International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2880-2884 www.ijaem.net ISSN: 2395-5252

Design and Analysis of Radial Engine

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Submitted: 20-05-2022 Revised: 30-05-2022 Accepted: 02-06-2022

ABSTRACT:
The Radial engine is a reciprocating type internal combustion engine same as like of piston cylinder arrangement except single change that is the piston in the cylinders reciprocate outward from central crankcase. This also called as "Star Engine" as it looks like a star when viewed from front.
The main objective of this project is to design the radial engine and simulate the equivalent stress, strain, total deformation and safety factor by using ANSYS software. The analysis process is performed for all the main components of radial engine.
Keywords - Radial Engine, CatiaV5, ANSYS, Piston, Master Rod, Connecting Rod.

I. INTRODUCTION

The Radial engine is a reciprocating type internal combustion engine in which the cylinders are mounted in a circle around the crankshaft and is reciprocate outward from central crankcase. This radial engine consist of odd number of cylinders (i.e.5) so that every other piston firing order can be achieved and if an even number of cylinders were used, an equally timed firing cycle would not be feasible. Here, one of the pistons is directly attached to the crankshaft with the help of master rod, and the remaining pistons with their connecting rods are attached around the edge of the master rod.

These engines were commonly used for aircraft engines before gas turbine engines came into existence.

II. WORKING

A radial engine works like four stroke internal combustion engine. Each cylinder has an inlet, compression, power and exhaust stroke. Here the cylinders are numbered from the top, going clockwise, with the first cylinder numbered 1. A five-cylinder engine fires in a 1,3,5,2,4 order.

As the cylinders fire, the rod assembly rotates around the crankshaft and spins like a bell crank would. The counterbalance weight sits opposite from the rod hub to prevent engine vibration.

III. APPLICATION

- Radial engines are generally used on aeroplanes because the shape allows it for the efficient packaging and air cooling behind a propeller.

IV. ADVANTAGES

- Easymaintenance
- Less vulnerable to critical damage
- Reliability – could still run with cylinder damage
- Versatility – becoming more desirable, increasingly more popular in experimental types
- Large frontal area provides for evenly distributed air cooling

V. DISADVANTAGES

- Requires hydraulic lock avoidance
- Larger displacement equates to bigger frontal area and higher drag component
- Engine has a higher number of parts, increases the possibility of oil leaks
- Less well controlled operating temperature
- Less capable of highaltitude performance

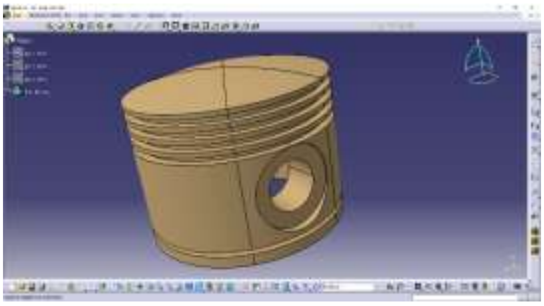
VI. DESIGN

For designingof Radial engine **Catia**software is used. CATIA is an acronym forComputer Aided Three-Dimensional Interactive Application. It is one of the leading 3D software used for Part Design, Generative Shape Design and also for the Assembly. These are only three of the many workbenches that CATIA offers. So, the parts required for our model are designed as follows :

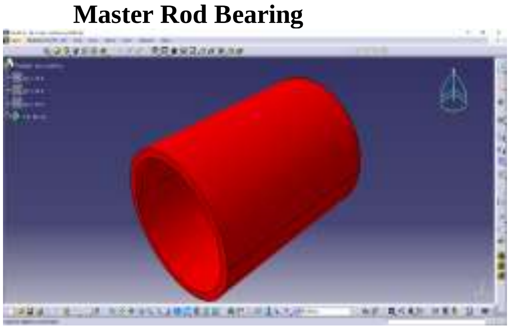
- **Master Rod**

- **Articulated Rod**

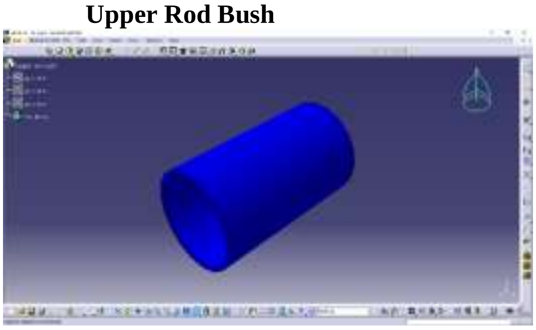
- **Piston**



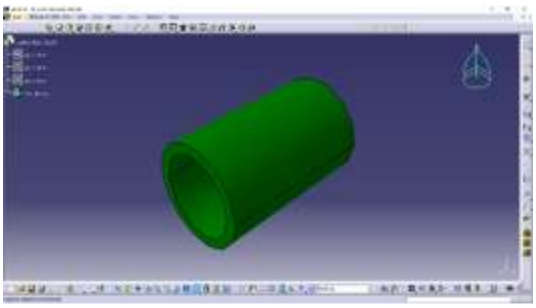
- **Master Rod Bearing**



- **Upper Rod Bush**



- **Lower Rod Bush**



- **Piston Ring**

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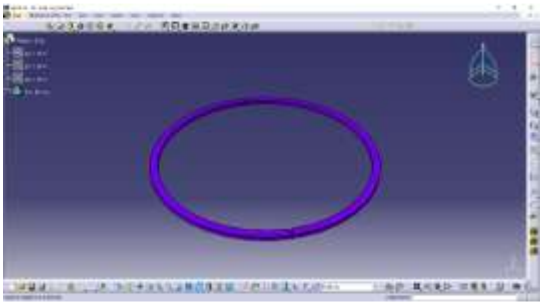
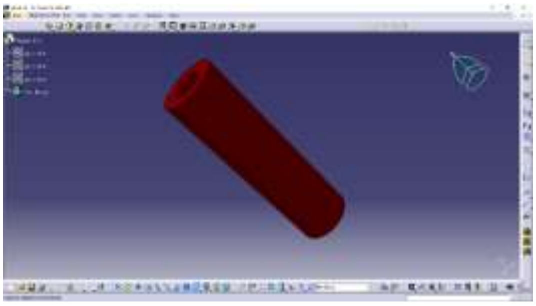
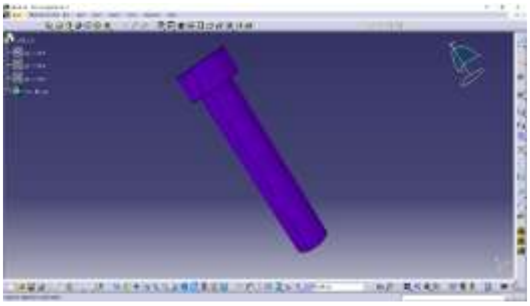


- **Piston Pin**



- **Piston Pin Plug**

- **Link Pin**



For the assembly, above-mentioned parts are used in required numbers.

- **Assembled View**

- **Exploded View**

VII. ANALYSIS

The analysis of Radial engine is done in ANSYS. This is Mechanical finite element analysis software used to simulate computer models of structures or machine components for analysing strength, toughness, elasticity, temperature distribution and many other attributes. So many types of analysis system are there in ANSYS but I worked with static structural analysis system.

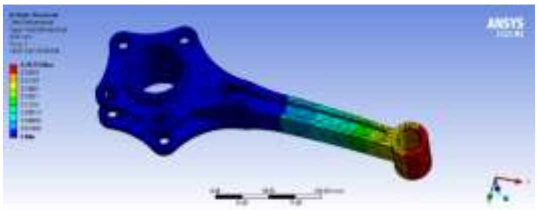
- **Static Structural Analysis**

Properties:

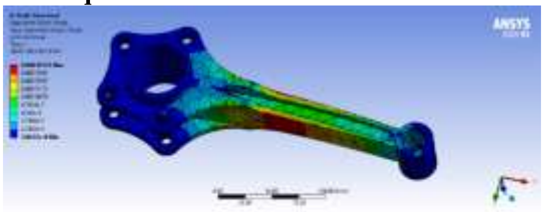
Material	Density (Kg/m^3)	Young's modulus (Gpa)	Poison's Ratio
Aluminium Alloy	2770	71	0.33
Cast carbon steel	7825	203400	0.2998

Analysis of Master Rod:

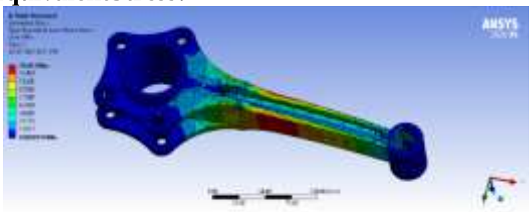
Total Deformation:



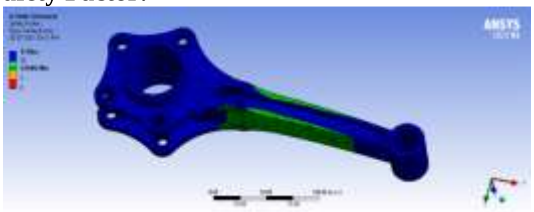
Total Equivalent Strain:



EquivalentStress:

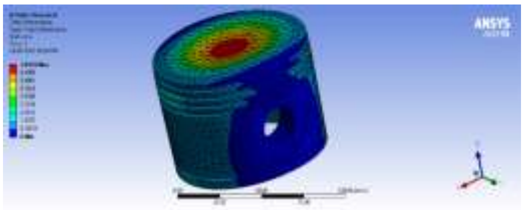


Safety Factor:



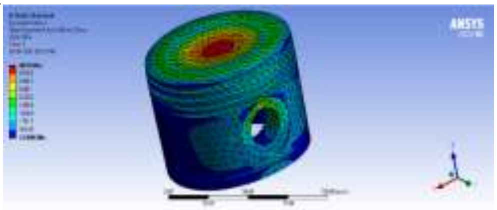
<u>Analysis of Piston</u>:

Total Deformation:

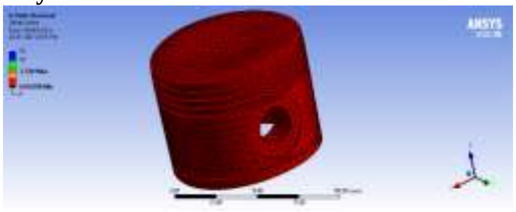


Total Equivalent Strain:

EquivalentStress:

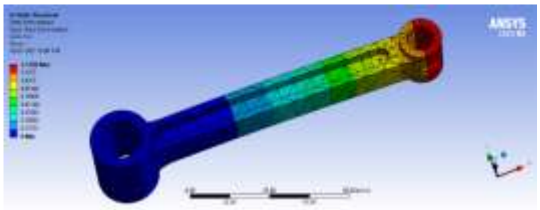


Safety Factor:

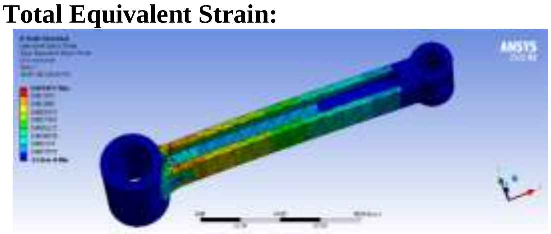


<u>Analysis of Articulated Rod</u>:

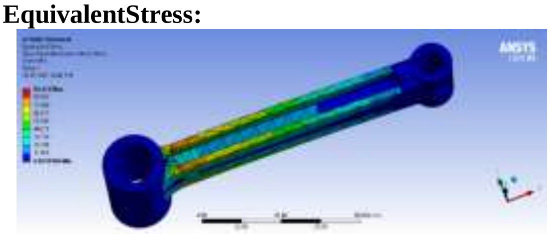
Total Deformation:



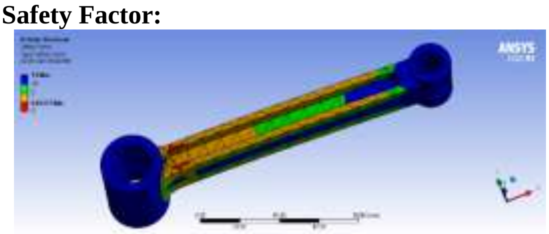
Total Equivalent Strain:



EquivalentStress:



Safety Factor:



VIII. RESULTS

Master Rod:

Material	Total Deformation (mm)	Total equivalent Strain	Equivalent Stress (MPa)	Safety Factor
Aluminum Alloy	0.29737	1.9755e-004	14.003	5.9086
Cast carbon steel	0.10383	6.8969e-005	14.005	12.838

Piston:

Material	Total Deformation (mm)	Total equivalent Strain	Equivalent Stress (MPa)	Safety Factor
Aluminum Alloy	7.0535	7.6402e-002	4879	1.6958e-002
Cast carbon steel	297.19	1.9086e-002	3846.6	4.6742e-002

Articulated Rod:

Material	Total Deformation (mm)	Total equivalent Strain	Equivalent Stress (MPa)	Safety Factor
Aluminum Alloy	1.3789	1.4011e-003	99.474	0.83177
Cast carbon steel	0.48166	4.9076e-004	99.815	1.8013

IX. CONCLUSION

- Modelling and analysis of the radial engine is done.
- Static structural analysis on this engine is done with two different materials i.e. aluminium alloy and cast carbon steel.
- Maximum stress, deformation, maximum strain and safety factor are noted and tabulated.
- From the static analysis result tables concluded that, deformation value for aluminium alloy is more in case of master rod and articulated rod.
- The stress value in case of all the three parts is almost similar for both the materials.

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