Modeling of a Radial Engine and Analysis of Articulated Rod

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Abstract - This report is deals with Modeling of Radial Engine and Analysis of Articulated Rod. The aim of the project is to model a five cylinder radial engine and to perform static analysis on articulated rod under known constrains and load conditions. The analysis has been performed on a full section of the given nodes. The functioning of Articulated Rod is similar to that of a connecting rod (i.e. to convert the reciprocating motion of the piston into rotary motion of crank shaft as in an I.C. Engine). Following design & analysis procedure is conducted. First The modeling part is done using Pro/Engineer software and the static analysis of articulated rod is done using ANSYS.

Keywords: Radial Engine; Articulated Rod; Pro/Engineer; Ansys Workbench Software

1. INTRODUCTION

An engine is a device which transforms one form of energy in to another form. However, while transforming from one form to another form, the efficiency of conversion plays an important role. Normally, a heat engine is a device which transforms the chemical energy of a fuel into thermal energy and utilizes this thermal energy to perform useful work [1]. Thus, thermal energy is converted to mechanical energy in a heat engine. Heat engines or broadly classified as two categories: Internal combustion engines (IC engines) is shown in Fig. 1 and External combustion engines (EC engines). As the name implies or suggests, the internal combustion engines are those engines in which the combustion of fuel takes place inside the engine cylinder. These are petrol, diesel and gas engines. In a steam engine, steam turbines the fuel which is feed into the cylinder, is in the form of steam which is already heated (or super heated) and is ready for working in the combustion cycle of the engine. But, in case of external combustion engines, the combustion of fuel takes place inside the engine cylinder by a spark and produces very high temperature as compared to steam engines [2].

The high temperature produced may ruin the metal of the cylinder, valve. It is therefore necessary to abstract some of the heat from the engine cylinder the abstraction of heat the cooling of cylinder may be effected by the surrounding air as in case of motor cycle or aero plane engine; or by the circulating water through the jackets surrounding the cylinder barrel and cylinder head [3]. The water cooling is mostly adopted for large pistons. Whereas external combustion engines or those in which combustion take place outside the engine.

Fig. 1 Internal combustion engines

Cylinder is one of the most important part of the engine in which the piston moves to and fro in order to develop power. Generally the engine cylinder has to withstand high pressure (move than 50 bar) and temperature (more than 200 degrees) thus the materials of engine cylinder should be such that it can retain sufficient strength at such a high pressure and temperature. For ordinary engines, the cylinder is made up of ordinary cast iron but for heavy duty engines it is made of steel alloys or aluminium alloys. In case of multiple cylinder engines, the cylinders are cast in one block known as cylinder block [4]. Cylinder head is fitted on one end of the cylinder and acts as a cover to close the cylinder bore. Generally, the cylinder head contains inlet and exit valves for admitting fresh charge and exhausting the burnt gases. In petrol engines the cylinder head also contains a spark plug for igniting the fuel air mixture, towards the end of compression stroke but in diesel engines the cylinder head contains nozzle (that is the fuel valve) for injecting the fuel into the cylinder.

The cylinder head is, usually, cast as one piece and bolted to one end of the cylinder. Generally, the cylinder block and cylinder head are made from the same material. A copper or asbestos gasket is provided between the engine cylinder head to make an air tight joint. Piston is considered as the heart of an IC engine, whose main function I to transmit the force by the burning of charge to the connecting rod. The piston is also greater Strength at higher temperatures. Piston rings are circular rings and made of special steel alloys which retain elastic properties even at high temperatures [5]. The piston rings are housed in the circumferential groves provided on the outer surface of the piston. Generally there are two sets of rings mounted for the piston the function of the upper rings is to provide air tight seal to pr event leakage of the burnt gasses into the lower portion. Similarly the
function of the lower rings is to provide effective seal to prevent leakage of the oil into the engine cylinder.

Connecting road is the link between the piston and crank shaft whose main function is to transmit force from the piston to the crank shaft. Crank shaft is considered as the back bone of an IC engine whose function is to convert the reciprocating motion of the piston into the rotary motion with the help of connecting rod. This shaft contains one or more eccentric portions called the cranks. That part of the crank to which bigger end of the connecting rod is fitted is called the crank pin. Special steel alloys are used for the manufacture crank shaft a special care is required for the design and manufacture of the crank shank. Crankcase is a cast iron case which holds the cylinder and crank shaft of an IC engine. It also server a stamp for the lubricating oil. The lower portion of the crank case is known as the bed plate which is fixed with the help of bolts. Fly wheel is a big wheel mounted on the crank shaft whose function is to maintain its speed constant it is done by storing excess energy during the power stroke which is returned during other strokes [6].

The nominal inner diameter of the working cylinder is called the cylinder bore and is designed by the letter “d”. The area of a circle of diameter equal to the cylinder bore is called the piston area and is designed by the letter “A”. The nominal distance through which a working piston moves between two successive reversals of its direction of motion is called the stroke and is designed by the letter l. The position of the working piston and the moving parts which are mechanically connected to it at the moment when the direction of the position is reverse at either end of the stroke is called is dead centre there are two dead centers in the engine one top dead centre two bottom dead centers. It is dead centre when the piston is farthest the crankshaft. It is designed as TDC. It is called as inner dead center. It is dead centre when the piston is nearest to the crankshaft. It is designed as BDC. It is called the outer dead center [7].

2. INTRODUCTION TO RADIAL ENGINE

The radial engine has been the work horse of military & commercial air craft ever since the 1920’s and the world war-I is shown in Fig. 2. Radial engine was used in al U.S. Bombers and transports aircraft and in the most of the other categories of aircrafts. They were developed to a peak of efficiency and dependability and even today. In the jet age, many are still in operation throughout the world in all types of duty [8].

The radial engines reached their Zenith during WWII (World War II). There are some radial engines around today, but they are not that common. Most propeller-driven planes today use more traditional engine configurations (like a flat four-cylinder) or modern gas turbine engines. Gas turbines are much lighter than radial engines for the power they produce. The radial engine idea is very simple; it takes the pistons and arranges them in a circle around the crankshaft.

2.1 Radial Engine

The radial engine has the lowest weight to horse power ratio of all the different types of piston engines. It has the advantages of greater during because of the area preserved to the air, and it eliminates some problem in cooling. However dependability and efficiency of engine have made it mostly widely used type of large aircraft equipped with reciprocating engine [9].

A Single row radial engine has a odd number of cylinders extending radially from the centre line of the crank shaft. The number of cylinders usually ranges from 5 to 9 cylinders. The radially engine are arranged even ally in the same circular plane, and all the pistons are connected to a single throw 360° crankshaft thus reducing the both the number of working parts and the weight.

2.2 Types of Radial Engine’s

These are types of radial engines: 3-CYLINDER ENGINE (Szekely SR-3L), 5-CYLINDER ENGINE (Kinner K5), 6 - CYLINDER ENGINE (Curtiss Challenger R-600), 7- CYLINDER ENGINE (Jacobs R-755) and 9- CYLINDER ENGINE (Wright Cyclone r-1820).

2.3 CAD/CAM/CAE

Computer-aided design (CAD) is the use of a Wide range of computer-based tools that assist engineers, architects and other design professionals in their design activities. It is the main geometry authoring tool within the product Lifecycle Management process and involves both software and sometimes special-purpose hardware. Current packages range from 2D vector based drafting systems to 3D parametric surface and solid design modelers.
CAD Packages can be classified into three types: 2D drafting systems (e.g. Auto CAD, Micro station); mid-range 3D solid feature modelers (e.g. Iron CAD, Solid works, Solid Edge); and high-end 3D hybrid systems (e.g. Pro/ENGINEER, CATIA, NX Unigraphics) is shown in Fig. 3. Computer-aided manufacturing (CAM) is the use of computer-based software tools that assist engineers and machinists in manufacturing product and components. CAM is a programming tool that makes it possible to manufacture physical models using computer aided design (CAD) programs.

CAM has been considered as a numerical control (NC) Programming tool wherein three dimensional (3D) models of components generated in CAD software are used to generate CNC code to drive numerically controlled machine tools. Computer-aided engineering (CAE) is the use of information technology to support engineers in tasks such as, analysis, simulation, design, manufacture, planning, diagnosis, and repair. Software tools that have been developed to support these activities are considered CAE tools. CAE tools are being used, for example, to analyze the robustness and performance of components and assemblies. The term encompasses simulation, validation and optimization of products and manufacturing tools. In the future, CAE systems will be major providers of information to help support design teams in decision making. CAD/CAM and CAE are used to design and develop products, which can be goods used by end consumers or intermediate goods.

2.4 Capabilities of CAD/CAM and CAE Systems

The Capabilities of modern CAD/CAM and CAE Systems include:

- 3D parametric feature based modeling. Solid modeling
- Automated design of assemblies, which are collections of parts and/or other Assemblies.
- Create Engineering drawings from the solid models.
- Re-use of design components
- Ease for modification of design of model and the production of multiple versions
- Automatic generation of Standard components of the design
- Validation/verification of designs against specifications and design rules.
- Simulation of designs without building a physical prototype
- Output of engineering documentation, such as manufacturing drawings, and Bills of materials to reflect the BOM required building the product.
- Import/Export routines to exchange data with other software packages.
- Output of design data directly to manufacturing facilities.

3. INTRODUCTION TO PRO/E

As the words one of the supplier of software, specially intended to support a total link integrated product development process, parametric technology corporation (PTC) is recognized as a strategic power which can help to manufacture to turn a process into competitive advance, greater market share and higher profit and information management. Fully associated pro/E solutions encompass all aspects of the development cycle and cut design time by half, improve product quality and ensure a team’s success. Pro/E mechanical design solution will improve our design productivity allowing us to finish more complex and challenging project in less time. Leading companies around the world have standardization on pro/E to help their design and cover today’s most comprehensive, integrated project product development environment available today. PTC’s mechanical design solution delivers all the tools we need to transform the product development process into strategic competitive advantage for any company. Pro/E engineer provides engineers with a revolutionary to approach to mechanical design automation based on a unique, parametric, feature based solid modeling technology.

Feature-based means that we create parts and assemblies by defining feature like extrusion, slots, holes rounds and so on, instead of specifying low-level geometry like lines, circles and arc. Parametric means that physical shape of the part or assembly is driven by the values assigned other attributes (primary dimensions) of its features. We may define or modify the feature dimensions or other attributes at any time (within limits) is shown in Fig. 4. Any change will automatically propagate through the model. Solid modeling means that the computer model we create is able to contain all the information that a real solid object would have. It has volume and therefore, if you provide a value for the design of the material, if has mass inertia. Unlike a surface model knows which side of this surface is solid material. The most useful thing about solid modeling is that is impossible to create a computer model that is ambiguous or physically non-realizable.

Sketch module enables to create section. Sketcher techniques are in used in many areas of pro/E. using sketcher mode we create geometry without regard to the exact relationship between parts of the sketcher or the exact values of dimensions. When we generate the sections, pro/E makes explicit assumptions is shown in Fig. 5 and Fig. 6. This starts by adding a set of default datum planes and creating the first solid and surface features, then continue to add to achieve the designed shape by creating various construction features are protrusions, slots, and cuts, holes, shafts, chamfers, ribs, shells, pipes etc. Using convection CAD systems mainly uses this module to create complex 3-D images those are otherwise difficult to create. It mainly includes features like sweep, blend, helical sweep and variable section blend etc.
4. RESULTS AND DISCUSSION

Drawing module available with basic pro/E provides us with the basic functionally document, our solid modules or surface modules. Drawing share a two-way associates with the model, when we makes changes to the model in the part or assembly mode, the system automatically updates and reflects the changes likewise, any changes that we make to the model in drawing mode, become immediately visible on other modes. It extends the drawing capability offered by pro/E. We can use basic pro/E as a standalone product to create, view and annotate models and drawings. Pro/E detail supports additional view types and multi sheets. It offers numerous commands for manipulating items in a drawing and enables us to add it to customize engineering drawing with sketched geometry, create drawing formats and makes multiple cosmetic changes to drawings.

There are a number ways that will be inserted with the program, involving menu picks, keyboard entry and special mouse functions. Pull down menus: the main pulls down menus are inserted across the top of pro/E window. The file menu is clicked to open it and a list of direct analogs and functions similar to windows command appear. The curser is moved across to each pull down menu is turned when we have a quick link at the available commands. Some menu commands open up a second level menu. Commands available in the current contexts are always grayed out. Short cotton buttons: immediately below the pull down menu is a row shortcut buttons, some buttons appear on this row under different parts of the program. Then the cursor is moved across the buttons, a pop up button will tell the name of the button. Also the command is described in a line of text below the command message window. New buttons can be added to customize this area. Special mouse functions: locations within the graphic window are generally identified using a left mouse click. However, all three-mouse buttons have been set up to provide short cut for operations within the graphic window. Pro/E effort intelligent product modeling, is consisting familiar parametric features that any change. Finite Element Analysis, today, has become a powerful tool in obtaining numerical solutions for a wide of range of engineering problems.

Operations done in ANSYS
1. Import the IGES model to ANSYS
2. Brick 8 node 45 is chosen as the element type
3. The model was meshed by choosing a smart size 4
4. The left side lower end was constrained
5. Load was applied on the Right side at a node 1715
6. The LS was solved and required contours were plotted
7. Importing and analyzing above file in ANSYS Multi physics
8. Imported model in ANSYS
5. CONCLUSION

The present model 5-cylidered radial engine is successfully modeled using Pro/Engineer software. The stress values obtained during the analysis of articulated rod using Ansys are found to be well within the limits and the model is found to be safe under the given loading and boundary conditions. The time consumed in modeling and manufacturing has drastically reduced. With the usage of ANSYS software the dimensional accuracy can be maintained and it enhances the speed of solution reduced time factor. We can distinguish the stress and deflection at various places and also we can find out failure region.

REFERENCES


