DESIGN AND THERMAL ANALYSIS OF RADIAL ENGIN

DEBBATI VENKATESH, debbati.venkat@gmail.com
Master of Technology
Dr. I.SATYANARAYAN, isnmechprofessor@gmail.com
Professor, M.Tech (IIT-KGP), Ph.D., MIE, MIST, MISHMT
P.VIJAY KUMAR, vijaykumar2290@gmail.com
ASST Professor, M.Tech
M.V.B.KALYAN, vasistakalyan29@gmail.com
ASST Professor, M.Tech

SRI INDU Institute of Engineering & Technology (formerly ASEC)Main Road, Sheriguda, Ibrahimpatnam, R.R.Dist.501510.Telangana State, India.

Abstract:

The radial engine is a reciprocating type internal combustion engine. In these internal combustion engine cylinder point outwards from a central crankshaft as it looks like the spokes of a wheel. It resembles a stylized star when viewed from the front, and is called a star engine.

This reciprocating engine is a primary source of power generation in various mechanical applications from power generation to automobiles to increase the speed of engine and for more power transmission radial engines are used. Radial engine is one in which five pistons are associated to crank shaft along with connecting rod. Radial engines are commonly used in aero craft, ships etc.

This Engine assembly consists major components they are Master Rod, Piston, and Connecting Rod. Shows the main internal mechanism of radial Engine having five cylinders. And importing the components which are developed in SOLID WORKS. And to find out how heat is transforms from one object to another which are connected positioning components, Applying the existing material and another material by applying thermal analysis and show the comparison between materials when the temperatures are acting

The main object of this project is to design the radial engine in thermal analysis by varying the temperature using different materials as Al 1060 alloy, cast carbon steel and grey cast iron on piston, connecting rod and master rod. By applying above materials varying temperatures cast carbon steel is preferred as the better material because it is withstanding the heat. The minimum and maximum values of piston, connecting rod and master rod by using cast carbon steel are 653.8k and 1500k, 299.3k and 500k, 372.008k and 500k.

Keywords

Radial Engine, Thermal Analysis, Piston, Master Rod, Solid Works, Cast Carbon Steel, Ai 1060..

1. Introduction

The Radial Engine is a reciprocating type internal combustion engine configuration in which the cylinders point outward from a central crankshaft like the spokes on a wheel. This type of engine was commonly used in most of the aircrafts before they started using turbine engines. In a Radial Engine, the pistons are connected to the crank shaft with a master-and-articulating-rod assembly. One of the pistons has a master rod with a direct attachment to the crankshaft. The remaining pistons pin their connecting rods` attachments to rings around the edge of the master rod. Four-stroke radials always have an odd number of cylinders per row, so that a consistent every-other-piston firing order can be maintained, providing smooth operation. This is achieved by the engine taking two revolutions of the crankshaft to complete the four strokes. Which means the firing order for a 9-cylinder radial engine is1,3,5,7,9,2,4,6,8 and then again back to cylinder number 1.This means that there is always a two-piston gap between the piston on its power stroke and the next piston on fire(the piston on compression). If an even number of cylinders was used the firing order would be something similar to1,3,5,7,9,2,4,6,8,10 which leaves a three-piston gap between firing pistons on the first crank shaft revolution, and only one piston gap on the second crankshaft revolution. This leads to an uneven firing order within the engine, and is not ideal

The Four-stroke consequence of every engine is:

a) Intake

b) Compression

c) Power

d) Exhaust

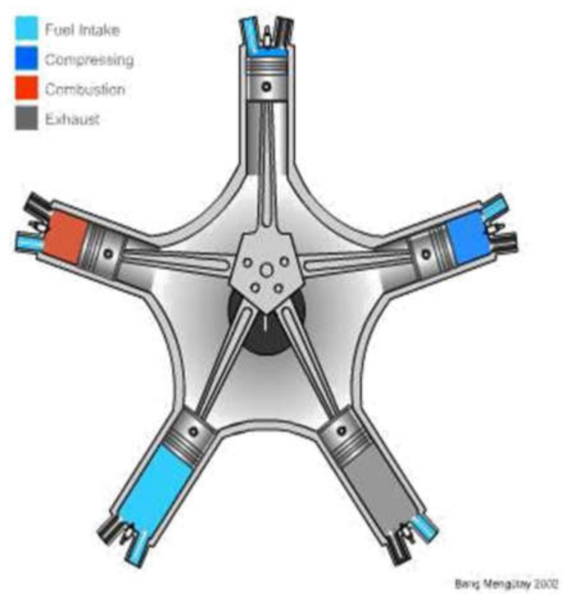

Fig.1.1 Operations performed in radial engine

An operations performed in radial engine is shown fig.1.1, in Most radial engines use overhead poppet valves driven by pushrods and lifters on a cam plate which is concentric with the crankshaft, with a few smaller radials. A few engines utilize sleeve valves instead.

At least five companies build radials today. Vedeneyev engines produces the M-14P model, 360 Hp (270kW)(up to 450 Hp(340kW) radial used on Yakovlevs and Suk hoi, Su-26 and Su-29aerobic aircraft. The M-14P has also found great favor among builders of experimental aircrafts, such as the Culp`s Special and Culp‟s Sop with Pup, Pitts S12 “Monster” and the Murphy “Moose”. Engines with 110 Hp (82kW) 7-cylinders and 150 Hp (110 kW) 9-cylinders are available from Australia‟s Rotec Engineering. HCIA aviation offers the R180 5-cylinders (75 H (56kW)) and R220 7-cylinders (110 Hp (82kW)), available “ready to fly” and as a “build it yourself” kit. Verner Motor from the Czech Republic now builds several radial engines. Models range in power form 71 Hp (53 kW) to 172 Hp (128 kW). Miniature radial engines for model air plane use are also available from Seidel in Germany, OS and Saito Seisakusho of Japan, and Techno power in the USA. The Saito firm is known for making 3 different sizes of 3-cylinder engines, as well as a 5-cylinder example, as the Saito firm is the specialist in making a large line

Applications and Advantages of Radial Engines:

Fig 1.2 Radial engine in vehicles

Radial engines have several advantages for airplanes:

- They can produce a lot of power. A typical radial engine in a B-17 has nine cylinders, displaces 1,800 cubic inches (29.5 liters) and produces 1,200 horsepower.

- Radial engines have a relatively low maximum rpm (rotations per minute) rate, so they can often drive propellers without any sort of reduction gearing.

- Because all of the pistons are in the same plane, they all get even cooling and normally can be air-cooled. That saves the weight of water-cooling.

Radial engines reached their zenith during WWII. There are some radial engines around today, but they are not that common. Most propeller-driven planes today use more traditional engine configurations (like a flat four-cylinder) or modern gas turbine engines. Gas turbines are much lighter than radial engines for the power they produce.

Existing system:

There are some radial engines around today, but they are not that common. Most propeller-driven planes today use more traditional engine configurations (like a flat four-cylinder) or modern gas turbine engines. Gas turbines are much lighter than radial engines for the power they produce.

These days, most large airplanes have started using turboprops and jet propulsion systems. But the reality is that for those who own smaller airplanes or fleets, a radial engine may be a much better option. Understanding why, can help you understand why that radial engine though an old model could still be the best call for your plane.

The radial engine started its life decades ago, and was the most common option before turbine engines were introduced. They‟ve been found on everything from crop dusting planes to bombers, and continue to be used to this day. Here are just some of the numerous benefits that are offered by radial engines, all of which are good reasons that you might want to consider one for your aircraft.

Proposed system:

In present work thermal analysis of radial engine has been performed on three parts of engine such as piston, connecting rod and master rod by applying temperature and finding heat temperature by analysis.

The main objective of this work is to investigate the temperature variation between different materials through thermal by using solid works simulation, simulation. In order to maintain the temperature normal with other materials are Al 1060 alloy, grey cast iron and cast carbon steel.

The radial engine started its life decades ago, and was the most common option before turbine engines were introduced. They‟ve been found on everything from crop dusting planes to bombers, and continue to be used to this day. Radial engines have a relatively low maximum rpm (rotations per minute) rate, so they can often drive propellers without any sort of reduction gearing.

- Because all of the pistons are in the same plane, they all get even cooling and normally can be air-cooled. That saves the weight of water-cooling.

- In radial engine the basic material used for manufacturing is cast iron but the in this project we have used cast carbon steel and AL 1060 alloy.

- These alloys are analysed in thermal Analysis by applying temperature 1500kelvin on piston and 500kelvin on master rod and connecting rod.

2. Project Design

In this project, we are going to design a five cylinder radial engine. We are going to design its parts and do the assembly as well as we take temperature in thermal analysis which will help us in deciding the feasibility and practicality of our design. We also going to learn about the problems faced during assembly and material selection for the three cylinder engine. Also the reason for selection of various points during our design process. In three cylinder radial engine the reciprocating motion of piston is converted to the rotating motion of flywheel which is done by connecting a shaft to flywheel at one end and piston holder at other. The cylinder radial engine not only have application as an automobile engine but it can also used in industries for carrying loads or may be used as a belt mover in the conveyor. This may also be used in production of electricity for small scale use like mobile charging etc. we have chosen this design because it has variety of application and abundant positive points for society and as well as environment was done in solid works.

Solid Works is mechanical design automation software that takes advantage of the familiar Microsoft Windows graphical user interface. A Solid Works model consists of parts, assemblies, and drawings.

- Typically, we begin with a sketch, create a base feature, and then add more features to the model. (One can also begin with an imported surface or solid geometry).

- We are free to refine our design by adding, changing, or reordering features.

- Associatively between parts, assemblies, and drawings assures that changes made to one view are automatically made to all other views.

- We can generate drawings or assemblies at any time in the design process.

- The Solid works software lets us customize functionality to suit our needs.

Solid works mechanical design automation software is a feature-based, parametric solid modelling design tool which advantage of the easy to learn windows ^{TM} graphical user interface.

We can create fully associate 3-D solid models with or without while utilizing automatic or user defined relations to capture design intent.

Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

Design intent is how the creator of the part wants it to respond to changes and updates. For example, you would want the hole at the top of a beverage can to stay at the top surface, regardless of the height or size of the can. Solid Works allows you to specify that the hole is a feature on the top surface, and will then honour your design intent no matter what the height you later gave to the can. Several factors contribute to how we capture design intent are Automatic relations, Equations, added relations and dimensioning.

Features refer to the building blocks of the part. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, etc. This shape is then extruded or cut to add or remove material from the part. Operation-based features are not sketch-based, and include features such as fillets, chamfers, shells, applying draft to the faces of a part, etc.

Building a model in Solid Works usually starts with a 2D sketch (although 3D sketches are available for power users). The sketch consists of geometry such as points, lines, arcs, conics (except the hyperbola), and spines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity.

The parametric nature of Solid Works means that the dimensions and relations drive the geometry, not the other way around. The dimensions in the sketch can be controlled independently, or by relationships to other parameters inside or outside of the sketch.

3. Analysis and Simulation of Radial Engine

Thermal Analysis On Piston

(a) AL 1060 Alloy Material: Thermal Results

Name	Type	Min	Max
Thermal1	TEMP: Temperature	946.204 Kelvin Node: 4582	1500 Kelvin Node: 3732

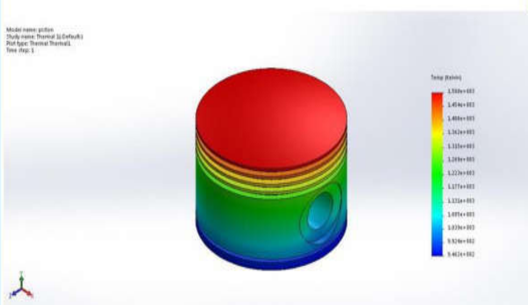

Fig 2.1 Sketch of piston is formed by using Al 1060 alloy by simulation and analysis

By applying thermal analysis on piston using AL 1060 ALLOY material heat is produced, the applied temperature is 1500 kelvin. The minimum temperature is 946.204 kelvin present at node 4582 and the maximum temperature is 1500 kelvin is present at node 3732.

Properties		Components
Name:	**Al 1060 Alloy**	**SolidBody 1(Hole3)(piston)**
Model type:	**Linear Elastic Isotropic**	
Default failure criterion:	**Max von Mises Stress**	
Thermal conductivity:	**2 W/(cm.K)**	
Specific heat:	**215.105 Cal/(kg.C)**	
Mass density:	**2700 g/cm^3**	

Table 2.1: material properties of piston using Al 1060 alloy

The above Table 2.1 shows the properties of the Al 1060 alloy material by applying 1500k temperature on piston we mesh the material .after this the thermal analysis fig will be formed automatically by generating all the information of material. Here after analysis we get Thermal conductivity, specific heat and mass density. The values are thermal conductivity 2W/kg.c, specific heat 215.105 cal/kg.c,mass density 2700 g/cm.

(B) Cast Carbon Steel Material:

By applying thermal analysis on piston using CAST CARBON STEEL material heat is produced. The applied temperature is 1500 kelvin. The minimum temperature is 653.827 kelvin present at node 4582 and the maximum temperature is 1500 kelvin is present at node 3732.

(C) Grey Cast Iron:

By applying thermal analysis on piston using GREY CAST IRON material heat is produced. The applied temperature is 1500 kelvin. The minimum temperature is 1316.95 kelvin present at node 2281 and the maximum temperature is 1500 kelvin is present at node 383.

4. Results and Discussion

A. Thermal Analysis On Piston With Different Materials:

Material	Temperature	Minimum	Maximum
Al 1060 alloy	1500 K	946.204 K	1500 K
Cast carbon steel	1500 K	653.827 K	1500 K
Grey cast iron	1500 k	1316.95 k	1500 k

Table 4.1: Maximum and minimum values of

piston by using thermal analysis

By comparison of above results cast carbon steel can be preferred because it emits less temperature than remaining materials. In above three materials applying thermal analysis on piston, according to the temperature heat is produced in all materials. But the capacity of withstanding the heat is good for cast carbon steel so cast carbon is preferred as better one.

B. Thermal analysis on connecting rod:

Material	Temperature	Minimum	Maximum
Al 1060 alloy	500 K	339.992 K	500 K
Cast carbon steel	500 K	299.35 K	500 K

Table 4.2 Maximum and minimum values of connecting rod by using thermal analysis

By comparison of above results cast carbon steel can be preferred because it emits less temperature than remaining materials. In above two materials applying thermal analysis on connecting rod, according to the temperature heat is produced in all materials. But the capacity of withstanding the heat is good for cast carbon steel so cast carbon is preferred as better one.

C. Thermal Analysis On Master Rod:

Material	Temperature	Minimum	Maximum
Al 1060 alloy	500 K	446.827 K	500 K
Cast carbon steel	500 K	372.0081 K	500 K

Table 5.3 Maximum and minimum values of master rod by using thermal analysis

By comparison of above results cast carbon steel can be preferred because it emits less temperature than remaining materials. In above two materials applying thermal analysis on connecting rod, according to the temperature heat is produced in all materials. But the capacity of withstanding the heat is good for cast carbon steel so cast carbon is preferred as better one.

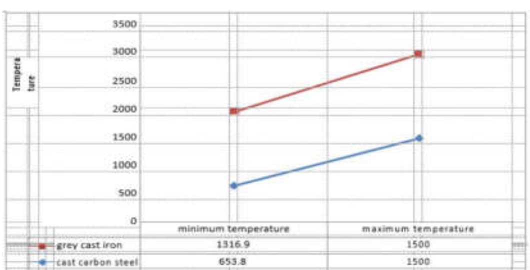

Fig 5.2 Graph between cast carbon steel and grey cast iron

The above graph shows the comparison of two different materials for better presence of the material. Here we have taken cast carbon steel and grey cast iron and compared heat temperature. By comparing both cast carbon steel is the best and the graph has drawn between temperature and materials which are used for making of radial engine parts. The minimum and maximum temperatures for cast carbon steel are 653.8kelvin and 1500kelvin and for grey cast iron 1316.9kelvin and 1500kelvin.

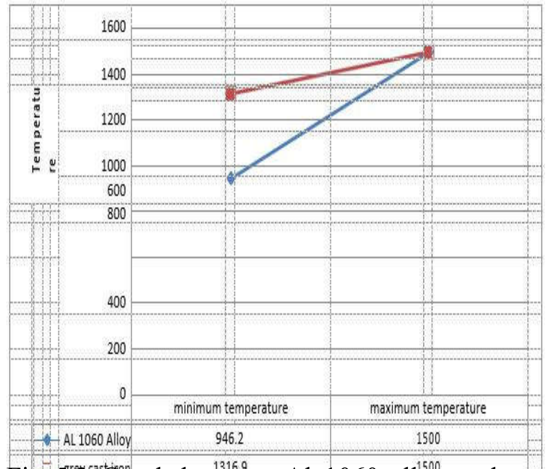

Fig 5.3 Graph between Al 1060 alloy and grey cast iron

The above graph shows the comparison of two different materials for better preference of the material. Here we have taken Al 1060 alloy and grey cast iron and compared heat temperature. By comparing both cast carbon steel is the best and the graph has drawn between temperature and materials which are used for making of radial engine parts. The minimum and maximum temperatures for Al 1060 alloy are 946.2kelvin and 1500kelvin and for grey cast iron 1316.9kelvin and 1500kelvin.

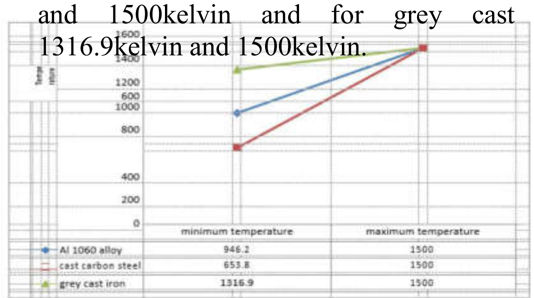

Fig 5.4 Graph between Al 1060 alloy, cast carbon steel and grey cast iron on piston

The above graph shows the comparison of three different materials for better preference of the material. Here we have taken Al 1060 alloy, cast carbon steel, grey cast iron for piston and compared heat temperature. By comparing three cast carbons steel is the best and the graph has drawn between temperature and materials which are used for making of radial engine parts. The minimum and maximum temperatures for Al 1060 alloy are 946.2kelvin and 1500kelvin and for cast carbon steel 653.8kelvin and 1500kelvin grey cast iron 1316.9kelvin and 1500kelvin.

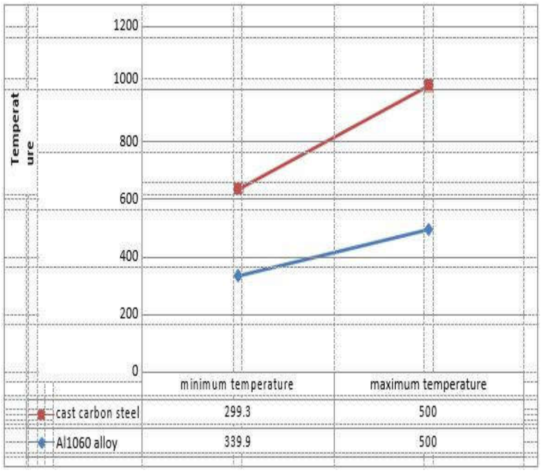

Fig 5.6 Graph between Al 1060 alloy and cast carbon steel for master rod

The above graph shows the comparison of two different materials for better preference of the material. here we have taken Al 1060 alloy and cast carbon steel for master rod and compared heat temperature. By comparing both cast carbon steel is the best and the graph has drawn between temperature and materials which are used for making of radial engine parts. The minimum and maximum temperatures for Al 1060 alloy are 446.827kelvin and 500kelvin and for cast carbon steel 371.009 and 500kelvin

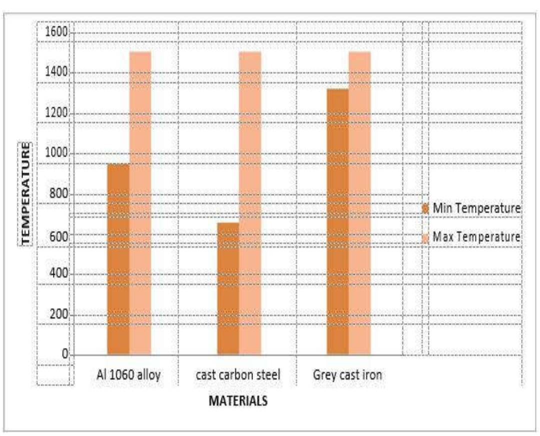

Fig 5.5 Graph between Al 1060 alloy and cast carbon steel for connecting rod

The above graph shows the comparison of tw different materials for better preference of th material. Here we have taken Al 1060 alloy an cast carbon steel for connecting rod and compare heat temperature. By comparing both cast carbo steel is the best and the graph has drawn betwee temperature and materials which are used fc making of radial engine parts. The minimum an maximum temperatures for Al 1060 alloy ar 339.3kelvin and 500kelvin and for cast carbo steel 299.3kelvin and 500kelvin.

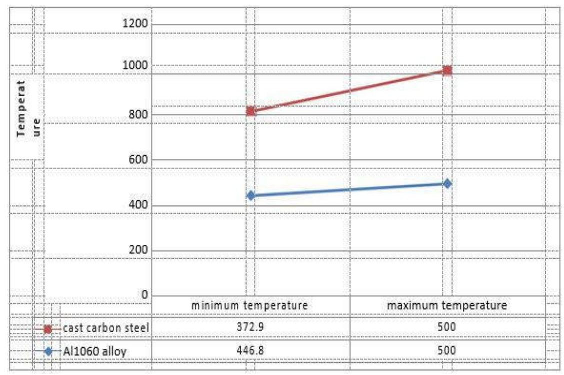

Fig 5.7 Graph between Al 1060 alloy, cast carbon steel and grey cast iron on piston The above graph shows the comparison of three different materials for better prefernce of the material. Here we have taken Al 1060 alloy, cast carbon steel, grey cast iron for piston and compared heat temperature. By comparing three cast carbon steel is the best and the graph has drawn between temperature and materials which are used for making of radial engine parts. The minimum and maximum

temperatures for Al 1060 alloy are 946.2kelvin and 1500kelvin and for cast carbon steel 653.8kelvin and 1500kelvin grey cast iron 1316.9kelvin and 1500kelvin.

CONCLUSION

- In this project Radial engine is modeled and done analysis in solid works software.
- Radial engine is modelled in solid works software using various commands.
- Then thermal analysis has done in solid works simulation tool by applying temperature.
- Different parts of radial engine such as piston, connecting rod and master connecting rod has undergone thermal analysis in solid works simulation tool by applying different materials.
- By applying temperature on all materials each and every different material is studied.
- Engine will be operated with high pressurized air for efficient working.
- Material replacement gives another option for improvement of engine.
- Design modification give better and efficient working of engine.
- Designing of an engine at all is a very complicated process which involves serious of other processes that are hard to be designed

REFERENCES

1. W.D. Callister, Jr.,(2010), "Materials Science and Engineering": An Introduction, 8th edition, Wiley & Sons

2. Reciprocating Compressor Performance and Sizing Fundamentals, a Practical Guide to Compressor Technology, Second Edition, By Heinz P. Bloch Copyright 2006 John Wiley & Sons, Inc.

3. Sasa Trajkovic, The Pneumatic Hybrid Vehicle, A New Concept for Fuel Consumption Reduction, Doctoral ,thesis, Division of Combustion Engines, Department of Energy Sciences, Faculty of Engineering, Lund university.

4.Abhishek lal, 2013- international journal of renewable energy research, New York, 1966. (Recent, authoritative. Includes theory, materials design, and manufacturing).

5. Mr F. A. Pathan, Static Analysis of connecting Rod for weight Optimization.

6. Kuldeep B, “Analysis and optimization of connecting rod using Alfasic composites”.

7. Prof. N.P.Doshi, “Analysis of Connecting Rod Using Analytical and Finite Element Method”.

8. Zhang, “New Continental Aircraft Engines” Automotive and Aviation Industries 93, Dec. 15,1945. (Post war series of horizontal opposed air-cooled engines).

9. B.S.Patel "A Study of parts of radial engine, Eng.J.3, March-Apri 1956,12. (Review of G.M. methods and techniques).

10. S.K.M.Asikul Islam"Compressed air vehicles" Trans.SAE 46,243(1940).(c0ntinental-opposed cylinder air-cooled lin.)

11."Thermal engineering" by R.K.Rajpu