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INTEGRATION LIFE CYCLE DESIGN AND PERFORMANCE ANALYSIS OF LOUVERED FIN AUTOMOBILE RADIATOR USING FEA TOOLS

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ABSTRACT

Radiators are used to transfer thermal energy from one medium to another for the purpose of cooling. Radiators are used for cooling internal combustion engines, mainly in automobiles but also in piston-engine aircraft, railway locomotives, motorcycles, stationary generating plant. The radiator transfers the heat from the fluid inside to the air outside, thereby cooling the fluid, which in turn cools the engine. Research is being carried out for several decades now, in improving the performance of the heat exchangers, having high degree of surface compactness and higher heat transfer abilities in automotive industry. In this thesis, the compact heat exchangers have fins, louvers and tubes. Present study uses the analysis tool to perform a numerical study on a compact heat exchanger at different mass flow rates. The computational domain is identified from literature and validation of present numerical approach is established first. Later the numerical analysis is extended by modifying chosen geometrical and flow parameters like louver pitch, air flow rate, water flow rate, fin and louver thickness, by varying one parameter at a time and the results are compared. The material used for fins of radiator is Aluminum alloy 6061. Modeling is performed in CATIA and analysis is performed in ANSYS. Recommendations have to be made on the optimal values and settings will be based on the variables tested, for the chosen compact heat exchanger.

1.0 INTRODUCTION

Radiators are heat exchangers used to transfer thermal energy from one medium to another for the purpose of cooling and heating. The majority of radiators are constructed to function in automobiles, buildings, and electronics. The radiator is always a source of heat to its environment, although this may be for either the purpose of heating this environment, or for cooling the fluid or coolant supplied to it, as for engine cooling. Despite the name, radiators generally transfer the bulk of their heat via convection, not by thermal radiation, though the term "convector" is used more narrowly; see radiation and convection, below.

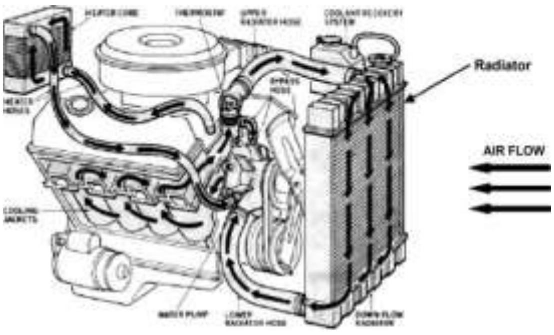

Figure: 1.1. Radiator

The radiator transfers the heat from the fluid inside to the air outside, thereby cooling the fluid, which in turn cools the engine. A typical radiator used in automobile. Radiators are also often used to cool automatic transmission fluids, air conditioner refrigerant, intake air, and sometimes to cool motor oil or power steering fluid. Radiators are typically mounted in a position where they receive airflow from the forward movement of the vehicle, such as behind a front grill.

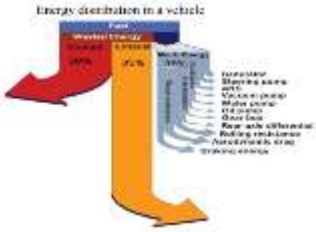

Figure: 1.2. Energy distribution

There are two primary classifications of heat exchangers according to their flow arrangement, parallel flow and counter flow. In parallel-flow heat exchangers, the two fluids enter the exchanger at the same end, and travel in parallel to one another to the other side. In counter-flow heat exchangers the fluids enter the exchanger from opposite ends.

1.1 Description

The experimental work identified from the open literature to validate the present computational methodology is that will be discussed in detail in this chapter. The authors tested air-side heat transfer and pressure drop characteristics of flow over louvered fins in compact heat exchangers experimentally. The test samples consist of two types of fin configurations. A series of tests were conducted to examine the geometrical parameters of louver pitch, louver arrangement (symmetrical and asymmetrical) and number of louver regions. Their calculated results indicate that a symmetrical arrangement of louvered fins provides a 9.3% increase in heat transfer performance and a 18.2% decrease in pressure drop than the asymmetrical arrangement of louvered fin. Also, for a constant rate of heat transfer and pressure drop, a 17.6% decrease of fin weight is observed for the symmetrical arrangement of fins and this is following by considerable decrease in total weight and cost of the heat exchanger. The results from this investigation indicate that the configuration of the louvered fins has the dominant influence on the heat transfer and pressure drop.

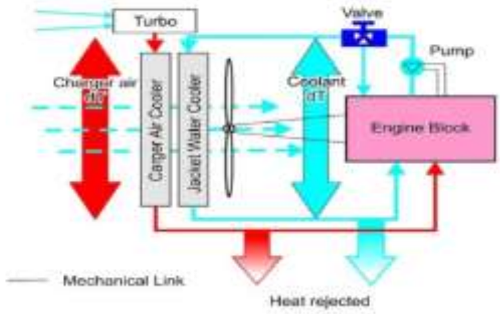

Figure: 1.3. Symmetrical Arrangement

1.2 Physical model

The geometric construction details of the louvered, finned compact heat exchanger studied presently. The louver with a symmetry pattern domain is chosen for the present numerical study. The fin geometry indicates that it has a periodicity in the tube height-wise (span) direction and in the lateral direction too.

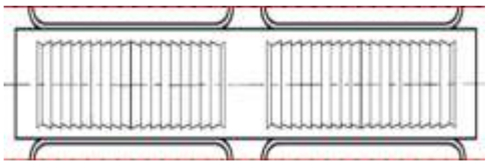

Figure : 1.4. Louver Fin Pattern

Due to the symmetry of the geometry, the computational domain is confined to one fin pitch in the span-wise direction and one tube pitch in the lateral direction, which is highlighted with a dashed red line. Since the geometry of the heat exchanger is periodic in nature, a smaller portion of the geometry is considered for the computational analysis.

1.3 Classification of Radiators

It mainly consists of an upper tank and lower tank and between them is a core. The upper tank is connected to the water outlets from the engines jackets by a hose pipe and the lover tank is connect to the jacket inlet through water pump by means of hose pipes.

There are 2-types of cores:

- Tubular
- Cellular

1.4 Materials used in Radiators

From the early years of the automotive industry up until today, various materials have been used to construct radiators. As the technology of car production progressed, so did the choice of substances increased. This was done in order to provide maximum cooling effect, ensuring the integrity of both the device and car. Here are the different kinds of car radiators.

1.4.1 Copper-Brass
In the event that a copper-brass radiator has outlived its usefulness, modern types are 100% recyclable, making it friendly to the environment. The two major problems with brass radiators were that they're very expensive and, over time, would suffer from rust, making them very inefficient in the long run. This is why they were eventually replaced with.

1.4.2 Plastic
The lightness of the weight results to better fuel economy. Production of plastic car components was made by machines, and not humans, which is why they are more cost-efficient.

1.4.3 Aluminum
Aluminum has a high thermal conductivity, meaning it conducts heat very well, absorbing it faster. This state allows hot coolant passing aluminum tubes to be cooled instantly, which is beneficial when it returns for another cycle to cool the car engine. Depending on the manufacturer, a radiator made entirely from aluminum. That's a 41% increase in efficiency when compared to its brass counterpart.

2.0 LITERATURE REVIEW

Oliet et al. [1] (2007) studied different factors which influence radiator performance. It includes air, fin density, coolant flow and air inlet temperature. It is catch that heat transfer and performance of radiator strongly affected by air & coolant mass flow rate. As air and coolant flow increases cooling capacity also increases. When the air inlet temperature increases, the heat transfer and thus cooling quantity decreases. Smaller fin spacing and greater louver fin angle have higher heat transfer. Fin density may be increased till it blocks the air flow and heat transfer rate reduced.

Sulaiman et al. [2] (2009) this study has shown that the CFD simulation is a useful tool in enhancing the design of the fan blade. In this paper this study has shown a simple solution to design a slightly aerodynamic shape of the fan hub.

Chacko et al. [3] (2005) The CFD make able optimization led to radiator cover configuration that eliminated these re-circulation area and increased the flow towards the radiator core by 34%. It is anticipated that this increase in radiator core flow would important to increase the radiator thermal efficiency.

Jain et al. [4] (2012). This study showed how the flow of air was intermittent by the hub obstruction, thereby resulting in unwanted reverse flow regions. The different orientation of blades was also considered while operating CFD analysis. The study revealed that a left oriented blade fan with counterclockwise rotation 5 performed the same as a right oriented blade fan with rotating the clockwise direction. The CFD results were in accord with the experimental data measured during physical testing.

Singh et al. [5] (2011) studied about the issues of geometric parameters of a centrifugal fan with backward- and forward-curved blades has been inspected. Centrifugal fans are used for improving the heat dissipation from the internal combustion engine surfaces. The parameters studied in this study are number of blades, outlet angle and diameter ratio. In the range of parameters considered, forward curved blades have 4.5% lower efficiency with 21% higher mass flow rates and 42% higher power consumption compared to backward curved fan. Experimental investigations suggest that engine temperature drop is significant with forward curved blade fan with insignificant effect on mileage.

3.0 DESIGN SOFTWARES USED

The software to be used in design is CATIA V5 and testing of design is ANSYS. CATIA Elements is a software application within the CAID/CAD/CAM/CAE category, along with other similar products currently on the market. CATIA Elements is a parametric, feature-based modeling architecture incorporated into a single database philosophy with advanced rule-based design capabilities. The capabilities of the product can be split into the three main heading of Engineering Design, Analysis and Manufacturing. This data is then documented in a standard 2D production drawing or the 3D drawing standard ASME Y14.41-2003.

3.1. Engineering Design

CATIA Elements offers a range of tools to enable the generation of a complete digital representation of the product being designed. In addition to the general geometry tools there is also the ability to generate geometry of other integrated design disciplines such as industrial and standard pipe work and complete wiring definitions. Tools are also available to support collaborative development. A number of concept design tools that provide up-front Industrial Design concepts can then be used in the downstream process of engineering the product. These range from conceptual Industrial design sketches, reverse engineering with point cloud data and comprehensive freeform surface tools.

3.2. Analysis

ANSYS Elements has numerous analysis tools available and covers thermal, static, dynamic and fatigue FEA analysis along with other tools all designed to help with the development of the product. These tools include human factors, manufacturing tolerance, mould flow and design optimization. The design optimization can be used at a geometry level to obtain the optimum design dimensions and in conjunction with the FEA analysis.

3.3. Introduction to CATIA

CATIA (Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault Systems. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. CATIA competes in the high-end CAD/CAM/CAE market with Cero Elements/Pro and NX (Unigraphics).

The 3D CAD system CATIA V5 was introduced in 1999 by Dassault Systems. Replacing CATIA V4, it represented a completely new design tool showing fundamental differences to its predecessor. The user interface, now featuring MS Windows layout, allows for the easy integration of common software packages such as MS Office, several graphic programs or SAPR3 products (depending on the IT environment).

The concept of CATIA V5 is to digitally include the complete process of product development, comprising the first draft, the Design, the layout and at last the production and the assembly. The workbench Mechanical Design is to be addressed in the Context of this CAE training course.

Sets of workbenches can be composed according to the user's preferences. Therefore Dassault Systems offers three different software installation versions. The platform P1 contains the basic features and is used for training courses or when reduced functionality is needed. For process orientated work the platform P2 is the appropriate one. It enables, apart from the basic design features, analysis tools and production related functions. P3 comprises specific advanced scopes such as the implementation of external software packages.

CATIA can be applied to a wide variety of industries, from aerospace and defense, automotive, and industrial equipment, to high tech, shipbuilding, consumer goods, plant design, consumer packaged goods, life sciences, architecture and construction, process power and petroleum, and services. CATIAV4, CATIA V5, Pro/ENGINEER, NX (formerly Unigraphics), and Solid Works are the dominant systems.

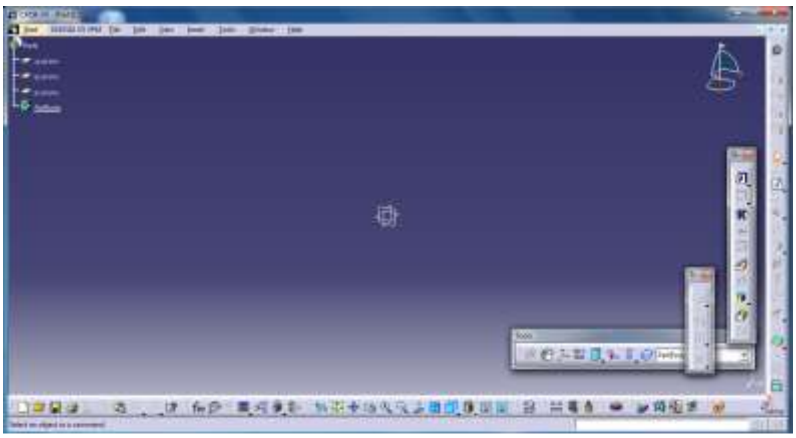

Figure: 3.1: Home Page of CatiaV5

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4.0 DESIGN METHODLOGY OF AUTOMOBILE RADIATOR FINS

4.1 Modeling of Automobile Radiator in CATIA V5

This Automobile Radiator is designed using CATIA V5 software. This software used in automobile, aerospace, consumer goods, heavy engineering etc. it is very powerful software for designing complicated 3d models, applications of CATIA Version 5 like part design, assembly design.

The same CATIA V5 R19 3d model and 2d drawing model is shown below for reference. Dimensions are taken from. The design of 3d model is done in CATIA V5 software, and then to do test we are using below mentioned software's.

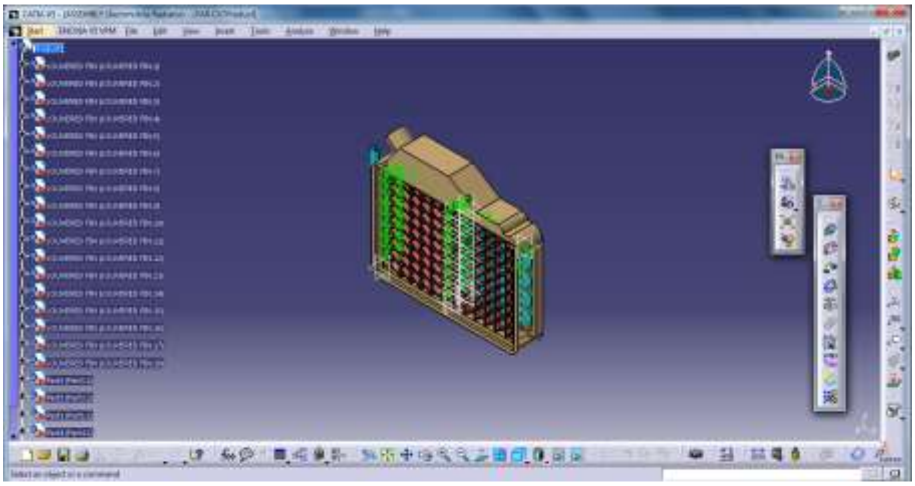

Figure: 4.1: Model design of Automobile Radiator in CATIA-V5

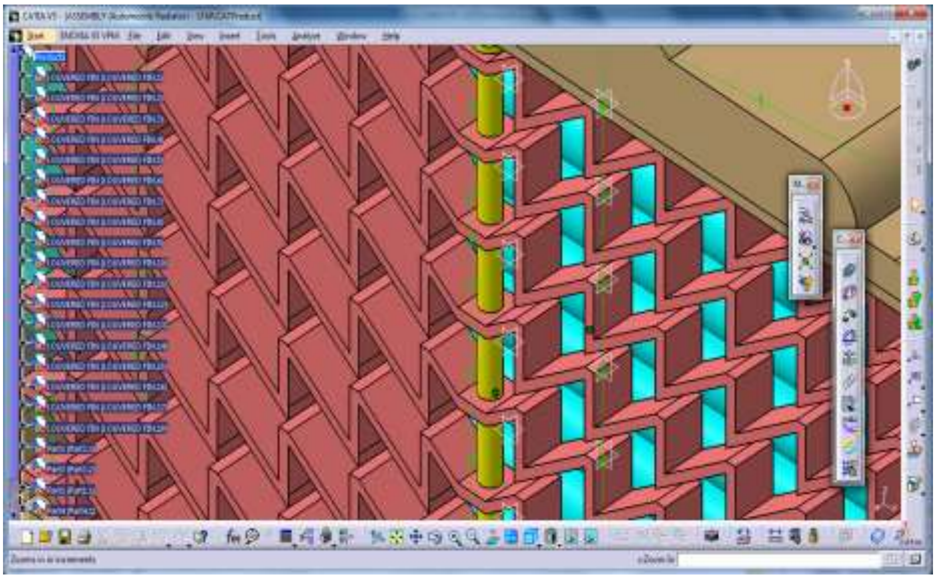

Figure: 4.2: Model arrangement in CATIA-V5

Journal of Engineering Sciences
Vol 13, Issue 04, APRIL/2022
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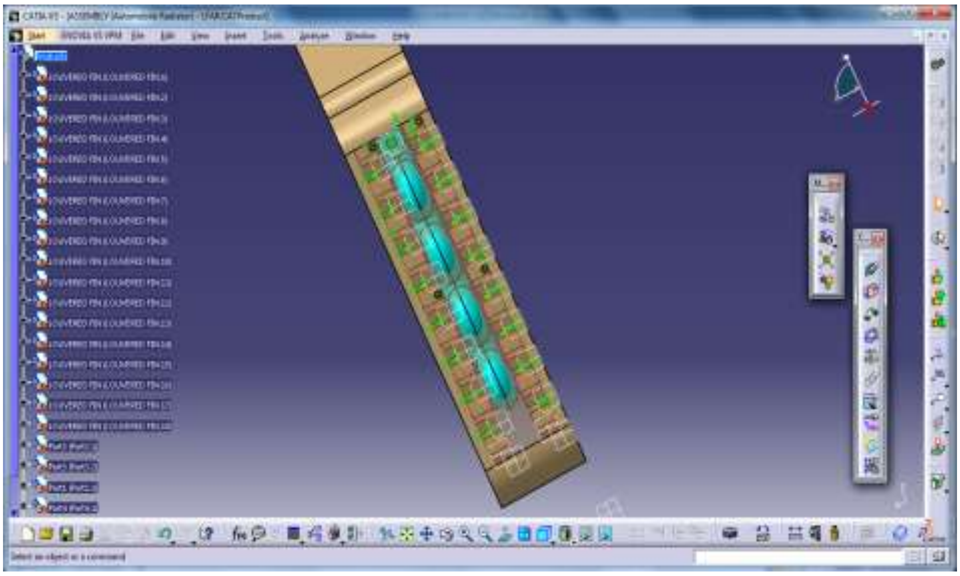

Figure: 4.3: Model arrangement in CATIA-V5

5.0. DISCUSSION ON ANALYSYS RESULT

5.1 Results of Nodal Temperature analysis:

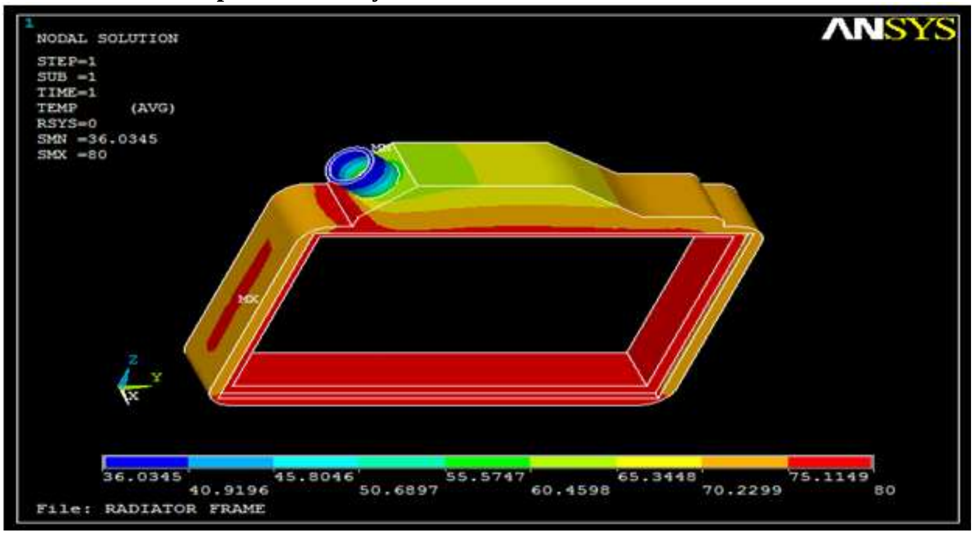

Figure: 5.1: Nodal Temperature of RADIATOR FRAME

Vol 13, Issue 04, APRIL/2022
ISSN NO:0377-9254

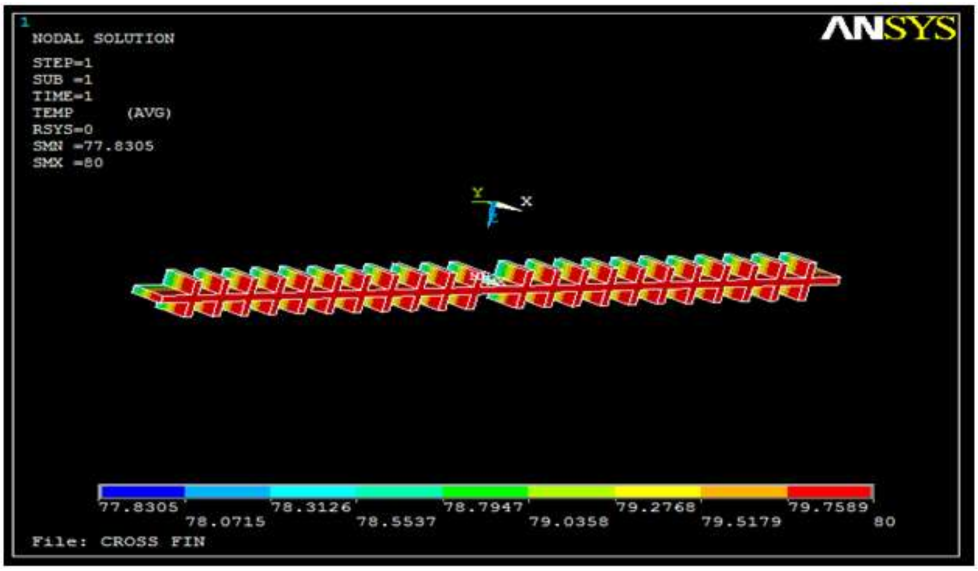

Figure: 5.3: Nodal Temperature of CROSS FIN

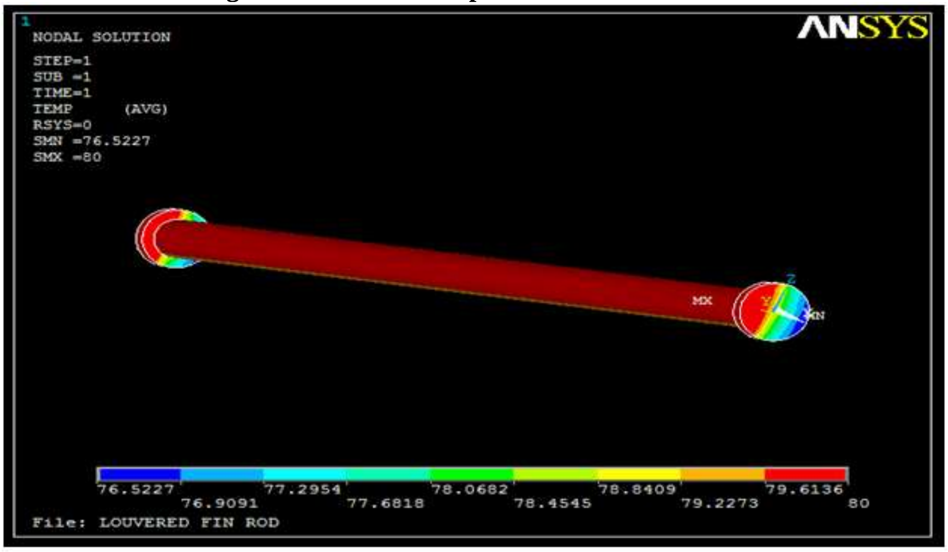

Figure: 5.4: Nodal Temperature of LOUVERED FIN ROD

5.2 Results of Thermal Gradient analysis:

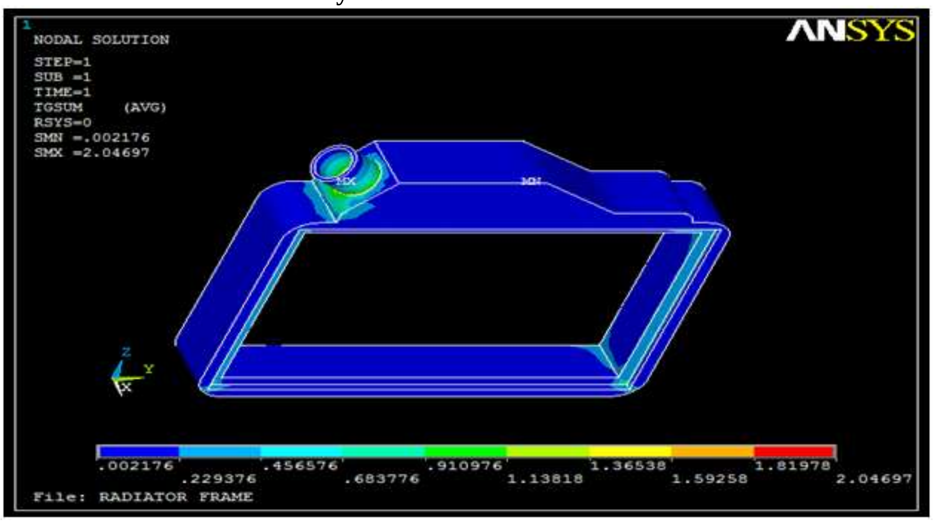

Figure: 5.5: Thermal Gradient of RADIATOR FRAME

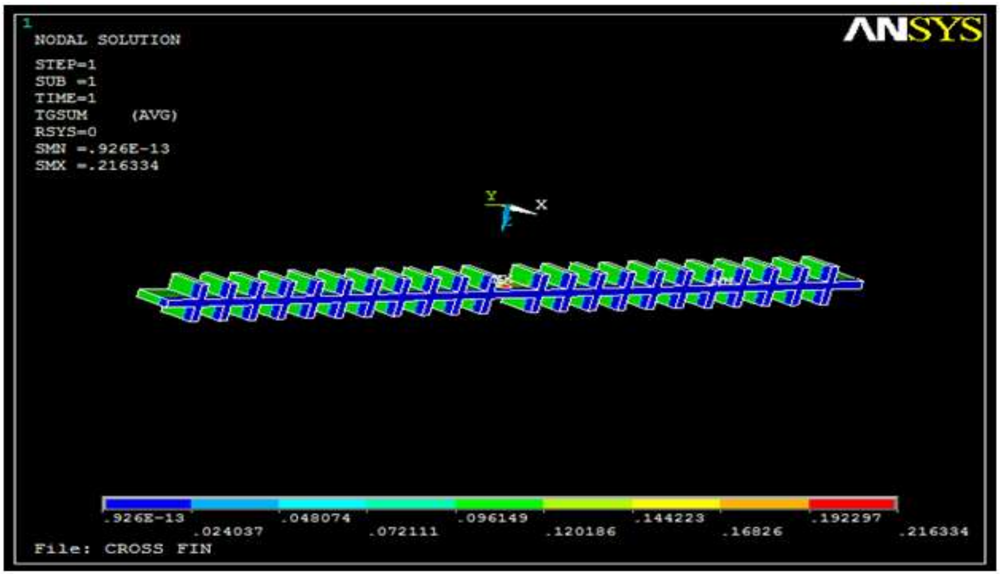

Figure: 5.6: Thermal Gradient of CROSS FIN

5.3 Results of Thermal Flux analysis:

Figure: 5.7: Thermal Flux of RADIATOR FRAME

Figure: 5.8: Thermal Flux of LOUVERED FIN

Figure: 5.9: Thermal Flux of CROSS FIN

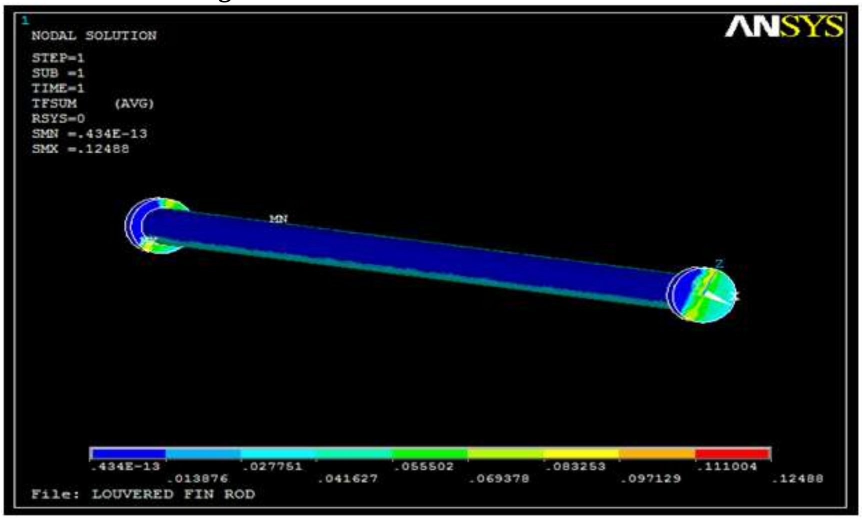

Figure: 5.10: Thermal Flux of LOUVERED FIN ROD

CONCLUSION

In this project a radiator is designed, it has been modified by specifying louver fins. 3D model is designed in CATIA.

TABLE FOR RESULTS:

S.No	Radiator Frame	Louvered Fin	Louvered Fin Rod
Nodal Temperature	36.03	76.59	76.52
Temperature Gradient	2.04	0.278	0.89
Thermal Flux	0.28	0.038	0.12
Heat Flow	0.79	0.002	0.02

The analysis tool ANSYS is used to perform thermal analysis on components of radiator at different areas. By observing the analysis results, the nodal temperature is increased by 76.5; temperature gradient is increased by 0.278 for the modified model of the radiator with louvered fins.

COMPARISION RESULTS:

S.No	Louvered Fin	Cross Fin
Nodal Temperature	76.59	77.83
Temperature Gradient	0.278	0.216
Thermal Flux	0.038	0.030
Heat Flow	0.002	0.006

Heat transfer analysis is performed to analyze the heat transfer rate to determine the thermal flux. The material taken is Aluminum alloy 6061 for thermal analysis. By observing the thermal analysis results, and thermal flux rate is 0.0389; the Heat flow rate is 0.0027 on the surface medium for the modified model of radiator.

REFERENCES

[1] Performance Improvement of a Automobile Radiator Using Conjugate Thermal CFD Analysis by Oliet G.C

[2] Performance Investigation of an Automotive Car Radiator Operated With Nano fluid as a Coolant by Durgesh kumar Chavan, Sulaiman.

[3] Chacko, 1998, Turbulence Modeling for CFD, DCW Industries Inc., La Canada, California.

[4] Wolf, I., Frankovi,Jain I., A numerical and experimental analysis of neat transfer in a wavy fin and tube heat exchanger, Energy and the Environment (2006) pp.91-101.

[5] Study on Performance Evaluation of Automotive Radiator by JP Yadav and Bharat Raj Singh

[6] Zakardas, Pelaez, R.B., Ortega, J.C., Cejudo-Lopez, J.M., A three-dimensional numerical study and comparison between the air side model and the air/water side model of a plain fin and tube heat exchanger, Applied Thermal Engineering, 30 (2010), pp.1608-1615.

[7] Kunawat, Sahin, H.M., Dal, A.R., Baysal, E., 3-D Numerical study on correlation between variable inclined fin angles and thermal behavior in plate fin-tube heat exchanger, Applied Thermal Engineering, 27 (2007), pp.1806-1816.

[8] Jama, Shih, T.-H., Liou, W.W., Shabbir, A., Yang, Z., and Zhu, J., 1995, A New k-e Eddy-Viscosity Model for High Reynolds Number Turbulent Flows - Model Development and Validation. Computers Fluids, 24(3):227-238.

[9] R. Saidur, K.Y. Leong and H.A. Mohammad, A Review on Applications and Challenges of Nanofluids. Renewable and Sustainable Energy Reviews, 15, 3 (2011), 1646–1668.

[10] Saitejesh, Wen, M.Y. Ho, C.Y., Heat transfer enhancement in fin and tube heat exchanger with improved fin design, Applied Thermal Engineering, 29(2009), pp.1050-1057.

[11] Yu, W.M., Sheen, P.J., Heat transfer and friction characteristics of fin and tube heat exchangers, International Journal of Heat and Mass Transfer, 43 (2000), pp.1651-1659.