Design, Modification and Analysis of Two Wheeler Cooling Sinusoidal Wavy Fins

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***Abstract*:In the current world, I.C.Engine has become the main prime mover beacause of its easier availability and high power capability. No other Engines can completely replace this I.C.Engine. But certain modification and innovation can save lot of fuel and give high efficiency. Engine life and effectiveness can be improved with effective cooling. The cooling mechanism of the air cooled engine is mostly dependent on the fin design of the cylinder head and block. The heat is conducted through the engine parts and is convected to air through the surfaces of the fins. Insufficient removal of heat from engine will lead to high thermal stresses and lower engine efficiency. As the air-cooled engine builds heat, the cooling fins allow the air to take the heat away from the engine. Low rate of heat transfer through cooling fins is the main problem. The main aim of our work is to study various researches done in past to improve heat transfer rate of cooling fins by changing cylinder block fin geometry and also to invent a new fin structure that would prove to be better. And CFD Analysis was done to check various parameters which enhances the heat transfer.**

Keywords: Heat Transfer, CFD, fins, Turbulence, Thermal Stress, I.C.Engine.

I. INTRODUCTION

An air cooled motorbike engine dissipates waste heat from the cylinder through the cooling fins to the cooling air flow created by the relative motion of moving motorbikes. The cooling system is an important engine subsystem. The air cooling mechanism of the engine is mostly dependent on the fin design of the cylinder head and block. It also depends on the velocity of the vehicle and the ambient temperature as described by R.K.Rajput[1]. The conduction heat transfer from inner wall to fin surface is given as 1:

$$q = k\,(T_b - T_{fin}) \qquad (1)$$

The convection heat transfer from fin surface to atmosphere air by free and forced air is given as 2 :

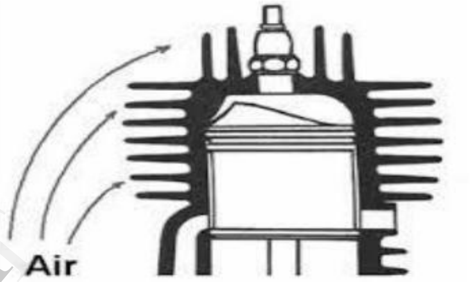
$$q = h\,(T_b - T_{air}) \qquad (2)$$

This heat transfer from the fin is influenced by many fixed and variable constraints such as fin array, fluid flow velocity, fin geometry; shape and material etc. Many experimental methods are available in literature to analyse the effect of these factors on the heat transfer rate.

The effect of cooling of internal combustion engine cylinder in free air is studied.

The analysis of fin is important to increase the heat transfer rate. Computational Fluid Dynamic (CFD) analysis and Flow Simulation Analysis have shown improvements in fin efficiency by changing fin geometry, fin pitch, number of fins, fin material and climate condition.

Of these, wavy fins are particularly attractive for their simplicity of manufacture, potential for enhanced thermal-hydraulic performance and ease of usage in both plate-fin and tube-fin type exchangers.



Heat transfer augmentation from a horizontal rectangular fin by *sinusoidal* perforations whose bases parallel and towards the fin base under natural convection has been studied. It has concluded that the heat transfer rate increases with perforation and the change in the fin geometry and the configuration as compared to fins of similar dimensions without the perforation.

The temperature and heat transfer coefficient values from fin base to tip are not uniform which shows the major advantage of CFD for analysis of heat transfer. Curve and Zig-zag fin shaped cylinder block can be used for increasing the heat transfer from the fins by creating turbulence for upcoming air. Extensive Studies of fins were also available in literatures [3-5].

II. MODIFICATIONS IN OUR MODEL

The basic structure of the fin available in the current engine model of two wheelers is a Flat structured fin. Our idea is that to change the shape of the structure as a Sinusoidal structure. Our main aim is to increase the heat transfer rate in the Engine. This is because we can cool the engine more easily and increase the thermal efficiency.

The new structure was modeled in solidworks and had it thermally simulated using Ansys Fluent and Solidworks Flow Simulation software, and the results were positive compared to that of conventional flat fin structures.

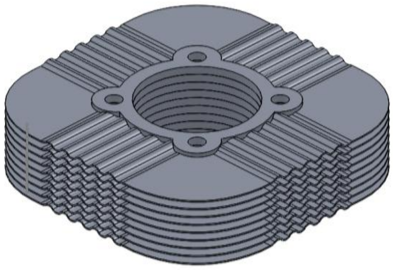


Figure 1: Finite Element model of our modified fin

Usually the material used for Engine Fins is Aluminum Alloy 204.The material chosen on the solidworks software isAluminium Alloy Al Alloy 5052-H38.

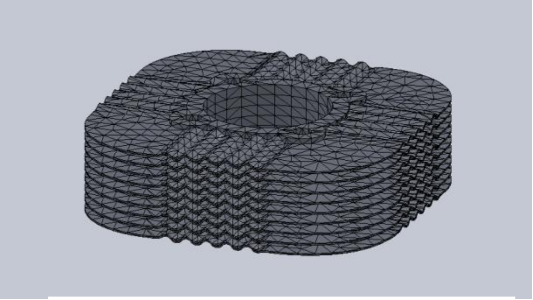


Figure 2: Meshed Model

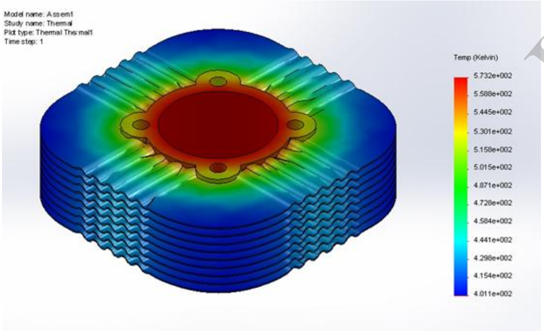


Figure 3: Thermal simulation in solidworks

This picture shows the thermally simulated model of the modified engine where the Base temperature applied on the cylinder circumference was 300^0C and the boundary conditions applied were $10W/m^2$ on all the faces of the engine and finely meshed and solved.

III. SAME TIP TEMPERATURE BUT DIFFERENT LENGTHS

The following picture is a modeling of different fins of different shapes and thickness modeled in a single cylinder block and simulated in an ideal initial and boundary conditions.

The decreased length represents the length required for the respective fin to dissipate the same amount of the heat to the surroundings. And we can see that the modified sinusoidal wavy fin needs the minimum length of fin to dissipate the heat produced from the engine.

Large engines like Royal Enfield 500cc engine fins can be brought to the reduced shape so that air resistance can be reduced.

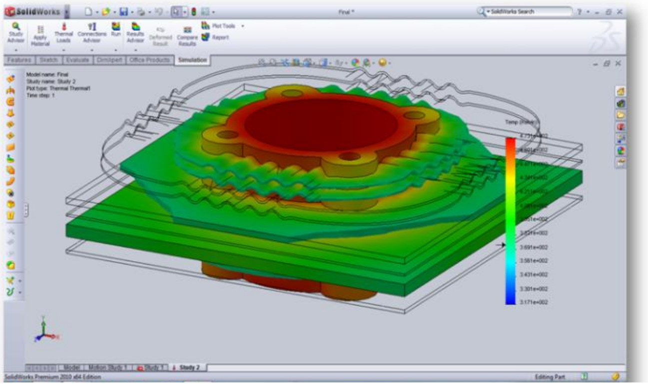


Figure 4: Thermal simulation of different shape, size fins

For the same length of fin in both the flat and wavy fins, the heat transfer is more. And for dissipating the same amount of the heat the length of the fin needed is shorter than that of other conventional fins.

IV. SIMULATION IN ANSYS

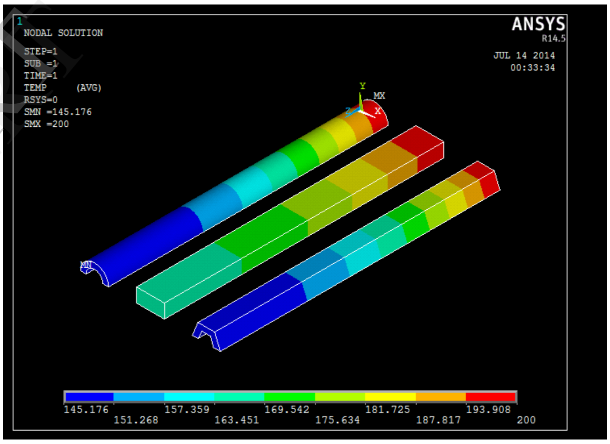


Figure 5: Thermal simulation of various cross sections of fins by ANSYS

The following picture fig:6 is the correlation of both the conventional flat fins and our modified wavy fins. The colour represents the temperature distribution and red colour indicates the base Temperature. The blue colour indicates the minimum tip temperature. On both the engines on the same point the temperature is indicated on the box with their co-ordinates and their nodes. The temperature difference between both the engines on the same point is in the range of 50^0C-60^0C.

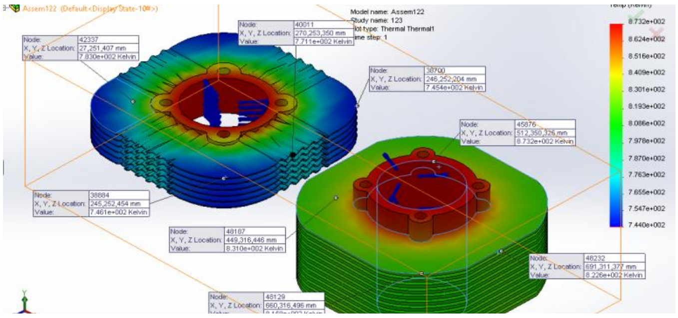


Figure 6: Correlation of both Flat finned Engine
And modified Sinusoidal wavy fins

V. FLOWANALYSIS

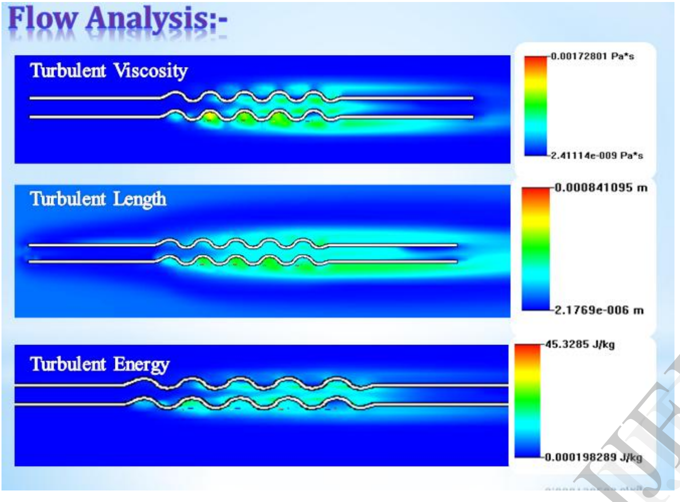


Figure 7: Solidworks Flow Simulation

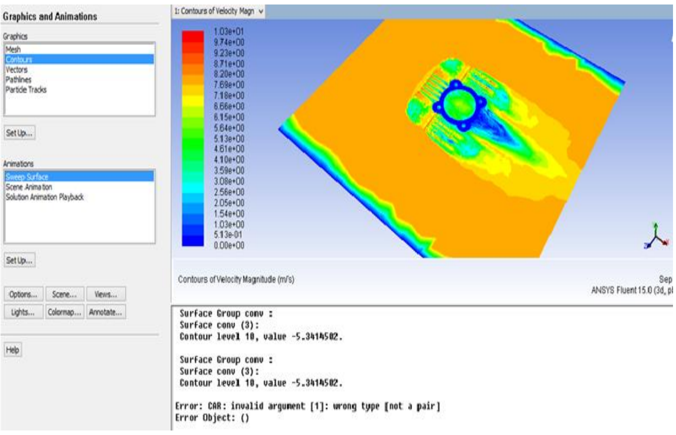
We know that for any heat transfer problem the flow analysis have to be done in order to determine the influence of various parameters. And we know that the turbulence plays the major role in enhancing the heat transfer.

From the Analysis the turbulence factors like Viscosity, Length and Energy plays the major role in heat dissipation rate.

Here from the left side of the picture the air enters at the velocity of 20m/s and flows towards the fins and exit from the other side of the fins.

We can see that the factors like Turbulence Viscosity, Turbulence Length and Turbulence Energy keep on increasing on moving towards the fins length from left to right of the Engine.

VI. FLUENT RESULT



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Surface Group conv :
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Contour level 10, value -5.3414502.

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Figure 8: ANSYS Fluent Result

These are the result obtained in the Ansys Fluent for a single Modified wavy fin and the result obtained is a velocity plot and there is a turbulence formation due to the increase in velocity over every curve which is shown in red colour.

VII. FURTHER RESEARCH

In order to increase the turbulence and vorticity formation, a small projection is made in the convex part of the fins across its length so that they act as nozzle and make the forced convection with more turbulence and swirls.

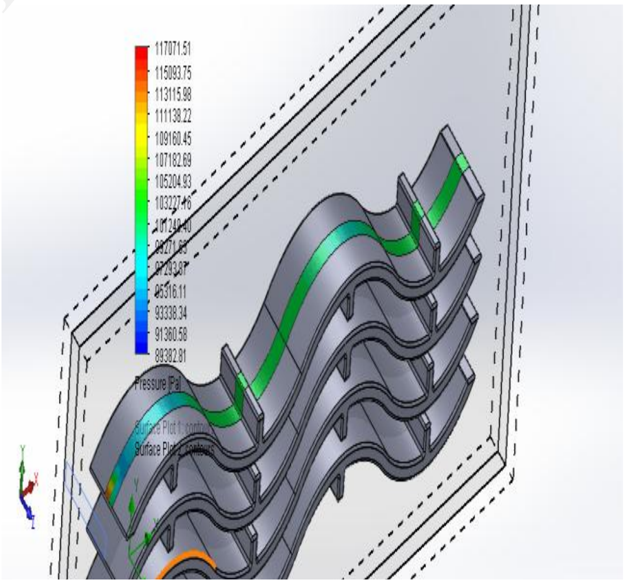

Figure 9: Modified fins with projections

This picture represents the projection on the convex part of the fins. The projection is in the order of 2-3 mm height and has the same thickness as that of the fin in order to reduce the manufacturing difficulty.

Further Research:-

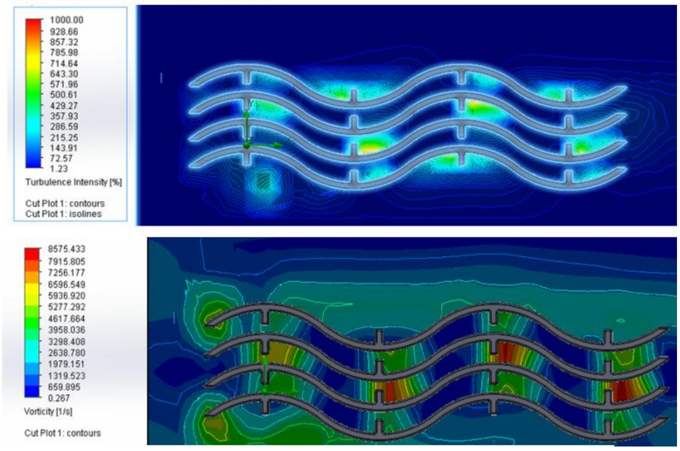

Figure 10: Modified fins with projections

The first picture represents the Turbulence Intensity% and the next picture represents the Vorticity on the Modified fins with external projection perpendicular to that of the fins.

The Red and yellow colour in first picture shows the turbulence contribution and the red colour in the vorticity shows the maximum vorticity formation in the second picture.

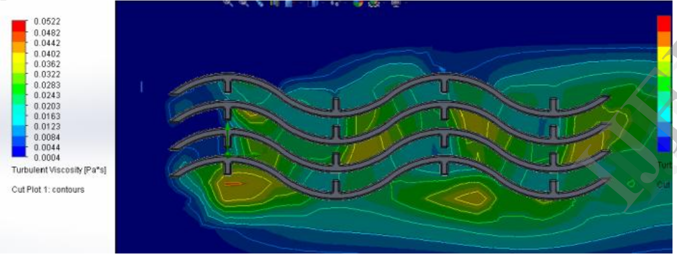

Figure 11: Modified fins with projections

This picture indicates the development of turbulent Viscosity when the air flows over the fins and they keep on increasing after crossing the projections.

VIII. COMPARISION IN ANSYS WORKBENCH

1. Pressure Comparision:

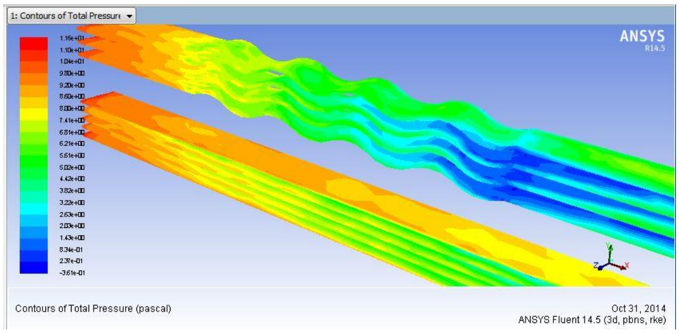

Figure 12: Pressure comparision of two fins projections

2. Temperature Comparision:

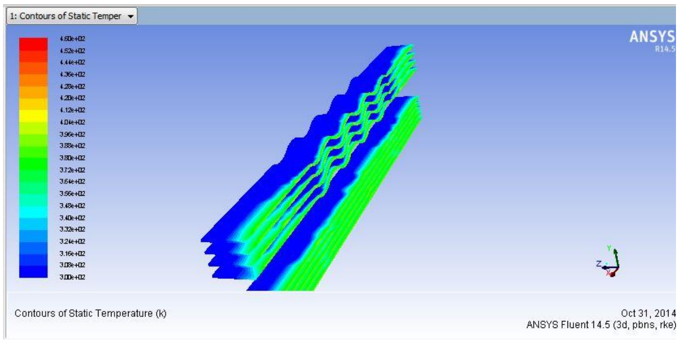

Figure 13: Temperature comparision of two fins projections

3. Turbulence Dissipation rate Comparision:

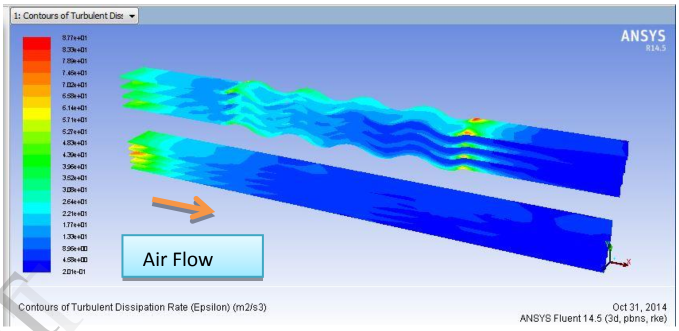

Figure 14: Turbulence Dissipation

The colour pattern is almost constant in wavy pattern compared to the flat fin model as shown in the above said figure 14.

4. Turbulence Kinetic Energy Comparision:

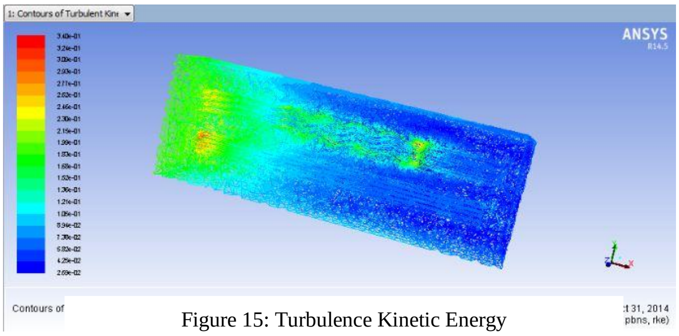

Figure 15: Turbulence Kinetic Energy

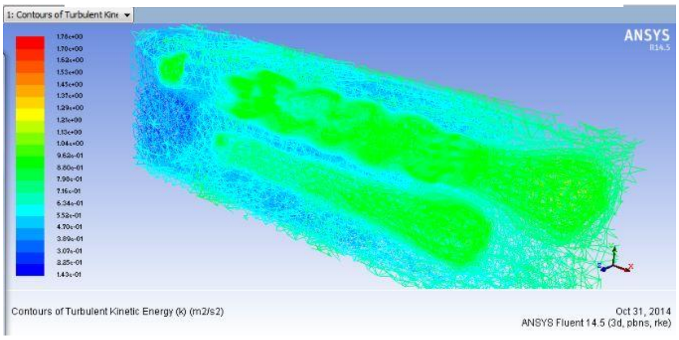

Figure 16: Turbulence Kinetic Energy

Here the turbulence kinetic energy is constant throughout the length in wavy fin compared to the flat fin which is maximum only in the initial length and gradually decreases as it moves along the length.

5. Turbulence Comparision:

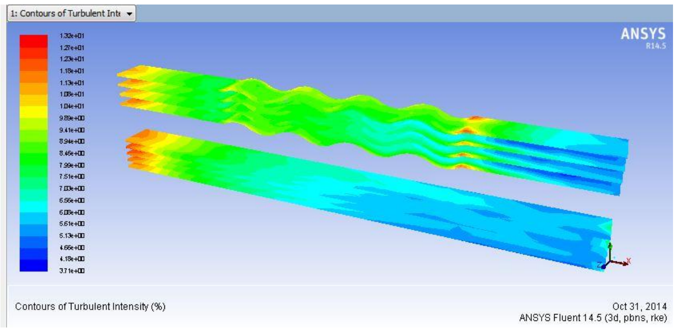

Figure 17: Turbulence Intensity

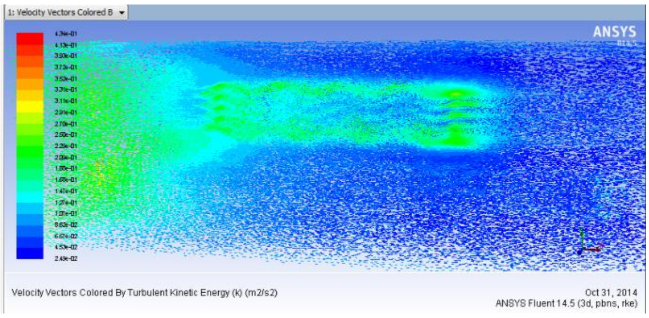

Figure 18: Vector in Turbulence Dissipation

6. Skin Friction Co-efficient Comparision:

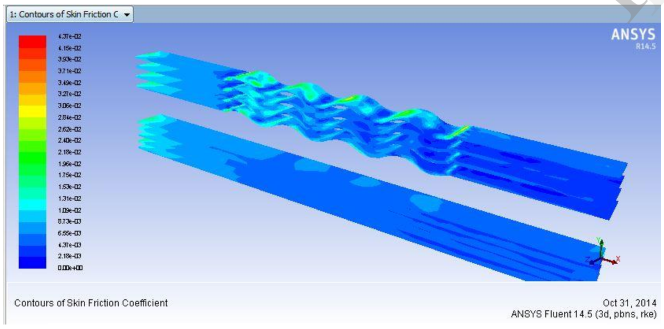

Figure 19: Skin Friction Co-efficient

7. Volume Rendering for Turbulent Eddy-Dissipation:

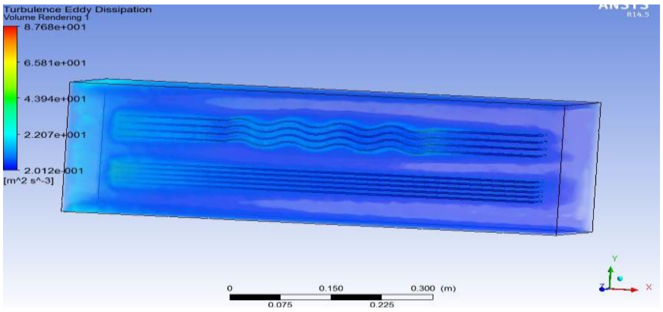

Figure 20: Turbulence Eddy Dissipation(Volume Rendering)

8. Volume Rendering for Turbulence Kinetic Energy:

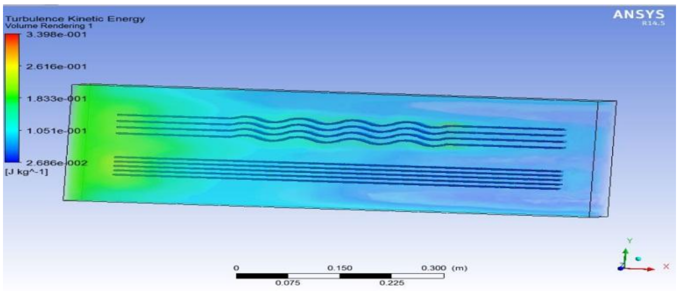

Figure 21: Turbulence Eddy Dissipation (Volume Rendering)

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whole length of this modified pattern which is constant from the point where the air enters up to the length of the fin.

9. Turbulent Dissipation in Solid Works Flow Simulation:

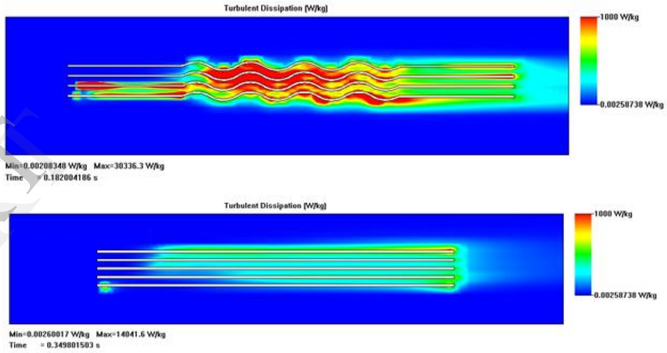

Figure 22: Turbulence Eddy Dissipation

From the fig.22 we can see that for the same initial conditions and same boundary conditions the turbulent dissipation is very much greater in this modified sinusoidal wavy pattern than the flat model.

In the wavy pattern the dissipation rate is higher represented by red colour whereas this rate is very low as represented in sky blue colour in flat structure for the range of 0.00258738 W/Kg to 1000W/Kg.

IX. CONCLUSION

Thus by simply changing the fin geometry from the flat fin to the sinusoidal wavy form the heat transfer rate is greatly improved leading to less thermal stress development.

Also faster as well as uniform cooling can be possible in this type of fin geometry.

The engine efficiency and effectiveness can be increased because of reduction in fin size and weight.

Due to the development of wavy fins with projection on the convex area of the fins more turbulence and vorticity is formed which further improve the heat transfer rate.

Thus manufacturing this type of fins will be economical and a become a feasible product to our Country.

X. REFERENCES

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