# Design and Analysis of Connecting Rod Using Femap with Nx-Nastran

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***Abstract---*** *This project involves modeling and analysis of the connecting rod for the transport engine system. In I.C Engines or steam engines, the force produced by the fuel or steam pushes the piston in the cylinder which causes the reciprocating movement can be transferred to the crank shaft of I.C Engines or wheel of steam engines through some intermediate elements such as piston rod or connecting rod.*

***Keywords---*** *Nx-Nastran, Femap, Design and Analysis of Connecting.*

## I. INTRODUCTION

### *1.1 Connecting Rod*

In modern automotive internal combustion engines, the connecting rods are most usually made of steel for production engines, but can be made of alumunium (for lightness and the ability to absorb high impact at the expense of durability) or titanium (for a combination of strength and lightness at the expense of affordability) for high performance engines, or of cast iron for applications such as motor scooters. They are not rigidly fixed at either end, so that the angle between the connecting rod and the piston can change as the rod moves up and down and rotates around the crankshaft.

### *1.2 Description*

The connecting rod is under tremendous stress from the reciprocating load represented by the piston, actually stretching and relaxing with every rotation, and the load increases rapidly with increasing engine speed. Failure of a connecting rod, usually called "throwing a rod" is one of the most common causes of catastrophic engine failure in cars, frequently putting the broken rod through the side of the crankcase and thereby rendering the engine irreparable; it can result from fatigue near a physical defect in the rod, lubrication failure in a bearing due to faulty maintenance, or from failure of the rod bolts from a defect, improper tightening, or re-use of already used (stressed) bolts where not recommended.

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**Received: 20 Feb 2019 | Revised: 09 Mar 2019 | Accepted: 02 Apr 2019** 

### *1.3 Source of Engine Wear*

A major source of engine wear is the sideways force exerted on the piston through the con rod by the crankshaft, which typically wears the cylinder into an oval cross-section rather than circular, making it impossible for piston rings to correctly seal against the cylinder walls. Geometrically, it can be seen that longer con rods will reduce the amount of this sideways force, and therefore lead to longer engine life.

### *1.4 Master Connecting Rod*

The master rod carries one or more ring pins to which are bolted the much smaller big ends of slave rods on other cylinders. Radial engines typically have a master rod for one cylinder and slave rods for all the other cylinders in the same bank. Certain designs of V engines use a master/slave rod for each pair of opposite cylinders. On the other hand, some V engines use simple rods side by side on a single crankpin, or separate crankpins for each cylinder. In certain types of engine, master/slave rods are used rather than the simple type shown in the picture below.

### *1.5 Parts of A Connecting Rod*

- In internal combustion engines, the gudgeon pin is that which connects the piston to the connecting rod and provides a bearing for the connecting rod to pivot as it moves.
- In very early engine designs (including those driven by steam and also many very large stationary or marine engines), the gudgeon pin is located in a sliding crosshead that connects to the piston via a rod.
- The gudgeon pin is typically a forged short hollow rod made of a steel alloy of high strength and hardness that may be physically separated from both the connecting rod and piston or crosshead.
- The design of the gudgeon pin, especially in the case of small, high-performance automotive engines is challenging.
- The gudgeon pin has to operate under some of the highest temperatures experienced in the engine, with difficulties in lubrication due to its location, while remaining small and light so as to fit into the piston diameter and not unduly add to the reciprocating mass.

### *1.6. Connecting Rod Bolts*

A shaft with a helical groove or thread formed on its surface and provision at one end to turn the screw. Its main uses are as a threaded fastener used to hold objects together, and as a simple machine used to translate torque into linear force. It can also be defined as an inclined plane wrapped around a shaf A screw used as a threaded fastener consists of a shaft, which is normally usually cylindrical and in many cases tapering to a point at one end and with a helical ridge or thread formed on it, and a head at one end which can be rotated by some means.

### *1.7 ROD Bush*

One type of bushing is a hardened threaded fixing hole which allows one assembly to be fixed to another by means of a screw or threaded bolt. The use of a bushing can make assembly easier because it avoids the need for a separate nut and washer on the other side of the fixed material. Bushings can be fitted into sheet material by riveting - often the rivet itself incorporates the bushing.

### *1.8 Bearings*

A typical plain bearing is made of two parts. For example, a rotary plain bearing can be just a shaft running through a hole. A simple linear bearing can be a pair of flat surfaces designed to allow motion.Plain bearings may carry load in one of several ways depending on their operating conditions, load, relative surface speed, clearance within the bearing, quality and quantity of lubricant, and temperature. If full-film conditions apply, the bearing's load is carried solely by a film of fluid lubricant, there being no contact between the two bearing surfaces.

### *1.9 D-DRAWING of the Connecting Rod*

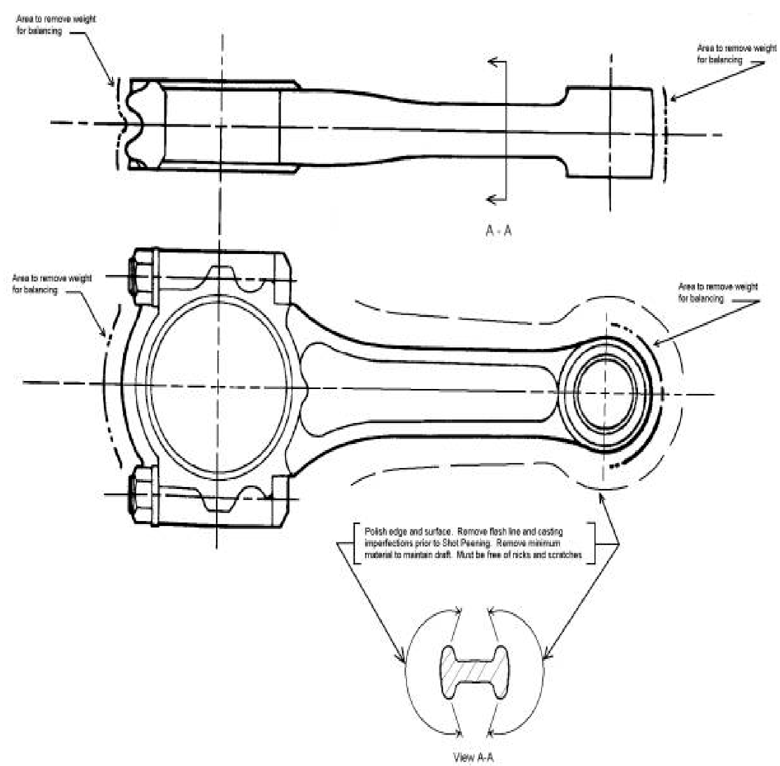


Fig. 1: 2D-Drawing of connecting rod

### *1.10 Force Acting On Connecting Rod*

The connecting rod is under tremendous stress from the reciprocating load represented by the piston, actually stretching and relaxing with every rotation, and the load increases rapidly with increasing engine speed. Failure of a connecting rod is one of the most common causes of catastrophic engine failure in cars, frequently putting the broken rod through the side of the crankcase. When building a high performance engine, great attention is paid to the connecting rods, eliminating stress risers by such techniques as grinding the edges of the rod to a smooth radius, shotpeening to relieve internal stress, balancing all connecting rod and piston assemblies to the same weight and magnafluxing to reveal otherwise invisible small cracks which would cause the rod to fail under stress. In addition, great care is taken to apply the torque to the connecting rod bolts; often these bolts must be replaced rather than reused. The big end of the rod is fabricated as a unit and cut or cracked in two, to establish precision fit around the

International Journal of Psychosocial Rehabilitation, Vol. 23, Issue 03, 2019
ISSN: 1475-7192

big end bearing shell.

## II. LITERATURE REVIEW

### *2.1 History of Connecting Rod*

In order to understand the true impact the automobile has had on our society, would have to go back in time over one hundred years. A time without the simplicity of hopping into a vehicle to take us anywhere to go, is almost uncomfortable to many people. But for the early automotive engineers, the tremendous advancements in automotive technology would be even more surprising. In the last 50 years, cars have learned to think, adjust, and even protect. But this is just the tip of the iceberg. High performance is now the catch phrase. will be modeled and analyzed. It will become apparent exactly why these parts are so important to the operation of an automobile, and furthermore how prone to failure they can be. However, before too much more is said on the engineering details, a little background information is necessary.

### *2.2 Location of Connecting Rod in A Engine*

Fig (3) shows the main parts of an engine. Surface "L" is where combustion occurs, air enters through "M", and "H" is the shaft through which power is accumulated and delivered out of the engine. The combustion occurs against the top surface of the piston (F) and pushes the connecting rod (G) downward, causing the shaft to move in a circular motion.

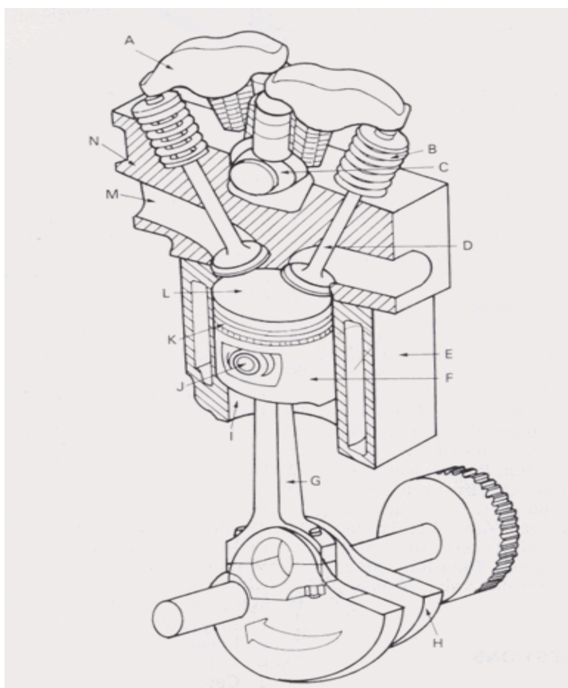


Fig 2: Parts of an engine

### *2.3 Stress -Strain Diagram*

To understand the strength of each material in a situation like this, it is need to understand a stress-strain diagram (pictured below). Each material behaves in a similar manner when placed under a load. There is a period of elastic deformation, in which the material is stretched, but it returns to its original size when unloaded. The point at which it fails to return to the original specifications is called the yield stress.

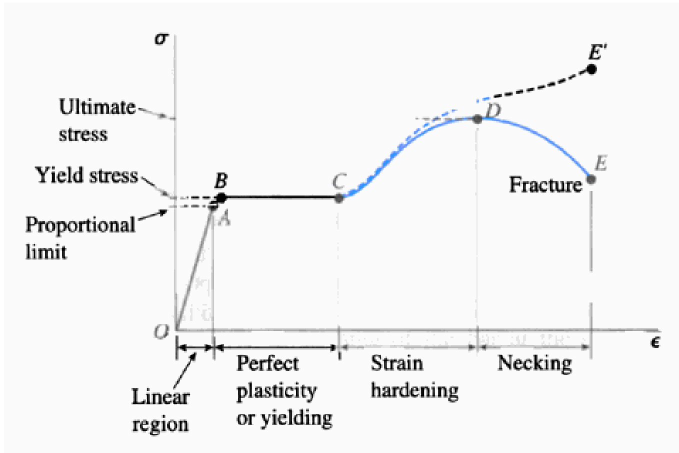


Fig. 3: Stress-strain diagram

### *2.4 Introduction to Pro-E*

- With Pro/ENGINEER Wildfire, we can quickly create design models in an intuitive, windows-style interface.
- Manipulating and orienting the design models is an important basic skill that you will use whenever working in Pro/ENGINEER Wildfire.
- The navigator is another important tool in Pro/ENGINEER wildfire, the navigator used to quickly locate, preview and open design models.
- Pro/ENGINEER is parametric feature-based three-dimensional Solid modeling CAD software created by Parametric Technology Corporation (PTC).

### *2.5 Analysis*

#### *2.5.1 Introduction to NX Nastran*

NX Nastran is a premium computer aided engineering (CAE) tool that major manufactures worldwide rely on for their critical engineering computing needs to produce safe, reliable and optimized designs within increasingly shorter design cycle times. For over 30 years, Nastran has been the analysis solution to choice in every almost every major industry including aerospace, defense, automotive, ship building, heavy machinery, medical and consumer products an industry standard for the computer aided analysis of stress, vibration, structural failure/durability, heat transfer, noise/acoustics and flutter/aero elasticity.

#### *2.5.2 Types of NX Nastran Solvers*

- NX Nastran-Basic - The core subset of NX-Nastran and includes toughest suit of linear static, normal modes, buckling analysis and heat transfer capabilities.

**Received: 20 Feb 2019 | Revised: 09 Mar 2019 | Accepted: 02 Apr 2019** 

- NX Nastran- Advanced non linear - Provides the capabilities to analyze FE models with non linear behavior due to contacting parts, material, non linear ties and/or geometric non linear ties(that is; large deformations).
- NX Nastran - Dynamic Response - calculates forced dynamic response to inputs (loads or motions) that vary with time or frequency.

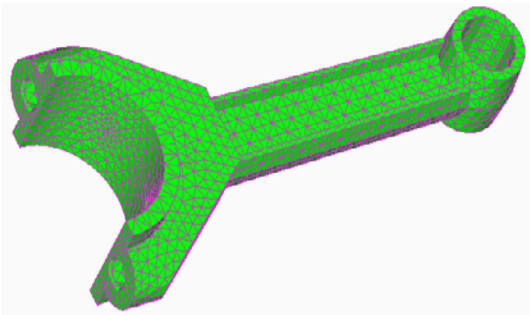

Fig 4: Meshed model under compression

The meshed image of connecting rod which is shown above

## III. RESULTS

The analysis was performed according to the given load and constraint and the following results were obtained.

**THEORETICAL**

Compression load = **9954.92 N**

Tension load = **4441.06 N**

Compression stress **(**$\sigma_c$ ) = **71.82 N/mm$^2$**

Tension stress **(**$\sigma_t$ ) = **32.04 N/mm$^2$**

**FEMAP WITH NX-NASTRAN**

Compression stress **(**$\sigma_c$ ) = **70.92 N/mm$^2$**

Tension stress **(**$\sigma_t$ ) = **31.24 N/mm$^2$**

Deflection in compression load = **0.000233mm**

Deflection in tension load = **0.0114mm**

## IV. CONCLUSION

In this project modeling and analysis of connecting rod has been done using Pro-E and FEMAP with NX-NASTRAN .The results such as stress under tension load and compression load obtained from NX-NASTRAN were compared with the manual calculations. The results are accurate.

If a more accurate analysis was necessary, factors like cylinder friction, momentum, and dozens of other variables could have been taken into account.

But, given the assumptions that were made and the data acquired, this project still provided an interesting look at what happens inside an engine and what limitations each engine has placed upon it.

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