiator manufacturers.

TABLE 2 PARAMETRIC STUDIES

Parameters	CS : 1 x 3		CS : 2 x 3		CS : D3	
	Water	Air	Water	Air	Water	Air
T1 (K)	353	300	353	300	353	300
T2 (K)	308.067	312.93	307.95	313.18	307.94	313.36
Δ T (K)	44.933	12.93	45.05	13.18	45.06	13.36
Δ P (Pa)	0.00736	15.83	0.008183	3.725	0.0189	1.13
Vel (m/s)	0.00115	0.77	0.0012	0.78	0.001	0.9
Mass flow rate Kg/s	0.00116	0.062	0.00116	0.062	0.00116	0.062
Q_{act} (W)	218.80	-	218.85	-	218.24	-
Q_{max} (W)	255.95863	-	255.95863	-	255.95863	-
€	0.85	-	0.855	-	0.8526	-
SAD (m^2/ m^3)		972.87		1000.03		966

VI. CONCLUSION

The radiator size is reduced without affecting the heat transfer characteristics with improved rate of heat transfer. Depending on the requirements suitable modifications need to be incorporated thereby making the design more indigenous both from design point of view and economical point of view.

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