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DESIGN AND ASSEMBLY OF 4 CYLINDER ENGINE COMPONENTS AND STATIC ANALYSIS ON CRANKSHAFT

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ABSTRACT

An Internal combustion engine is characterized as an engine in which the chemical energy released inside the engine is directly converted to mechanical work, instead of an external combustion engine in which a different combustor is utilized to burn the fuel. There are number of components in the engine which are important for the effective functioning of an Engine. In this project we design some main components of a 4 cylinder I.C Engine and also attempt is done to study static analysis ona crankshaft from a single cylinder IC Engine. The modelling of engine components is done in CATIA V5 R20 software. Finite Element Analysis (FEA) is performed to see the stress variations at critical locations using the ANSYS 15.0 software on crankshaft by applying the boundary conditions. Static analysis is performed on the crankshaft to know the stress variations on it and it is performed by considering the three different alloys of steel.

Also to design a real engine, having into account all necessary calculations concerning with kinematics, dynamics and strength calculation of basic details. Another purpose of the project is to define the proper materials for each part. Next to that I will make 2D and 3D drawings on CATIA and animation of working Internal Combustion Engine.

I. INTRODUCTION

An engine or motor is a machine designed to convert one form of energy into mechanical energy. Heat engines, including internal combustion engines and external combustion engines (such as steam engines) burn a fuel to create heat, which then creates a force.The internal combustion engine was conceived and developed in the late 1800s. It has had a significant impact on society, and is considered one of the most significant inventions of the last century. The internal combustion engine has been the foundation for the successful development of many commercial technologies. For example, consider how this type of engine has transformed the transportation industry, allowing the invention and improvement of automobiles, trucks, airplanes and trains.

1.1 Types of engines

There are two major cycles used in internal combustion engines: Otto and Diesel. The Otto cycle is named after Nikolaus Otto (1832 – 1891) who developed a four-stroke engine in 1876. It is also called a spark ignition (**SI**) engine, since a spark is needed to ignite the fuel-air mixture. The Diesel cycle engine is also called a compression ignition (**CI**) engine, since the fuel will auto-ignite when injected into the combustion chamber. The Otto and Diesel cycles operate on either a four- or two-stroke cycle.

Since the invention of the internal combustion engine many pistons-cylinder geometries have been designed. The choice of given arrangement depends on a number of factors and constraints, such as engine balancing and available volume:

- In line
- Horizontally opposed
- Radial
- V shaped

1.2 In Line

The inline-four engine or straight-four engine is an internal combustion engine with every one of the four cylinders mounted in a straight line, or plane along the crankcase. The single bank of cylinders might be situated in either a vertical or a slanted plane with every one of the cylinders driving a typical crankshaft. Where it is slanted, it is in some cases called an inclination four. In a particular graph or when a condensing is utilized, an inline-four engine is recorded either as I4 or L4.

1.3 Horizontally opposed

A horizontally opposed engine is an engine in which the two cylinder heads are on opposite side of the crankshaft, resulting in a flat profile. Subaru and Porsche are two automakers that use horizontally opposed engine in their vehicles.

Horizontally opposed engines offer a low centre of gravity and thereby may a drive configuration with better stability and control. They are also wider than other engine configurations, presenting complications with the fitment of the engine within the engine bay of a front-engine car. This kind of engine is wide spread in the aircraft production.

1.4 Radial Engine

The radial engine is a responding sort internal combustion engine arrangement in which the cylinders point outward from a central crankshaft such as the spokes on a wheel. This arrangement was ordinarily utilized as a part of large aircraftengines before most substantial airplane began utilizing turbine engines.

In aradial engine, the pistons are associated with the crankshaft with amaster-and-articulating-rodassembly. One piston has amasterrod with adirect connection to the crankshaft. The remaining pistonspin their connecting rods` connection to rings around the edge of the master rod. Four-stroke radials always have odd number cylinders for each line, so that a steady every-other-pistonfiringorder can be maintained, giving smooth operation.

1.5 V Engine

V engine or Vee motor is a typical arrangement for aninternal combustion engine. The pistons and cylinders are adjusted in two separate planes or "banks", is that they seem, by all accounts, to be in a "V" when seen along the axis of the crankshaft. The Vee design generally decreases overall engine length, height and weight compared with the proportional inline arrangement.

Different cylinder bank angles of Vee are utilized as a part of various engines relying upon the quantity of the cylinders; there might be angles that work superior to anything others for stability. Extremely thin points of V consolidate a percentage of the benefits of the straight and V engine.

II. MAIN COMPONENTS OF THE ENGINE

2.1 Piston

Piston is one of the main parts in the engine. Its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a connecting rod.

Since the piston is the main reciprocating part of an engine, its movement creates an imbalance. This imbalance generally manifests itself as a vibration, which causes the engine to be perceivably harsh. The friction between the walls of the cylinder and the piston rings eventually results in wear, reducing the effective life of the mechanism.

2.2 Connecting Rod

The connecting rod is a major link inside of a combustion engine. It connects the piston to the crankshaft and is responsible for transferring power from the piston to the crankshaft and sending it to the transmission. There are different types of materials and production methods used in the creation of connecting rods. The most common types of connecting rods are steel and aluminum. The most common type of manufacturing processes is casting, forging and powdered metallurgy.

2.3 Crankshaft

The crankshaft is the part of an engine which translates reciprocating linear piston motion into rotation. To convert the reciprocating motion into rotation, the crankshaft has crankpins, additional bearing surfaces whose axis is offset from that of the crank, to which the “big ends” of the connecting rod from each cylinder attach.

2.4 Camshaft

Camshaft is frequently called “brain” of the engine. This is so because its job is to open and closed at just the right time during engine rotation, so that the maximum power and efficient cleanout of exhaust to be obtained. The camshaft drives the distributor to electrically synchronize spark ignition. Camshafts do their work through eccentric "lobes" that actuate the components of the valve train.

2.5 Piston Rings

The piston rings are used to decrease the friction between the piston and the cylinder. The piston rings reduce the contact surface between the piston and cylinder as result friction losses are reduced.

2.6 Introduction to CATIA

CATIA is a fully automation software which relates with the mechanical field. It is graphical user interface which is easy to learn and also the software is feature based and parametric solid modelling. We can draw 2D and 3D models of a part and accordingly the assembly of the parts can be done in it.

The shape or geometry of the model or assembly is dependent upon the values which are referred as constraints.

Modules such as sketcher module used to design 2D drawings, part design module is used to design the 3D models of geometry, and Assembly work design is used to assemble the different parts which are drawn in the part design module. Kinematics is used to give the simulation or motion to the part bodies which are designed and assembled in part and assembly design modules.

2.7 Different modules used in CATIA

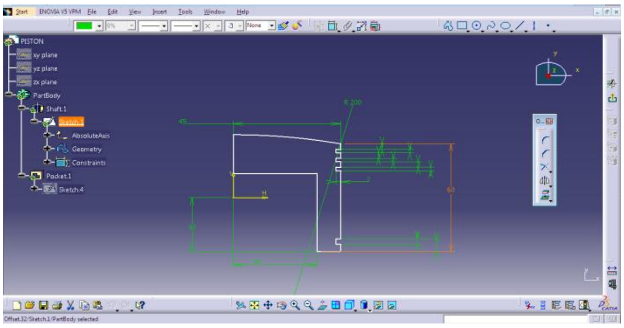
- Sketcher
- Part Design
- Assembly Design
- Kinematics

By Using the CATIA software the part designs were designed and assembly is made because compared to other software's CATIA is easy to design.

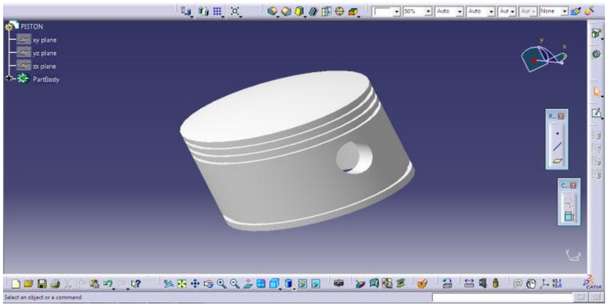
2.8 Design of Engine components

2.8.1 Piston

Outline diagram

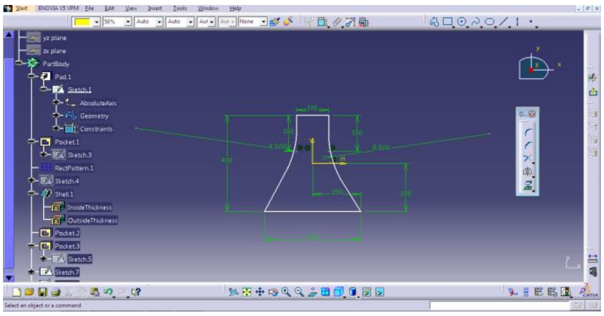


Completed view:



2.8.2 Cylinder head:

Outline diagram



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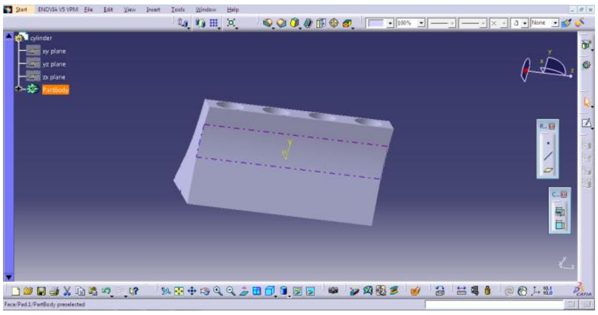
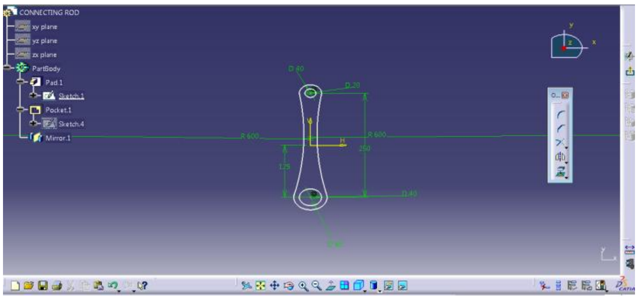
Completed view:

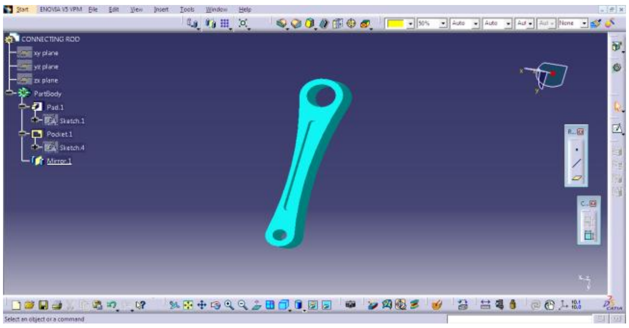


2.8.3 Connecting Rod

Outline view:

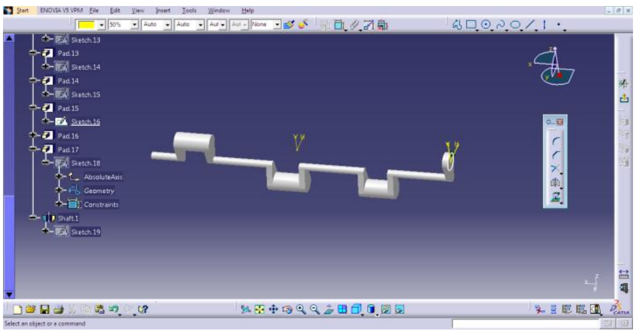


Completed view:

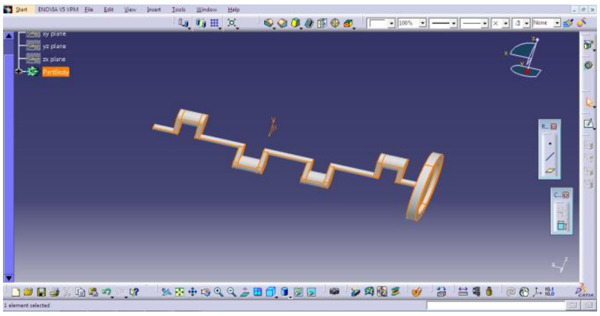


2.8.4 Crankshaft

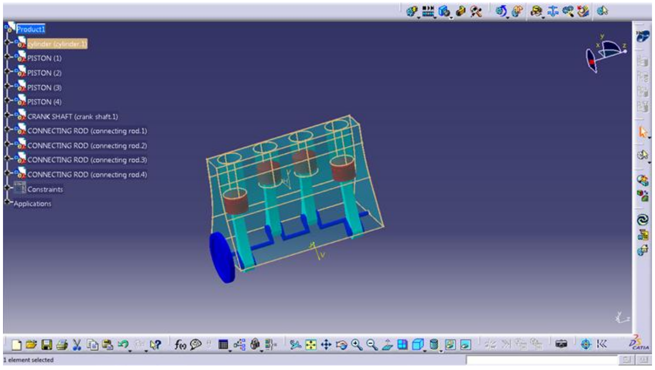
Outline view:



Completed view:



Assembled view:



III. FINITE ELEMENT ANALYSIS (FEA)

The fundamental idea in FEA is that the body or structure may be separated into littler components of finite measurements called “Finite Elements”. The original body or the structure is then considered as an array of these components associated at a limited number of joints called “hubs”. Straightforward capacities are approximated the removals over each limited component. Such accepted capacities are called “shape capacities”. This will signify the movement within the components as far as the relocation at the hubs of the components.

The Finite Element method is a scientific tool for resolving ordinary and partial differential comparison in light of the fact it is a numerical tool, it can take care of the complex issue that can be signified in differential mathematical statement from. The use of FEM is limitless as respects the arrangement of down to earth design issues. Because of high cost of processing power of years passed by, FEM has a history of being utilized to take care of complex and expense critical difficulties.

IV. MATERIAL PROPERTIES OF CRANKSHAFT

Material Name & Properties	**SAE 1046**	**SAE 1137**	**EN 9**
Young’s Modulus (E)	200Gpa	190 gpa	180 gpa
Poisson’s Ratio	0.28	0.30	0.30
Density	7.85g/cc	8g/cc	7800kg/m3

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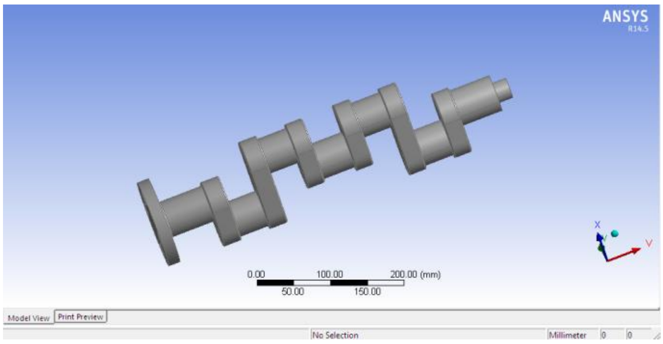
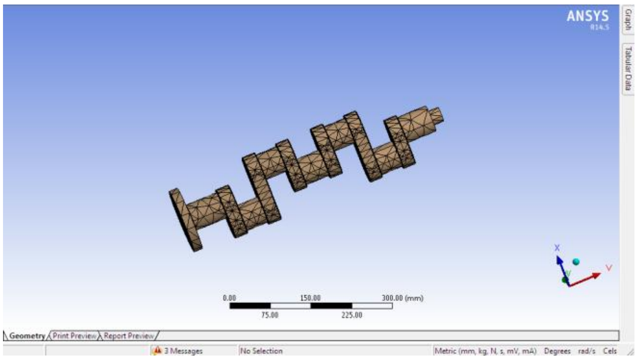
V. STATIC ANALYSIS OF CRANKSHAFT

Crankshaft imported model:



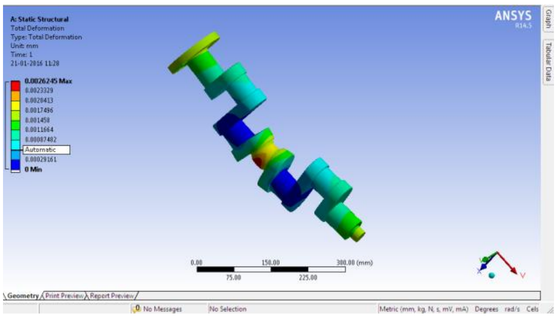
After meshing:



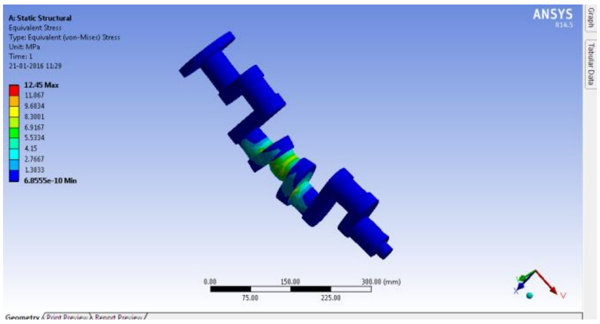
5.1 Material Type

5.1.1 Steel SAE 1046

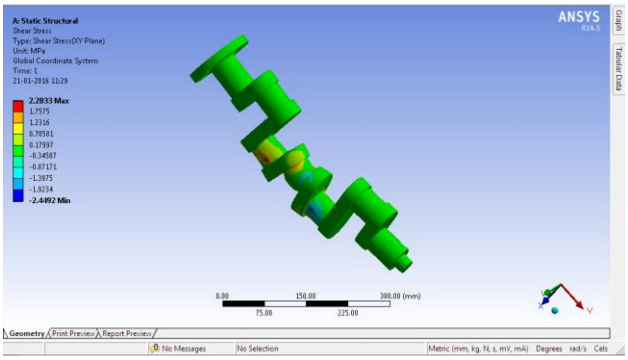
Total deformation:



Equivalent stresses:



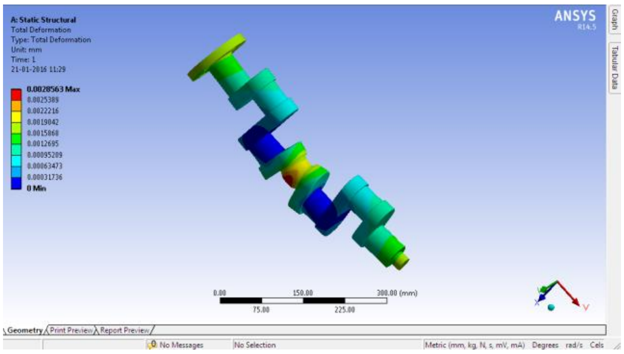
Shear stresses:



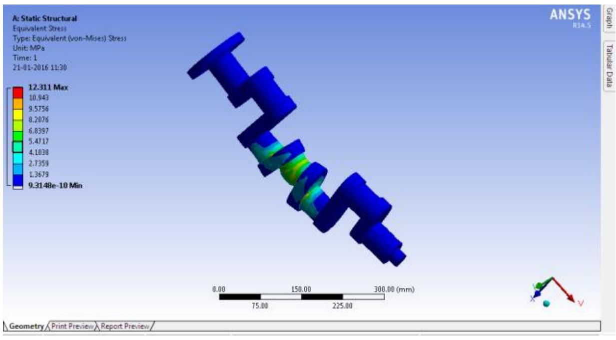
5.2 Material Type

5.2.1 Steel SAE 1137(chemical composition Fe-98, Mn-1.35, S-.08,P-0.06)

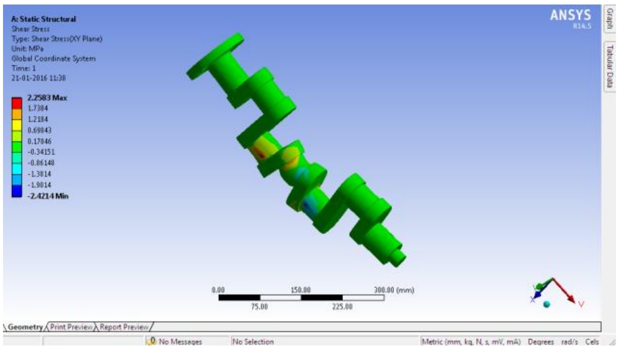
Total Deformation:



Equivalent stress:



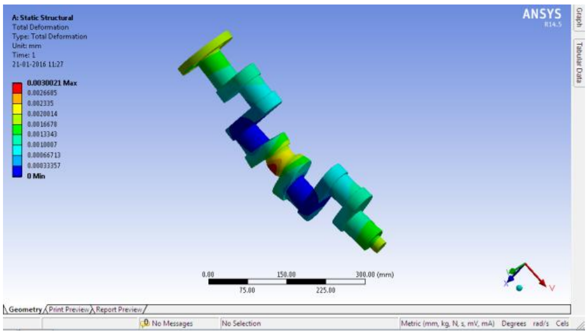
Shear stress:



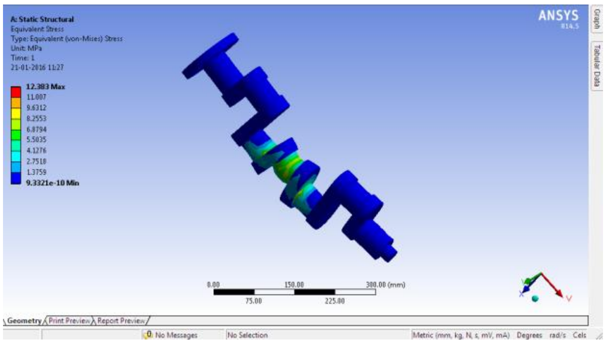
5.3 Material Type

5.3.1 Steel EN9(chemical composition c-50,Si-3.5, Mn-.75, S-.06, P-.06)

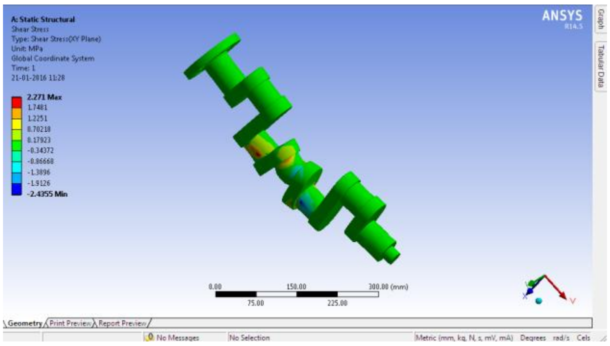
Total Deformation:



Equivalent stress:



Shear stress:



5.4 Numerical values obtained during analysis

The results were drawn from the analysis test on crankshaft by ANSYS and Crank pin fillet and journal fillet has found to be the weakest parts in the crankshaft and safe stress limit can be considered by doing the theoretical calculation.

si.no	material	Deformation	von-mises stress	Shear stress
1	SAE1046	0.002625	12.45	2.283
2	SAE1137	0.0028564	12.311	2.253
3	EN9	0.003002	12.3833	2.271

Table 1

VI. CONCLUSION

In this project we have designed the part diagrams of the engine components like piston, cylinder, and crankshaft and made the assembly of these components. We have designed the part design in 2D and 3D models and assembled it in the assembly design workbench.

Static analysis has been performed on the crankshaft to find the defects in the formation of crankshaft. Crank pin fillet and journal fillet has found to be the weakest parts in the crankshaft. Analysis was done by considering the three different materials and SAE 1046 material alloy of steel has found to be having less deformation while compared to others. In future prospects dynamic analysis can be done on crankshaft to test the fatigue strength.

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