DESIGN AND THERMAL SIMULATION OF WANKEL ENGINE ROTOR USING CATIA AND MSC PATRAN

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***ABSTRACT:* -** A Wankel Engine, Internal combustion engine, powered by Gasoline, that uses the triangular shaped rotor, or rotating part, to produce mechanical energy. Traditional Internal combustion engines use pistons instead of a rotor. Wankel engine is powerful for its weight and size, vibrates much less than piston engines, has few moving parts, and can run comparatively quietly and smoothly on different grades of fuel. At present the market of Wankel engines is limited to some special applications. This fact explains absence of commercial software products specially developed for this engine simulation and prediction of its performance. Conversely, there are available and widely used software products for simulation of reciprocating-piston engines performance. We have used mainly two Softwares namely, CATIA V5 for designing and modeling and MSC PATRAN and NASTRAN for thermal analysis. We have made thermal analysis for different materials. This will clearly differentiates the results from one another which will help in choosing the better material in real production.

Keywords: *-CATIA V5, MSC PATRAN, MSC NASTRAN.*

1. INTRODUCTION

1.1 WANKEL ENGINE:

The Wankel engine is a type of internal combustion engine which converts pressure into rotating motion with the help of eccentric rotor design. The engine is commonly called as a rotary design. The four stages cycles of this engine are intake, compression, ignition, and exhaust which occurs at each revolution at each of the three rotor tips that moving inside the oval like epitrochoid shaped housing, which enables the three power pulses per rotor revolution. The rotor is similar to a Reuleaux triangle with the sides somewhat flatter.

1.2 WANKEL ENGINE ROTOR:

The rotor has three convex faces, each of which acts as a piston. Each face of the rotor has a pocket in it, which increases the displacement of the engine, allows more space for air fuel mixture. The apex of each face is a metal blade that forms a seal to the outside of the combustion chamber. The rotor consists of a set of internal gear teeth which is fixed to the housing.

2. LITERATURE REVIEW

The literature recordings are based on design considerations i.e. shape, size, weight and impact conditions. Narise Venkatesh, Rajesh cvs, Dommeti Srinivasa Rao are the professors in Mechanical engineering had worked on the design and analysis of the Wankel engine. They used the software for designing the Wankel engine rotor was CATIA and ANSYS 15 was used for the steady state thermal analysis for the Wankel Engine Simulation. They designed the model according to the German Drawings in CATIA V5.

3. PROBLEM DEFINITION

The Wankel’s combustion chamber is long, thin, and moves with the rotor. This causes a slow fuel burn. Engines try to combat this by using twin spark plugs. Even with the two spark plugs, combustion is often incomplete, leading to raw fuel being dumped out the exhaust port. Design modification has to done as per the simulation results selecting of the best material and will also improve the strength of rotor.

4. METHODOLOGY

4.1 GENERAL PROCEDURE FOR DESIGN OF THE WANKEL ENGINE ROTOR:

Design is the international plan or drawing which produced to show the function and look or the workings of a object before it is made.

4.1.1 Sketcher:

The Sketcher is used to create 2D sketches of designs, and apply constraints to the sketched geometry. The sketcher is now the main important for developing 2D profiles that will be used to build the solid models.

4.1.2 Creating Pad:

Creating a Pad means extruding the profile or surface in one or two directions.

4.1.3 Creating Circular Patterns:

To create a circular pattern, we need to choose the type of parameters we wish to specify so that the application will be able to compute the location of the item that we copied.

4.1.4 Creating Pocket:

Creating a pocket in the sense to place a hole on the required position of the profile.

4.1.5 Creating Groove:

The groove command is used to eliminate some geometry from the shaft like components.

4.2 GENERAL PROCEDURE FOR THERMAL SIMULATION OF THE WANKEL ENGINE ROTOR:

Thermal simulation solutions enable you to model thermal responses including all the modes of heat transfer such as conduction, convection and radiation.

4.2.1 Meshing:

To convert from Infinite Equations to Finite number of Equations we have to mesh. We have used Msc Patran to discretize the components

4.2.2 Assigning Properties:

Properties includes assigning the relative thickness to the geometry. Specifying the No. of integration points as per the thickness of the geometry. Specifying the ELFORM (Element Formulation).

4.2.3 Apply Loads and Boundary Conditions:

The inside temperature of 700^0C and an outside temperature of 872^0C is applied for the respective faces of the wankel engine rotor geometry.

4.2.4 Run the Analysis:

The FE model is now ready to be run. The analysis run command may have options to specify solver version, memory size, and number of CPU's to better control execution. The analysis can be done in the software called MSC NASTRAN.

4.2.5 Review and Interpret Results:

It is highly recommended that the analysis results should be carefully reviewed and checked for accuracy before making any conclusion based on simulation.

5. SOFTWARE PACKAGE

5.1 CATIA:

CATIA V5 (Computer Aided Three Dimensional Interactive Application) version5, developed by Dassault Systems, France, is a completely re-engineered, next-generation family CAD/CAM/CAE software solutions for Product Lifecycle Management. Through its exceptionally easy-to-use and state-of-the-art user interface, CATIA V5 delivers innovative technologies for maximum productivity and creativity, from the inception concept to the final product. CATIA V5 reduces the learning the curve, as it allows the flexibility of using feature-based and parametric designs. The subject of interpretability offered by CATIA V5 includes receiving legacy data from the other CAD systems and from its own product data management modules. The real benefit is that the links remain associative. As a result, any change made to this external data gets notified and the model can be updated quickly.

5.2 MSC PATRAN:

Patran is the world's most widely used pre/post-processing software for Finite Element Analysis (FEA), providing solid modeling, meshing, analysis setup and post-processing for multiple solvers including MSC Nastran, Marc, Abaqus, LS-DYNA, ANSYS, and Pam-Crash. Patran provides a rich set of tools that streamline the creation of analysis ready models for linear, nonlinear, explicit dynamics, thermal, and other finite element solutions. Meshes are easily created on surfaces and solids alike using fully automated meshing routines, manual methods that provide more control, or combinations of both. Finally, loads, boundary conditions, and analysis setup for most popular FE solvers is built in, minimizing the need to edit input decks.

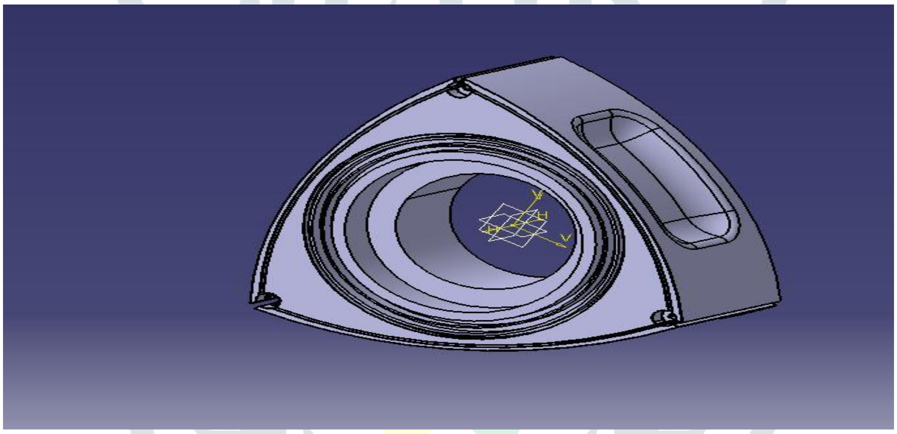
5.3 MSC NASTRAN:

MSC Nastran is a multidisciplinary structural analysis application used by engineers to perform static, dynamic, and thermal analysis across the linear and nonlinear domains, complemented with automated structural optimization and award winning embedded fatigue analysis technologies, all enabled by high performance computing. Engineers use MSC Nastran to ensure structural systems have the necessary strength, stiffness, and life to preclude failure (excess stresses, resonance, buckling, or detrimental deformations) that may compromise structural function and safety.

6. DESIGN

6.1 DESIGN OF WANKEL ENGINE ROTOR:

The Mazda Company uses the design in RX series bikes. The design of the Wankel engine rotor in CATIA V5 as shown below:



6.1 Design model in CATIA

6.2 THERMAL SIMULATION OF WANKEL ENGINE ROTOR:

The thermal simulation was done in the two software's namely MSC PATRAN and MSC NASTAN.

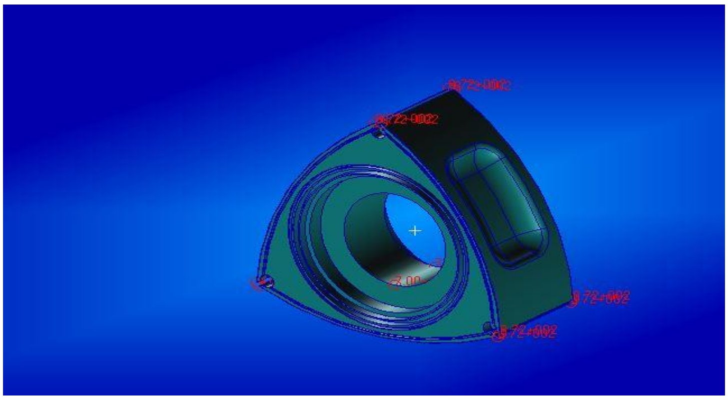
6.2.1 Materials:

Table6.1. Material Properties of Wankel Rotor

MATERIALS	PROPERTIES		
	Thermal conductivity (w/mk)	Density (kg/mm^3)	Specific Heat (j/kg-k)
Cast Iron	52	0.0000072	420.5
Aluminium	113	0.0000028	883
Steel	15.1	0.0000085	480

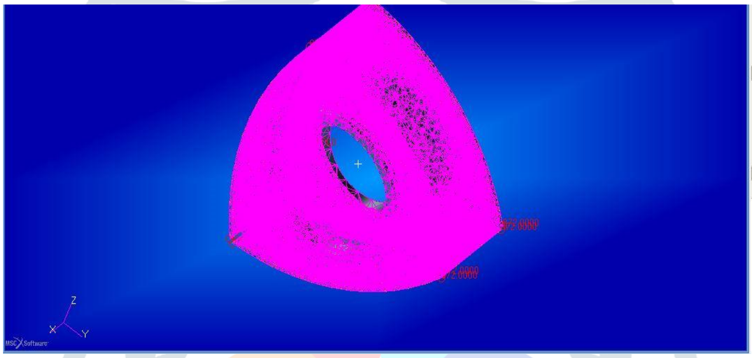
6.3 Applying Loads:

The initial temperature of 700^{0}C and final temperature of 872^{0}C is applied as shown below.



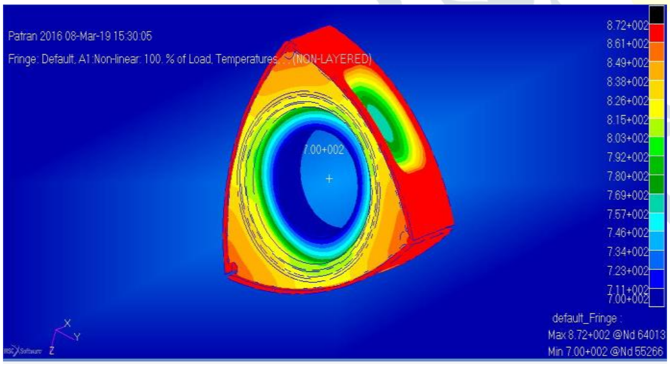
6.2 Position of loading acting on roof

6.4 Meshed portion of the Model:

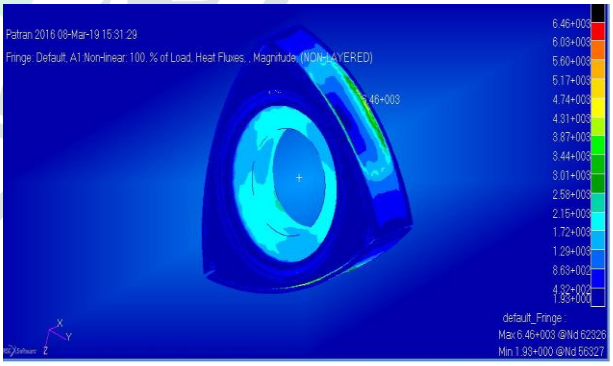


7. RESULT AND DISCUSSIONS

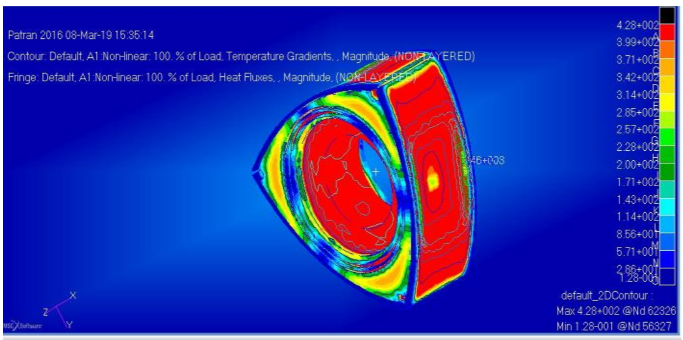
The Wankel Engine Rotor model is considered for analysing the thermal characteristics. Three different materials such as Steel, Aluminium and Cast iron are considered. A temperatures of 700^{0}C and 872^{0}C are given and the results are interpreted as follows.



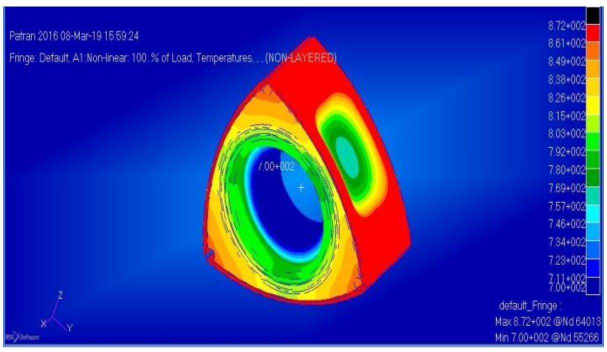
7.1 Temperature change for Steel Material



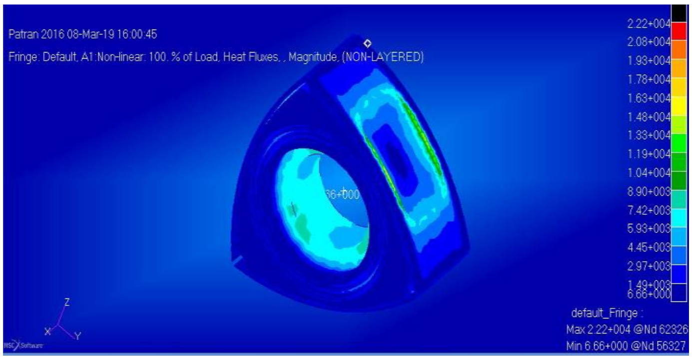
7.2 Heat flux for Steel Material



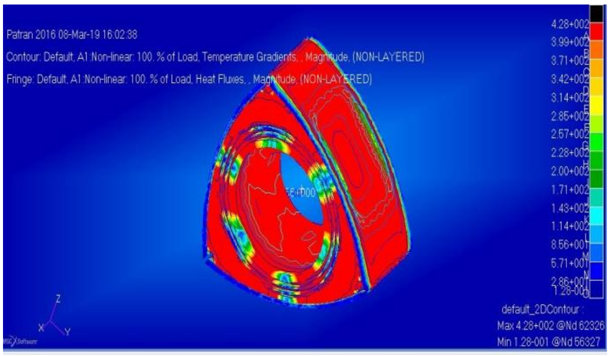
7.3 Temperature Gradient for Steel Material



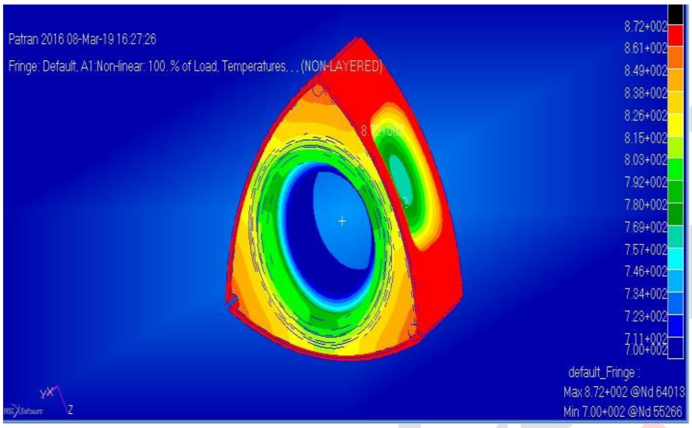
7.4 Temperature change for Cast Iron



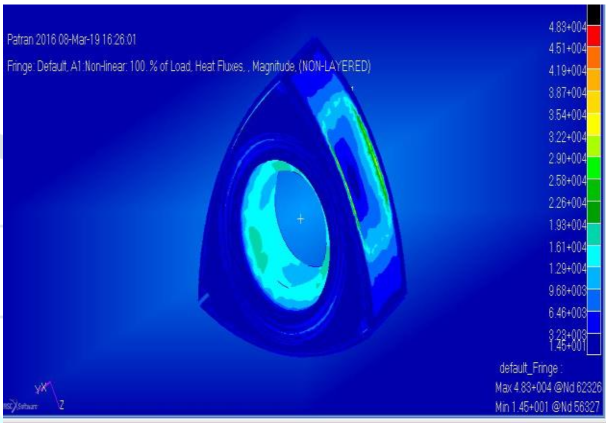
7.5 Heat flux for Cast iron



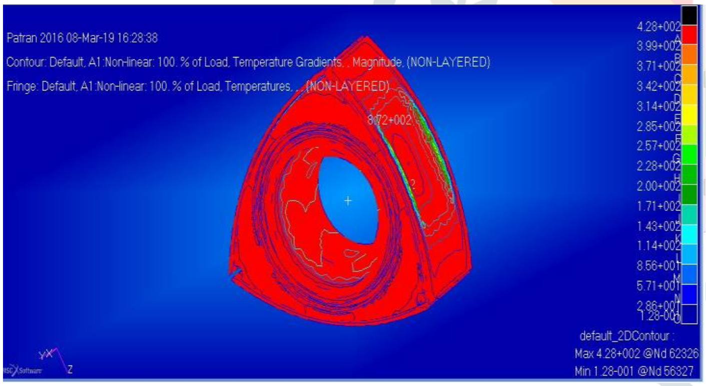
7.6 Temperature Gradient for Cast iron



7.7 Temperature change for Aluminum Material



7.8 Heat flux for Aluminum Material



7.9 Temperature Gradient for Aluminum Material

Table7.1. Results Table of Wankel Rotor Simulation

S.No	MATERIAL	TEMPARATURE (^{0}C)	HEAT FLUX (Watt/mm^{-2})	TEMPARATURE GRADIENT (^{0}C/mm)
1	STEEL	872	6456.84	427.61
2	CAST IRON	872	22235.48	427.61
3	ALUMINUM	872	48319.42	427.61

8. CONCLUSIONS AND SCOPE OF FUTURE WORK

8.1 CONCLUSION:

Thermal analysis is done on the Wankel engine rotor for three materials Stainless Steel, Cast Iron and Aluminium Alloy. Present used materials for Wankel engine rotor are Cast iron. We are replacing the material with Aluminium, since its density is less than that of other two materials thereby reducing the weight of Wankel Engine Rotor. By observing thermal analysis results, Heat flux is more for Aluminum that is heat transfer rate is more for Aluminum by comparing with other two materials. From the above observations of Wankel engine rotor thermal simulation, depends upon the Heat flux rate, we concluded that Aluminum is the best suitable material.

8.2 FUTURE SCOPE:

The rotary engine might be down for now, but don’t count it out just yet, as Mazda is now developing a new rotary engine, with a special new ignition system. Word from Japan is that the next generation of rotary engine, which is currently known as 16 X Renesis, will use lasers instead of spark plugs. A laser would need a smaller hole on the combustion chamber, which would help in more controlled combustion and hence would improve fuel economy, which has long been the downfall of the rotary motor. The new engine is said to have grown in size, from 1.3-liters to 1.6-liters, however since it is partly made from aluminum and is physically smaller, it will be lighter and more powerful than the old 13B motor.

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