Design and Analysis of A V12 Engine by Using Different Materials

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Abstract **A V12 engine is an eight-cylinder v configuration engine with the cylinders mounted on the crankcase in two sets of four, with all eight pistons driving a common crankshaft is set at a right angle to each other, some at a narrower angle, with 45^0, 60^0, and 72^0 most common.V12s have used the somewhat more complex cross plane crankshaft with heavy counterweights to eliminate the vibrations. This results in an engine that is smoother than a v6, while being considerably less expensive than a v12. In a racing car, the engine can be made much lighter. This makes the engine more responsive and smoother. In a large heavy-duty engine, a V6 can run slower and prolonging engine life. In motorsports V12s are common and league have been a popular engine choice in purpose-designed engines for race-cars in many different types and classes of automotive racing, with use for example in the Formula-1 or the American NASCAR-racing The main objective of the project is how to develop the prototype of V8 engine assembly using CAD tool CATIA. This Engine assembly consists major components they are Piston, Connecting Rod Assembly, and Crank Shaft, Cylinder head, Cam Shaft, Valves, crank case, oil tank and spark plug with required dimensions. The components which are developed in CATIA are also analyzed in it using simulation tool. The structural and thermal analysis of piston, crank shaft, cam shaft and valve is performed for 800k thermal loading and the results of temperature distribution of the components are shown. Finally the analysis results of the components are compared and the best suited material is selected.**

Key words: v12 engine components, comparison engine part materials, catia designs, analysis.

I. INTRODUCTION

The idea of the internal combustion engine was first invented in 1680 by the Dutch physicist Christian Huygens (though it was never made). Further attempts were made in the 1850s and 1960s. There are two ideas about how this engine works. By chance, both designs were put into use in 1876: Sir Dugard Clark's two-stroke engine and Nicholas Otto's four-stroke engine. This four-stroke design called the Otto cycle has become the basis of all modern engines (1a). It is not that it is the only 4-stroke design, but that the Atkinson cycle was not developed until 6 years later (1882). It is very similar, but emphasizes efficiency and fuel economy. In addition, the Miller cycle developed in the 1940s was changed again to improve efficiency (through the use of compressors).

So far, all these types of internal combustion engines have alternative designs, but there are also rotary designs. It will not go into these details in detail, but their completeness is worth mentioning; the first developed in 1924 was a rotary engine (although it was not ready for mass production until 1958), the little-known Wolf- Hart engine (two-stroke piston ball engine of the 1970s). Developed as a competitor to the Wankel engine, but never achieved much success), a piston ball engine (more modern 4-stroke design), and more recently a quasi-gas turbine engine (patented in 1996, but still working) on prototypes.

V12 Engine:

V12 engine is a twelve-cylinder piston engine in which two rows of six cylinders are arranged in a V shape around a common crankshaft. V12 engines are more common than V10 engines. However, they are not as common as V8 engines. Manufactured the first V12 engine. 1904 Used for rowing. Due to its balanced engine characteristics and smooth power transmission, V12 engines were very popular in early luxury cars, ships, airplanes and tanks. After the V12 aircraft engine was largely replaced by jet engines, it reached its peak in World War II. In Formula One, the V12 engine became popular in the late 1960s and early 1990s.

The most common use of V12 engines in the 21st century has been marine engines, railway locomotives, large stationary engines and European sports/luxury cars.

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1.1.Main components of the engine:

1 Piston:

The piston is one of the main components of the engine and is used to transmit the force of the expanding gas in the cylinder to the crankshaft through the connecting rod. Since the piston is the main piston of the engine, its movement will produce imbalance. Unbalance usually manifests as vibration, which makes the engine significantly rougher. The friction between the cylinder wall and the piston ring will eventually cause wear and shorten the life of the mechanism. Unacceptable, which is why many reciprocating engines rely on heavy noise cancellation devices to reduce noise and volume.

Fig:1.1.Piston

2 Piston Rings:

The annular groove represents a recessed area on the circumference of the piston for fixing the piston ring. The annular surface is two parallel annular groove surfaces as the sealing surface of the piston ring. Expandable split ring for sealing between piston and cylinder wall. Piston rings are usually made of cast iron. Cast iron maintains its original shape under the influence of heat, tension, and other dynamics.

Fig:1.2.Piston Rings

3 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 are casting, forging and powdered metallurgy. The most common connecting rod found in production vehicle engines is a cast rod. This type of rod is created by pouring molten steel into a mold and then machining the finished product. This type of rod is reliable for lower horsepower producing engines and is the least expensive to manufacture.

Fig:1.3.Connecting Rod

4.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. It typically connects to a flywheel, to reduce the pulsation characteristic of the four stroke cycle, and sometimes a torsional or vibrational damper at the opposite end, to reduce the torsion vibrations often caused along the length of the crankshaft by the cylinders farthest from the output end acting on the torsion elasticity of the metal

Fig1.4.Crankshaft

5.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 clean out of exhaust to be obtained. Camshafts do their work through eccentric "lobes" that actuate the components of the valve train. The camshaft itself is forged from one piece of steel, on which the lobes are ground. On single-camshaft engines there are twice as many lobes as there are cylinders, plus a lobe for fuel pump actuation and a drive gear for the distributor. Driving the camshaft is the crankshaft, usually through a set of gears or a chain or belt.

Fig:1.5.Camshaft

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1.2.Objective:

The main objective of the project is how to develop the prototype of V12 engine assembly using CAD tool CIATIA. This Engine assembly consists major components they are Piston, Connecting Rod Assembly, and Crank Shaft, Cylinder head, Cam Shaft, Valves, crank case, oil tank and spark plug with required dimensions. The components which are developed in catia are also analyzed in it using simulation tool. The structural and thermal analysis of piston, crank shaft, cam shaft and valve is performed for 800k thermal loading and the results of temperature distribution of the components are shown. Finally the analysis results of the components are compared and the best suited material is selected

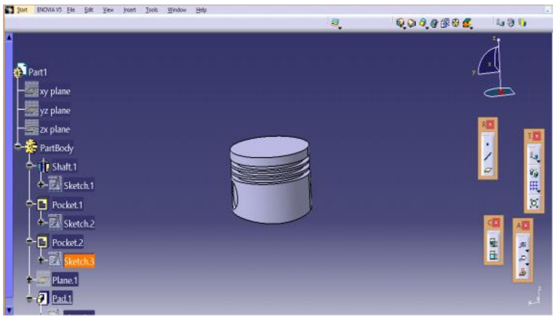
II. LITERATURE REVIEW

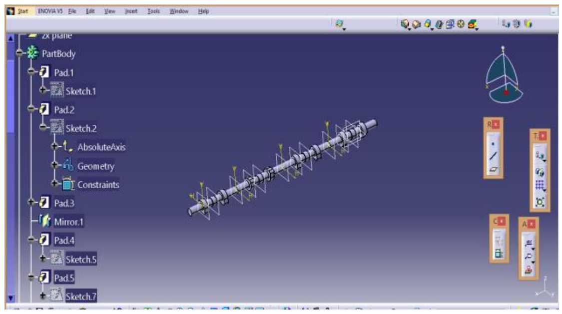
- Design and Structural Analysis of a V12 Engine by using different materials. Method "International Journal of Innovative Research in Science, Engineering and Technology.BodireddyHemasundaram,,D.Suresh,Vol 2,Issue10,November2015.
- Bodireddy Hema sundaram analysed of v12 engine has been done in solid works soft ware. Simulation has carried out on piston, connecting rod and crank shaft with different materials respectively. After studied the result he concluded that alloy steel has better load resistance and low deformation.
- Yildiray Yildizet. al. (1) , have research the control of spark ignition (SI) internal combustion (IC) engine fuel-to-air ratio (FAR) using an adaptive control method of time-delay systems. The objective is to maintain the in- cylinder FAR at a prescribed set point, determined primarily by the state of the three-way catalyst (TWC), so that the pollutants in the exhaust are removed with the highest efficiency. Two controllers, an Adaptive Feed Forward Controller (AFFC) and an Adaptive Posicast Controller (APC), have been developed and implemented in a test vehicle.

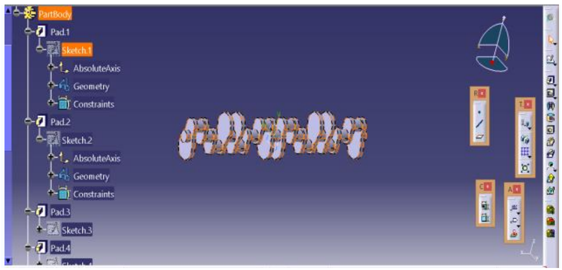
III. MODELLING

Design Procedure of V12 Engine:

CATIA (Computer Aided Three-dimensional Interactive Application) (in English typically articulated) is a multi-stage CAD/CAM/CAE business programming suite created by the French organization Dassault Systems coordinated by Bernard Charles. Written in the C++ programming dialect, CATIA is the foundation of the Dassault Systems programming suite.







IV. FINITE ELEMENT ANALYSIS:

Ansys:

ANSYS is general-purpose finite element analysis software, which enables engineers to perform the following tasks:

- Build computer models/transfer CAD model of structures, products, components /systems.
- Apply operating loads or other design performance conditions.
- Study the physical responses such as stress levels, temperatures distributions/the impact of electromagnetic fields.
- Optimize a design early in the development process to reduce production costs.
-

Meshing:

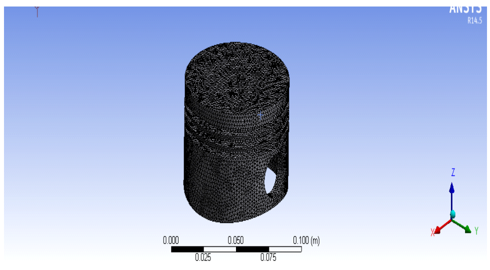


Fig:4.1.Meshing of piston

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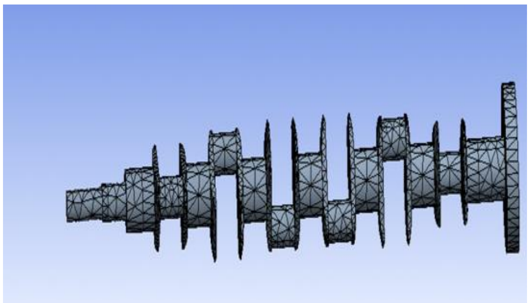


Fig:4.2.Meshing of crankshaft

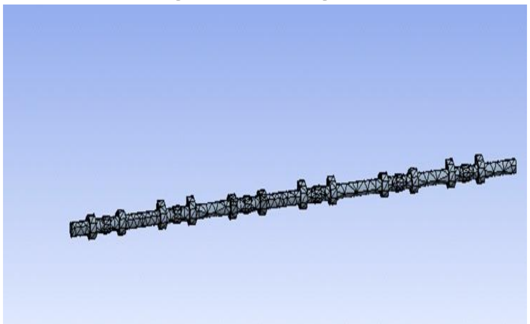


Fig:4.3.Meshing of camshaft

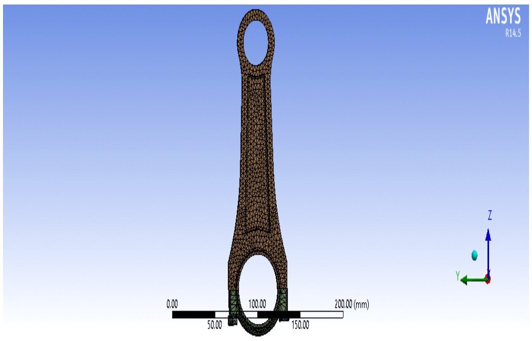


Fig:4.4.Meshing of connecting rod

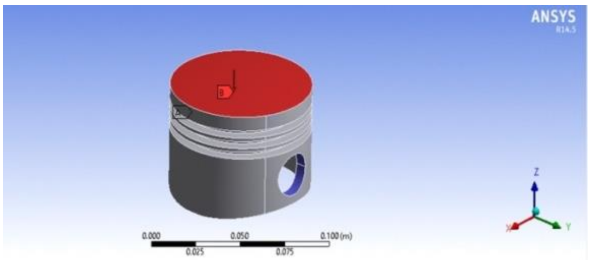
V. RESULTS AND DISCUSSION

In this chapter, the results obtained for the analysis of v8 engine system for the original profile and dynamic structural analysis are discussed. And also explained the graphs plotted by comparing those results.

Material Data for Piston (cast iron):

2 Model (A4):

Static Structural:

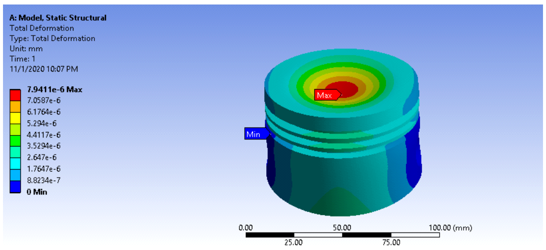


Results 5.1. (Cast Iron):

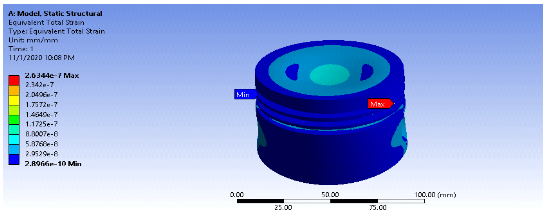
Object Name	Total Deformation	Equivalent Elastic Strain	Equivalent Stress	Strain Energy	Maximum Shear Elastic Strain	Structural Error	Maximum Shear Stress
Minimum	0. mm	2.8966e-010 mm/mm		1.9646e-005 MPa	1.4423e-010 mm/mm	2.2517e-018 mJ	1.1094e-005 MPa
Maximum	7.9411e-006 mm	2.6344e-007 mm/mm		4.9229e-002 MPa	3.4417e-007 mm/mm	1.404e-009 mJ	2.6475e-002 MPa

Figure 5.1.

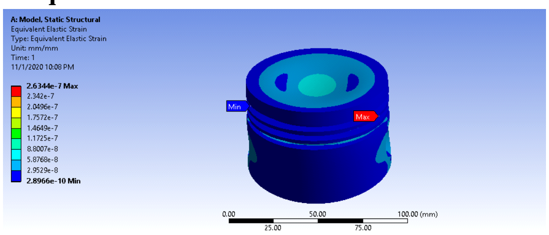
1.Total Deformation



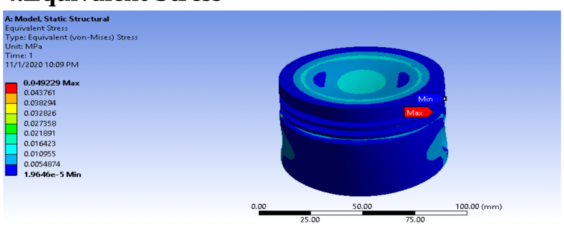
2.Equivalent Total Strain



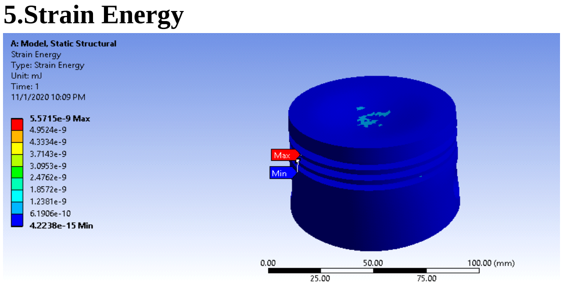
3.Equivalent Elastic Strain



4.Equivalent Stress



5.Strain Energy



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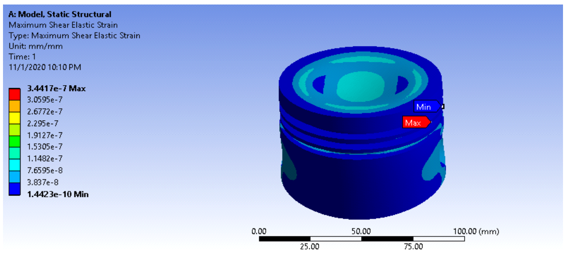
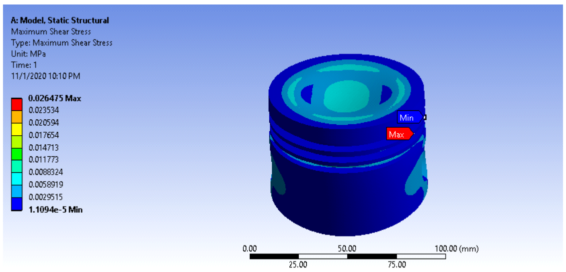
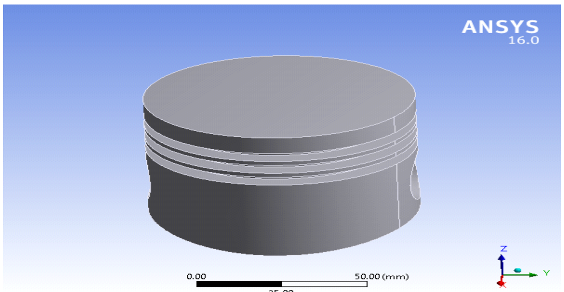
6.Maximum Shear Elastic Strain



7.Maximum Shear Stress



8.Material Data - Aluminum silicon carbide:

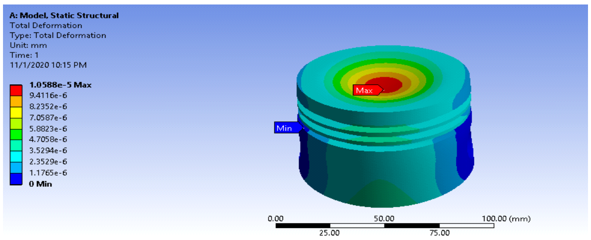


Results 5.2. (Aluminum silicon carbide)

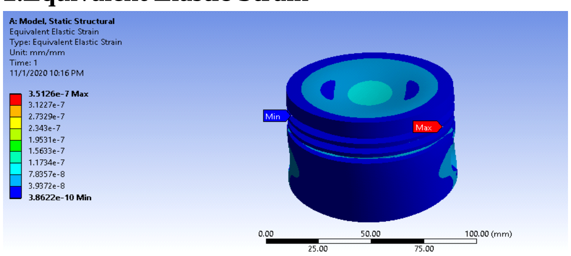
Object Name	*Total Deformation*	*Equivalent Elastic Strain*	*Equivalent Total Strain*	*Equivalent Stress*	*Strain Energy*	*Structural Error*
Minimum	0. mm	3.8622e-010 mm/mm		1.9646e-005 MPa	5.6318 e-015 mJ	3.0024e -018 mJ
Maximum	1.0588e-005 mm	3.5126e-007 mm/mm		4.9229e-002 MPa	7.4287 e-009 mJ	1.872e-009 mJ

Figure:5.2.

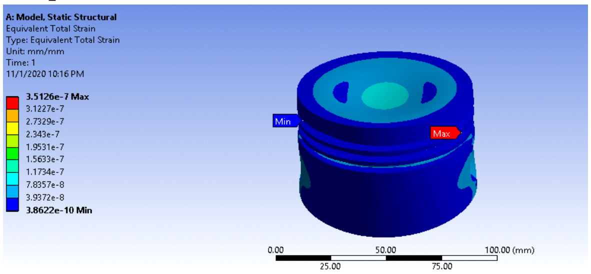
1.Total Deformation



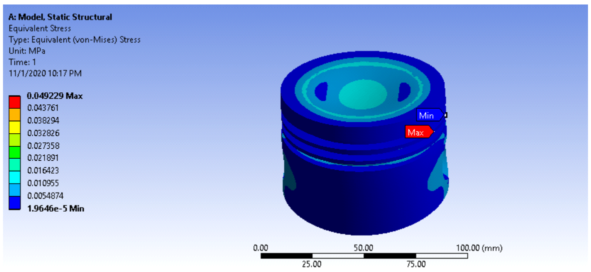
2.Equivalent Elastic Strain



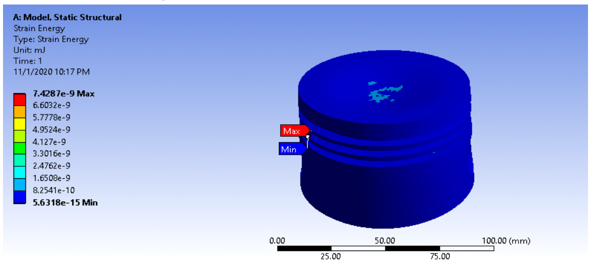
3.Equivalent Total Strain



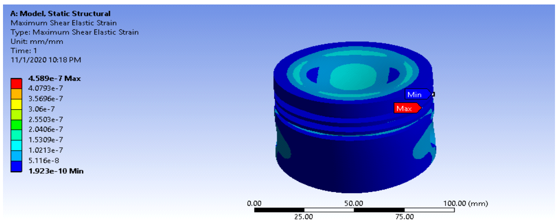
4.Equivalent Stress



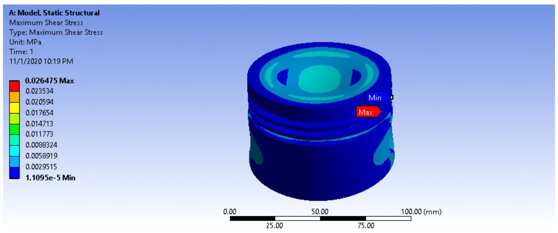
5.Strain Energy



6.Maximum Shear Elastic Strain

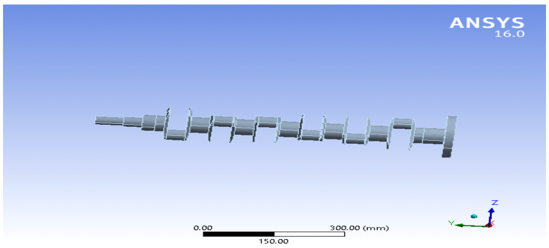


7.Maximum Shear Stress



2 Material Data for Crankshaft:

<u>8.Carbon steel:</u>



Crankshaft by using Carbon steel

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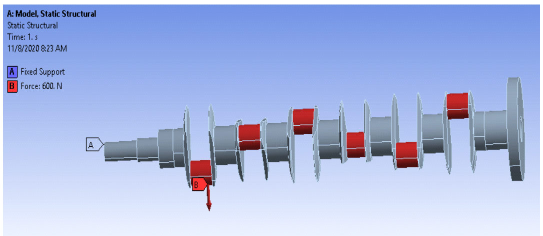
9.Static structural

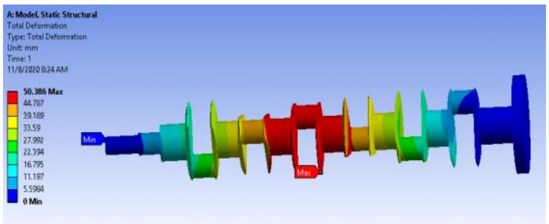


Results 5.3. (*Carbon steel*)

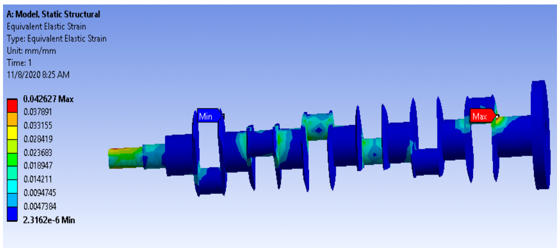
Object Name	*Total Deformation*	*Equivalent Elastic Strain*	*Equivalent Total Strain*	*Equivalent Stress*	*Structural Error*	*Strain Energy*
Minimum	0. mm	2.3162e-006 mm/mm	2.3162e-006 mm/mm	5.1056e-004 MPa	5.6825e-009 mJ	1.1964 e-007 Mj
Maximum	50.386 mm	4.2627e-002 mm/mm	4.2627e-002 mm/mm	16.956 Mpa	103.49 mJ	118.93 mJ

Figure.5.3.

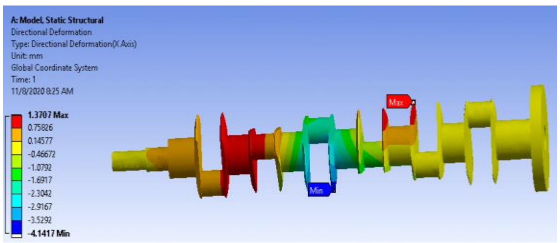
Total Deformation



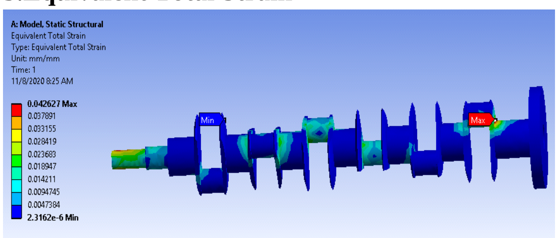
1.Equivalent Elastic Strain



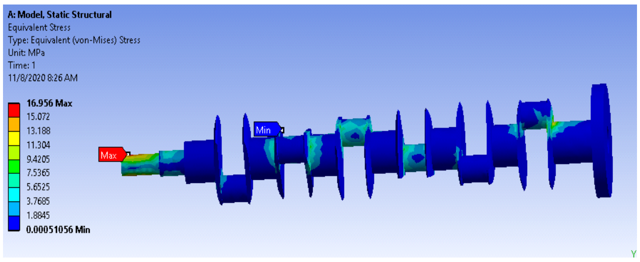
2.Directional Deformation



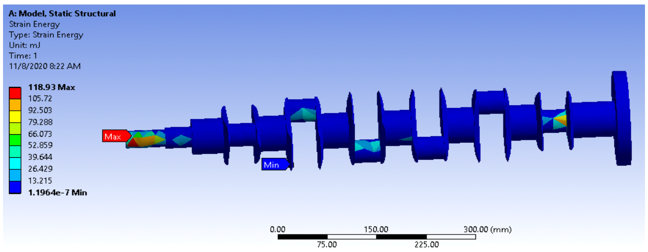
3.Equivalent Total Strain



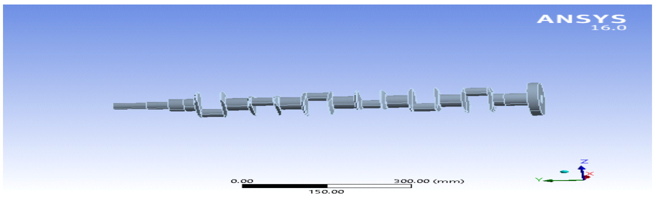
4.Equivalent Stress



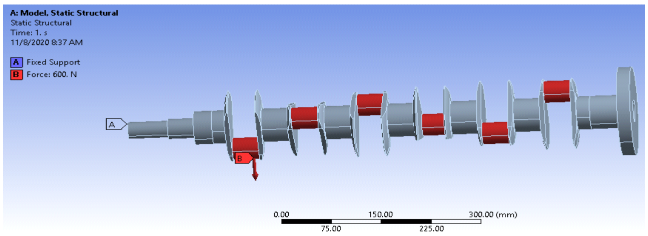
5.Strain Energy



B. Material Data- 6.Aluminum Alloy:



7.Static Structural:

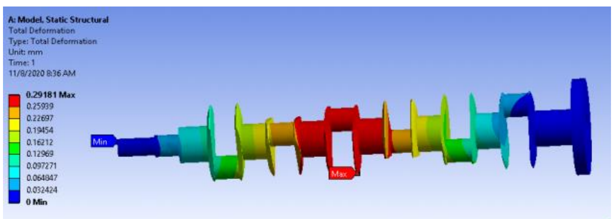


Results 5.4. (*Aluminum Alloy*):

Object Name	*Total Deformation*	*Equivalent Elastic Strain*	*Directional Deformation*	*Equivalent Total Strain*	*Equivalent Stress*	*Structural Error*	*Strain Energy*
Minimum	0. mm	1.3991 e-008 mm/mm	-2.4022e-002 mm	1.3991 e-008 mm/mm	3.4941 e-004 MPa	3.469e -011 mJ	6.4902e-010 mJ
Maximum	0.29181 mm	2.4297 e-004 mm/mm	8.2546e-003 mm	2.4297 e-004 mm/mm	17.036 Mpa	0.60074 mJ	0.68867 mJ

Figure:5.4.

1.Total Deformation



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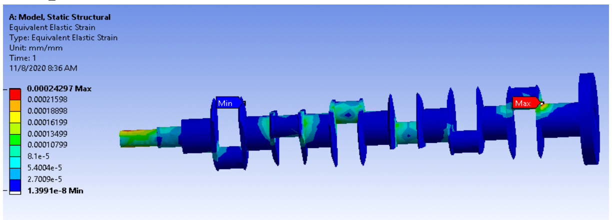
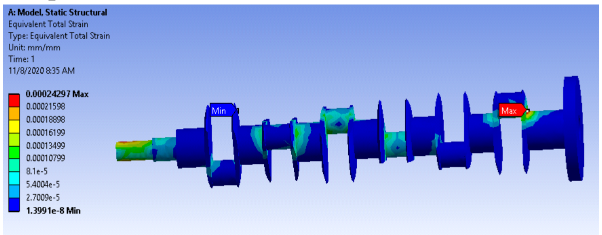
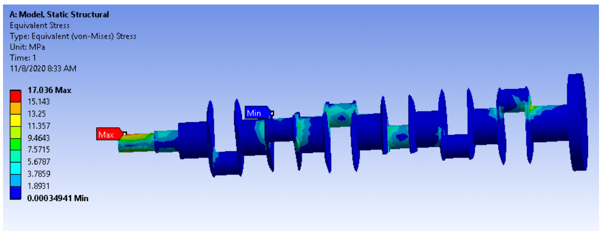
2.Equivalent Elastic Strain



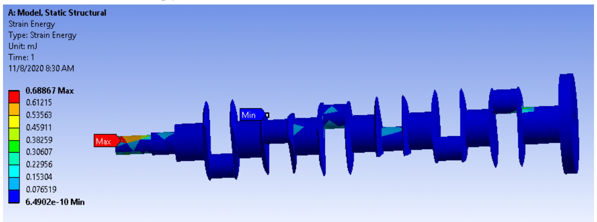
3.Equivalent Total Strain



4.Equivalent Stress

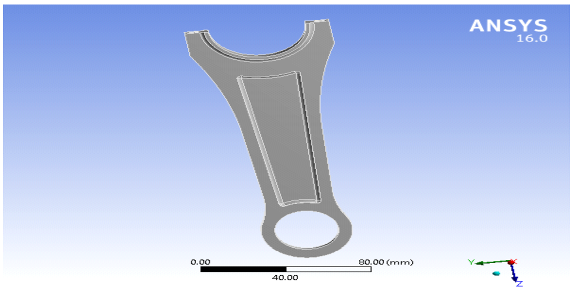


5.Strain Energy



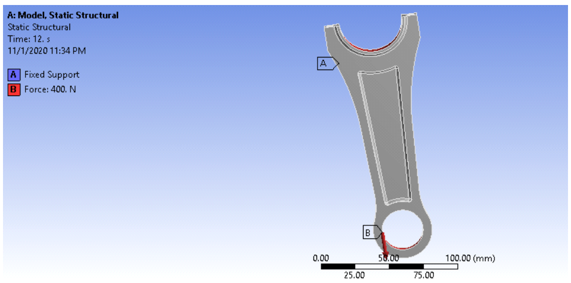
<u>Material data of connecting rod:</u>

<u>6.Material Data-Titanium Alloy</u>



Connecting rod by using Titanium alloy

7.Static Structural:

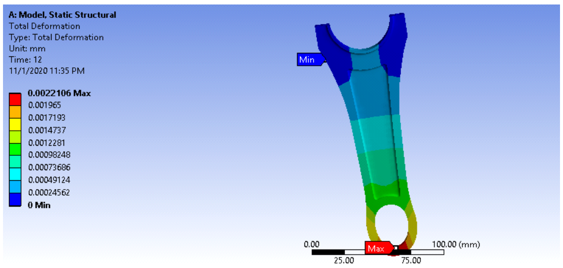


Results 5.5. (Titanium Alloy)

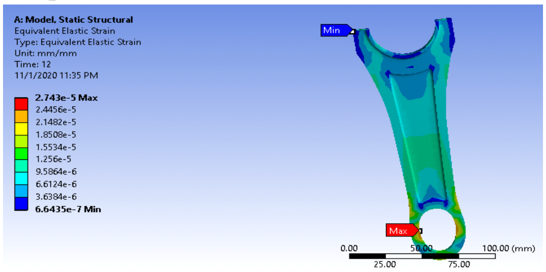
Object Name	*Total Deformation*	*Equivalent Elastic Strain*	*Equivalent Stress*	*Directional Deformation*	*Strain Energy*
Minimum	0. mm	6.6435e-007 mm/mm	3.0954e-002 MPa	-4.9034e-005 mm	1.6331e -008 mJ
Maximum	2.2106e-003 mm	2.743e-005 mm/mm	2.6201 Mpa	5.1671e-005 mm	7.0486e -004 mJ

Figure:5.5.

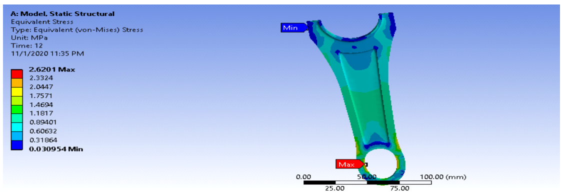
Total Deformation



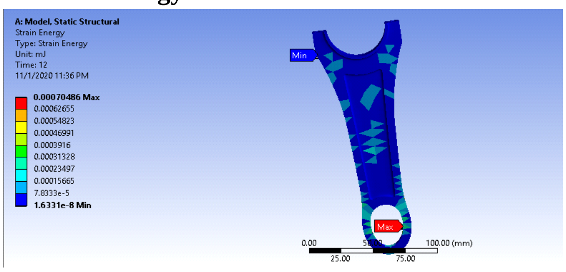
1.Equivalent Elastic Strain



2.Equivalent Stress



3.Strain Energy



<u>B. Material Data -4. Mild steel</u>:

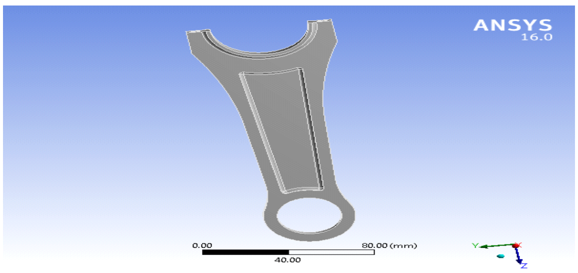


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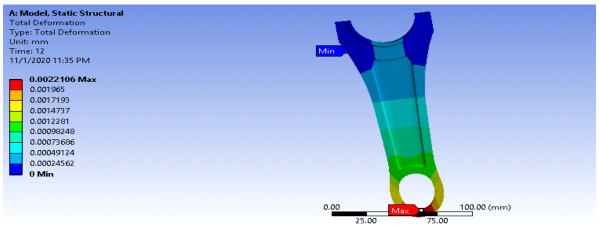
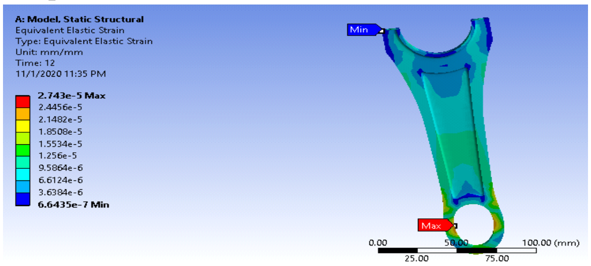
Figure:5.6.

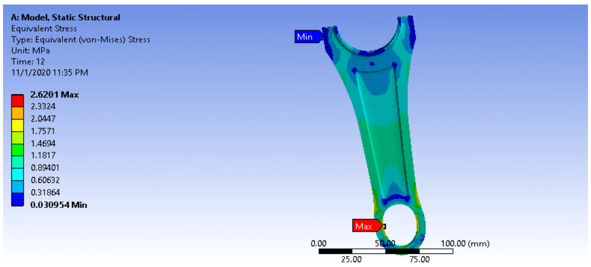
1.Total Deformation



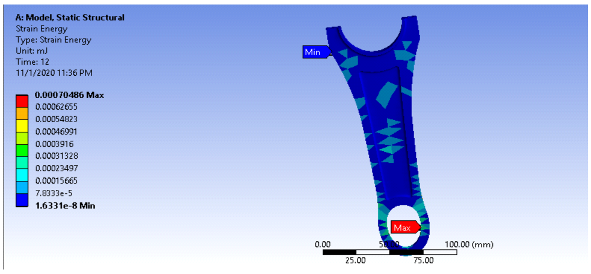
2.Equivalent Elastic Strain



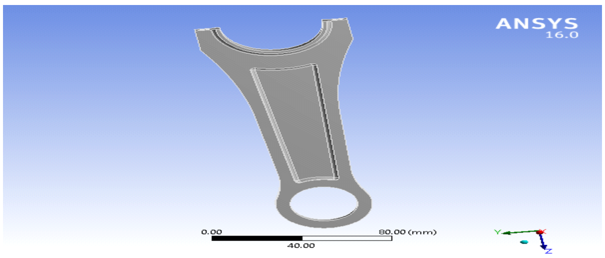
3.Equivalent Stress



4.Strain Energy



B. Material Data - Mild steel:

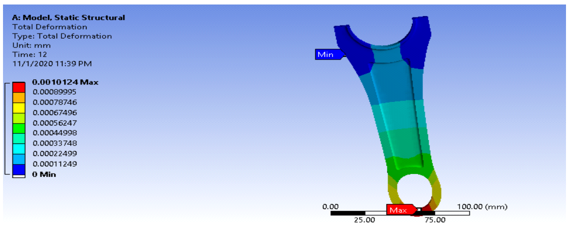


Results 5.6. (Mild Steel)

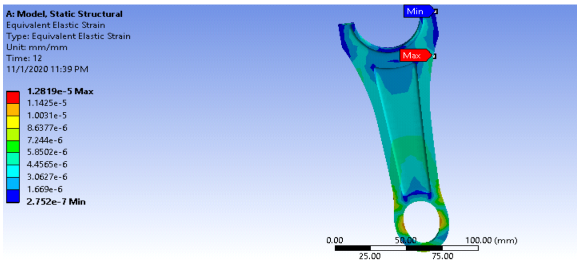
Object Name	*Total Deformation*	*Equivalent Elastic Strain*	*Equivalent Stress*	*Directional Deformation*	*Strain Energy*
State	Solved				
Minimum	0. mm	2.752e-007 mm/mm	2.8563e-002 MPa	-1.799e-005 mm	6.6077e-009 mJ
Maximum	1.0124e-003 mm	1.2819e-005 mm/mm	2.6276 MPa	1.8859e-005 mm	3.2366e-004 mJ

Figure:5.6.

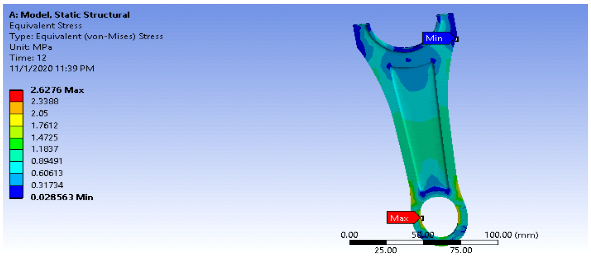
1.Total Deformation



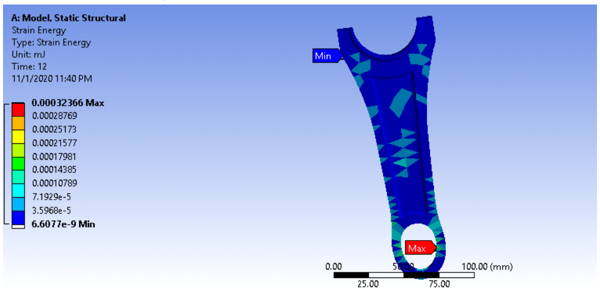
2.Equivalent Elastic Strain



3.Equivalent Stress



4.Strain Energy



VI. CONCLUSION

- Modeling and analysis of v12engine has been done in catia software.
- Simulation has carried out on piston, connecting rod,crank shaft and camshaft. With different materials respectively.
- After studied the piston result we can conclude that aluminum silicon carbide has better load resistance and low deformation.
- For crankshaft result observing carbon steel is better than aluminum alloy due to less deformation and better loads withstand ability value.
- Cam shaft results observing the aluminum alloy is better deformation value and better withstand in von

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misses stress and strain loads comparing the AISI 4140 alloy steel.

- For observing connecting rod results mild steel is better deformation and titanium grade 1 is more von misses stress value.

REFERENCES

[1] Jerald A. Caton (1) developed a thermodynamic cycle simulation for a spark-ignition engine which included the use of multiple zones for the combustion process.

[2] Yusaf et al (2) discussed analytically and has provided data on effect of compression ratio, equivalence ratio and spark timing on a hydrogen fuelled engine as a guideline for the engine design.

[3] Michael T. Nelson and Alvon C. Elrod (3) had developed an isometric representation of portion of an intake camshaft with Variable Valve Timing (VVT)..

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[6] Rumer man, Judy. "U.S. Centennial of Flight Commission - Early Aircraft Engines". (6)Centennialofflight.net. Retrieved 2014-09-04.

[7] Hyun Kyu Suhet. al. (6) , has investigated multiple injection strategies for the improvement of combustion and exhaust emissions characteristics in a low compression ratio (CR) engine.

[8] Park et al.(7) studied the effect of nitriding and fillet rolling on fatigue life of crankshafts made of microalloyed steel and quenched and tempered alloy steel.

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