Dynamic Load Analysis Of A Connecting Rod

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Abstract: The main objective of this study was to explore weight and cost reduction opportunities for a production forged steel connecting rod. This has entailed performing a detailed load analysis. The conclusion of this study that the connecting rod can be designed and optimized under a load range comprising tensile load corresponding to 360° Crank angle at the maximum engine speed as one extreme load, and compressive load corresponding to the peak gas pressure as the other extreme load. Furthermore, the existing connecting rod can be replaced with a new connecting rod made of C-70 steel that is 10% lighter and 25% less expensive due to the steel’s fracture crackability.

\[ C-70 = (C-0.7, Si-0.2, Mn-0.25) \]

Keywords: connecting rod, load

1. Introduction

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. Aluminum alloys are preferred engineering material for automobile, aerospace and mineral processing industries for various high performing components that are being used for varieties of applications owing to their lower weight, excellent Thermal conductivity properties. Among several series of aluminum alloys, heat treatable Al6061 and Al7075 are much explored, among them Al6061 alloy are highly corrosion resistant and are of excellent extricable in nature and exhibits Moderate strength and finds much applications in the fields of construction (Building and high way), automotive and marine applications.

1.1 Sketcher

Sketcher is used to create two-dimensional representations of profiles associated within the part. We can create a rough outline of curves, and then specify conditions called constraints to define the shapes more precisely and capture our design intent. Each curve is referred to as a sketch object.

1.2 Creating A New Sketch

To create a new sketch, chose Start⇒Mechanical Design⇒Sketcher then select the reference plane or sketch plane in which the sketch is to be created.

1.3 Sketch Plane

The sketch plane is the plane that the sketch is located on. The sketch plane menu has the following options:

Face/Plane: With this option, we can use the attachment face/plane icon to select a planar face or existing datum plane. If we select a datum plane, we can use the reverse direction button to reverse the direction of the normal to the plane.

XC-YC, YC-ZC, and ZC-XC: With these options, we can create a sketch on one of the WCS planes. If we use this method, a datum plane and two datum axes are created.
2.2 CREATION OF SOLID/SURFACE BODIES
We can create solid bodies by padding the sketch geometry to create associative features or Creating primitives for the basic building blocks, then adding more specific features (for example, holes and slots etc.). Shifting the sketch and non-sketch geometry lets us to create a solid body with complex geometry. This method also gives us total control over the editing of the body. Editing is done by changing the swept creation parameters or by changing the sketch. Editing the sketch causes the swept feature to update to match the sketch.

Dress-up features are used to modify the part bodies according to given specifications these are the most important features to modify the objects.

3 MODELLING PROCEDURE
3.1 CONNECTING ROD & SHANK
To create the above part following features are used.
   a) Pad
   b) Pocket
   c) Edge Fillet

Create a plane parallel to right plane with required dimension as shown below.

On the newly created plane draw a sketch as shown below and exit work bench. Use the pad tool to add the material normal to sketch with required dimension we get the part as shown in below fig.

On the top plane draw a sketch for shank as shown below and exit work bench. Use the pad tool to add the material normal to sketch with required dimension we get the part as shown in below fig.

Next step is to create a shank between those to cylinder this can be done by taking normal plane which is perpendicular to those cylinder.
After completing all the parts we will enter into assembly module In CATIA Assembly is also one of module to assemble the components whichever we designed in part MODELLING, in this we have two assembly methods one is bottom-up assembly and the other is top down assembly, in bottom-up assembly existing parts only can be assembled where as in top down assembly we can create parts in assembly module also, here we have already designed components so we follow bottom-up assembly.

To enter into catia assembly, open catia as usual then the default window is the assembly module and it shows the product window.

Now to insert the components go to insert menu – existing component – select product tree label it opens file selection window then browse the location of file and select – open it opens the part in assembly module. Now it is not constrained so to constrain the part use fix constraint tool from the constraints tool bar and select the component the component will be fixed at current location as shown below. (Used constraint is fixed constraint only).
7 ANALYSIS & DETAILS OF CONNECTING ROD

Crankshaft radius 48.5 mm  
Connecting rod length 141.014 mm  
Piston diameter 86 mm  
Mass of the piston assembly 0.434 kg  
Mass of the connecting rod 0.439 kg  
Is about the center of gravity 0.00144 kg m  
Distance of C.G. from crank end center 36.44 mm  
Maximum gas pressure 37.29 Bar  

8 FEA MODELING OF CONNECTING ROD

Finite element mesh was generated using parabolic tetrahedral elements with various element lengths of 2.5 mm (20719 elements), 2 mm (37373 elements), 1.5 mm (77316 elements), and 1 mm (226409 elements).

8.1 Boundary condition-

BOUNDARY CONDITIONS

Loading

Static FEA

The crank and piston pin ends are assumed to have a sinusoidal distributed loading over the contact surface area.  
This is based on experimental results. The normal pressure on the contact surface is given by:

\[
p = p_0 \cos \theta
\]

The load is distributed over an angle of 180°. The total resultant load is given by:

\[
Pt = \frac{\pi}{2} p_0 (\cos^2 \theta) r t d\theta = \frac{p_0}{\pi/2} r t \pi/2
\]

\[
r, t - \text{radius of head and thickness of head}
\]

\[
\theta - \text{total angle at which the load is applied}
\]

The normal pressure constant \( p_0 \) is, therefore, given by:

\[
p_0 = \frac{Pt}{r t \pi/2}
\]

The tensile load acting on expression from the force analysis of the connecting rod, \( Pt \), can be obtained using the of the slider crank mechanism. Compressive loading of the connecting rod, the crank and the piston pin ends are assumed to have a uniformly distributed loading through 120° contact surface. The total resultant load is given by:

\[
Pc = \frac{\pi}{3} p_0 (\cos \theta) r t d\theta = \frac{p_0}{\pi/3} r t \sqrt{3}
\]

The normal pressure constant is then given by:

\[
p_0 = \frac{Pc}{(r t \sqrt{3})}
\]

In this study four finite element models were analyzed. FEA for both tensile and compressive loads were conducted. Two cases were analyzed for each case, one with load applied at the crank end and restrained at the piston pin end, and the other with load applied at the piston pin end and restrained at the crank end. In the analysis carried out, the axial load was 26.7 kN (6 kips) in both tension and compression.
9 RESULT

The pressure constants for 26.7 kN are as follows:

Compressive Loading:
Crank End:
\[ p_0 = \frac{26700}{(24 \times 17.056 \times \sqrt{3})} = 37.66 \text{ MPa} \]
Piston pin End:
\[ p_0 = \frac{26700}{(11.97 \times 18.402 \times \sqrt{3})} = 69.98 \text{ MPa} \]

Tensile Loading:
Crank End: \[ p_0 = \frac{26700}{(24 \times 17.056 \times (\pi/2))} = 41.5 \text{ MPa} \]
Piston pin End: \[ p_0 = \frac{26700}{(11.97 \times 18.402 \times (\pi/2))} = 77.17 \text{ MPa} \]

References


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