Sudan University of Science & Technology

College of Engineering

School of Mechanical Engineering

Power Department

A project Submitted in Partial Fulfillment of the Requirement for the Degree of
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TIGER GENERATOR CRANKSHAFT DESIGN

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الآية

قال تعالي:

(لَقَدْ أَرْسَلْنَا رُسُلَنَا بِالْبَيِّنَاتِ وَأَنْزَلْنَا مَعَهُمُ الْكِتَابَ وَالْمِيزَانَ لِيَقُومَ النَّاسُ بِالْقِسْطِ وَأَنْزَلْنَا الْحَدِيدَ فِيهِ بَأْسٌ شَدِيدٌ وَمَنَافِعُ لِلنَّاسِ وَلِيَعْلَمَ اللَّهُ مَنْ يَنْصُرُهُ وَرُسُلَهُ بِالْغَيْبِ إِنَّ اللَّهَ قَوِيٌّ عَزِيزٌ) سورة الحديد الاية (25).

صدق الله العظيم

الإهداء

إلى من أعطتنا من دمها وروحها وعمرها حبا وتصميما ودفعا لغدٍ أجمل.....

إلى الغالية التي لا نرى الأمل إلا من عينيها.....

الي الروح التي سكنت روحي

الي من تحت قدميها جنة الخلد

أمي الحبيبة

إلى حكمتي وعلمي.....إلى أدبي وحلمي.....إلى طريقي المستقيم.....

إلى ينبوع الصبر والتفاؤل والأمل.....

أبي العزيز

الشكر والعرفان

لابد لنا ونحن نخطو خطواتنا الأخيرة في الحياة الجامعية من وقفة نعود إلى أعوام قضيناها في رحاب الجامعة مع أساتذتنا الكرام الذين قدموا لنا الكثير باذلين بذلك جهودا كبيرة في بناء جيل الغد لتبعث الأمة من جديد......

وقبل أن نمضي نقدم أسمى آيات الشكر والإمتنان والتقدير والمحبة إلى الذين حملوا أقدس رسالة في الحياة......

إلى الذين مهدوا لنا طريق العلم والمعرفة......

إلى جميع أساتذتنا الأفاضل......

"كن عالما......فإن لم تستطع فكن متعلما، فإن لم تستطع فأحب العلماء، فإن لم تستطع فلا تبغضهم"

ونخص بالتقدير والشكر

المهندس: جعفر عبد الحميد

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التجريدة

يهدف المشروع لتصميم عمود مرفق لمولد تايقر وذلك باستخدام تقنية القياس المباشر للحصول علي الابعاد وذلك باستخدام الفيرنيا والمايكرميتر وقدمة القياس.

تم عمل تحليل كيميائى للنموذج لمعرفة نوع المادة المصنع منها الاصل. و تم تحليل إستاتيكى وديناميكى لمعرفة الاجهادات الناتجة من تاثير القوى بإستخدام برنامج أنسيس، وتم عمل نموذج ثلاثي الابعاد والرسومات التفصيلية له برنامج سوليد ويركس .

تم اختبار فولاذ الإنشاءات (فولاذ منخفض الكربون) بواسطة برنامج أنسيس لحساب الاجهادات المسلطه على عمود المرفق و مقارنتها بواسطة الاجهادات الناتجة عند إستخدام الفولاذ منخض الكربون و الفولاذ عالى الكربون (المادة المصنعة منها الاصل) .

من النتائج تبين ان الفولاذ منخفض الكربون لا يصلح لتصنيع العمود و تمت التوصيه على ان يتم التصنيع باستخدام الفولاذ عالى الكربون.

Abstract

The objective of the project to design tiger generator crankshaft by using direct measurement to calculate the dimensions by using vernia, micrometer and a ruler.

A chemical analysis had been done to know the material of the prototype. Then static and dynamic analysis had been done to determine the stress resulted by the forces on the crankshaft using ANSYS software.3D model and detail drawing had been done using solid works software.

Structural steel (low carbon steel) had been tested in ANSYS software to calculate the stress on crankshaft and compared to stress when using low and high carbon steel.

From the results it had been found that low carbon steel is not suitable for manufacturing of the crankshaft, and high carbon steel had been recommended for manufacturing of the crankshaft.

Chapter One

Introduction

Introduction

This project deals with the problem occurred in single cylinder tiger generator crank shaft. It consists of static and dynamic analysis of single cylinder tiger generator crank shaft. It identifies and solves the problem by using the modeling and simulation techniques. The main work was to model the crankshaft with dimensions and then simulate the crank shaft for static and dynamic analysis. The modeling software used is solid work for modeling the crank shaft. The analysis software ANSYS will be used for static and dynamic analysis of crank shaft for future work. The objectives involve modeling and analysis of crank shaft, so as to identify the effect of stresses on crank shaft, to compare various materials and to provide possible solution.

1.1 Project Problem

The tiger‘s generator more disrepair and its work properly just three month, after the three month must be change the mechanical parts, or when this parts were damaged must be through the engine completely, especially when mechanical parts were damaged like cylinder, piston and the crank shaft.

1.2 Project Significant

The importance of this project to provides the spare parts for Tiger 2500 DC generators (Crank Shafts) and resettle manufacture of this generators in the Sudan without need of importing any spare parts from outsides. New innovations will be the theme for the project as a whole. But more importantly the quest for technological capabilities will be the main focus.

1.3 Project Objectives

The objective of this project is to design crank shaft for single - cylinder two-stroke air-cooled generator (Tiger 2500 DC).That can be made it in the Sudan by using local materials so we can increase validity for this engines by change the damage crankshaft by the anther one which we made it, so eventually we can incorporates features. The objective of this project as below:

(1) Draw model for tiger generator crankshaft using solid work
(2) Analysis the tiger generator crankshaft using ANSYS software
(3) Draw detail drawing for tiger generator crankshaft

1.4 Project Methodology

Gathered data about two stroke engines from references and performed visits to switch Generators Company to collect data about two stroke generators, elyarmook industrial complex to measure weight and chemical analysis of the crankshaft, and drew 3D model and assembly by solid works and used ANSIS for static and dynamic analysis. Assembly had been prepared in solid works for crankshaft and save this part as IGES for exporting into ANSYS work bench Environment. Import IGES model in ANSYS workbench simulation module. Then apply material for crank shaft. After that the material applied to generate the Mesh for the Crank shaft. Then the boundary condition and type of analysis had been defined (static and dynamic analysis) at last the analysis and the results .

Chapter Two

Historical Background and Literature Review

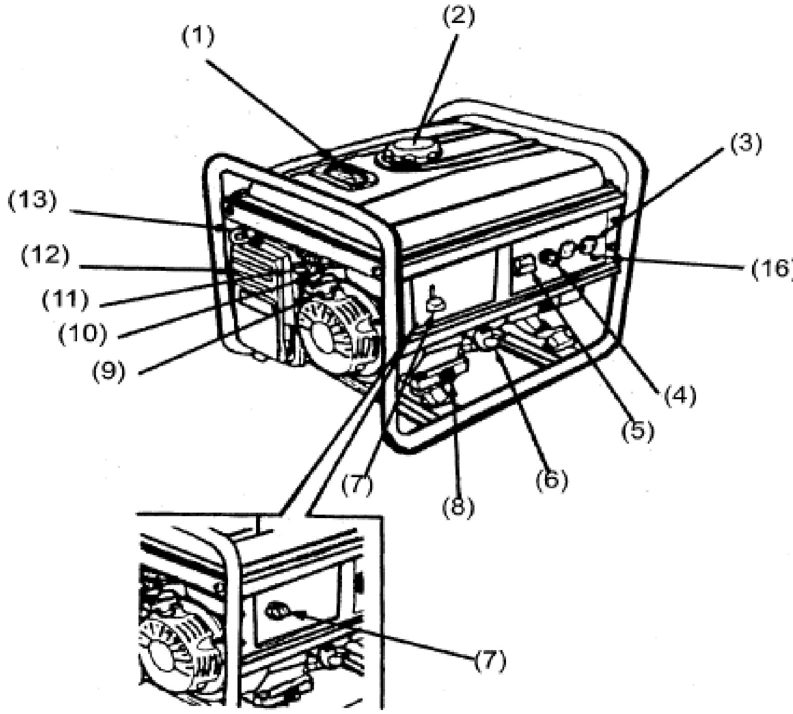
2.1 Tiger generator

The tiger air-cooled gasoline generators are widely used when electrical power is scarce .the generators provide a portable mobile solution in supplying power for field operations during project construction

Figure (2.1) Tiger Air-cooled gasoline engine generator

Table(2.1) Technical specifications about Tiger generator

Technical specifications in SI units Item Model		TG-2500	TG-3000	G-5000
Generator	Type	Brushless, revolving magnetic field, self –exciting, 2-pole, single-phase		
	Voltage regulator	Capacitor		
	Frequency (Hz)	60		
	Rated voltage (V)	120 / 240		
	Maximum output (kW)	3.0	3.2	6.5
	Rated Output (kW)	2.7	3.0	5.5
	Power factor (cos ϕ)			1.0

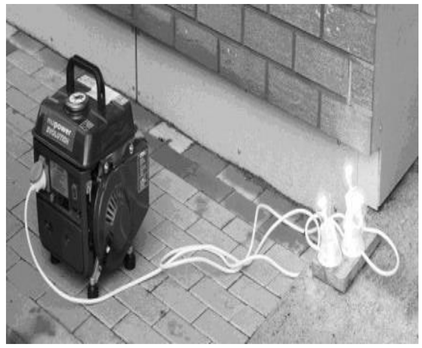


(1)FUEL GAUGE
(2)FUEL TANK CAP
(3)AC RECEPTACLES
(4)AC CIRCUIT BREAKER
(5)VOLTMETER
(6)OIL FILLER CAP
(7)ENGINE SWITCH
(8)OIL DRAIN PLUG
(9)RECOIL STARTER
(10)FUEL FILTERING CUP
(11)FUEL VALVE
(12)AIR CLEANER
(13)CHOKE ROD
(14)MUFFLER
(15)SPARK PLUG
(16)GROUND TERMINAL
(17)DC TERMINALS
(18)DC CIRCUIT PROTECTOR

Figure (2.2) The tiger generator parts

2.2 Two-stroke Engines

The two-stroke cycle engine was invented by Sir Dugald Clerk in England at the end of the 19th century. It is a form of engine using crankcase compression for the induction process, including the control of the timing and area of the exhaust, transfer and intake ports by the piston. The design was patented by Joseph Day in England in 1891. His engine was the original “three-port” engine and is the forerunner of the simple two-stroke engine which has been has in common usage since that time. Some of the early applications were in motorcycle and are well recorded by Counter. The first engines were produced by Edward Butler in 1887 and by J.D. Roots, in the form of the Day crankcase compression type, in 1892; both of these designs were for powered tricycles. Considerable experimentation and development was conducted by Alfred Scott, and his flying squirrel machines competed very successfully in tourist trophy races in the first quarter of the 20th century. They were designed quite beautifully in both the engineering and in the aesthetic sense. After that, two-stroke engines faded somewhat as competitive units in racing for some years until the supercharged DKW machines of the 30s temporarily revived their fortunes. With the banning of supercharging for motorcycle racing after the Second World War, the two-stroke engine lapsed again until 1959 when the MZ machines, with their tuned exhaust expansion chambers and disc valve induction systems, introduced a winning engine design which has basically lasted to the present day. Today, two-stroke-engine for motorcycles, scooters and mopeds are still produced in very large numbers for general transport and for recreational purposes, although the legislative pressure on exhaust emissions in some countries has produced a swing to a four-stroke engine replacement in some cases. Whether the two-stroke engine will return as a mass production motorcycle engine will depend on the result of research and development being conducted by all of the manufacturers at the present time.



(a) Mobile generator

(b) Motor cycle transport

(c) Three-wheeler

Figure 2.3: Current and future application of the two-stroke engines

The two-stroke engine is also used for lightweight power units which can be employed in various attitudes as handheld power tools. Such tools are chainsaws, brush cutters and concrete saws, to name but a few, and these are manufactured with a view to lightness and high specific power performance. The earliest outboard motors were pioneered by Evinrude in the United States about 1909, with a 1.5 hp unit, and two-stroke engines have dominated this application until the present day. Some of the current machines are very sophisticated designs, such as 300hp V6- and V8-engined outboards with remarkably efficient engines considering that the basic simplicity of the two stroke crankcase compression engine has been retained. Although the image of the outboard motor is that it is for sporting and recreational purposes, the facts are that the product is used just for as heavily for serious employment in commercial fishing and for everyday water transport in many parts of the world.

The racing of outboard motors is a particularly exciting form of automotive sport, some of the new recreational products which have appeared in recent times are Snowmobiles and water scooters, and the engine type almost always employed for such machines in the two-stroke engine. The use of this engine in a snowmobile is almost an ideal application, as the simple lubrication system of the two-stroke engine is perfectly suited for sub-zero temperature conditions. Although the snowmobile has been described as a recreational vehicle, it is actually a very practical means of everyday transport for many people in Arctic environment. The use of the two-stroke engine in snowmobiles has had an interesting history, and some quite sophisticated machines were product in the 1960s, such as the Auto-Union vehicle from West Germany and the simpler Wartburg from East Germany. The Saab car from Sweden actually won the Monte Carlo Rally with Eric Carlson driving it. Until recent times, Suzuki built a small two-stroke-engine car in Japan. With increasing ecological emphasis on fuel consumption rate and exhaust emissions, the simple two-stroke-engine car disappeared, but interest in the design has seen a resurgence in recent times as the legislative pressure intensifies on exhaust acid emissions. Almost all car manufacturers are experimenting with various forms of two-stroke-engine vehicles equipped with direct fuel injection, or some variation of that concept in terms of stratified charging or combustion.

The engine type has been use for trucks and locomotives, such as the designs from General Motors in America or Roots-Tilling-Stevens in

Britain. Both of these have been very successful in mass production. The engine type, producing a high specific power output, has also been a favorite for military installations in tanks and fast naval patrol boats.

2.3 Operation of a simple two-stroke engine

An example of a simple two-stroke engine is shown in the Figure 2.4 with the various phrases of the filling and emptying of the cylinder illustrated in Figure 2.5 (a)-(d). The simplicity of the engine is obvious, and with all the processes controlled by the upper and lower edges of the piston.

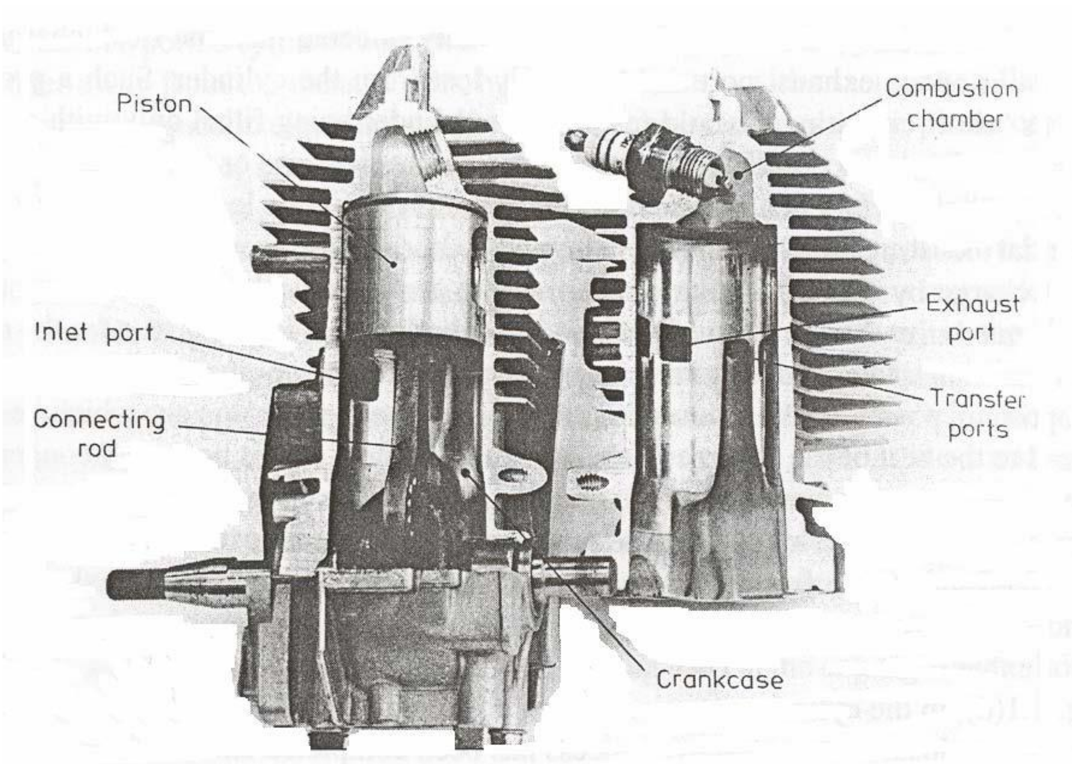
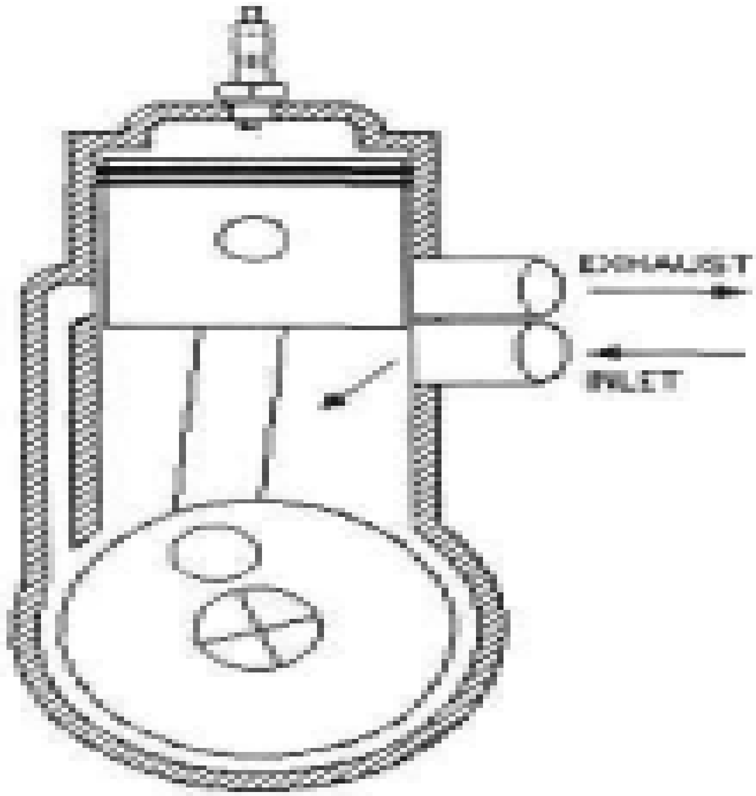


Figure 2.4: A simple two-stroke engine

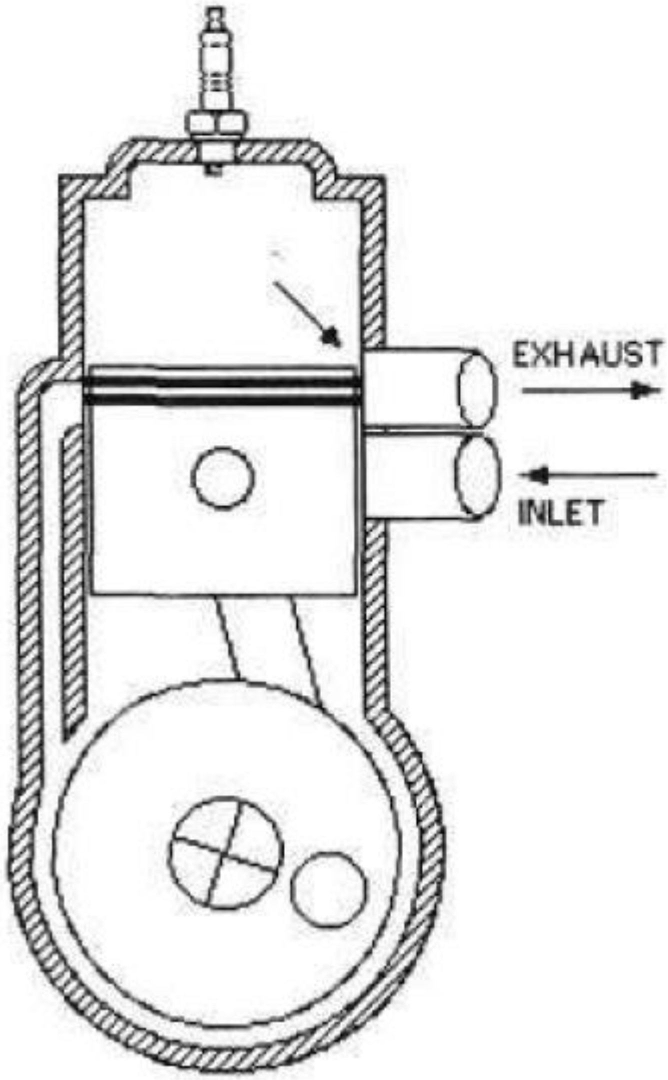
In Figure 2.5(a), the piston, the trapped air and fuel charge is being ignited by the spark plug, producing a rapid rise in pressure and temperature which will drive the piston down on the power stroke. Below the piston, the opened inlet port is inducing air from the atmosphere into the crankcase due to the increasing volume of the crankcase lowering the pressure below the atmospheric value. The crankcase is sealed around the crankshaft to ensure the maximum depression within it. To induce fuel into the engine, the various options exist of either placing a carburetor in the inlet tract, injecting fuel into the crankcase or transfer ducts.

In Figure 2.5 (b), the piston, the exhaust port has been opened. It is often called the release point in the cycle, and this allows the transmission into the exhaust duct of a pulse of hot, high-pressure exhaust gas from the combustion process.

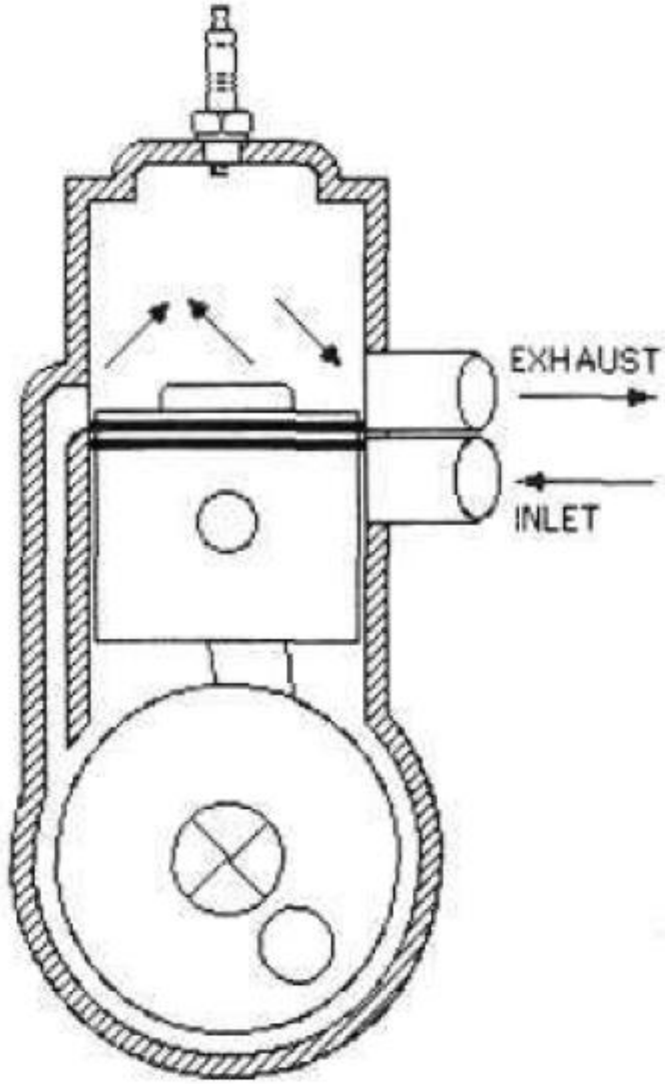
As the area of the port is increasing with crankshaft angle, and the cylinder pressure is falling with time, it is clear that the exhaust duct pressure profile with time is one which increases to a maximum value and then decays. Such a flow process is described as unsteady gas flow and such a pulse can be reflected from all pipe area changes, or at the pipe end termination to the atmosphere. These reflections have a dramatic influence on the engine performance. Below the piston, compression of the fresh charge is taking place. The pressure and temperature achieved will be a function of the proportionate reduction of the crankcase volume, i.e., the crankcase compression ratio.



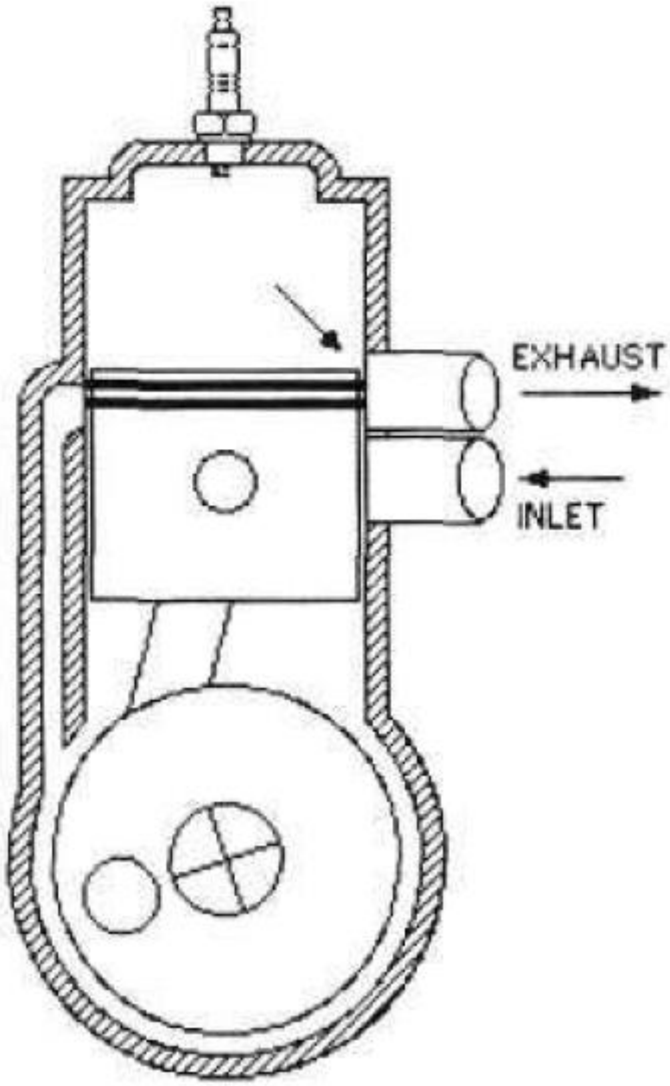
2.5(a) compression and induction



2.5.(b) Blowdown Exhaust Period



2.5(c) Fresh Charge Transfer



2.5(d) Approching Exhaust Closing

Figure 2.5 : processes of a simple two-stroke engine

In Figure 2.5 (c), the piston, the exhaust process, also called “blow-down”, is nearing completion and, with the piston having uncovered the ports, this connects the cylinder directly to the crankcase through the transfer ducts. If the crankcase pressure exceeds the cylinder pressure then the fresh charge enters the cylinder in what is known as the scavenge process. Clearly, if the transfer ports are badly directed then the fresh charge can exit directly out of the exhaustport and be totally lost from the cylinder.

In Figure 2.5 (d), in the cylinder, the piston is approaching what is known as the “trapping” point, or exhaust closure. The scavenge process has been completedand the cylinder is now filled with a mix of air, fuel if a carbureted design, and exhaust gas. As the piston rises, the cylinder pressure should also rise, but the exhaust port is still open and, barring the intervention of some unsteady gasdynamic effect generated in the exhaust pipe, the piston will spill fresh charge into the exhaust duct to the detriment of the resulting power output and fuel consumption. Should it be feasible to gas-dynamically plug the exhaust portduring this trapping phase, then it is possible to greatly increase the performance characteristics of the engine. After the exhaust port is finally closed, the true compression process begins until the combustion process is commenced by ignition. Not surprisingly, therefore, the compression ratio of a two-stroke engine is characterized by the cylinder volume after exhaust port closure and is called the trapped compression ratio to distinguish it from the value commonly quoted for the four-stroke engine. That value is termed here as the geometric compression ratio and is based on the full swept volume.
In summary, the simple two-stroke engine is a double-acting device. Above the piston, the combustion and power processes take place, whereas below the piston in the crankcase, the fresh charge is induced and prepared for transfer to the upper cylinder.

2.4 Software

2.4.1 Slid work

The Solid Works Software CAD software is a mechanical design automation application that lets designers quickly sketch out ideas, experiment with features and dimensions, and produce models and detailed drawings.

Document Structure

This document is organized to reflect the way that you use the Solid Works software. It is structured around the basic Solid Works document types: parts, assemblies, and drawings. For example, you create a part before you create an assembly.

Throughout the document, a bathroom vanity illustrates various tools and functions available to you in the software.

Parts are the basic building blocks in the Solid Works software. Assemblies contain parts or other assemblies, called subassemblies.

A Solid works model consists of 3D geometry that defines its edges, faces, and surfaces. The Solid Works software lets you design models quickly and precisely. Solid Works models are:

- Defined by 3D design.
- Based on components.

Solid works uses a 3D design approach. As you design a part, from the initial sketch to the final result, you create a 3D model. From this model, you can create 2D drawings or mate components consisting of parts or subassemblies to create 3D assemblies. You can also create 2D drawings of 3D assemblies.

When designing a model using Solid Works, you can visualize it in three dimensions, the way the model exists once it is manufactured.

One of the most powerful features in the Solid Works software is that any change you make to a part is reflected in all associated drawings or assemblies.

The solid works application includes user interface tools and capabilities to help you create and edit models efficiently.

Terminology

These terms appear throughout the solid works software and documentation.

Origin: Appears as two blue arrows and represents the (0, 0, 0) coordinate of the model. When a sketch is active, a sketch origin appears in red and represents the (0, 0, 0) coordinate of the sketch. You can add dimensions and relations to a model origin, but not to a sketch origin.

Plane: Flat construction geometry. You can use planes for adding a 2D sketch, section view of a model, or a neutral plane in a draft feature, for example.

Axis: Straight line used to create model geometry, features, or patterns. You can create an axis in different ways, including intersecting two planes. The solid works application creates temporary axes implicitly for every conical or cylindrical face in a model.

Face: Boundaries that help define the shape of a model or a surface. A face is a selectable area planar or non planar of a model or surface. For example, a rectangular solid has six faces.

Edge: Location where two or more faces intersect and are joined together. You can select edges for sketching and dimensioning, for example.

Vertex: Point at which two or more lines or edges intersect. You can select vertices for sketching and dimensioning.

2.4.2 ANSYS Mechanical

ANSYS Mechanical software offers a comprehensive product solution for structural linear/nonlinear and dynamics analysis. The product offers a complete set of element behavior, material models and equation solvers for a wide range of engineering problems.

ANSYS Structural: software addresses the unique concerns of pure structural simulations without the need for extra tools. The product offers all the power of

nonlinear structural capabilities in order to deliver the highest-quality, most reliable structural simulation results available. ANSYS Structural easily simulates even the largest and most intricate structures.

ANSYS Professional: software offers a first step into advanced linear dynamics and nonlinear capabilities. Containing the power of leading simulation technology in an easy-to-use package, ANSYS Professional tools provide users with high-level simulation capabilities without the need for high-level expertise. The package comes complete with a full contingent of linear elements, significant nonlinearities, the ability to solve complex assemblies, and the most requested set of solvers.

ANSYS Design Space: software is an easy-to-use simulation software package that provides tools to conceptualize design and validate ideas on the desktop. A subset of the ANSYS Professional product, ANSYS design space allows users to easily perform real-world, static structural and thermal, dynamic, weight optimization, vibration mode, and safety factor simulations on all designs without the need for advanced analysis knowledge.

ANSYS Rigid Body Dynamics: software provides incredibly short solution times for even the most complex multi-part assemblies undergoing large kinematic translations and rotations. It is an ANSYS workbench add-on module that works directly with ANSYS structural, ANSYS mechanical, and ANSYS multi physics.

2.5 Discuss the properties of plain carbon steel

Steel: The term steel is used for many different alloys of iron. These alloys vary both in the way they are made and in the proportions of the materials added to the iron. All steels, however, contain small amounts of carbon and manganese. In other words, it can be said that steel is a crystalline alloy of iron, carbon and several other elements, which hardens above its critical temperature. Like stated above, there do exist several types of steels which are among others plain carbon, stainless steel, alloyed steel and tool steel.

2.5.1 Plain carbon steel: Carbon steel is by far the most widely used kind of steel. The properties of carbon steel depend primarily on the amount of carbon it contains. Most carbon steel has a carbon content of less than 1%.

Carbon steel is made into a wide range of products, including structural beams, car bodies, kitchen appliances, and cans. In fact, there are 3 types of plain carbon steel and they are low carbon steel, medium carbon steel, high carbon steel, and as their names suggests all these types of plain carbon steel differs in the amount of carbon they contain. Indeed, it is good to precise that plain carbon steel is a type of steel having a maximum carbon content of 1.5% along with small percentages of silica, sculpture, phosphorus and manganese.

2.5.2 General properties of plain carbon steel: Generally, with an increase in the carbon content from 0.01 to 1.5% in the alloy, its strength and hardness increases but still such an increase beyond 1.5% causes appreciable reduction in the ductility and malleability of the steel.

Low carbon steel or mild steel: containing carbon up to 0.25% responds to heat treatment as improvement in the ductility is concerned but has no effect in respect of its strength properties.

Table 2.2**:** low carbon mechanical properties:

Description	Value	Unit
Mass density	8082.5	Kg/m^3
Poisson’s ratio	0.3	-
Compressive strength	1.8E+06	Pa
Yield stress	250	M Pa

High carbon steels: is steel-containing carbon in the range of 0.70 to 1.05% and is especially classed as high carbon steel. In the fully heat-treated condition it is very hard and it will withstand high shear and wear and will thus be subjected to little deformation. Moreover, at maximum hardness, the steel is brittle and if some toughness is desired it must be obtained at the expense of hardness. Depth hardening ability (normally termed as harden ability) is poor, limiting the use of this steel.

Furthermore, as it has been seen that hardness, brittleness and ductility are very important properties as they determine mainly the way these different carbon content steels are used. Considering the microstructure of slowly cooled steel; for mild steel, for instance, with 0.2% carbon. Such steel consists of about 75% of proeutectoid ferrite that forms above the eutectoid temperature and about 25% of pearlite .When the carbon content in the steel is increased, the amount of pearlite increases until we get the fully pearlitic structure of a composition of 0.8% carbon. Beyond 0.8%, high carbon steel contain proeutectoid cementide in addition to pearlite.

However, in slowly cooled carbon steels, the overall hardness and ductility of the steel are determined by the relative proportions of the soft, ductile ferrite and the hard, brottle cementite. The cementite content increases with increasing carbon content, resulting in an increase of hardness and a decrease of ductility, as we go from low carbon to high carbon steels.

Mechanical Properties

Table 2.3: High carbon steel mechanical properties

Description	**Value**	**Unit**
Mass density	8248.6	Kg/m^3
Poisson’s ratio	0.313	-
Compressive strength	3.1E+09	Pa
Yield stress	400	M Pa

Chapter Three

Project Methodology

3.1 Project Methodology

This project deals with the problem occurred in single cylinder engine crank shaft. It consists of static and dynamic analysis of single cylinder engine crank shaft. It identifies and solves the problem by using the modeling and simulation techniques. The topic was chosen because of increasing interest in higher payload, lower weight, higher efficiency and shorter load cycles in crankshaft. The main work was to model the crankshaft with dimensions and then simulate the crank shaft for static structural and fatigue analysis. The modeling software used is solid work for modeling the crank shaft. The analysis software ANSYS will be used for static and dynamic analysis of crank shaft for future work. The objectives involve modeling and analysis of crank shaft, so as to identify the effect of stresses on crank shaft, to compare various materials and to provide possible solution.

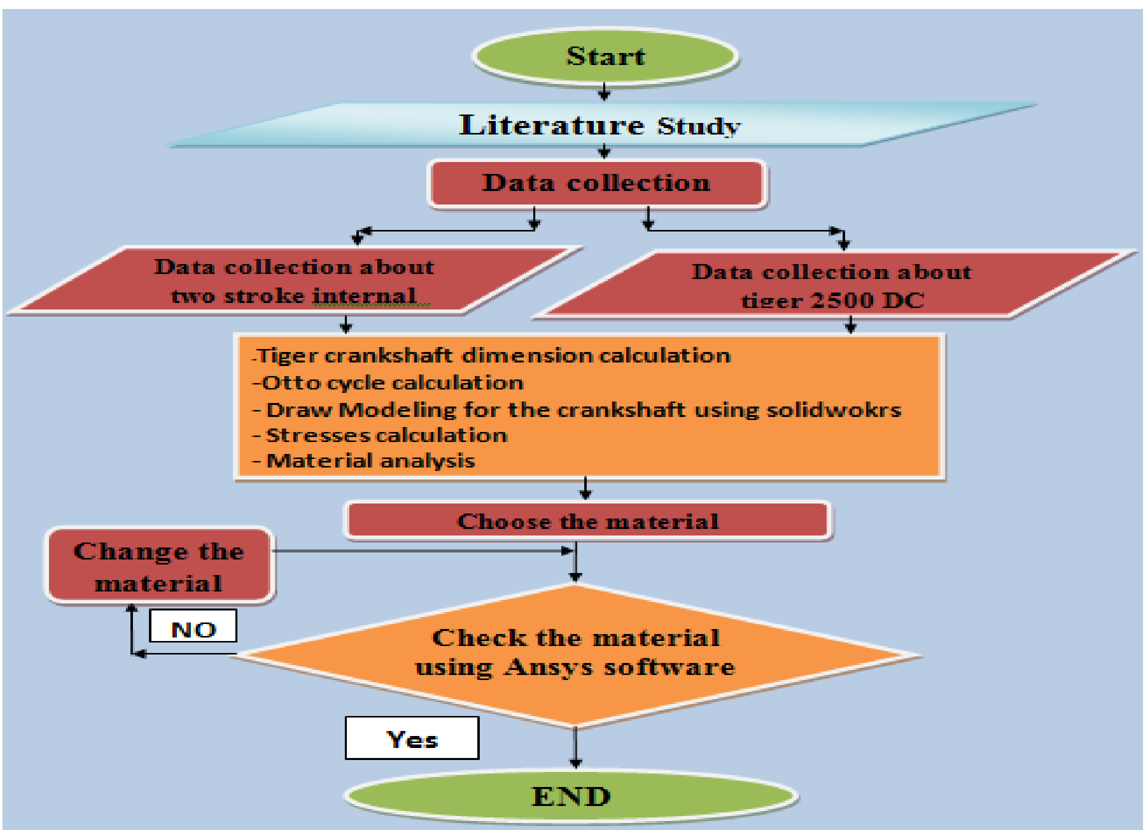


Figure (3.1) flow chart show the methodology of the project

Crankshaft, finite element analysis FEA ANSYS Software, Static Analysis; 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 consisting 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. 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 crank shaft. The magnitude of the forces depends on many factors which consist of crank radius, connecting rod dimensions, and weight of the connecting rod, piston, piston rings, and pin. Combustion and inertia forces acting on the crankshaft. Tensional load, Bending load. Crankshaft must be strong enough to take the downward force of the power stroke without excessive bending so the reliability and life of the internal combustion engine depend on the strength of the crankshaft largely. The crank pin is like a built in beam with a distributed load along its length that varies with crank positions. Each web is like a cantilever beam subjected to bending and twisting, bending moment which causes tensile and compressive stresses and twisting moment causes shear stress. There are many sources of failure in the engine one of the most common crankshaft failure is fatigue at the fillet areas due to the bending load causes by the combustion. The moment of combustion the load from the piston is transmitted to the crankpin, causing a large bending moment on the entire geometry of the crankshaft. At the root of the fillet areas stress concentrations exist and these high stress range locations are the points where cyclic loads could cause fatigue crank initiation leading to fracture.

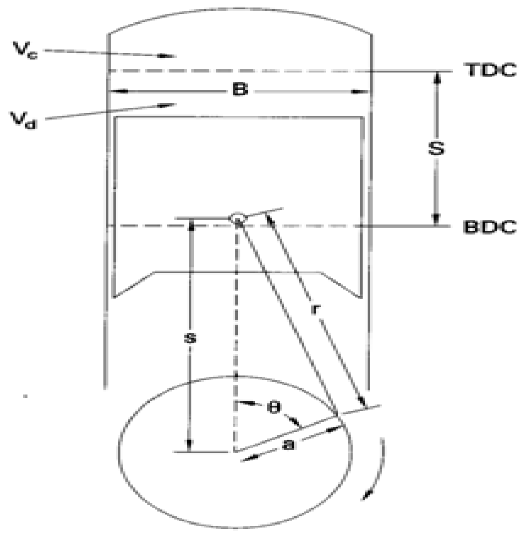


Figure (3.2) piston and cylinder geometry of reciprocating engine

Table 3.1: Dimensions for crankshaft

Type	**Single cylinder petrol engine**
Number of cylinder	1
cylinder diameter	45 mm
Diameter of crank pin	16.04 mm
Length of crank pin	36.07 mm
Stroke length	39.86 mm
crank shaft offset	19.93 mm

Connecting rod length	80 mm
Maximum gas pressure	827.27 Pa
Speed	300 rpm

N≡ engine speed rpm

Θ ≡ crank angle

a ≡ crank shaft offset

$S =$

$2a$

$$Vd = \frac{\pi}{4} * \ B^2 * S$$

B ≡ bore

r ≡ connecting rod length

$$F = \frac{\pi}{4} * D^2 * Pmax$$

F=$\frac{\pi}{4} * (0.045)^2 * (827.37)$

F = 1316 N

T= F*a

= 1316* 0.01993 =26.23 N. m

H1 = H2= F/2

=1316/2 = 658 N

Combustion Equation:

(C_6H_6 + CH_4) +a_{th} (O_2 +3.76 N_2)→ X CO_2 +Y H_2O + Z N_2

C balance:

X=7 Y=5

O_2 balance :

a_{th} = (7*2 +5)/2 = $\frac{19}{2}$

N_2 balance:

$$\frac{19}{2} * 3.76 = 35.72$$

∴ the equation:

$$(C_6H_6 + CH_4) + \frac{19}{2}(O_2 + 3.76 N_2) \rightarrow 7 CO_2 + 5H_2O + 35.72N$$

$$AFR = \frac{m^{\cdot}_{air}}{m^{\cdot}_{fuel}} \rightarrow \left[\frac{\frac{19}{2} * 4.76 * 29}{12 * 6 + 22}\right] = 13.95$$

13.95 kg of air need 1 kg of fuel ($C_6H_6 + CH_4$)

$C_{p\ air}$ = 1.005 kJ/kg .K

$C_{v\ air}$ = .718 kJ/kg .K

$C_{P\ CH4}$ =2.2 kJ/kg . k

Volumetric ratio :

$C_{P\ total}$ =(1.005/1) +(2.27/3.5) = 1.6535 kJ/kg .K (mixture)

$$\frac{Cp\ total}{Cv\ total} = \gamma = 1.2 \quad (20-2)$$

$C_{v\ total}$ = 1.37798 kJ/kg . K (mixture)

3.2 Geometry creation

Established three dimensional model of a diesel engine crankshaft by using solid work software and saved in(IGS) type. This includes:

3-3-1. Sketcher

3-3-2. Part modeling (part design)

3-3-3. Advanced Part Design

3-3-4. Surface Design

3-3-5. Assembly Design

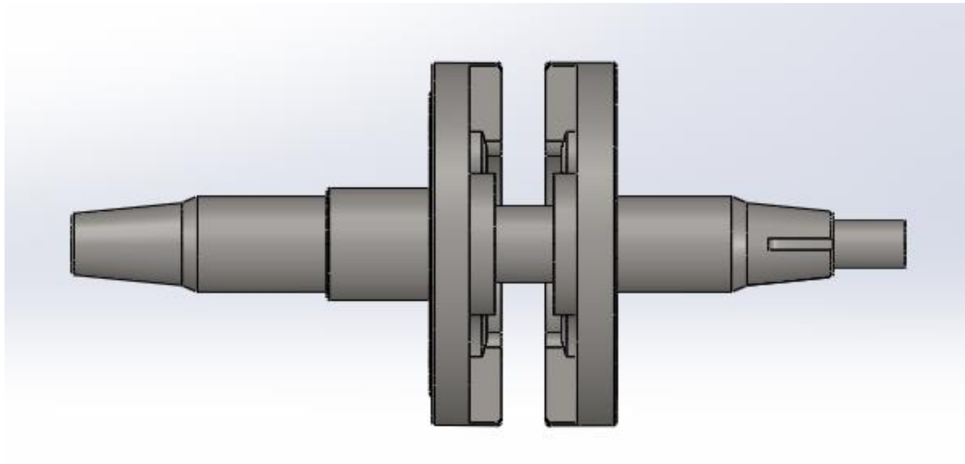


Figure (3.3) 3-D model of Crankshaft

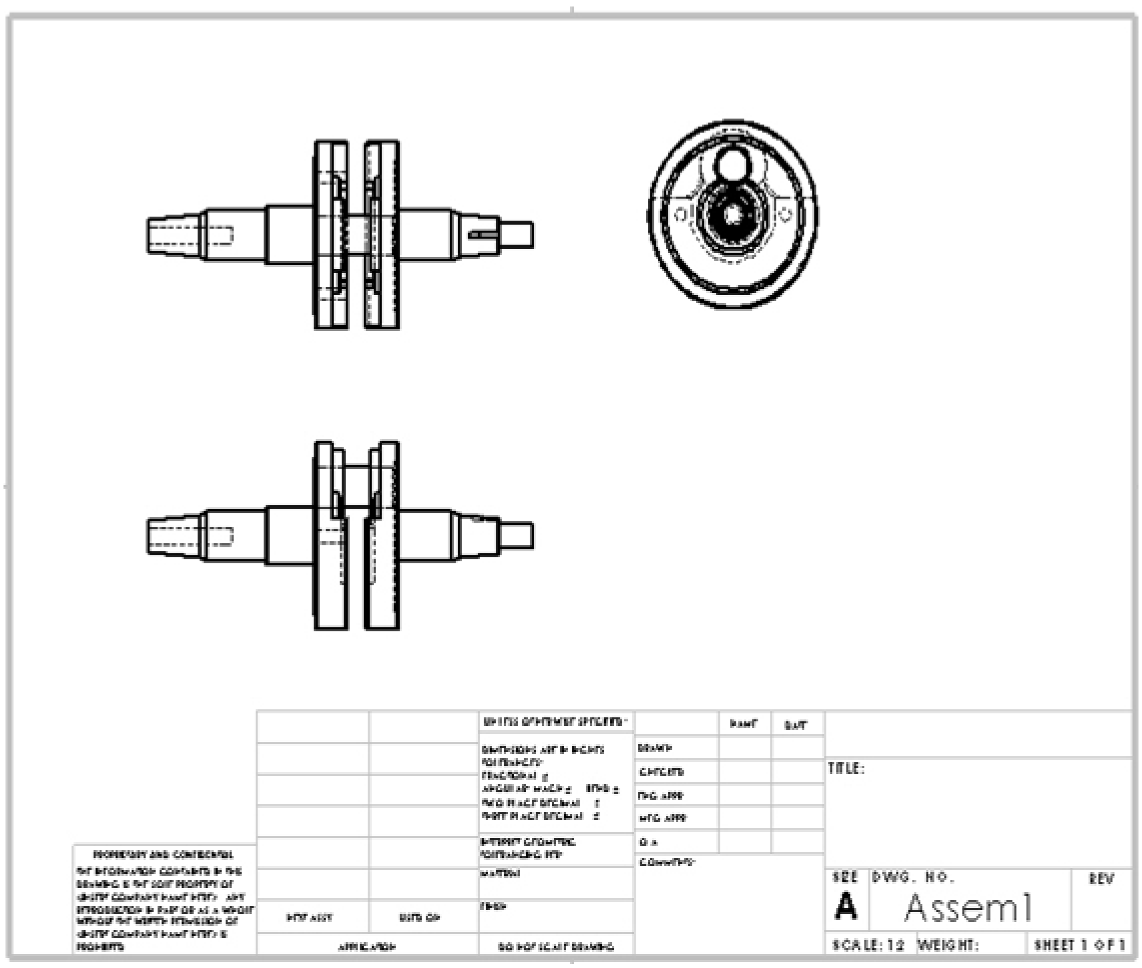


Figure (3.4) detail drawing for the crank shaft assembly

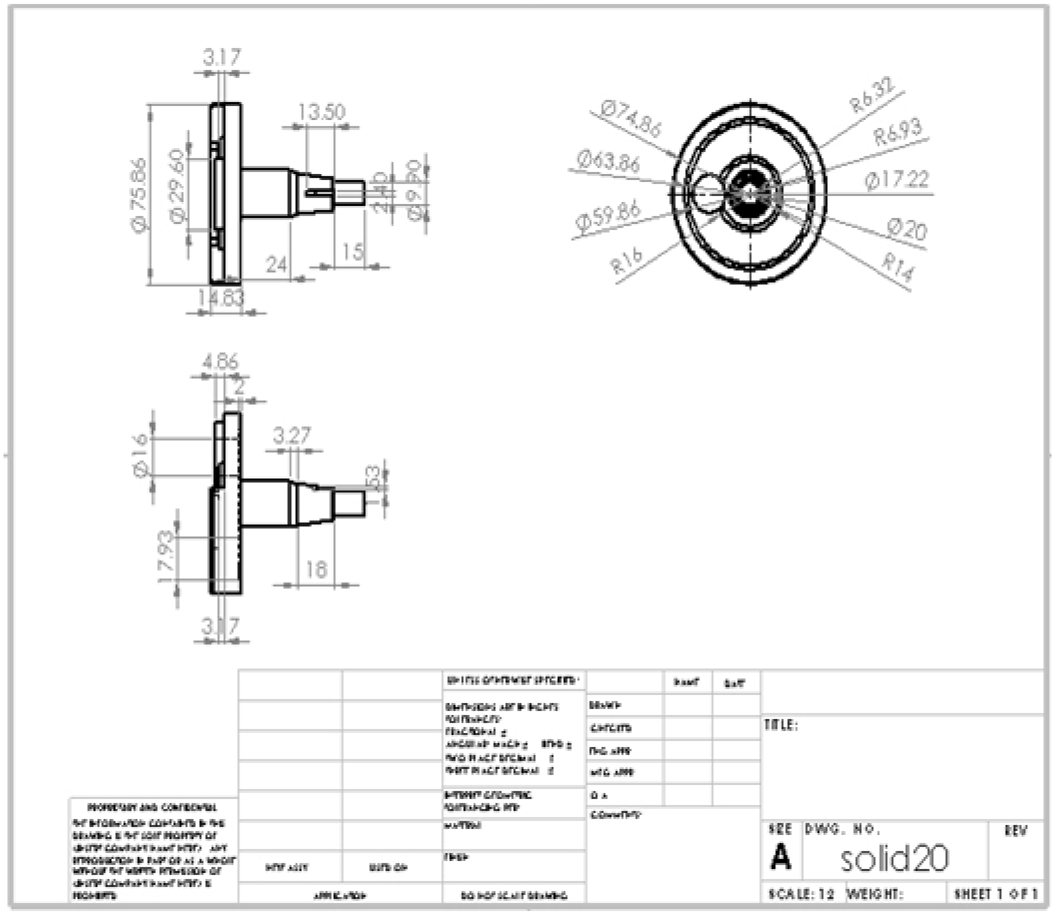


Figure (3.5) detail drawing for part 1

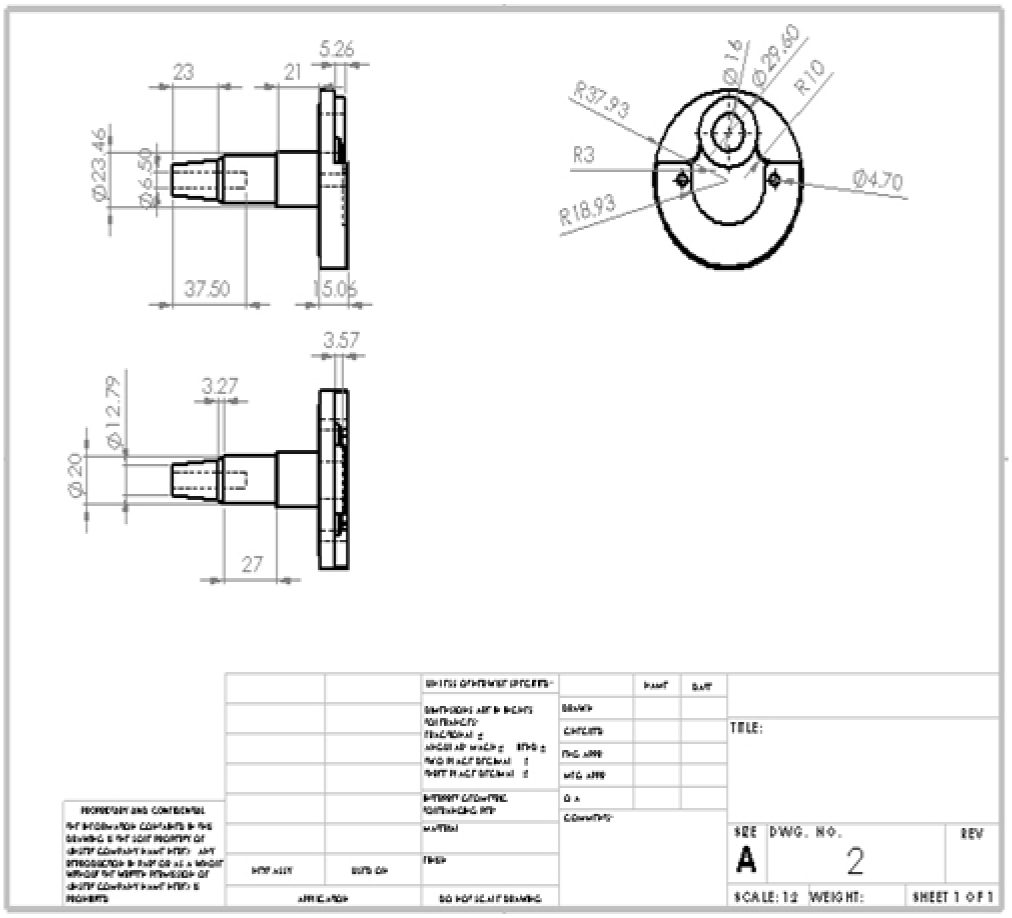


Figure (3.6) detail drawing for part 2

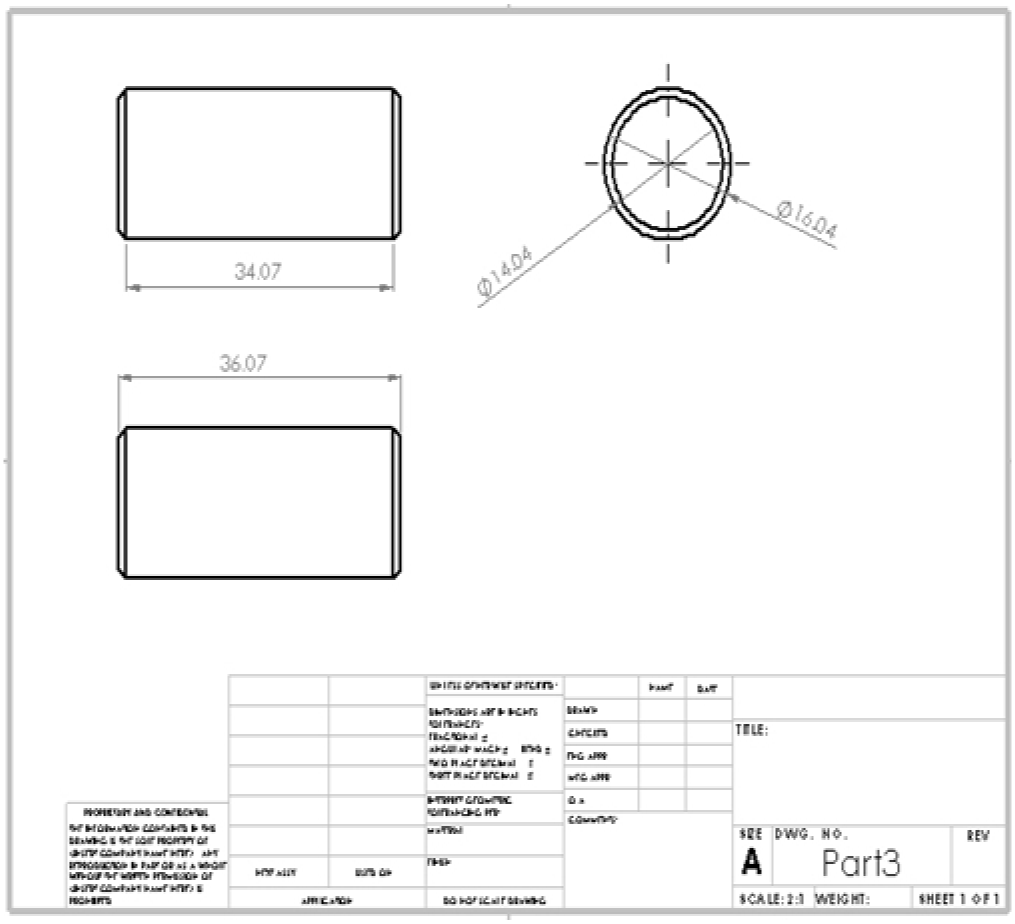


Figure (3.7) Detail drawing for part 3

3.3 Basic Steps in F.E.M.

Basically there six steps in F.E.M. which they are as follows.

3-4-1. Discretization (mesh generation)

3-4-2. Selecting the displacement function

3-4-3. Develop the element matrices and equations

3-4-4. Assemble element matrices

3-4-5. To find the unknowns

3-4-6. Interpretation of the results.

3.4 Need of Finite Element Method

There are number of needs of finite element method. But we are considering some basic needs.

3-5-1 to reduce the amount of prototype testing.

3-5-2 to simulate design that is not suitable for prototype testing.

3-5-3 Cost saving.

3-5-4 Time saving.

3.5 Mesh

The discretization of the structure or body into Finite Elements forms the basic first step in the analysis of a complicated structural system. Rules for discretization of the structure into elements:

1. Sub-division of a body or structure into finite elements should satisfy the following requirements:

2. Two distinct elements can have common points only on their common boundaries if such boundaries exist. No overlapping is allowed. Common boundaries can be points, lines or surfaces.

3. The assembled element should leave no holes within the two elements and approximate the geometry of the real body or structure as closely as possible to do.

4. When the boundary of a structure or body cannot be exactly represented by the elements selected, an error cannot be avoided. Such error is called geometric discretization error and it can be decreased by reducing the size

of the elements or by using elements allowing boundaries to become curved.

3.6 Element Properties

Modeling and Analysis of the Crankshaft using ANSYS software. ANSYS is general-purpose Finite Element Analysis (FEA) software package. Finite element analysis a numerical method of deconstructing a complex system into very small pieces called elements. The software implements equations that govern the behavior of these elements and solves them all creating a comprehensive explanation of how the system acts as a whole. The ANSYS workbench environment is an intuitive up-front finite element analysis tool that is used in conjunction with CAD systems or Design Model. ANSYS Workbench is a software environment for performing structural, thermal, and electromagnetic analyses. The workbench focuses on attaching existing geometry, setting up the finite element model, solving, and reviewing results.

3.7 Static Analysis

Used to determine displacements, stresses, strain, deformation etc. under static loading conditions in both linear and nonlinear static analysis. Nonlinearities include plasticity, stress stiffening, large deflection, large strain, hyper elasticity, contact surfaces, and creep Model Analysis of Crankshaft will be done using following steps:-

3.8.1 Click on new simulation file.

3.8.2 Give name as IGS.

3.8.3 Import geometry (crank.IGS) from folder of solid works files.

3.8.4 Meshing the model using the option generate mesh.

3.8.4 Select new analysis, Select static structural.

3.8.5 Apply boundary conditions.

3.8.6 Select the area for fixed support.

3.8.7 Find the total deformation for each mode by selecting solve option.

3.8.8 Find von- mises stress selecting von-mises option.

3.8.9 Generate report preview.

3.8.10 Save the file.

3.8 The steps of analysis

Import geometry (crank.IGS) from folder of solid works files

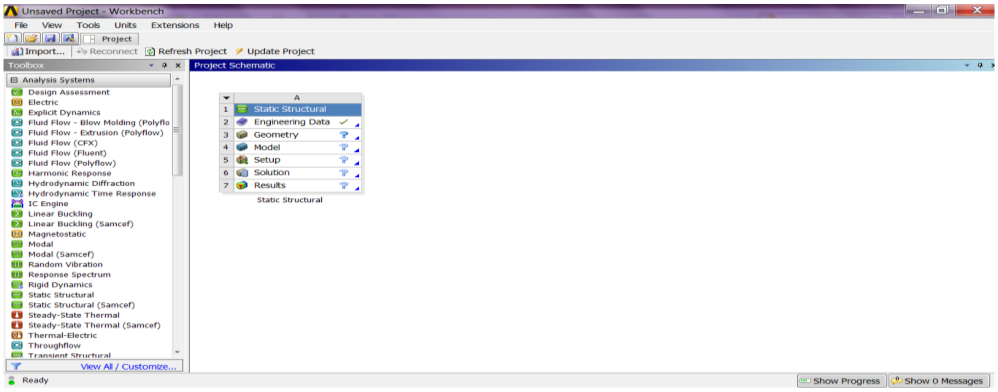


Figure (3.8) Import geometry

3.8.1 Attach Geometry

There are no geometry creation tools in the Mechanical application. You create your geometry in an external application or import an existing mesh file. Options to bring geometry into mechanical; include from within workbench using design modeler.

From a CAD system supported by workbench or one that can export a file that is supported by ANSYS workbench from within workbench using the external model component system. This feature imports an ANSYS Mesh (IGS) file. Before attaching geometry, you can specify several options that determine the characteristics of the geometry you choose to import. These options are: solid bodies, surface bodies, line bodies, parameters, attributes, named selections, material properties; Analysis Type (2D or 3D), allowing CAD associatively, importing coordinate systems (Import Work Points are only available in the design modeler application), saving updated CAD file in reader mode, “smart” refreshing of models with unmodified components, and allowing parts of mixed dimension to be imported as assembly components that have parts of different dimensions. The availability of these options varies across the supported CAD systems.

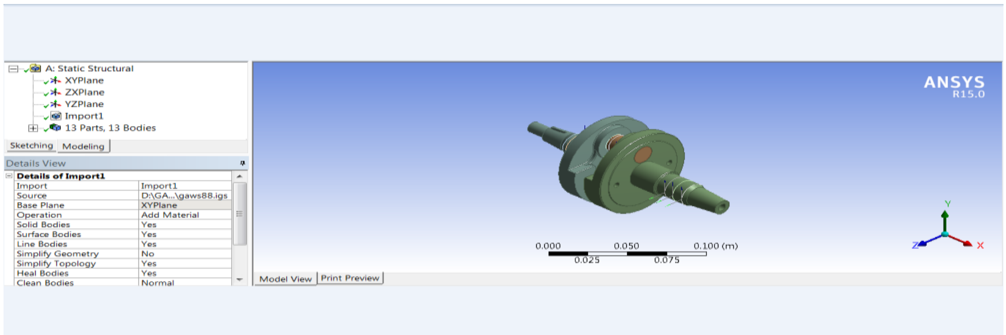


Fig (3.9) show Attach Geometry

3.8.2 Split Face

The split face option allows you to split a face at a desired location. Select the edge where the split will take place and hold down the left mouse button to slide the cursor on that edge to the desired split location. Release the left mouse button and press the middle mouse button to accept the location and to complete the face split operation. After that suppress line bodies.

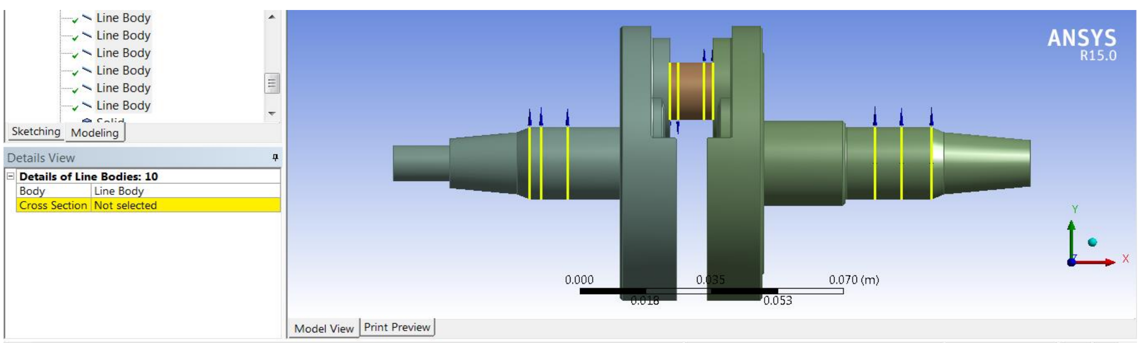


Figure: (3.10) suppress line bodies

Now t he model is ready to be analyze as static structural by choosing the global coordinate system to specify the axis (X.Y Z)

3.8.3 Connection

In the connection we specify the relationship between the surfaces. There was more than one of relationship but here we chose the bonded (solid to solid).

3.8.4 Mesh the model

The figure (3.12) shows the meshed model of crank shaft. The descretization (Mesh generation) is the first step of finite element Method. In this step the component or part is divided into number of small parts. In discretization the no. of nodes formed are (136492) and no of elements are (7339) The effect of force on each portion of the component is not same. The purpose of descretization is to perform the analysis on each small division separately.

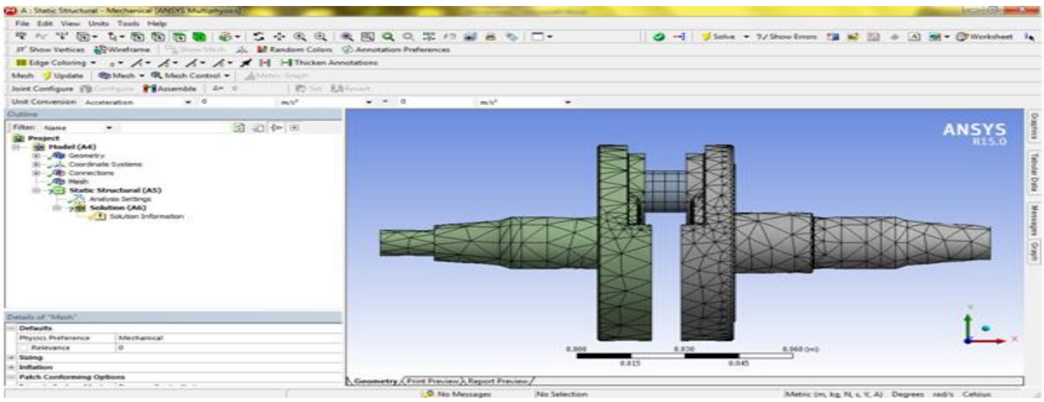


Figure:(3.11) show mesh of the model

3.8.5 Apply load

Apply Boundary condition to the crankshaft, the two ends of the crankshaft is to be fixed support, and component load {1316 N} is applied on the top of the crankpin surface. From the static structural insert.

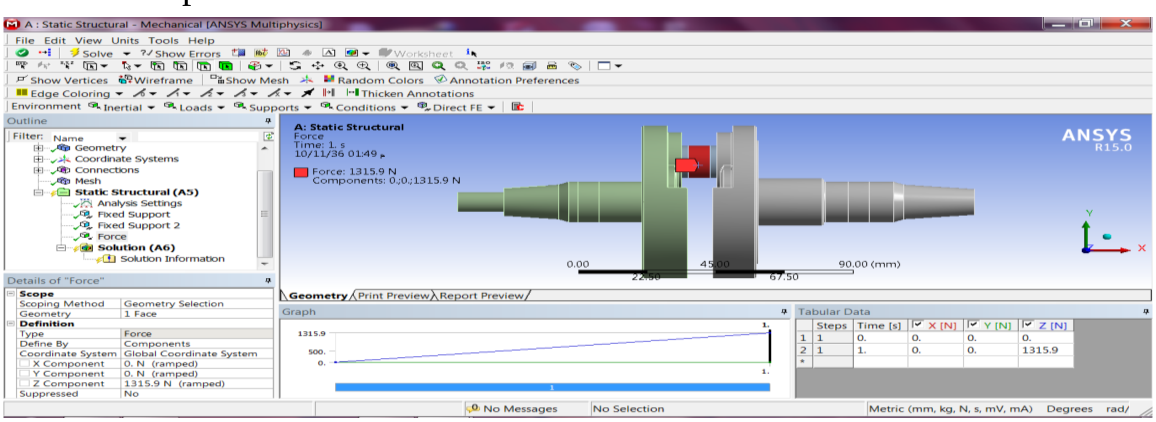


Figure (3.12) Apply Boundary condition the crankshaft

3.9 Chemical Analysis

Table (3.2) Steel 4104Din no 1.7035 (low carbon steel)

	C	Si	Mn	Cr	Mo	Ni	Al	Cu
Report	0.360	0.164	0.635	0.840	.098	0.000	0.041	.052
	Ti	Nb	Co	W	Pb	Fe	V	
Report	0.005	0.008	0.073	0.000	0.023	97.704	0.000	

Table (3.3) Steel 45DIN N0 1.0503(low carbon steel)

	C	Si	Mn	Cr	Mo	Ni	Al	Cu
Report	o.435	0.133	0.558	0.472	0.085	0.000	0.044	0.044
	Ti	V	Nb	Co	W	Pb	Fe	
Report	0.043	0.000	0.003	0.064	0.012	0.022	98.130	

Table (3.4) Steel .55v3 DIN No1.7176 (high carbon steel)

	C %	Si %	Mn %	Cr %	Mo %	Ni %	Al %	Cu %	Ti %
Report	0.688	0.156	0.567	0.704	0.094	0.000	0.048	0.052	0.002
	V %	Nb%	Co %	W %	Pb%	Fe %			
Report	0.000	0.008	0.070	0.000	0.023	97.589			

Chapter Four

Results and discussion

4-1 Results and discussion

The mean object of this project is to design a crank shaft for petrol generator two stroke on cylinder (Tiger 2500 DC) and prepare detail drawing which contain all required information about the crank shaft .the final goal is to prepare sheet ready for manufacturing for generator crank shaft so it could be can be produced in workshop .the modeling of the crank shaft were done using solid works software and the analysis were made using ANSYS software.

4-2 Model Part specification

Table 4.1 : Part specification

No.	**Part Name**	**Material**	**Quantity**
1	Right side of the crank shaft	Low carbon steel	1
2	Left side of the crank shaft	Low carbon steel	1
3	Crankpin	High carbon steel	1

4-3: Modeling

One of the most important things in design is modeling which help in understand working mechanism and explain line component and process (modeling) performed used Solid work program.

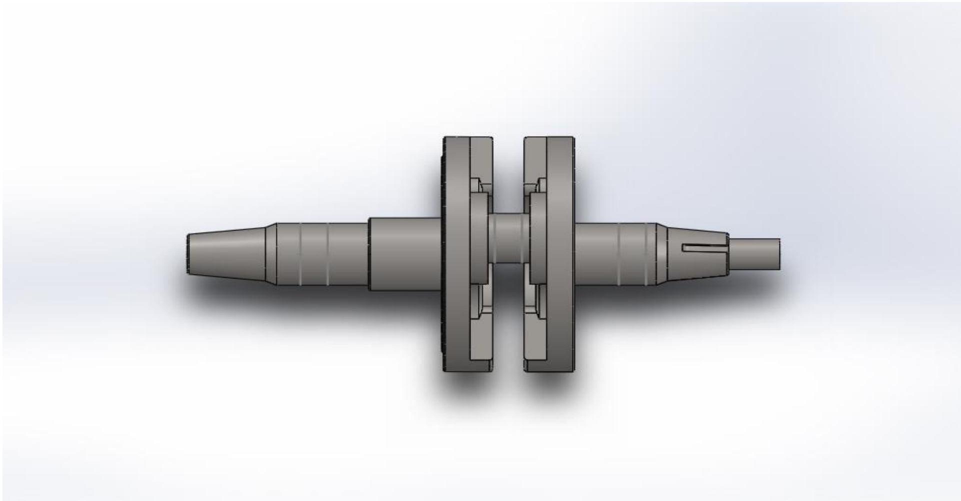


Figure (4.1) assembly model for the crankshaft

4.4 stress Analysis

Design analysis performed to the crankshaft to give confidence that component work correctly for a period of time with no failure (safe), In the analysis we compare the equivalent stress produced from specific applied force act in the crank shaft with the yield stress of the part's material if the equivalent stress exceed the yield stress that means the crank shaft will fail and don't success in its function.

When we divide the equivalent stress over yield stress the result must be more than one and we call it factor of safety which indicate to how much to the crank shaft can tolerate the load .There are a lot of programs dedicated for analysis and ANSYS is one of them and it used here for this purpose.

4.4.1 Equivalent stress

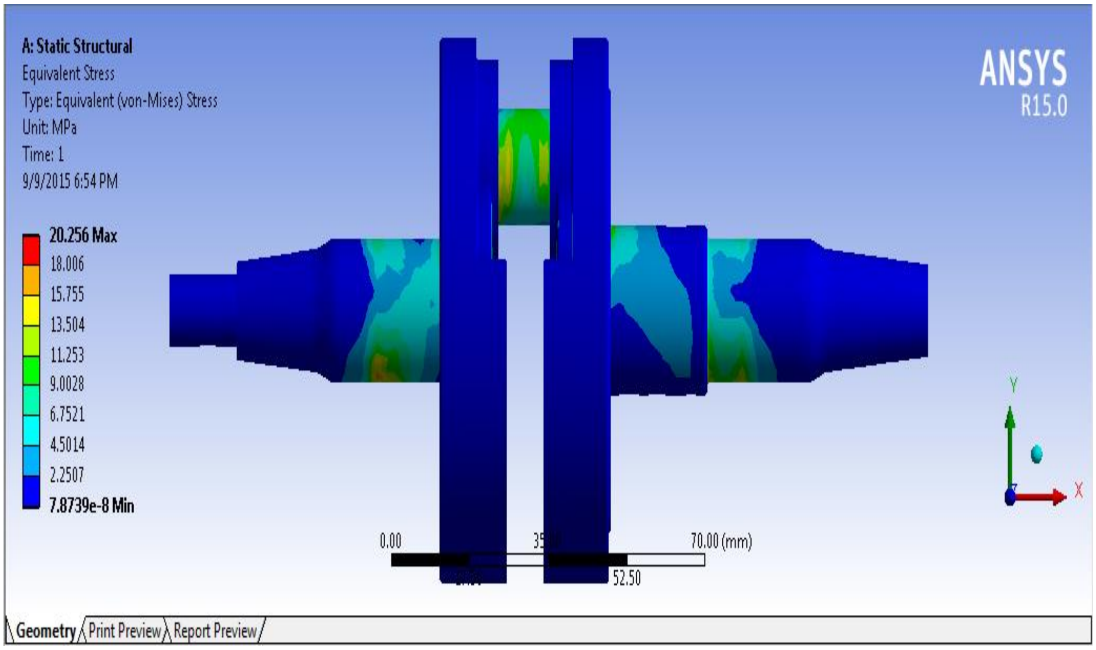


Figure (4.2) Equivalent stress using structural steel

Red color mean maximum Equivalent stress which equal 20.256 MPa and blue color mean minimum which equal 0.000000078739 MPa, yield stress =250 MPa safety factor =1.2

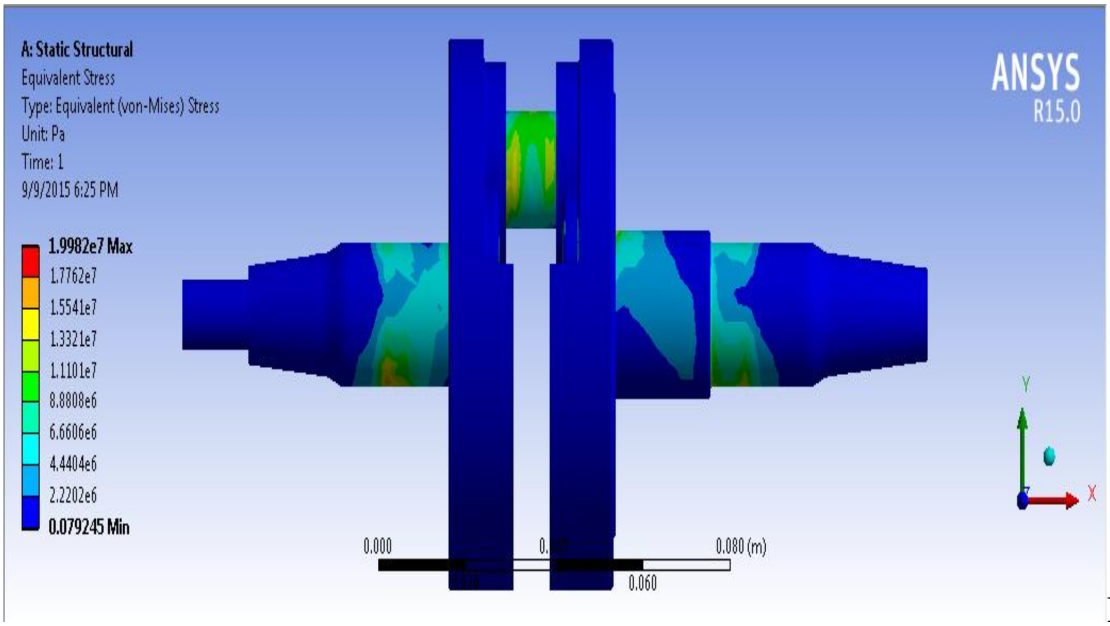
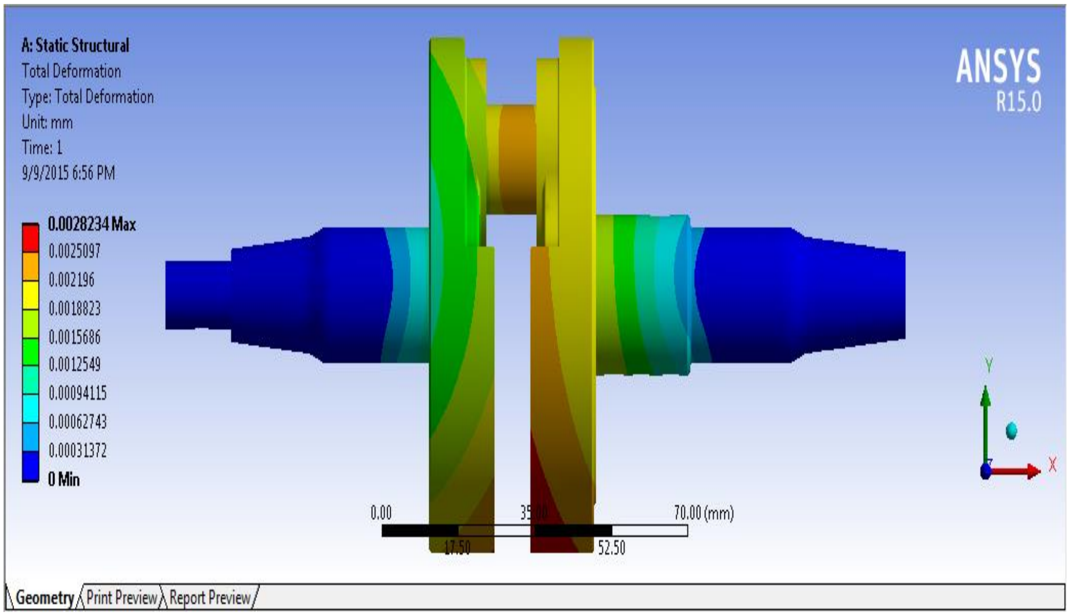


Figure (4.3) Equivalent stress using carbon steel

Red color mean maximum Equivalent stress which equal 19.982 MPa and blue color mean minimum which equal 0.000000079245 MPa, yield stress =250 MPa safety factor =1.2.

4.4.2 Total Deformation



Figure(4.4)Total Deformation using structural steel

Red color means maximum total deformation which equal 0.0028234 mm and blue color mean minimum deformation which equal zero.

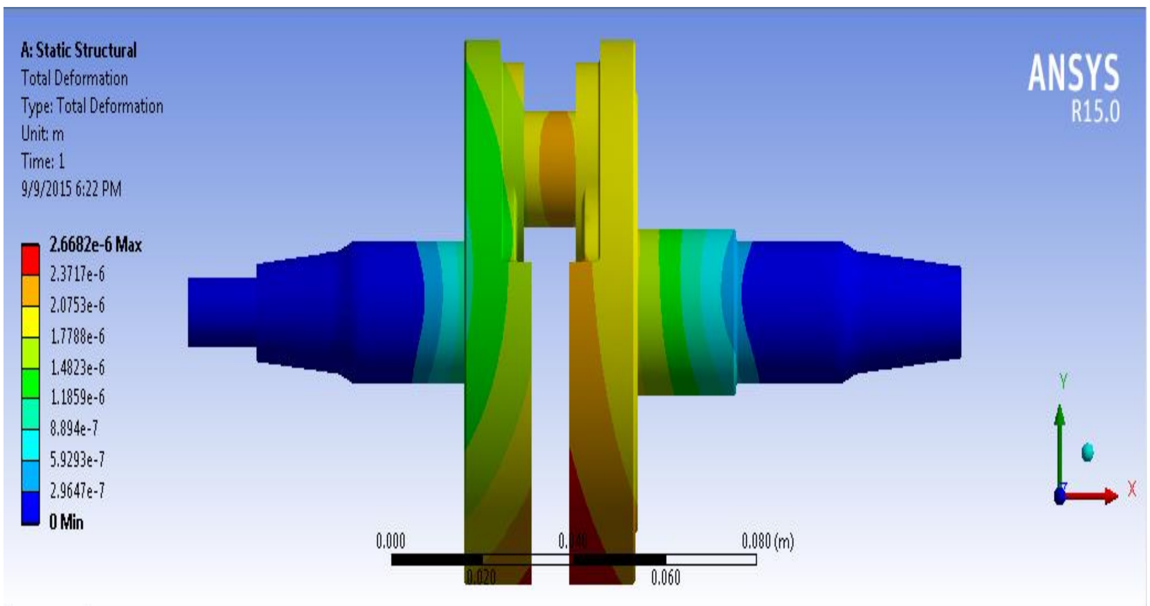


Figure (4.5) Total Deformation using carbon steel

Red color means maximum total deformation which equal 0.0.0027 mm and blue color mean minimum deformation which equal zero.

4.4.3 Maximum Principal Stress

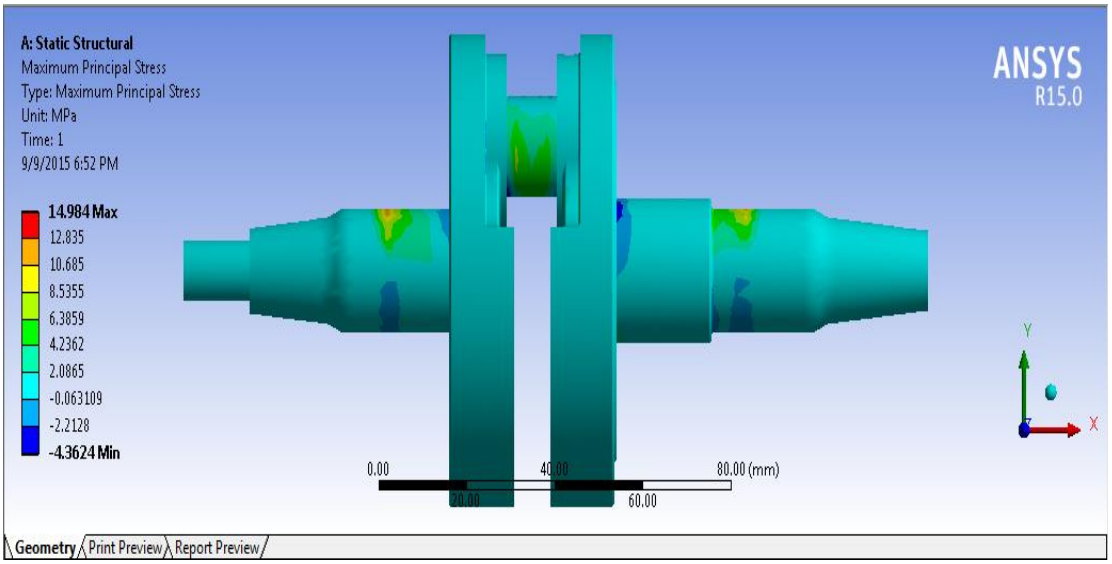


Figure (4.6) Maximum Principal Stress using structural steel

Red color mean maximum stress which equal 14.984 Mpa and blue color mean minimum which equal -4.3624 Mpa, yield stress =250 Mpa

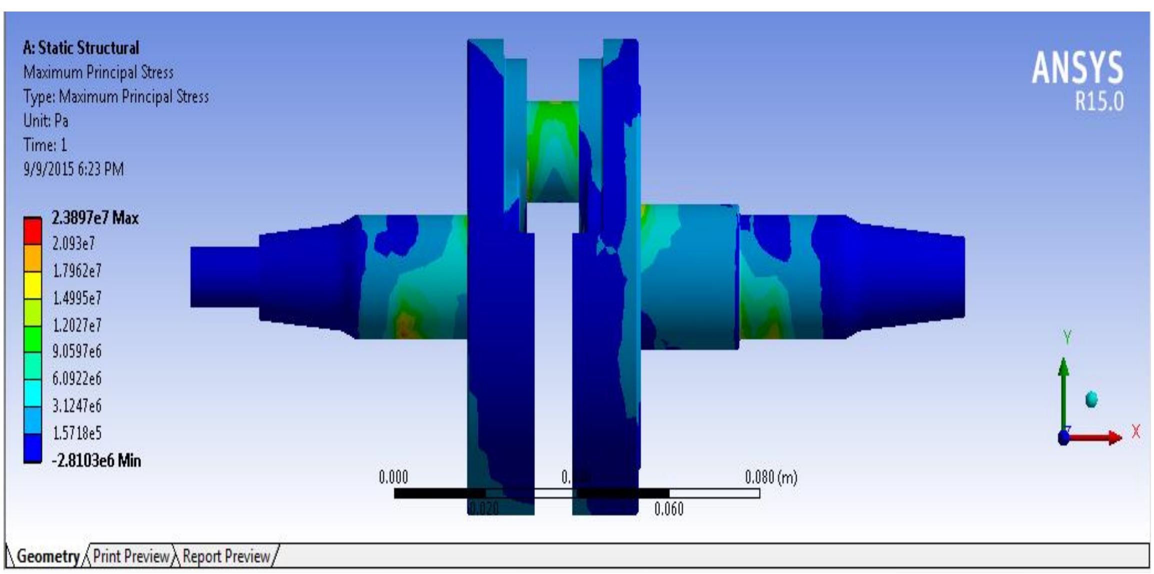


Figure (4.7) Maximum Principal Stress using carbon steel

Red color means maximum Principal Stress which equal 23.897 Mpa and blue color means minimum Principal Stress which equal -2.8103Mpa.

4-5: Dynamic Analysis

Crankshaft is a large component with a complex geometry in the engine, which converts the reciprocating displacement of the piston to a rotary motion with a four link mechanism. This study was conducted on a single cylinder two stroke cycle engine.

In this study a dynamic simulation was conducted on a crankshaft from a single cylinder two stroke engine. The dynamic analysis was done by simulation in ANSYS

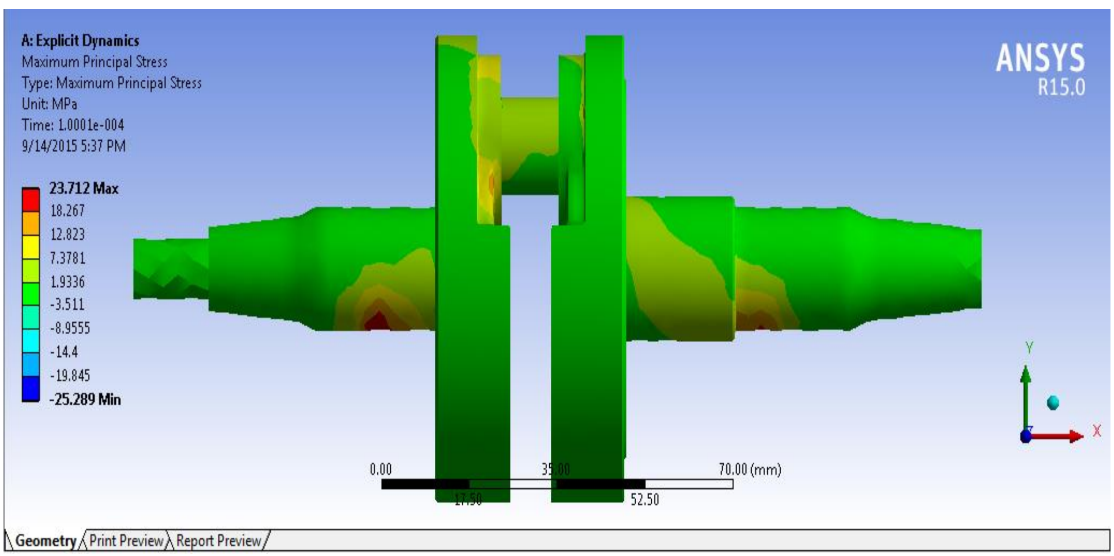


Figure (4.8) Maximum Principal Stress using structural steel

Red color means maximum Principal Stress when we use structural steel which equal 23.7122 Mpa and blue color means minimum Principal equal -25289 Mpa

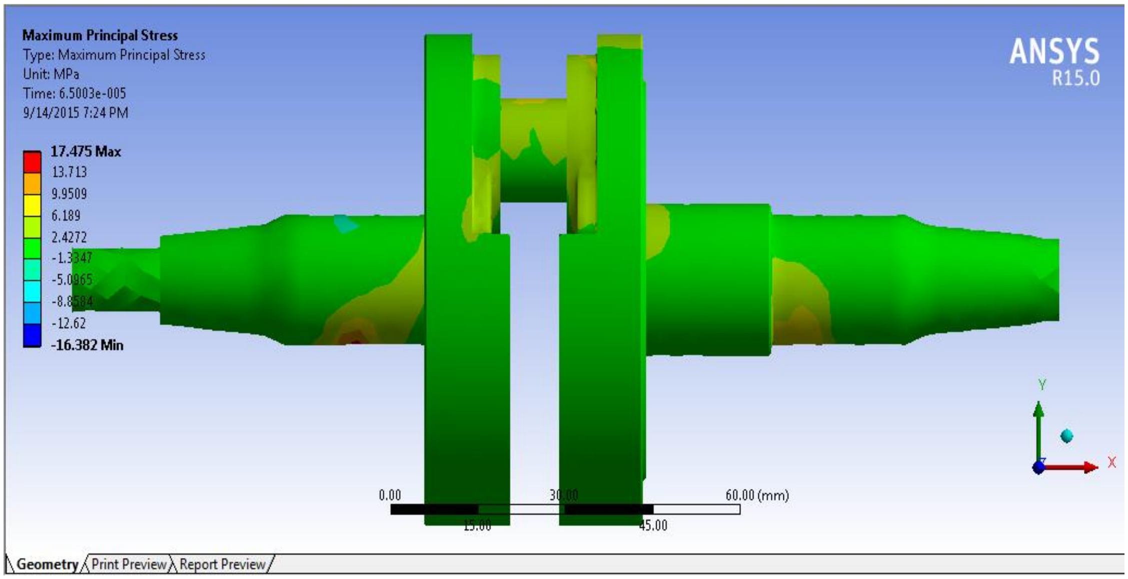


Figure (4.9) Maximum Principal Stress using carbon steel

Red color means maximum Principal Stress when we use carbon steel which equal 17.475 Mpa and blue color means minimum Principal Stress which equal -16.382 Mpa.

4.6 Discussion

From the static analysis noticed that the Maximum Principal Stress using structural steel is 14.984 Mpa and Maximum Principal Stress using carbon steel is 23.897 Mpa .

From the dynamic analysis had be notice that the Maximum Principal Stress using structural steel is 17.475 Mpa and Maximum Principal Stress using carbon steel is 23.712 Mpa.

From the results above had be notice that carbon steel is approval for the design and manufacturing of the crankshaft since the Maximum Principal Stress of the carbon steel from the results is lower than t he it’s yield strength .

Chapter Five

Conclusions and Recommendation

5-1: Conclusion

The new design is similar to old design in form, dimension and mechanism but there are some differences in material because the new material is suitable, available, and can work properly in Sudan environment without failure.

The prototype was made of low carbon steel and high carbon steel. The yield strength of low carbon steel is 250mpa and for high carbon steel is 400mpa. The material chosen for model was structural steel which has the same yield strength of low carbon steel. From the analysis is same that high carbon steel is more /probable for the design of the crankshaft.

5-2: Recommendation

From the chemical analysis for the actual model it had been noticed that part 1 and part 2 were made from low carbon steel to reduce the cost which directly affect the efficiency of the crankshaft. also from the chemical analysis it had been noticed that part3 were made from high carbon steel because the force act on it so it must have high yield strength to resist the force.

From the mechanical analysis it had been noticed that the hardening of the crankshaft is just on surface.

From the above to increase the life time of the crankshaft it recommend that the three parts of the crankshaft should be manufactured from high carbon steel and there must be total and deep hardening of the crankshaft.

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