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MODELING AND ANALYSIS OF CRANK SHAFT

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ABSTRACT:

A crankshaft related to crank is a mechanical part able to perform a conversion between reciprocating motion and rotational motion. In a reciprocating engine, it translates reciprocating motion of the piston into rotational motion; whereas in a reciprocating compressor, it converts the rotational motion into reciprocating motion. In order to do the conversion between two motions, the crankshaft has "crank throws" or "crankpins", additional bearing surfaces whose axis is offset from that of the crank, to which the "big ends" of the connecting rods from each cylinder attach.

Crankshaft is one of the critical components for the effective and precise working of the internal combustion engine. In this paper a static simulation is conducted on a crankshaft from a single cylinder 4-stroke diesel engine.

In this project a three- dimensional model of diesel engine crankshaft is created using solid works 2016 design software. Finite element analysis (FEA) is performed on the crank shaft. The static analysis is done using solid works simulation tool by applying load and various materials on it and structural deformations are which are generated such as stress, deformation and strain are noted.

INTRODUCTION

Crank shaft is a large component with a complex geometry in the I.C engine, which converts the reciprocating displacement of the piston to a rotary motion with a four bar link mechanism. Crankshaft consists of shaft parts, two journal bearings and one crankpin bearing. The Shaft parts which revolve in the main bearings, the crank pins to which the big end of the connecting rod are connected, the crank arms or webs which connect the crank pins and shaft parts. In addition, the linear displacement of an engine is not smooth; as the displacement is caused by the combustion chamber therefore the displacement has sudden shocks. The concept of using crankshaft is to change these sudden displacements to as smooth rotary output, which is the input to many devices such as generators, pumps and compressors. It should also be stated that the use of a flywheel helps in smoothing the shocks.

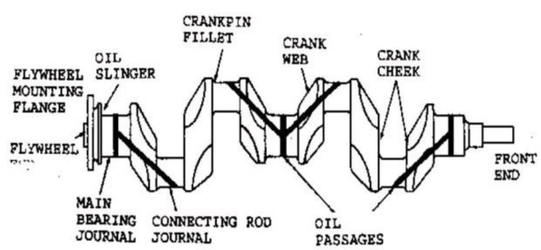


Fig1: Parts Attached To Crank Shaft

Major forces applied on Crank shaft

Crankshaft experiences large forces from gas combustion. This force is applied to the top of the piston and since the connecting rod connects the piston to the crank shaft, the force will be transmitted to the crankshaft. The magnitude of the forces depends on many factors which consist of crank radius, connecting rod dimensions, weight of the connecting rod, piston, piston rings, and pin.

Principle of Crankshaft

A crankshaft is a fundamental feature in a vehicle's engine. It is the system that converts linear energy into rotational energy. This enables the wheels to drive the car forward. All the pistons in the engine are attached to the crank which is also connected to the flywheel. The crank works in association with other engine components to achieve a synchronized motion.

FOUR-STROKE CYCLE

The four strokes refer to intake, compression, power and exhaust. On the intake stroke, the piston starts down as the intake valve opens to allow air and fuel into the cylinder. As soon as the piston arrives at the base of the intake stroke, it triggers closure of the intake valve. The air-fuel mixture is retained in the cylinder. This mixture is compressed severely by the piston as it moves up. The cylinder contents are ignited by the spark plug during which process expansion occurs. The combustion process lowers the piston which turns the crank to yield power to drive the vehicle. The exhaust valve then opens to release the exhaust once the piston gets to the bottom of the cylinder.

CRANKSHAFT-CAMSHAFT OPERATIONS

The crank moves the pistons up and down inside the cylinders. The movement of the pistons is regulated by the crank. A component known as the camshaft also ensures that the pistons work properly. Whenever the crank rotates, the camshaft must also rotate along with it. This is because the two components are linked together. The two engine parts have a synchronized movement. When the camshaft rotates it causes the intake and outtake valves to open. This allows a flow of air which is important to cause explosions in the cylinder. Explosions are created inside the cylinders in the engine. The explosions exert pressure on the pistons so that they maintain their movement. These explosions result in movement of the wheels. The moving pistons give rise to jerky movements. The flywheel which is found at the end of the shaft helps to ease the erratic movement. When the shaft moves, it causes the flywheel to adopt a circular motion. Notches in the flywheel help it to achieve a more regular motion. This motion eventually causes the vehicle's wheels to turn since the flywheel is connected to other engine parts.

WORKING OF CRANK SHAFT

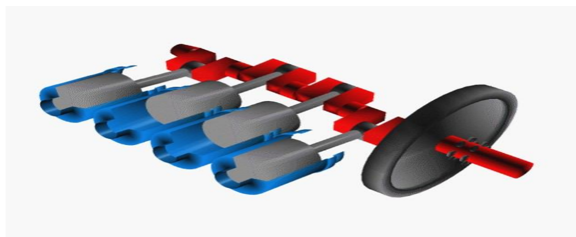


Fig.2: Inline cylinder piston arrangement to crank shaft

Power from the burnt gases in the combustion chamber is delivered to the crankshaft through the piston, piston pin and connecting rod. The crankshaft changes reciprocating motion of the piston in cylinder to the rotary motion of the flywheel. Conversion of motion is executed by use of the offset in the crankshaft. Each offset part of the crankshaft has a bearing surface known as a crank pin to which the connecting rod is attached. Crank-through is the offset from the crankshaft centre line. The stroke of the piston is controlled by the throw of the crankshaft. The combustion force is transferred to the crank-throw after the crankshaft has moved past top dead centre to produce turning effort or torque, which rotates the crankshaft. Thus all the engine power is delivered through the crankshaft.

CRANK SHAFT MECHANISM

A crank is an arm attached at right angles to a rotating shaft by which reciprocating motion is imparted to or received from the shaft. It is used to convert circular motion into reciprocating motion, or vice versa. The arm may be a bent portion of the shaft, or a separate arm or disk attached to it. Attached to the end of the crank by a pivot is a rod, usually called a connecting rod. The end of the rod attached to the crank moves in a circular motion, while the other end is usually constrained to move in a linear sliding motion.

The term often refers to a human-powered crank which is used to manually turn an axle, as in a bicycle crankset or a brace and bit drill. In this case a person's arm or leg serves as the connecting rod, applying reciprocating force to the crank. There is usually a bar perpendicular to the other end of the arm, often with a freely rotatable handle or pedal attached.

Crankshaft Materials

The steel alloys typically used in high strength crankshafts have been selected for what each designer perceives as the most desirable combination of properties.

Medium-carbon steel alloys are composed of predominantly the element iron, and contain a small percentage of carbon (0.25% to 0.45%, described as "25 to 45 points" of carbon), along with combinations of several alloying elements, the mix of which has been carefully designed in order to produce specific qualities in the target alloy, including hardenability, nitridability, surface and core hardness, ultimate tensile strength, yield strength, endurance limit (fatigue strength), ductility, impact resistance, corrosion resistance, and temper-embrittlement resistance.

The alloying elements typically used in these carbon steels are manganese, chromium, molybdenum, nickel, silicon, cobalt, vanadium, and sometimes aluminium and titanium. Each of those elements adds specific properties in a given material.

CRANKSHAFT MANUFACTURING PROCESSES

Many high performance crankshafts are formed by the forging process, in which a billet of suitable size is heated to the appropriate forging temperature, typically in the range of 1950 - 2250°F, and then successively pounded or pressed into the desired shape by squeezing the billet between pairs of dies under very high pressure. These die sets have the concave negative form of the desired external shape. Complex shapes and / or extreme deformations often require more than one set of dies to accomplish the shaping.

Fig.3: Crank shaft

CRANK SHAFT DESIGN SPECIFICATION

(For single cylinder)

Design of crankshaft when the crank is at an angle of maximum twisting Moment

Force on the Piston F_p = Area of the bore x Max. Combustion pressure = $\frac{\pi}{4}$ x D^2 x P_{max} = 14.52 KN

In order to find the thrust in the connecting rod (F_Q), we should first find out the angle of inclination of the connecting rod with the line of stroke (i.e. angle Ø).

We know that

$$\text{Sin } Ø = \frac{\text{Sin } \theta}{(L/R)} = \sin 35^0/4$$

Which implies Ø = 8.24°

We know that thrust in the connecting rod

$$F_Q = \frac{FP}{\cos Ø}$$

From this we have,

Thrust on the connecting rod F_Q KN

Thrust on the crank shaft can be split into Tangential component and the radial component.

1) Tangential force on the crank shaft, FT = F_Q sin (θ+ Ø) KN

2) Radial force on the crank shaft, $F_R = F_Q \cos(\theta + Ø)$ KN

Reactions at bearings (1 & 2) due to tangential force is given by

$H_{T1=}H_{T2}$= (FT*b_1)/b KN (Since b1=b2=b/2)

Similarly, Reactions at bearings (1 & 2) due to radial force is given by,

$H_{R1=}H_{R2}$= (FR*b_1)/b KN (Since b1=b2=b/2)

Design of crankpin

Let dc = Diameter of crankpin in mm. We know that the bending moment at the centre of the crank pin

Mc = HR1 x b2 KN-mm

From this we have the equivalent twisting moment

$Te = \sqrt{(Mc^2 + Tc^2)}$

We know that equivalent twisting moment (Te)

Te = $(\pi/16)*(d_c)$ 3 * τ

SOLIDWORKS

Solid Works is mechanical design automation software that takes advantage of the familiar Microsoft Windows graphical user interface.

It is an easy-to-learn tool which makes it possible for mechanical designers to quickly sketch ideas, experiment with features and dimensions, and produce models and detailed drawings.

A Solid Works model consists of parts, assemblies, and drawings.

- Typically, we start with a sketch, make a base element, and after that add more highlights to the model. (One can likewise start with a insert surface or strong geometry).
- We are allowed to refine our plan by including, changing, or reordering highlights.
- Associativity between parts, assemblies, and drawings that progressions made to one view are consequently made to every other view.
- We can create illustrations or congregations whenever in the design procedure.

Solid works mechanical design robotization programming is a component based, parametric strong demonstrating configuration instrument which preferred standpoint of the simple to learn windows TM graphical user interface. We can make completely relate 3-D strong models with or without while using programmed or client characterized relations to catch plan purpose.

Outline aim is the means by which the maker of the part needs it to react to changes and updates. For instance, you would need the gap at the highest point of a drink can to remain at the best surface, paying little respect to the stature or size of the can. Strong Works enables you to determine that the opening is an element on the best surface, and will then respect your plan aim regardless of what the stature you later provided for the can. Several factors add to how we catch outline purpose are Automatic relations, Equations, added relations and dimensioning.

Several ways a part can be builded like

Layer-cake approach: The layer-cake approach constructs the section one piece at a time, including each layer, or feature, onto the past one.

Potter's wheel approach:

The potter's wheel approach manufactures the part as a solitary rotated feature. As a solitary draw speaking to the cross area incorporates all the data and measurements important to influence the part as one to include.

Manufacturing approach:

In an assembly, the simple to draw relations is mates. Similarly as outline relations characterize conditions, for example, tangency, parallelism, and concentricity as for portray geometry, get together mates characterize identical relations as for the individual parts or segments, permitting the simple development of assemblies. Solid Works likewise incorporates extra propelled mating highlights, for example, designed gear and cam supporter mates, which permit displayed, adapt congregations to precisely recreate the rotational development of a real apparatus prepare.

At long last, sketches can be made either from parts or congregations. Perspectives are naturally produced from the strong model, and notes, measurements and resistances would then be able to be effortlessly added to the illustration as required. The illustration module incorporates most paper sizes and norms.

A Solid Works display comprises of parts, assemblies, and drawings.

(1) Part: Individual segments are attracted the type of part illustrations.

(2) Assembly: The individual parts are collected in this district.

(3) Drawings: This contains definite data of the get together.

MODELLING OF CAM SHAFT

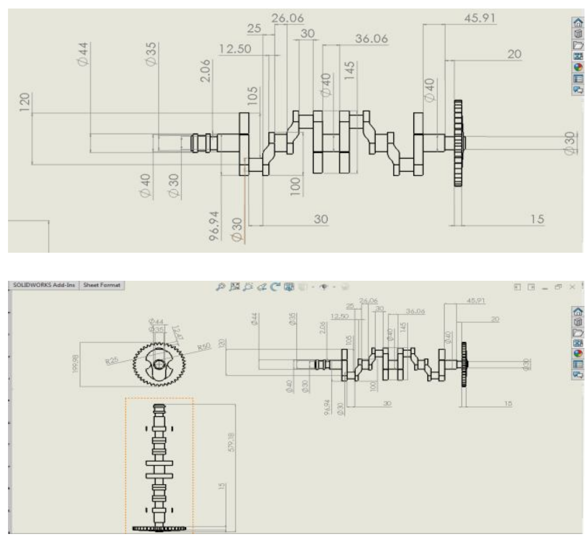


Fig.4: Dimensions of crank shaft

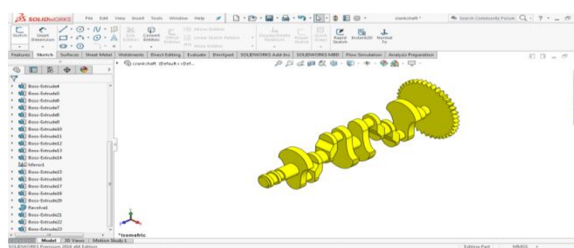


Fig.5: Cam shaft

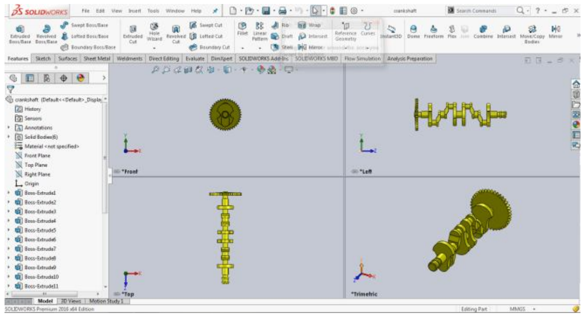


Fig.6: Four views of cam shaft

INTRODUCTION TO SIMULATION

Solid Works Simulation is a plan investigation framework completely coordinated with Solid Works. Strong Works Simulation gives recreation answers for straight and nonlinear static, recurrence, clasping, warm, weariness, weight vessel, drop test, direct and nonlinear dynamic and streamlining examinations.

Powered by quick and exact solvers, Solid Works Simulation empowers you to tackle huge issues instinctively while you plan. Solid Works Simulation comes in two packs: Solid Works Simulation Professional and Solid Works Simulation Premium to fulfill your investigation needs. Solid Works Simulation abbreviates time to showcase by sparing time and exertion in hunting down the ideal plan.

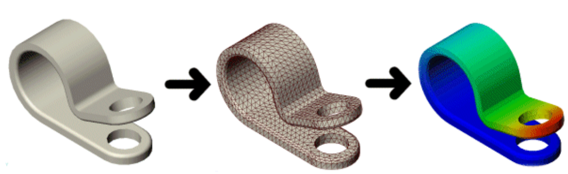


Fig.7: Simulation example

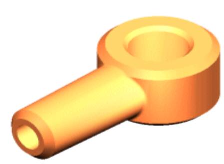
Benefits of Simulation:

Subsequent to building your model, you have to ensure that it performs effectively in the field. Without investigation devices, this assignment must be replied by performing costly and tedious item advancement cycles. An item advancement cycle regularly incorporates the accompanying advances:

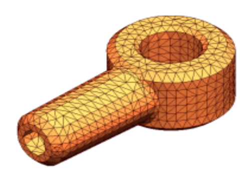
1. Building your model.
2. Building a model of the outline.
3. Testing the model in the field.
4. Evaluating the consequences of the field tests.
5. Modifying the outline in light of the field test comes about.

Basic Concepts of Analysis:

The product utilizes the Finite Element Method (FEM). FEM is a numerical system for examining building outlines. FEM is acknowledged as the standard investigation technique because of its all inclusive statement and reasonableness for PC execution. FEM partitions the model into numerous little bits of straightforward shapes called elements adequately supplanting a mind boggling issue by numerous basic issues that should be unraveled all the while.



CAD model of a part

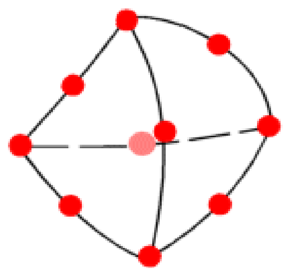


Model subdivided into small pieces (elements)

Elements share regular focuses called nodes. The way toward isolating the model into little pieces is called meshing.

The conduct of every component is notable under all conceivable help and load situations. The limited component technique utilizes elements with various shapes.

The reaction anytime in an element is interjected from the reaction at the element nodes. Every node is completely depicted by various parameters relying upon the investigation compose and the element utilized. For instance, the temperature of a node completely depicts its reaction in warm examination. For auxiliary examinations, the reaction of a node is depicted, when all is said in done, by three interpretations and three pivots. These are called degrees of flexibility (DOFs). Examination utilizing FEM is called Finite Element Analysis (FEA).



A tetrahedral element. Red dots represent nodes. Edges of an element can be curved or straight.

The software details the conditions administering the conduct of every element contemplating its availability to different elements. These conditions relate the reaction to known material properties, restraints, and loads.

Analysis Steps:

You complete a study by performing the following steps:

- Create an investigation characterizing its examination write and options.
- If required, characterize parameters of your investigation. A parameter can be a model measurement, material property, force value, or any other input.
- Define material properties.
- Specify restrictions and burdens.
- The program naturally makes a mixed work when diverse geometries (solid, shell, auxiliary individuals and so on.) exist in the model.
- Define part contact and contact sets.
- Mesh the model to separate the model into numerous little pieces called elements. Fatigue and optimization thinks about utilize the lattices in referenced examinations.
- Run the examination.
- View comes about.

Specific capabilities of Solid works Simulation:

1. **Static Analysis:**

At the point when loads are connected to a body, the body twists and the impact of burdens is transmitted all through the body. The outside loads incite inward loads and responses to render the body into a condition of balance. Linear Static examination displacements, strains, stresses, and response forces under the impact of connected loads.

2. **Thermal Stress Analysis:**

Changes in temperature can actuate considerable misshapenness, strains, and stresses. Thermal stress examination alludes to static analysis that incorporates the impact of temperature.

Perform thermal stress examination utilizing one of the accompanying choices:

- Using a uniform ascent or drop in temperature for the entire model.
- Using a temperature profile coming about because of a consistent state or thermal analysis.
- Using a temperature profile from Flow Simulation.

3. **Frequency analysis :**

On the off chance that the plan is subjected to dynamic situations, static examinations can't be utilized to assess the reaction. Recurrence studies can enable you to stay away from reverberation and plan vibration confinement frameworks. They additionally frame the reason for assessing the reaction of straight powerful frameworks where the reaction of a framework to a dynamic domain is thought to be equivalent to the summation of the commitments of the modes considered in the investigation.

4. Dynamic analysis :

Dynamic analysis includes:

- Design auxiliary and mechanical frameworks to perform without disappointment dynamic environment.
- Modify framework's qualities (i.e., geometry, damping systems, material properties, and so forth.) to lessen vibration impacts.

5. Buckling analysis :

Used to calculate the clasping loads and decide the clasping mode shape. Both linear (Eigen esteem) and nonlinear buckling investigations are conceivable.

6. Non-linear static analysis :

Every single genuine structure carryon non linearly somehow at some level of stacking. At times, straight investigation might be sufficient. In numerous different cases, the straight arrangement can deliver incorrect outcomes in light of the fact that the presumptions whereupon it is based are abused. Non linearity can be caused by the material conduct, extensive removals, and contact conditions. We can utilize a nonlinear report to take care of a direct issue. The outcomes can be marginally extraordinary because of various procedures. In the nonlinear static investigation, dynamic impacts like inertial and damping powers are not considered.

7. Drop test studies :

Drop test examines assess the impact of the effect of a section or assembly with an inflexible or adaptable planar surface. Dropping a protest on the floor is a commonplace application and henceforth the name. The program figures effect and gravity stacks naturally. No different load or limitations are permitted.

8. Fatigue Analysis :

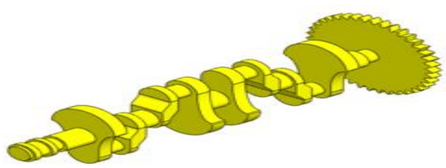
Weakness is the prime reason for the disappointment of numerous items, particularly those made of metals. Cases of disappointment because of weariness incorporate, pivoting hardware, jolts, plane wings, customer items, seaward stages, ships, vehicle axles, bridges, and bones.

9. Pressure vessel Design study :

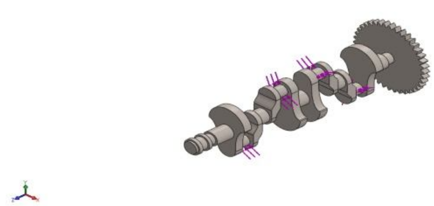
In a Pressure Vessel Design study, you combine the results of static studies with the desired factors. Each static study has a different set of loads that produce corresponding results. These loads can be dead loads, live loads (approximated by static loads), thermal loads, seismic loads, and so on. The Pressure Vessel Design study combines the results of the static studies algebraically using a linear combination or the square root of the sum of the squares (SRSS).

STATIC ANALYSIS OF CAM SHAFT

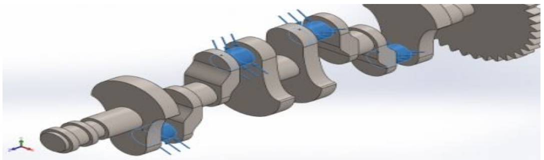
Model:



Fixed:



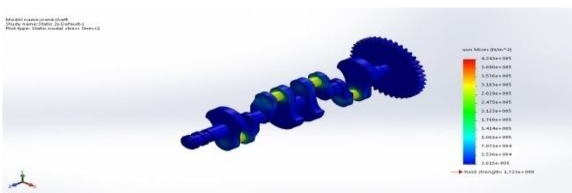
Load: 1000N



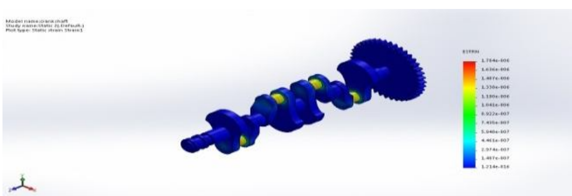
Mesh:

MATERIAL: Stainless steel

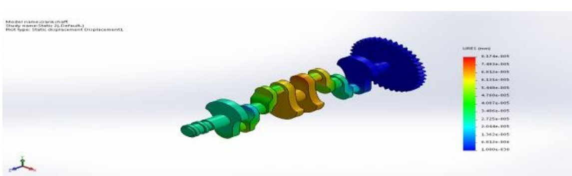
Stress:



Strain:

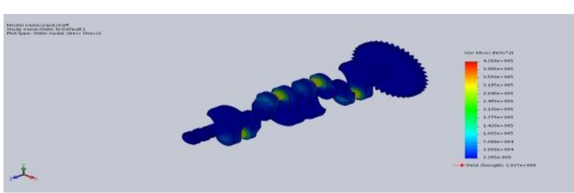


Deformation:

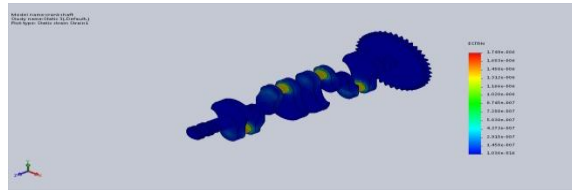


MATERIAL: 1023 Carbon steel

Stress:



Strain:



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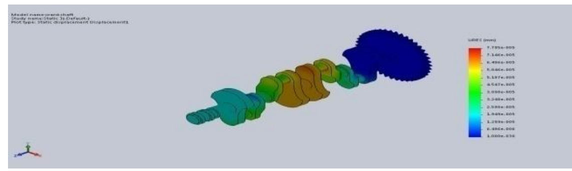
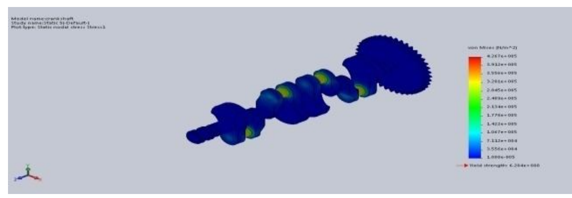
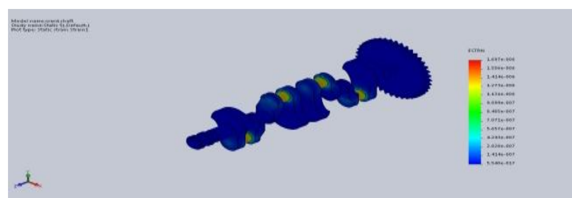


MATERIAL: Alloy steel

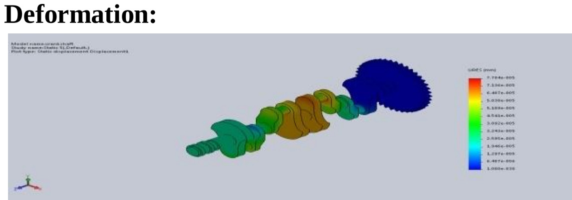
Stress:



Strain:

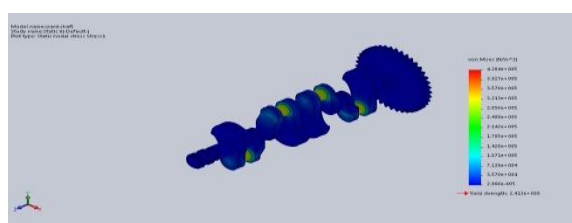


Deformation:

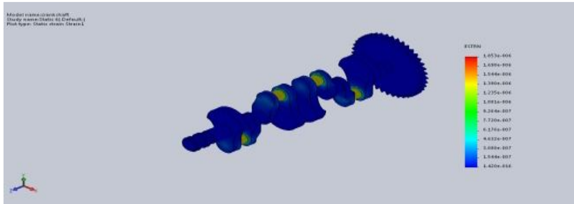


MATERIAL: Cast alloy steel

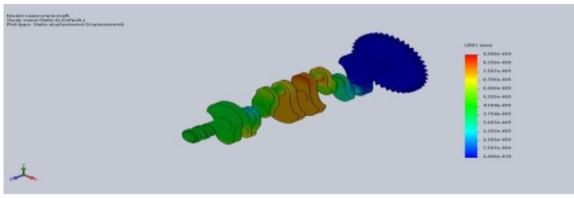
Stress:



Strain:



Deformation:



RESULTS:

STATIC STRUCTURAL RESULTS:

Material	Max Stress	Total Deformation	Max Strain
Stainless Steel	424345	8.17424e-005	1.78437e-006
1023 Carbon Steel	425949	7.79513e-005	1.74903e-006
Alloy Steel	426742	7.78422e-005	1.69702e-006
Cast Alloy Steel	428366	9.00856e-005	1.85274e-006

CONCLUSION:

- Modeling and analysis on crank shaft is done
- Modeling of crank shaft is done using solid works 2016 design software
- Static analysis on crank shaft is carried out in solid works simulation tool.
- One end is fixed and force acted on crank shaft is 1000N
- Static analysis is carried out on crank shaft at this load by applying various materials such as stainless steel, carbon steel, alloy steel and cast alloy steel
- Thus in this project we did modeling of crank shaft using solid works design software and at 1000N of load by applying various materials as discussed above the structural deformations developed in the crank shaft are noted and tabulated.
- From the results we can conclude that structural deformations such as stress, deformation and strain obtained for each individual material at applied load are tabulated, the material which has obtained low stress value is considered as the preferable material.
- From the results obtained alloy steel got less stress, deformation and strain values compared to other materials.

REFERENCES

1) Rincle Garg, Sunil Baghla, "Finite element analysis and optimization of crankshaft", International Journal of Engineering and Management Reaserch, vol-2,Issue-6,ISSN: 2250-0758, Pages:26-31, December 2012.
2) C.M Balamurugan, R. Krishnaraj, Dr.M.sakhivel, K.kanthavel, Deepan Marudachalam M.G, R.Palani, "Computer Aided modelling and optimization of Crankshaft", International Journal of scientific and Engineering Reaserach, Vol-2, issue-8, ISSN:2229-5518, August-2011.
3) Gu Yingkui, Zhou Zhibo, "Strength Analysis of Diesel Engine Crankshaft Based on PRO/E and ANSYS", Third International Conference on Measuring Technology and Mechatronics Automation, 2011.
4) Abhishek choubey, Jamin Brahmbhatt, "Design and Analysis of Crankshaft for single cylinder 4-stroke engine", International Journal of Advanced Engineering Reaserch and studies, vol-1, issue-4, ISSN:2249-8974, pages: 88-90, July-sept 2012.
5) R.J Deshbhratar, Y.R Suple, " Analysis and optimization of Crankshaft using FEM",

International Journal of Modern Engineering Reasearch, vol-2, issue-5, ISSN:2249-6645, pages:3086-3088, Sept-Oct 2012.

6) Farzin H. Montazersadgh and Ali Fatemi " Stress Analysis and Optimization of Crankshafts Subjected to Dynamic Loading", AISI, August 2007.
7) Xiaorong Zhou., Ganwei Cai., Zhuan Zhang. Zhongqing Cheng., 2009, "Analysis on Dynamic Characteristics of Internal Combustion Engine Crankshaft System," International Conference on Measuring Technology and Mechatronics Automation.
8) Farzin H. Montazersadgh and Ali Fatemi., 2007,"Dynamic Load and Stress Analysis of a Crankshaft," SAE Technical Paper No. 010258, Society of Automotive Engineers
9) Jonathan Williams, Farzin Montazersadgh, and Alifatemi.,2007, "FatiguePerformance Comparison And Life Prediction Of Forged Steel And Ductile Cast Iron Crankshafts," Published in Proceeding of the 27th Forging Industry Technical Conference in Ft.Worth,Texas
10) Shenoy, P. S. and Fatemi, A., 2006, "Dynamic analysis of loads and stresses in connecting rods", IMechE, Journal of Mechanical Engineering Science, Vol. 220, No. 5, pp. 615- 624