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Design and Analysis Connecting Rod Made Up of Alloy Steel (35Mn_2Mo28) & Alloy Aluminum (74530) By Using Ansys

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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, thus converting the reciprocating motion of the piston into rotary motion of the crank. Existing connecting rod is manufactured by using Carbon steel. This paper describes modeling and analysis of connecting rod. In this project connecting rod is replaced by alloy steel (35mn2mo28) & alloy aluminum (74530). A 2D drawing is drafted from the calculations. A parametric model of connecting rod is modeled using PRO-E 4.0 software. Analysis is carried out by using ANSYS software. Finite element analysis of connecting rod is done by considering two materials, viz... alloy steel (35mn2mo28) & alloy aluminum (74530). The best combination of parameters like Von misses stress and strain, Deformation, Factor of safety and weight reduction for two wheeler piston were done in ANSYS software.**

Keywords: Rod, Alloy Steel, 35Mn_2Mo28, Alloy Aluminum, Ansys tool, Engineering Design.

I. INTRODUCTION

Today, connecting rods are best known through their use in internal combustion piston engines, such as automotive engines. These are of a distinctly different design from earlier forms of connecting rods, used in steam engines and steam locomotives. One source of energy in automobile industry is internal combustion engine.

Internal combustion engine converts chemical energy into Mechanical energy in the form of reciprocating motion of piston. Crankshaft and Connecting rod convert reciprocating motion into rotary motion. Connecting rod is one of the important driving parts of Light vehicle engine it forms a simple mechanism that converts linear motion into rotary motion that means the connecting rod is used to transfer linear, reciprocating motion of the piston into rotary motion of the crankshaft.

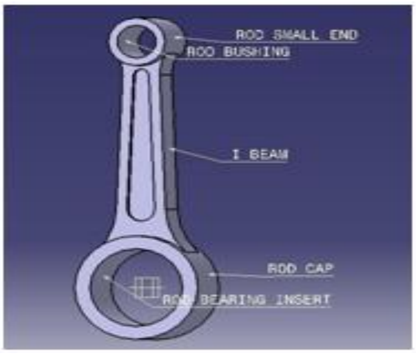

Figure 1: Connecting Rod Image

Connecting rod must be capable of transmitting axial tension, axial compression, and bending stress caused by the thrust and pull of the piston and by centrifugal force. The internal combustion engine connecting rod is critical component which is subjected to complex loading. There are various forces acting on connecting rod i.e. force on the piston due to gas pressure and inertia of the reciprocating parts, force due to inertia of the connecting rod or inertia bending forces, force due to friction of piston rings and of the piston, force due to friction of piston pin bearing and crank pin bearing. The inertia loads on connecting rod are varying time to time under in-service conditions. Connecting rod design is very complex because the connecting rod works in very complicated condition.

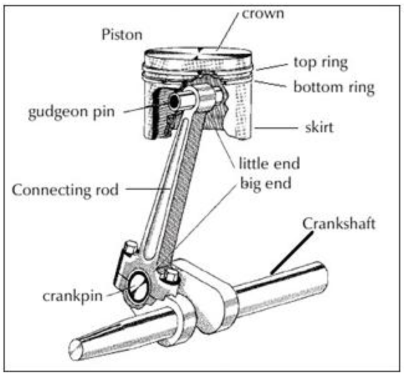

Figure 2: Assemble view of Connecting Rod

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Connecting rod is among large volume production component in the internal combustion engine. The maximum stress occurs in the connecting rod near the piston end due to thrust of the piston. The tensile and compressive stresses are produced due to the gas pressure, and bending stresses are produced due to centrifugal effect. From the viewpoint of functionality, connecting rods must have the highest possible rigidity at the lowest weight.

1.1 Connecting Rod

The intermediate component between crank and piston is known as connecting rod. Connecting rod is also known as connecting rod and is used to connect the piston to crankshaft. As a connecting rod is rigid, it may transmit either a push or a pull and so the rod rotates the crank through both halves of a revolution, i.e. piston pushing and piston pulling. Earlier mechanisms, such as chains, could only pull. In a few two stroke engines, the connecting rod is only required to push.

1.2 Classification of Connecting Rod

The classification of connecting rod is made by the cross sectional point of view i.e. I – section, H – section, Tabular section, Circular section. In low speed engines, the section of the rod is circular, with flattened sides.

1.3 Types of Connecting Rod

Connecting rod with nut and bolt- The connecting rod with cap at the larger end is joined by means of bolt and nut as shown in fig.1.5. This type of connecting rod is most widely used in multi cylinder engines. For example trucks, tractor etc.

Figure 3: Connecting Rod with nut and bolt

Connecting rod without nut and bolt – This type of connecting rod consist of single parts itself. And mostly used in single cylinder engine. For example bikes, scooter etc. This is shown in fig.1.6.

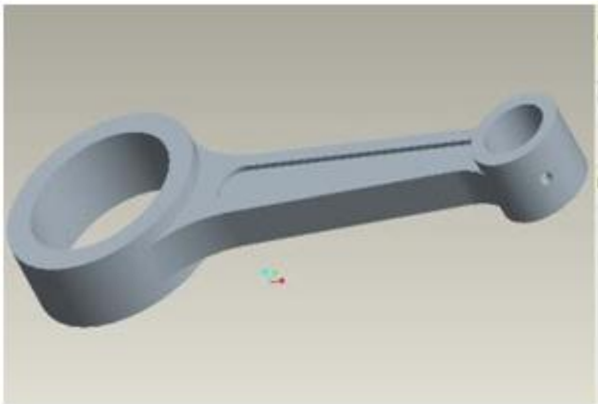

Figure 4: Connecting Rod without nut and bolt

1.4 General Materials Used In Connecting Rod

The connecting rod of internal combustion engines are mostly manufactured drop forging. It should have adequate strength and stiffness with minimum weight. The materials of connecting rods range from mild or medium carbon steels to alloy steels. In industrial engines, carbon steel with ultimate tensile strength ranging from 550 to 670 Mpa is used. In transport engines, alloy steel having strength of about 780 to 940 Mpa is used e.g., manganese steel is commonly used. For connecting rods of low speed horizontal gas engines, the Material may be sometimes steel casting. For high speed engines, the connecting rods may be made of Duralium and aluminum alloys.

II. SPECIFICATION OF THE PROBLEM

The objective of the present work is to design and optimize a connecting rod based upon its fatigue life. Steel and aluminum are used to analyze the connecting rod. The material of connecting rod will be optimized depending upon the analysis result. CAD model of connecting rod will be created in PRO-E and it'll be analyzed in ANSYS, FEMFAT and OPTISTRUCT. After analysis a comparison will be made between existing material and alternate material which will be suggested for the connecting rod in terms of weight, factor of safety, stiffness, deformation and stresses.

2.1 Stresses in Connecting Rod

The stresses in the connecting rod are set up by a combination of forces. They are induced in a connecting rod as combinations of axial stresses, bending stresses and thermal stresses which are subjected to during to cylinder gas pressure (Compressive only) and the inertia force arising on account of reciprocating action (both tensile as well as compressive), whereas bending discovery, volume 24, Number 83, October 4, 2014 stresses are caused due to the centrifugal effects. The various forces acting on the connecting rod are:

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- The combined effect of gas pressure on the piston and the inertia of the reciprocating parts.
- Friction of the piston rings and of the piston.
- Inertia of the connecting rod.
- The friction of the two end bearings i.e. of the piston pin bearing and the crank pin bearing.
- Thermal stresses.

III. EXPERIMENTATION DESIGN

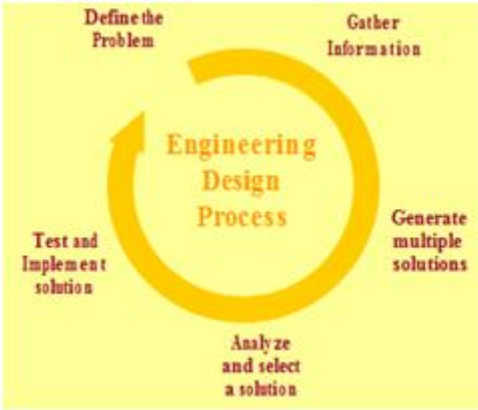
Upon creating a physical prototype identical in geometry and mechanical properties to the intended component during production, the same is set up for testing under identical service conditions for the component on field. A comparison of the results obtained through physical experimentation and the analytical (using simulation/ software) could offer a basis for validation.

3.1 Design Process

The basic five-step process usually used in a problem-solving works for design problems as well. Since design problems are usually defined more vaguely and have a multitude of correct answers, the process may require backtracking and iteration. Solving a design problem is a contingent process and the solution is subject to foreseen complications and changes as it develops. Until the Wright brothers actually built and tested their early gliders, they did not know the problems and difficulties they would face controlling a powered plane. The five steps used for solving design problems are

1. Define the problem
2. Gather pertinent information
3. Generate multiple solutions
4. Analyze and select a solution
5. Test and implement the solution

The first step in the design process is the problem definition. This definition usually contains a listing of the product or customer requirements and specially information about product functions and features among other things. In the next step, relevant information for the design of the product and its functional specifications is obtained. A survey regarding the availability of similar products in the market should be performed at this stage. Once the details of the design are clearly identified, the design team with inputs from test, manufacturing, and marketing teams generates multiple alternatives to achieve the goals and the requirements of the design. Considering cost, safety, and other criteria for selection, the more promising alternatives are selected for further analysis. Detail design and analysis step enables a complete study of the solutions and result in identification of the final design that best fits the product requirements. Following this step, a prototype of the design is constructed and functional tests are performed to verify and possibly modify the design. When solving a design problem, you may find at any point in the process that you need to go back to a previous step. The solution you chose may prove unworkable for any number of reasons and may require redefining the problem, collecting more information, or generating different solutions. This continuous iterative process is represented in the following figure.



The objective of the connecting rod is to connect the piston to the crank or crankshaft together with the crank; they form a simple mechanism that converts linear motion into rotating motion. The work described here carried out the design optimization of connecting rods using the ANSYS software. Due to market competitiveness it is important for clients to be able to produce an optimized preliminary design (with minimum weight in as short a time as possible). The optimization procedure was performed in two phases. Phase 1, was used to Optimize the small end and shank of the rod while Phase 2, was used for the big end. Typical design variables for Phase 1 were the width, depth and taper ratios of the shank, and the wall thickness of the small end.

Typical design variables for Phase 2 were the radius of the big end, and the objective function was to give the optimum design parameter. A number of random designs would be generated by varying the values of the design variables within the specified limits before the Optimizer 'homed' in to the best design.

As connecting rod is subjected to stresses caused by

- Combined effect of gas pressure on the piston and the inertia of the reciprocating parts,
- Friction of the piston rings and of the piston force and
- Inertia of the connecting rod.

It leads to stresses and deformation in connecting rod so a structural analysis of connecting rod has been carried out. The main objective of work is to suggest the optimum design

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parameter for the connecting rod. The strain and stress contours have been plotted and patterns are studied. The results are compared and verified with available existing results. The optimization of connecting rod also achieve reducing the weight of the engine component, thus reducing inertia load, reducing engine weight and improving the engine performance and fuel economy. The main design parameter of the connecting rod.

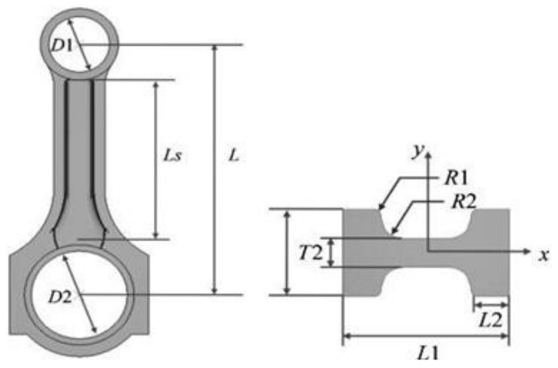

Figure 5: Design parameter of the Connecting Rod

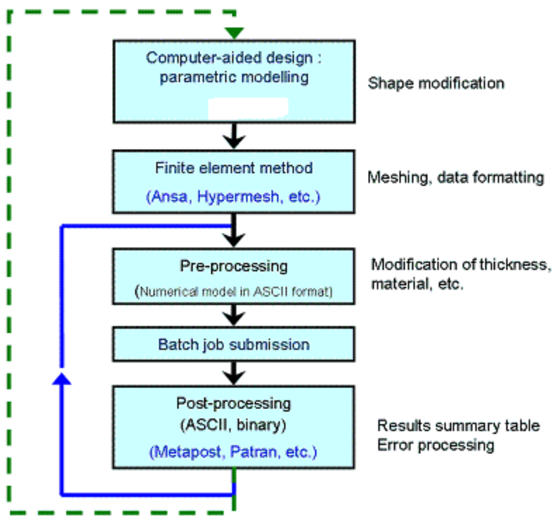

Figure 6: Application areas of CAD/CAM/CAE

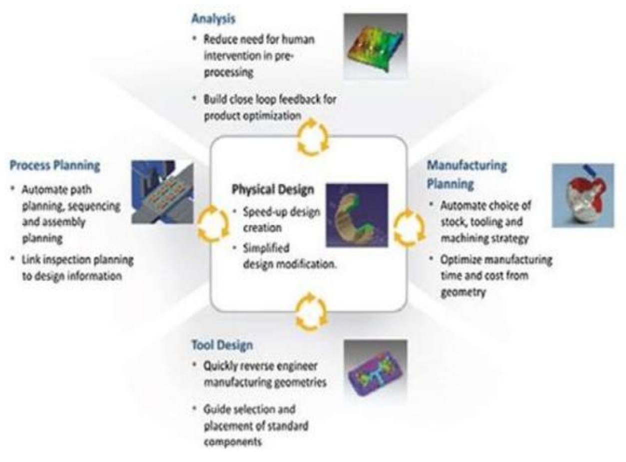

Figure 7: Process of ANSYS

3.2 Finite Element Analysis

FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition. There are generally two types of analysis that are used in industry: 2-D modeling, and 3-D modeling. While 2-D modeling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results.

Modeling, however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively. Within each of these modeling schemes, the programmer can insert numerous algorithms (functions) which may make the system behave linearly or non-linearly. Linear systems are far less complex and generally do not take into account plastic deformation. Non-linear systems do account for plastic deformation, and many also are capable of testing a material all the way to fracture.

Engineering analysis of mechanical systems have been addressed by deriving differential equations relating the variables of through basic physical principles such as equilibrium, conservation of energy, conservation of mass, the laws of thermodynamics, Maxwell's equations and Newton's laws of motion. However, once formulated, solving the resulting mathematical models is often impossible, especially when the resulting models are nonlinear partial differential equations. Only very simple problems of regular geometry such as a rectangular of a circle with the simplest boundary conditions were tractable.

The finite element method (FEM) is the dominant discretization technique in structural mechanics. The basic concept in the physical interpretation of the FEM is the subdivision of the mathematical model into disjoint (non-overlapping) components of simple geometry called finite elements or elements for short. The response of each element is expressed in terms of a finite number of degrees of freedom characterized as the value of an unknown function, or functions, at a set of nodal points.

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IV. METHODOLOGY USED

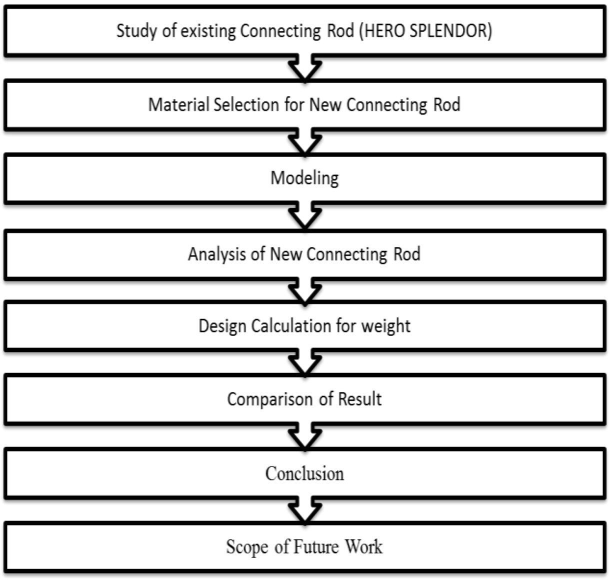

Table 1: Properties of Forged Alloy Steel

Material properties	Alloy steel (35Mn2Mo28) & Alloy Aluminum (74530) of value
Young's Modulus(E)	$2.1x10^5$Mpa
Poisson's Ratio	0.3
Density	7.2g/cc
Tensile Strength	750 Mpa
Volume	$14944mm^3$
Behavior	Isotropic

V. RESULT AND DISCUSSION

Effect of Alloying Elements Steel

5.1 Molybdenum

A very small quantity (0.15 to 0.30%) of molybdenum is generally used with chromium and manganese (0.5 to 0.8%) to make molybdenum steel. These steels possess extra tensile strength and are used for air-plane fuselage and automobile parts. It can replace tungsten in high speed steels.

5.2 Manganese

It improves the strength of the steel in both the hot rolled and heat treated condition. The manganese alloy steels containing over 1.5% manganese with a carbon range of 0.40 to 0.5% are used extensively in gears, axles, shafts and other parts where high strength combined with fair ductility is required. The principal uses of manganese steel are in machinery parts subjected to severe wear. These steels are all cast and ground to finish.

5.3 Vanadium

It aids in obtaining a fine grain structure in tool steel. The addition of a very small amount of vanadium (less than 0.2%) produces a marked increase in tensile strength and elastic limit in low and medium carbon steels without a loss of ductility. The chrome-vanadium steel containing about 0.5 to 1.5% chromium, 0.15 to 0.3% vanadium and 0.13 to 1.1% carbon have extremely good tensile strength, elastic limit, endurance limit and ductility. These steels are frequently used for parts such as springs, shafts, gears, pins and many drop forged parts.

5.4 Silicon

The silicon steels behave like nickel steels. These steels have a high elastic limit as compared to ordinary carbon steel. Silicon steels containing from 1 to 2% silicon and 0.1 to 0.4% carbon and other alloying elements are used for electrical machinery, valves in I.C. engines, springs and corrosion resisting materials.

5.5 Aluminum Alloy when Compared with Steel

- Aluminum is three times lighter than steel and yet can offer high strength when alloyed with the right elements.
- Aluminum can conduct electricity six times better than steel and nearly 30 times better than stainless steel.
- Aluminum provides excellent corrosion resistance.
- Aluminum is easy to cut and form.
- Aluminum is nontoxic for food applications.
- Aluminum is non-magnetic therefore arc blow is not a problem during welding.
- Aluminum has a thermal conductivity rate five times higher than steel. The high thermal conductivity creates a great heat sink which can create insufficient weld fusion on parts over 4 mm and weld burn through issues on parts less than 3 mm.
- Aluminum provides welds that are less viscous which is a problem when trying to get weld fusion with the short circuit mode. Pulsed MIG is beneficial on all aluminum applications. The viscosity is beneficial when using spray or pulsed transfer for all position welds.
- Aluminum has a low melting point 1,200 degrees F, this is more than half that of steel. For a given MIG wire diameter the transition short to spray weld current for aluminum is much lower than it is for steel.

VI. CONCLUSION

A parametric model of connecting rod is modeled using PRO-E 4.0 software and analysis is carried out by using ANSYS software. Finite element analysis of connecting rod is done by considering two materials, viz.. alloy steel

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(35mn2mo28) & alloy aluminum (74530). The best combination of parameters like Von misses stress and strain, Deformation, Factor of safety and weight reduction for two wheeler piston were done in ANSYS software. In future, while a new design Connecting Rod Alloy Steel ($35Mn_2$ Mo28) & Alloy Aluminum (74530) by using software, it may reduce the effect of producing the cost of the Connecting Rod.

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