Design and Analysis of Radial Engine using Parametric Software such as SOLIDWORKS and ANSYS

Shailesh Govindbhai Goyani[1], Viraj Nileshkumar Kakadia[2]
[1,2]*Mechanical Engineering Department, B.M.C.E.T., Surat, Gujarat, India*

Abstract- **In a car or any other vehicle there are many devices embedded in the body, which require power to get going; for that, a reciprocating engine plays a crucial role of primary source for power generation in the system. Further, to overcome the barrier of the limited speed of the single cylinder reciprocating engine, radial engines are used. The radial engine is a kind of reciprocating engine where pistons are kept together by the single crankshaft with the help of connecting rod. The aim of this paper to indicate the design of engine with given parameters to know stress, strain, load, and so on with the help of computer software (ANSYS). To cite the comparison between two materials for connecting rod.**

Index terms- Radial engine, Thermal analysis, ANSYS, connecting rod, reciprocating engine.

I. INTRODUCTION

In the current past, the demand for diesel engines has amplified rapidly. This is mostly because of their higher thermal efficiency, improved performance and reliability. In the previous days, diesel engines were considered to be top pollutants than petrol engines. However, with the constant improvements in technology, there is a considerable decrease in the emission levels in diesel engines. Still, the research works are persistent in bringing down the levels of emissions; concurrently, the efforts are ongoing in the direction of improving the overall engine performance. In diesel engines, the fuel is injected straight into the combustion chamber. Here the piston crown is a portion of the combustion chamber. Fuel atomization, vaporization and fraternization of fuel and air occurs in a quick series inside the combustion chamber in a fraction of a second. This can be accomplished with the following: good combustion chamber, suitable in-cylinder air motion and fuel injection arrangement. Swirl is mainly used for getting satisfactory fuel-air mixing proportions. Air swirl is generated with the provision of a proper inlet port, and it is amplified after the compression stroke by forcing the air towards the cylinder axis into the bowl-in-piston combustion chamber. Swirl is a prearranged rotation of air about the cylinder alignment. Though some decay of swirl arises due to the existence of friction during the cycle, intake generated surge persists through the compression process as well as in the combustion and expansion processes. The nature of the whirling flow in an actual engine is challenging to determine. Accordingly, steady-state tests are regularly used to characterize swirl. Swirl ratio is well-defined as the solid-body rotating flow, which has equivalent angular momentum to the actual stream, divided by crankshaft angular speed. The radial engine is a reciprocating kind internal combustion engine arrangement in which the cylinders emit outward from a central crankcase alike the spokes of a wheel. It looks like a stylized star when watched from the front, and is called a “star engine”.

The radial engine usually uses smaller number cam lobes than other kinds. As, most four-strokes, the crankshaft takes two revolutions to finish the four strokes of every piston (exhaust, intake, compression, combustion). The camshaft disc is geared to rotation gentler and in a different direction to the crankshaft. The cam lobes are located in two rackets for the intake and exhaust. For example, four cam lobes help all the five cylinders, while ten would be requisite for a standard inline engine with a similar amount of cylinders and valves.

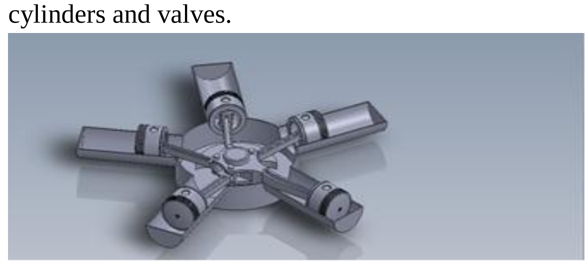

FIG – 1.1 3D Modeling of Radial Engine

II. AIM AND OBJECTIVES

A. Aim

In nowadays the most problem with the radial engine is noise and oil lubrication due to several components. So the objective of the project is trying to reduce noise as much as possible with change dimensions of some parts as well as change the material of the engine.

B. Objective

To produce much power with minimum rpm (rotation per minute) with lower noise as possible. Due to this advantages radial engine is mostly use in Aircraft, Tanks and also sometimes this type of motor is used in ships.

In radial engine fluid cooling method is not required; this is the main advantage of the radial engine due to this saving weight of the engine and increases durability. Hence, typically higher power to weight ratio. In a radial engine, we can achieve better STOL performance. (STOL performance means higher power output at lower rpm).

III. FUNDAMENTAL OF DESIGN AND ANALYSIS FOR CONNECTING ROD

The connecting rod is the transitional member among the piston and the Crankshaft. Its prime function is to convey the push and pull from the piston pin to the crank pin, thus transforming the reciprocating motion of the piston into rotary motion of the crankshaft. This paper labels designing and Analysis of the connecting rod. Currently, the prevailing connecting rod is fabricated by using Carbon steel. In this diagram is drafted from the calculations. A parametric model of the Connecting rod is calculated using SOLIDWORKS software, and to that model, analysis is supported out by using ANSYS Software. Finite element analysis of connecting rod is completed by considering the materials, Aluminum alloy 4032-T6. The finest combination of parameters like Von misses Stress and strain, Deformation, Factor of safety and weight reduction for two-wheeler piston were finished in ANSYS software. Forged steel has an additional factor of safety, diminish the weight, surge the stiffness and lessen the stress and stiffer than other material similar to carbon steel. By Fatigue analysis, we can define the lifetime of the connecting rod.

The connecting rod forms a vital part of an internal combustion engine. Dissimilar types of loads while experiencing its operation act upon the connecting rod. One of the chief reasons subsidizing to its failure is fatigue. This study aims to redesign the connecting rod by joining the manufacturing procedure effects into the analysis and obtain a better fatigue presentation. The redesign is meant to reduce the weight of the part. Heavy duty application's connecting rod was carefully chosen for the study. The analytically calculated loads performing on the small end of the connecting rod were used to transmit out the static analysis using ANSYS. Stress attention was detected near the transition between the short end and shank. A piston-crank connecting-rod assembly was simulated for one complete cycle (0.02 seconds) using ADAMS to obtain the loads acting on the small end of the connecting rod.

IV. DESIGN PARAMETER FOR THE PARTS OF RADIAL ENGINE

1. Piston
2. Piston rod
3. Piston rings
4. Master Rod
5. Flywheel

PISTON: - Piston is one of the leading parts of the engine. Its purpose is to handover force from flue gas in the cylinder to the crankshaft through a connecting rod. Since the piston is the central reciprocating portion of an engine, its movement produces an imbalance. This imbalance usually manifests itself as a vibration, which causes the engine to be perceivably punitive. The friction amongst the walls of the cylinder and the piston rings ultimately results in wear, dropping the active life of the mechanism. The sound arose from a reciprocating engine can be unbearable and as a result, many reciprocating engines trust on heavy noise suppression equipment to reduce droning and loudness. To convey the energy of the piston to the crank, the piston is linked to a connecting rod which is in turn linked to the crank. Because the rectilinear movement of the piston must be converted to a rotational motion of the crank, the mechanical harm is experienced as a result. Generally, this leads to a decline in the overall effectiveness of the combustion process. The motion of the crankshaft is not smooth since the energy supplied by the piston is not continuous, and it is impulsive. There is a necessity for valves and camshafts. During the opening and closing of the valves, mechanical noise and vibrations may be encountered. When designing the piston, we use constructive parameters of already existing engines. The elements of the piston are calculated without determining the variable way of loading. This reflects on the allowable stress.

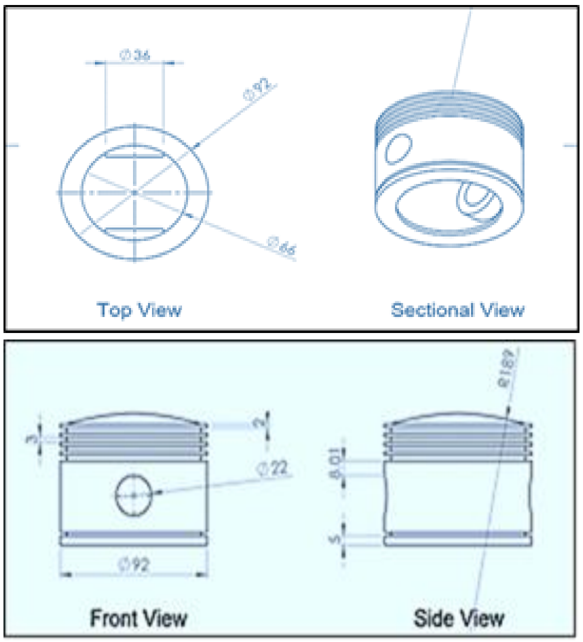

FIG – 1.2 Drafting of Piston


FIG – 1.3 3D Modeling of Piston

PISTON ROD: - The connecting rod is a significant link intimate of a combustion engine. It links the piston to the crankshaft and is in charge of transporting power from the piston to the crankshaft and conveyance it to the transmission. There are different types of materials and production methods used in the formation of connecting rods. The most common kinds of connecting rods are steel and aluminium. The utmost common kind of manufacturing processes is casting, forging and powdered metallurgy. The connecting rod is the top common reason for catastrophic engine failure. It is under a massive amount of load pressure and is regularly the recipient of specialised care to make sure that it does not fail prematurely. The sharp edges are polished smooth to reduce stress risers on the connecting rod. The connecting rod is too shot-peened, or hardened, to raise its strength against cracking. In best high-performance applications, the connecting rod is balanced to prevent unwanted harmonics from creating excessive wear.

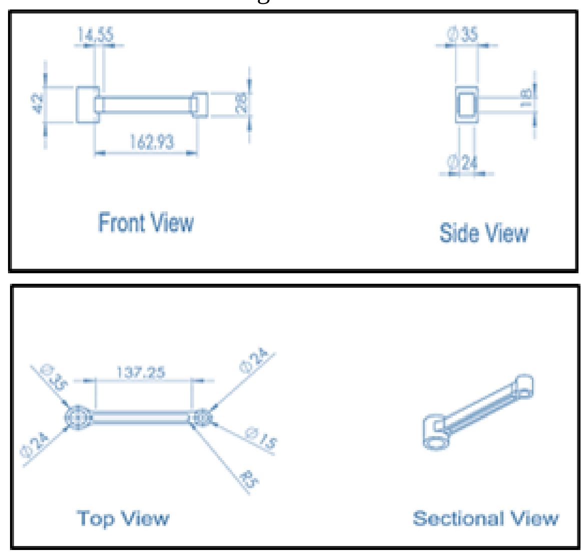

FIG – 1.4 Drafting of Connecting Rod

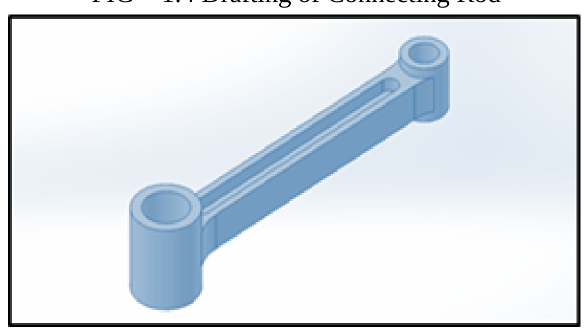
FIG – 1.5 3D Modeling of Connecting Rod

PISTON RINGS: - A ring groove is a dug in the area situated all over the boundary of the piston that is used to keep a piston ring. Ring lands are the two parallel faces of the ring groove whose purpose is to the closing surface for the piston ring. A piston ring is an elastic split ring used to provide a seal among the piston and the cylinder wall. Piston rings are generally fabricated from the cast iron. Cast iron preserves the integrity of its original shape under heat, load, and other dynamic forces. Piston rings cover the combustion chamber, conduct heat from the piston to the cylinder wall, and return oil to the crankcase. Piston ring size and arrangement very subjected to engine design and cylinder material. Piston rings are generally used on small engines consist of the compression ring, wiper ring, and oil ring. A compression ring is the piston ring placed in the ring groove neighbouring to the piston head. The compression ring lids the combustion chamber from any leakage throughout the combustion process. When the air-fuel combination is ignited, pressure from flue gases is applied to the piston head, pushing the piston toward the crankshaft. The pressurized gases travel through the breach among the cylinder wall and the piston and into the piston ring recess. Combustion gas pressure pushes the piston ring counter to the cylinder wall to form a seal. Pressure applied to the piston ring is roughly proportional to the flue gas pressure.

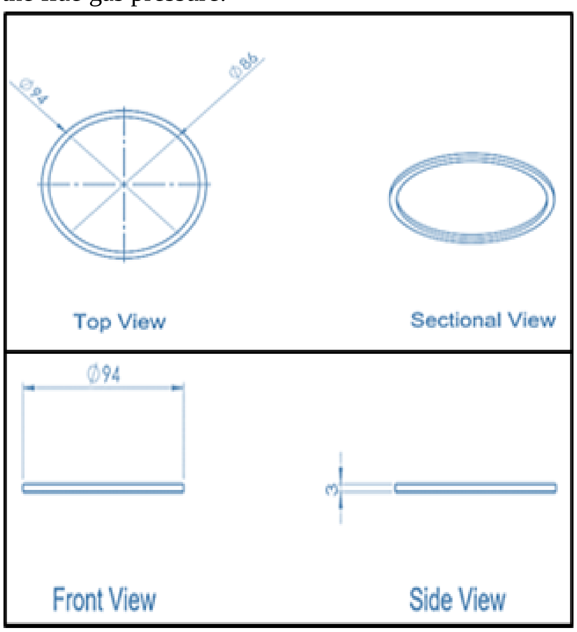

FIG – 1.6 Drafting of Piston Ring

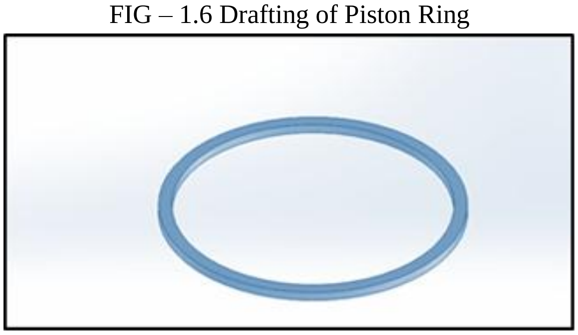

FIG – 1.7 3D Modeling of Piston Ring

MASTER ROD: - The master rod is identical to any other connecting rod excluding that it is constructed to arrange for the attachment of the articulated rods. For each articulated connecting rod has a bushing of nonferrous metal. Typically, bronze, forced or shrunk into place to serve as a knuckle pin bearing. The knuckle pins may be detained tightly in the master rod holes by a press fit, or they may be of the full floating type depending upon engine design.

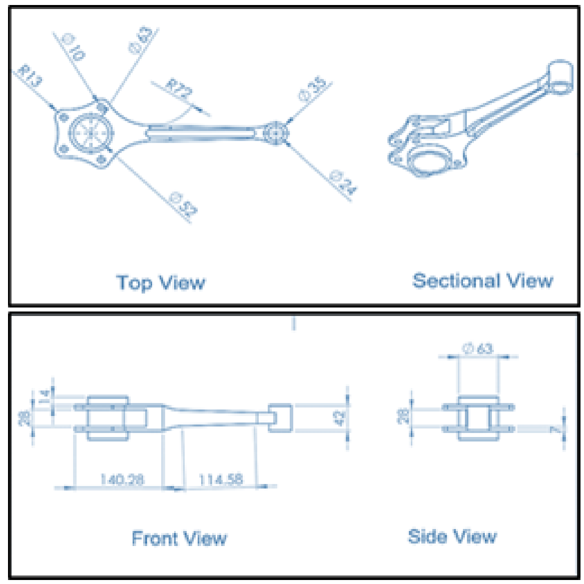

FIG – 1.8 Drafting of Master Rod

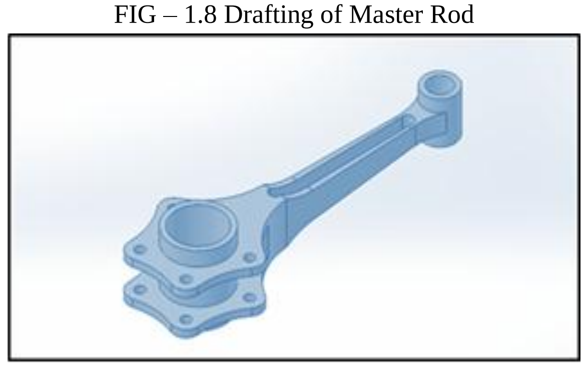

FIG – 1.9 3D Modeling of Master Rod

FLYWHEEL: - The flywheel is a cast iron, aluminum, or zinc disk that is attached at one end of the crankshaft to deliver inertia for the engine. Inertia is the property of matter by which any physical body keeps on in its state of relaxation or unchanging motion unless and until acted by an external force. Inertia isn't a force; it is a characteristic of matter. During a reciprocating engine, combustion occurs at distinct intervals. The inertia of the flywheel offers a dampening effect on the engine as a whole to nullify out radial acceleration forces and rpm deviations produced in the engine. During individual stroke of an internal combustion engine, the flywheel, crankshaft and other engine modules are exaggerated by oscillations in speed and force. During the power stroke in a four-stroke cycle engine, the crankshaft is speeded up swiftly by the sudden movement of the piston and connecting rod assembly.

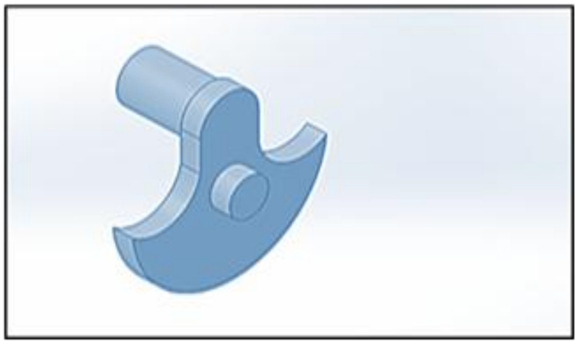

FIG – 1.10 3D Modeling of Flywheel

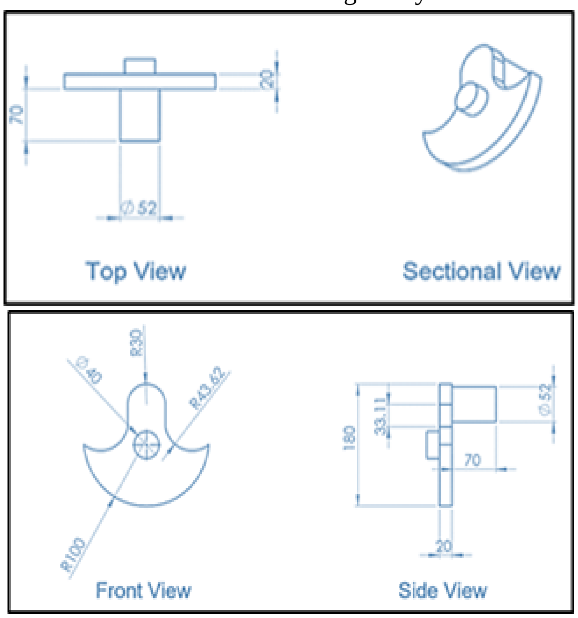

FIG – 1.11 Drafting of Flywheel

V. READING TABLE OF MASTER-ROD

READING 1:

Materials	Von misses (MPa)	Total Deformation (mm)
Aluminium alloy 4032-T6	49.19	0.9140
Aluminum alloy 7075	49.20	0.9532
Stainless steel 12L14	49.40	333.70
Steel 316L	49.40	0.3337
Grey cast iron	49.30	3.7080

READING 2:

Materials	Von misses (MPa)	Total Deformation (mm)
Aluminium alloy 4032-T6	63.57	1.1730
Aluminium alloy 7075	63.60	1.2240
Stainless steel 12L14	63.68	428.40
Steel 316L	63.68	0.4284
Grey cast iron	63.67	4.7600

VI. 3D MODELING ASSEMBLY

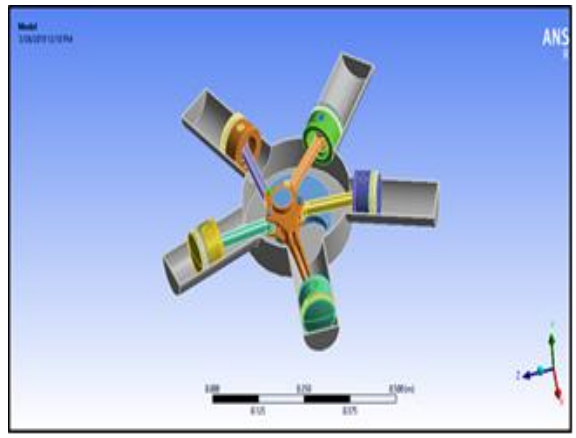

FIG – 1.12 3D Modeling of Assembly in ANSYS

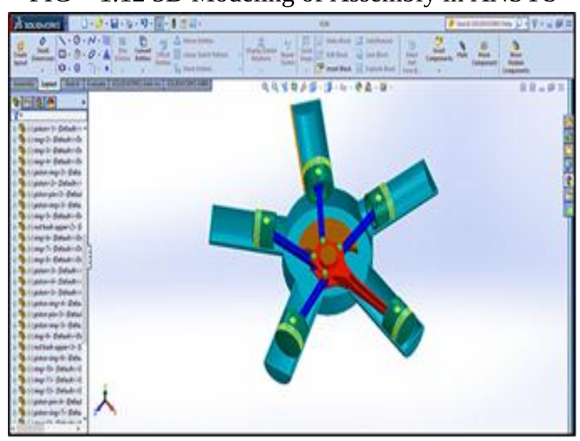

FIG – 1.13 3D Modeling of Assembly in SOLIDWORKS

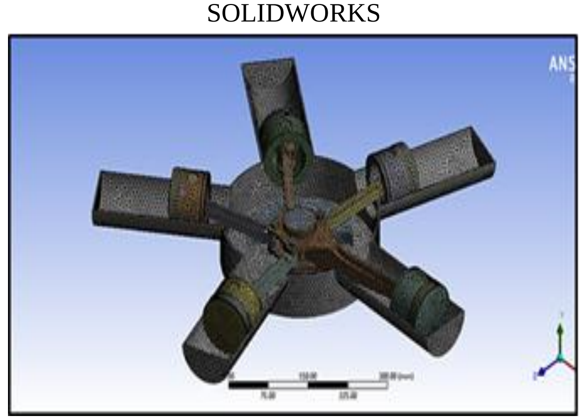

FIG – 1.14 Meshing of Assembly in ANSYS

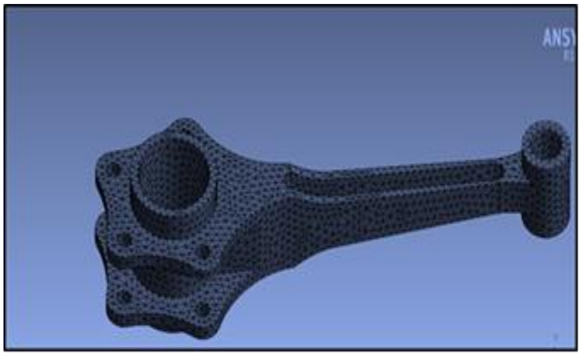

FIG – 1.15 Meshing of Master Rod in ANSYS

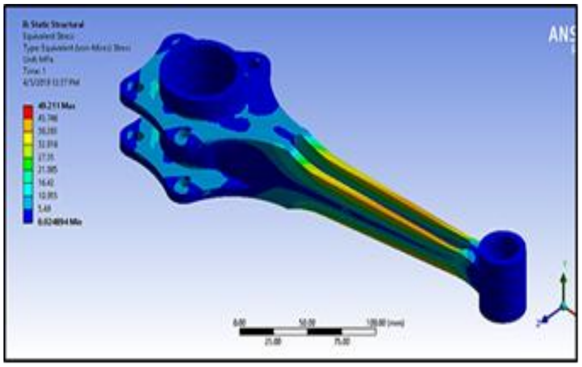

FIG – 1.15 Equivalent Stress of Master Rod in ANSYS

VII. BOUNDARY CONDITIONS

1. A is Fixed or constraint over the all DOF from the channel section.
2. Forces apply at Master Rod at all the circle at which all connecting rod are joints.
3. Self-weight of the body is due to the centre of gravity effect in a downward direction towards the ground.

VIII. CONCLUSION

Designing an engine at all 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 and even the proper shape of all different parts. The design of the radial engine is not a less complicated process than any other engine. It has crankcase 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, rods; it has a cam mechanism that in the conventional engines is called camshaft, and let us not forget about the gear mechanism that is some ways different than the gear mechanism in the conventional engines, but the way it works is the same in both engines. Moreover, the crankshaft- the same as in an ordinary engine but with fewer journals, more comfortable to be manufactured. The crankshaft is a fantastic part of the engine; torque is transmitted into the distance is exciting.

There are several different stages that we passed until the final engine was wholly designed. In the way, to the end, we met lots of difficulties and problem about the way every single part is done. Had lots of problems also with the program we used to make the whole assembly and simulations- SOLID WORKS.

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