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Design Assembly and Static- Dynamic Analysis of 5 Cylinder Radial Engine

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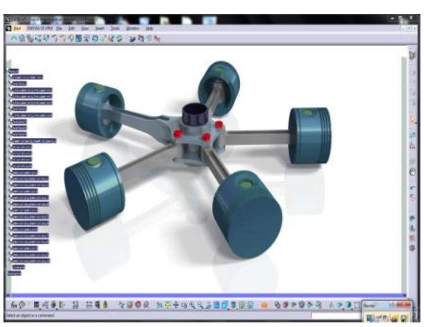
ABSTRACT:

The radial engine is a reciprocating type internal combustion engine configuration in which the cylinder radiates outward from a central crankcase like a spoke of wheel. The radial configuration was commonly used for aircraft engine. Designing of a radial engine is a very complicated process which involves serious of other processes that are hard to be designed. It takes a very long time of thinking of the proper dimensions, proper material (default aluminum) and even the proper shape of all different parts. It has crank case that is a little bit different than the other engines but although that is hard to be figured out too. It also has pistons, cylinders, connecting rods, The designing is done through CATIA V5 software and the analysis process has been completed through ANSYS14.5. Although nowadays used radial engine is a little engine that was not in the beginning of the aerospace transportation. Now radial engine is very helpful and mainly used because of its small weight and size. That makes it comfortable and suitable for any machine that is close of space. Despite of its small size and weight it does not make it less powerful than other engines. It was also comfortable for the World War II airplanes when the engine was in its peak. When it is war you need more space for fuel, power, weapons and bullets than any other things and than any other time. So radial engine was a great invention. By using different material analysis is done through ANSYS. All though materials are Phoshorized navel brass, Titanium alloy, aluminum alloy(default aluminum). Static and model analysis is done on Master Connecting Rod using different materials and followed by structural and analysis on sleeve piston connecting rod assembly on titanium and aluminum.

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 crankshaft 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.

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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 is 1,3,5,7,9,2,4,6,8 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 to 1,3,5,7,9,2,4,6,8,10 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

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.

HISTORY OF RADIAL ENGINE: The very first design of internal combustion aero engine made was that of Charles Manly, who built a five-cylinder radial engine in 1901 for use with Langley`s 'aerodrome' , as the latter inventor decided to call what has since become known as the aero-plane. Manly made a number of experiments, and finally decided on radial design, in which the cylinders are so rayed round a central crank-pin that the pistons act successively upon it. By this arrangement a very short and compact engine is obtained, with a minimum of weight, and a regular crankshaft rotation and perfect balance of inertia forces.

When Manly designed his radial engine, high speed internal combustion engines were in their infancy, and the difficulties in construction can be partly realized when the lack of manufacturing methods for this high-class engine work, and the lack of experimental data on the various materials, are taken into account. During its tests, Manly`s engine developed 52.4 brake horsepower at a speed of 950 revolutions per minute, with the remarkably low weight of only 1.09 kg per horsepower, this latter was increased to 1.64 kg when the engine was completed by the addition of ignition system, radiator, petrol tank, and all accessories, together with the cooling water for the cylinders. In Manly`s engine, the cylinders were of steel, machined outside and inside to 1.625 of a mm thickness. On the side of the cylinder, at the top end, the valve chamber was brazed, being machined from a solid forging. The casing which formed the water-jacket was of sheet steel, 0.52 of a mm in thickness, and this also was brazed on the cylinder and to the valve chamber. Automatic inlet valves were fitted

2.NOW-A-DAYS RADIALENGINES:

At least five companies build radials today. VEDENEYEV Enginesproduces the M-14P model, 360 HP (270kW) (up to 450 HP (340kW) radial used on YAKOVLEVS and SUKHOI, Su-26 and Su-29 aerobic aircraft. The M-14P has also found great favor among builders of experimental aircrafts, such as the Culp`s Special and CULPS SOPWITH 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. HCI Aviation offers the R180 5-cylinders (75 HP (56kW)) and R220 7- cylinders

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(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 airplane use are also available from Seidel in Germany, OS and Saito Seisakusho of Japan, and TECHNOPOWER 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 of miniature four-stroke engines for model use in both methanol-burning glow plug and gasoline-fueled spark plug ignition engine formats.

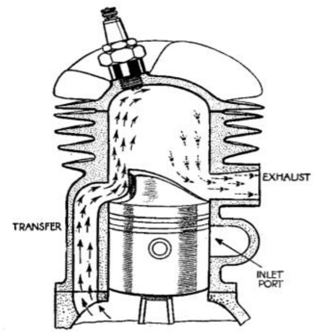
PARTS OF RADIAL ENGINE:

The radial engine having the three main components are

- Piston
- Piston rings
- Gudgeon pin
- Connecting rod
- Master connecting rod

Slipper pistons:

A **slipper piston** is a piston for a petrol engine that has been reduced in size and weight as much as possible. In the extreme case, they are reduced to the piston crown, support for the piston rings, and just enough of the piston skirt remaining to leave two lands so as to stop the piston rocking in the bore. The sides of the piston skirt around the gudgeon pin are reduced away from the cylinder wall. The purpose is mostly to reduce the reciprocating mass,



thus making it easier to balance the engine and so permit high speeds. A secondary benefit may be some reduction in friction with the cylinder wall, however as most of this is due to the parts of the piston that are left behind, the benefit is minor.

Deflector pistons:

Deflector pistons are used in two-stroke engines with crankcase compression, where the gas flow within the cylinder must be carefully directed in order to provide efficientscavenging. With cross scavenging, the transfer (inlet to the cylinder) and exhaust ports are on directly facing sides of the cylinder wall. To prevent the incoming mixture passing straight across from one port to the other, the piston has a raised rib on its crown. This is intended to deflect the incoming mixture upwards, around thecombustion chamber. Much effort, and many different designs of piston crown, went into developing improved scavenging. The crowns developed from a simple rib to a large asymmetric bulge, usually with a steep face on the inlet side and a gentle curve on the exhaust. Despite this, cross scavenging was never as effective as hoped. Most engines today use Schnuerle porting instead. This places a pair of transfer ports in the sides of the cylinder and encourages gas flow to rotate around a vertical axis, rather than a horizontal axis.

Piston rings

The split piston ring was invented by John Ramsbottom who reported the benefits to the Institution of Mechanical Engineers in 1854. It soon replaced the hemp packing hitherto used in steam engines.[2] The use of piston rings at once dramatically reduced the frictional resistance, the leakage of steam, and the mass of the piston, leading to significant increases in power and efficiency and longer maintenance intervals. The piston ring (PR) is a split band pressed against the wall of the cylinder by springs (S) mounted in the inner "junk ring" (JR). The tongue (T) maintains the seal as the ring expands and splits apart. A **piston ring** is a split ring that fits into a groove on the outer diameter of a piston in a reciprocating engine such as an internal combustion engine or steam engine.

The three main functions of piston rings in reciprocating engines are :

1. Sealing the combustion chamber so that there is no transfer of gases from the combustion chamber to the crank.
2. Supporting heat transfer from the piston to the cylinder wall.
3. Regulating engine oil consumption

The gap in the piston ring compresses to a few thousandths of an inch when inside the cylinder bore. Piston rings are a major source of hint to identify if the engine is two stroke or four stroke.Three piston rings suggest that it is a four stroke engine while two piston rings suggest that it is a two stroke engine.

Gudgeon pin

In internal combustion engines, the **gudgeon pin** (UK, **wrist pin** US) connects the piston to the connecting rod and provides a bearing for the connecting rod to pivot upon as the piston moves.[1] In very early engine designs (including those driven by steam and also many very large stationary or marine engines), the gudgeon pin is located in a sliding crosshead that connects to the piston via a rod. A gudgeon is a pivot or journal. The origin of the word gudgeon is the Middle English word gojoun, which originated from the Middle French word goujon. Its first known use was in the 15th century

The gudgeon pin is typically a forged short hollow rod made of a steel alloy of high strength and hardness that may be physically separated from both the connecting rod and piston or crosshead The design of the gudgeon pin, especially in the case of small, high-revving automotive engines is challenging. The gudgeon pin has to operate under some of the highest temperatures experienced in the engine, with difficulties in lubrication due to its location, while remaining small and light so as to fit into the piston diameter and not unduly add to the reciprocating mass. The requirements for lightness and compactness demand a small diameter rod that is subject to heavy shear and bending loads, with some of the highest pressure loadings of any bearing in the whole engine. To overcome these problems, the materials used to make the gudgeon pin and the way it is manufactured are amongst the most highly engineered of any mechanical component found in internal combustion engines.

Connecting rod In a reciprocating piston engine, the **connecting rod** or **conrod** connects the piston to the crank or crankshaft. Together with the crank, they form a simple mechanism that converts reciprocating motion into rotating motion. Connecting rods may also convert rotating motion into reciprocating motion. Historically, before the development of engines, they were first used in this way. As a connecting rod is rigid, it may transmit either a push or a pull and so the rod may rotate the crank through both halves of a revolution, i.e. piston pushing and piston pulling. Earlier mechanisms, such as chains, could only pull. In a few two-stroke

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engines, the connecting rod is only required to push. Today, connecting rods are best known through their use in internal combustion piston engines, such as automotive engines. These are of a distinctly different design from earlier forms of connecting rods, used in steam engines and steam locomotives.

MasterConnecting rod

When the engine is working the piston rod is under variable in size and direction gas forces and inertia forces. That is why it is made of high quality steel with high resistance of fatigue (40,45). The piston rod is contained by upper head, trunk, lower head. The dimensions of the rod could be determined over existing engines.

CONCLUSION :

The designing of a radial engine is indeed a very complicated process which involves series of other processes and design calculations that are needed to be performed for designing.

From the above analysis on imported design from catia V5 we conclude that alloy material titanium has better sustainable properties when compared to other alloy materials i.e. Phospharized navel brass alloy, aluminum alloy(present material)

Now a day's Aluminum alloy is widely used because it has good Equivalent Elastic Strain and deformation coefficient

But titanium alloy material has better advantage than aluminum alloy material because of its low weight, low deformation factor and high stress handling properties

In modal analysis all these material has nearly equal value and among them Titanium Alloy has good dynamic frequency

FUTURE SCOPE

It is suggested that the analysis approach could be successful approach applied to titanium alloy and Aluminum alloy under different loads.

The results show that the analysis of master Connecting rod with different materials can be a simple way to find out the stress and deformation.

The stress and deformation obtained by this method are for future use for more elaborate for structural analysis with different materials.

By the analysis with different materials of the master connecting rod the equipment life may also increase.

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