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Design Analysis of Connecting Rod and Crank Shaft

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ABSTRACT

The connecting rod is the intermediate member between the piston and the crankshaft. Its primary function is to transmit the push and pull from the piston pin to the crank pin and thus convert the reciprocating motion of the piston into rotary motion of the crank.In our project we design a connecting rod for a diesel engine for two different materials Carbon Steel,forzen steel and Aluminum alloy. Both the designs are modeled in 3D modeling software CATIA.The designs are validated by performing the structural analysis on connecting rod under different load conditions in analysis software Ansys 14.5. In structural analysis, the constraint is STRESS, STRAIN and deformation. We have done static analysis on connecting rod. Optimization is done to verify the better material for connecting rod

INTRODUCTION: Connecting rods are widely used in variety of car engines. The function of connecting rod is to transmit the thrust of the piston to the crankshaft, and as the result the reciprocating motion of the piston is translated into rotational motion of the crankshaft. It consists of a pin-end, a shank section, and a crank end. Pin-end and crank-end pin holes are machined to permit accurate fitting of bearings. One end of the connecting rod is connected to the piston by the piston pin. The other end revolves with the crankshaft and is split to permit it to be clamped around the crankshaft. The two parts are then attached by two bolts. Connecting rods are subjected to forces generated by mass and fuel combustion. These two forces results in axial and bending stresses. Bending stresses appear due to eccentricities, crankshaft, case wall deformation, and rotational mass force. Therefore, a connecting rod must be capable of transmitting axial tension, axial compression, and bending stresses caused by the thrust and pull on the piston and by centrifugal force. The connecting rod of the tractors is mostly made of cast iron through the forging or powder metallurgy. The main reason for applying these methods is to produce the components integrally and to reach high productivity with the lowest cost. Nevertheless, connecting rod design is complicated because the engine is to work in variably complicated conditions and the load on the rod mechanism is produced not only by pressure but also inertia. When the repetitive stresses occur in connecting rod it leads to fatigue phenomenon which can cause so dangerous ruptures and damages. An example of the fatigue analysis and design was presented in 2003 by some researchers. A rupture due to the fatigue and the method of correcting the connecting rod design was also reported presented a strengthening method for the connecting rod design. Finite element (FEM) method is a modern way for fatigue analysis and estimation of the component longevity which has the following advantages compared to the other methods. Through this method, we can access the stress/strain distribution throughout the whole component which enables us to find the critical points authentically. This achievement seems so useful particularly when the component doesn't have a geometrical shape or the loading conditions are sophisticated. The influential component factors are able to change such as material, cross section conditions etc. Component optimization against the fatigue is performed easily and quickly. Analysis is performed in a virtual environment without any necessity for prototype construction. Totally these qualities, lead to savings in time and cost. For the reason that the connecting rod failure is usually due to the fatigue phenomenon, consequently in this research a U650 tractor connecting rod behavior, from the fatigue point of view, is investigated through the ANSYS software.

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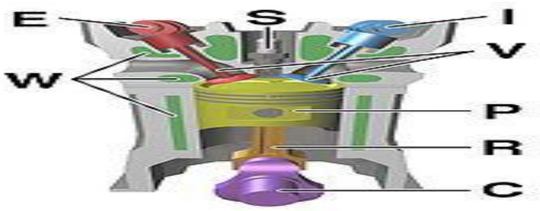
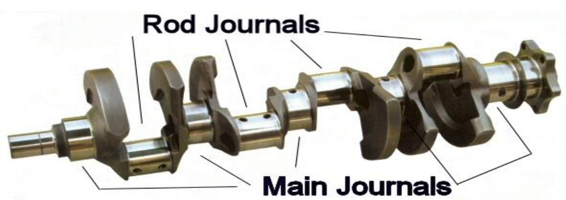
Design:



Components of a typical, four stroke cycle, DOHC piston engine. (E) Exhaust camshaft, (I) Intake camshaft, (S) Spark plug, (V) Valves, (P) Piston, (R) Connecting rod, (C) Crankshaft, (W) Water jacket for coolant flow. Large engines are usually multicylinder to reduce pulsations from individual firing strokes, with more than one piston attached to a complex crankshaft. Many small engines, such as those found in mopeds or garden machinery, are single cylinder and use only a single piston, simplifying crankshaft design. This engine can also be built with no riveted seam



The crankshaft main journals rotate in a set of supporting bearings ("main bearings"), causing the offset rod journals to rotate in a circular path around the main journal centers, the diameter of which is twice the offset of the rod journals. The diameter of that path is the engine "stroke": the distance the piston moves up and down in its cylinder. The big ends of the connecting rods ("conrods") contain bearings ("rod bearings") which ride on the offset rod journals.

FORCES IMPOSED ON A CRANKSHAFT: The obvious source of forces applied to a crankshaft is the product of combustion chamber pressure acting on the top of the piston. High-performance, normally-aspirated Spark-ignition (SI) engines can have combustion pressures in the 100-bar neighborhood (1450 psi), while contemporary high-performance Compression-Ignition (CI) engines can see combustion pressures in excess of 200 bar (2900 psi). A pressure of 100 bar acting on a 4.00 inch diameter piston will produce a force of 18,221 pounds. A pressure of 200 bar acting on a 4.00 inch diameter piston produces a force of 36,442 pounds. That level of force exerted onto a crankshaft rod journal produces substantial bending and torsional moments and the resulting tensile, compressive and shear stresses. However, there is another major source of forces imposed on a crankshaft, namely Piston Acceleration. The combined weight of the piston, ring package, wristpin, retainers, the conrod small end and a small amount of oil are being continuously accelerated from rest to very high velocity and back to rest twice each crankshaft revolution. Since the force it takes to accelerate an object is proportional to the weight of the object times the acceleration (as long as the mass of the object is constant), many of the significant forces exerted on those reciprocating components, as well as on the conrod beam and big-end, crankshaft, crankshaft, bearings, and engine block are directly related to piston acceleration. Combustion forces and piston acceleration are also the main source of external vibration produced by an engine.

However, the counterweights are not always directly opposite the rod journals. For example, the commonly-used production version of a two-plane 90° V8 crankshaft has no counterweights around the center main journal, as shown in Figure 1 above. In that case, the centroid of each counterweight, instead of being 180° from its respective journal, is offset (to approximately 135°) in order to place the net counterbalancing forces in the optimal location. Note also (in Figure 1**)** that the front and rear counterweights are larger (thicker) than the others in

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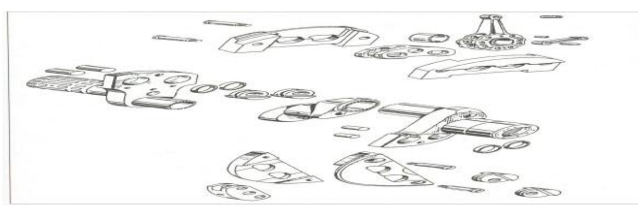
order to fully counterbalance the end-to-end moments.

Crankshafts at the upper end of the motorsport spectrum are manufactured from billet. Billet crankshafts are fully machined from a round bar ("billet") of the selected material (**Figure 4**). This method of manufacture provides extreme flexibility of design and allows rapid alterations to a design in search of optimal performance characteristics. In addition to the fully-machined surfaces, the billet process makes it much easier to locate the counterweights and journal webs exactly where the designer wants them to be. This process involves demanding machining operations, especially with regard to counterweight shaping and undercutting, rifle-drilling main and rod journals, and drilling lubrication passages. The availability of multi-axis, high-speed, high precision CNC machining equipment has made the carved-from-billet method quite cost-effective, and, together with exacting 3D-CAD and FEA design methodologies, has enabled the manufacture of extremely precise crankshafts which often require very little in the way of subsequent massaging for balance purposes.

There is an old argument that a forged crank is superior to a billet crank because of the allegedly uninterrupted grain flow that can be obtained in the forging process. That might be true of some components, but with respect to crankshafts, the argument fails because of the large dislocations in the material that are necessary to move the crankpin and counterweight material from the center of the forging blank to the outer extremes of the part. The resulting grain structure in the typical V8 crank forging exhibits similar fractured grain properties to that of a machined billet. More than one crankshaft manufacturer has told me that there is no way that a forging from the commonly used steel alloy SAE-4340 (AMS-6414) would survive in one of today's Cup engines. Some years ago, there was an effort at Cosworth to build a Formula One crankshaft by welding together various sections, which comprised the journals, webs and counterweights. The purported intent was to be better able to create exactly the shape and section of the various components, thereby reducing MMOI while achieving the same or better stiffness. While no one was willing to divulge details about the effort, it is rumored to have been run once or twice then abandoned due to the high cost and complexity compared to the measurable benefits.



A crankshaftis 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.It is typically connected 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 torsional vibrations often caused along the length of the crankshaft by the cylinders farthest from the output end acting on the torsional elasticity of the metal.

CATIA: CATIA - which stands for Computer Aided Three-dimensional Interactive Application - is the most powerful and widely used CAD (computer aided design) software of its kind in the world. CATIA is owned/developed by Dassault Systems of France and until 2010, was marketed worldwide by IBM. Anything and everything you see had to be designed before it could be manufactured. The pen on your desk, your desk, and the chair you're sitting in, your appliances, your automobile, etc. The list is almost endless. Today, nearly all products are designed on computers. Computers are even designed on computers. CATIA plays a major role in the design process. Architects are now using CATIA. The great Guggenheim Museum in Spain, considered an architectural masterpiece, was designed using CATIA.CATIA is used by the automotive and aerospace industries for automobile and aircraft product and tooling design. There are thousands of companies the world over using CATIA. For every company that uses CATIA for product design, there are hundreds of suppliers to those companies that also use CATIA. CATIA is found in a variety of industries throughout the world. Some of these industries include; Aerospace, Appliances, Architecture, Automotive, Construction, Consumer Goods, Electronics, Medical, Furniture, Machinery, Mould and Die, and Shipbuilding.CATIA has played a major role in NASA's design of the Space Shuttle. The military - working with private industry uses CATIA for the design of "jet-fighter" aircraft, aircraft carriers, helicopters, tanks and various other forms of weaponry.

Systems engineering: The CATIA Systems Engineering solution delivers a unique open and extensible systems engineering development platform that fully integrates the cross-discipline modeling, simulation, verification and business process support needed for developing complex 'cyber-physical' products. It enables organizations to evaluate requests for changes or develop new products or system variants utilizing a unified performance based systems engineering approach. The solution addresses the Model Based Systems Engineering (MBSE) needs of users developing today's smart products and systems and comprises the following elements: Requirements Engineering, Systems Architecture Modeling, Systems Behaviour Modeling & Simulation, Configuration Management & Lifecycle Traceability, Automotive Embedded Systems Development (AUTOSAR Builder) and Industrial Automation Systems Development (Control Build).CATIA uses the open Modelica language in both CATIA Dynamic Behaviour Modelling and Dymola, to quickly and easily model and simulate the behavior of complex systems that span multiple engineering disciplines. CATIA &Dymola are further extended by through the availability of a number of industry and domain specific Modelica libraries that enable user to model and simulate a wide range of complex systems – ranging from automotive vehicle dynamics

Electrical systems: CATIA offers a solution to facilitate the design and manufacturing of electrical systems spanning the complete process from conceptual design through to manufacturing. Capabilities include requirements capture, electrical schematic definition, interactive 3D routing of both wire harnesses and industrial cable solutions through to the production of detailed manufacturing documents including form boards.

Fluid systems: CATIA offers a solution to facilitate the design and manufacturing of routed systems including tubing, piping, Heating, Ventilating & Air

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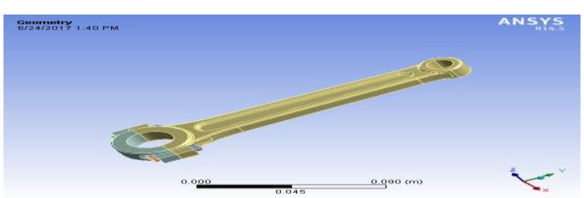
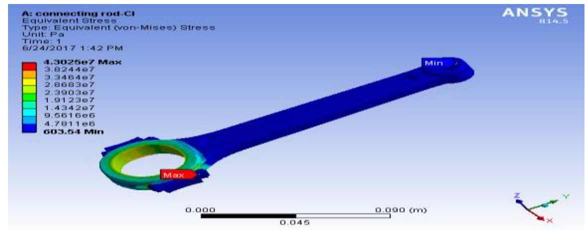
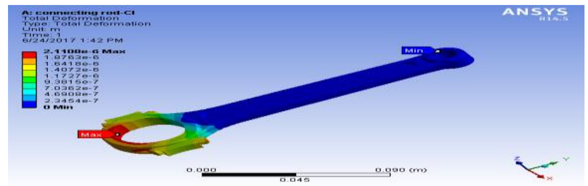
Conditioning (HVAC). Capabilities include requirements capture, 2D diagrams for defining hydraulic, pneumatic and HVAC systems, as well as Piping and Instrumentation Diagram (P&ID). Powerful capabilities are provided that enables these 2D diagrams to be used to drive the interactive 3D routing and placing of system components, in the context of the digital mock-up of the complete product or process plant, through to the delivery of manufacturing information including reports and piping isometric drawings.

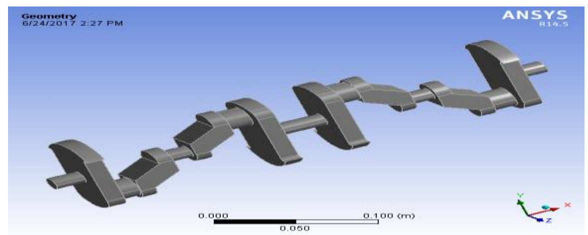
Industries; CATIA can be applied to a wide variety of industries, from aerospace and defence, automotive, and industrial equipment, to high tech, shipbuilding, consumer goods, plant design, consumer packaged goods, life sciences, architecture and construction, process power and petroleum, and services. CATIA V4, CATIA V5, Pro/ENGINEER, NX (formerly Unigraphics), and SolidWorks are the dominant systems

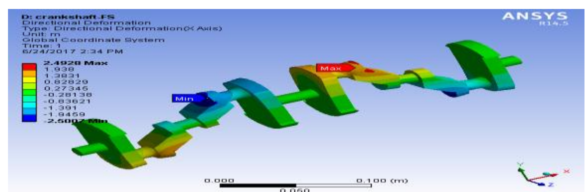
ANSYS: ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyse by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.











Conclusion: Connecting rod and Crankshaft are one of the critical components for the effective and precise working of the internal combustion engine. In this project a structural analysis is conducted on connecting rod and crankshaft from a 4 cylinder diesel engine. A three-dimension model of diesel engine connecting rod and crankshaft is created using Catia software. Finite element analysis (FEA)is performed to obtain the variation of stress magnitude at critical locations. Simulation inputs are taken from the engine specification chart. The structural analysis is done using FEA Software ANSYS which resulted in the load spectrum applied to connecting rod and crank. This load is applied to the FE model in ANSYS, and boundary conditions are applied according to the engine mounting conditions. The analysis is done for finding critical location in connecting rod and crankshaft. Stress variation over the engine cycle and the effect of deformations are investigated. The materials used in this project are cast iron, forged steel and 42CrMn alloy. As we observe in the analysis in the connecting rod and crankshaft we have done the static analysis if we observe in this models here we have found out the stress are almost near for all the materials. Here forged steel material strain, deformation and directional deformation are less to compare to other materials. We can conclude that the forged steel material is the best material for connecting rod and crank shaft and has the better life efficiency and better output.

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