

Sizing Procedure of Hold Open ROD

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ABSTRACT

In this paper, we describe the entire process of designing a hold open rod. A hold open rod also known as engine cowl strut is used to hold or hatch the engine cover of an aircraft after being opened manually or automatically. It supports a considerable amount of weight and resists loads coming from various sources. It is desirable that the rod supports its own weight and any other exterior load so as to avoid any accidents during cleaning, repairing or checking of engine.

1. INTRODUCTION

Airplane maintenance now-a-days has become a very specialized task. In order to clean, repair or replace any part of the engine we need to have some opening to view and change parts in the engine. Also, the engine cannot be left opened for any section throughout the whole flight. For this reason, the engine is covered by a cover known as engine cowl. Now, during the servicing of the engine the cover is needed to be held at a certain height. In order to reduce human efforts, a rod is fixed between the cowl skin and the engine. A hold open rod also known as engine cowl strut is used to hold or hatch the engine cover of an aircraft after being opened manually or automatically. They support a considerable amount of weight and resist loads coming from various sources. It is desirable that these rods support weight so as to avoid any accidents during cleaning, repairing or checking of engine.



Fig. 1

Depending upon the requirement and availability there are following types of hold open rods:

- (1) Telescoping struts: this type of strut opens up and closes like a telescope.
- (2) Scissor/folding struts: these type of struts can be folded from the centre when closing the lid and opens up and are fixed when the lid is opened.
- (3) Fixed length struts: this type of strut has fixed length and hence, is the most simplest and least complex.

The components used in this type of hold open rod are:

- (a) Rod: This is the main part of the body and has fixed length.
- (b) Rod ends: These are present on both sides of the rod joining the main rod to the cowl and skin using bearings.

2. CASES

Customer provided us with the following specifications which the strut needs to withstand:

- (1) 75 lbf of axial load due to engine cowl and 25 knots of wind speed (shown in fig 2)
- (2) 375 lbf of axial load due to engine cowl and wind of speed 65 knots along with 200 lbf of abuse load perpendicular to the axis of strut (shown in fig 3)
- (3) Minimum temperature is 75 degree C and maximum is 250 deg C

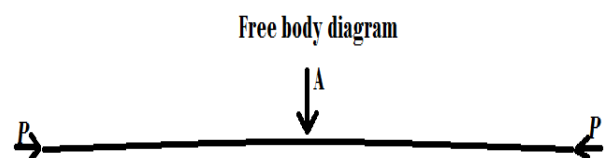


Fig. 2

Free body diagram



Fig. 3

3. CALCULATIONS

Calculations are done in two excel sheets for the first two cases. For the third case, the thermal stress is avoided by leaving space for thermal expansion. Our main purpose is to find out the correct outer inner diameter and most importantly the thickness of rod so that it withstands the entire load without failure or buckling. For this, stresses acting on the rod combined, should be less than the proof stress for SS304 i.e. 215 MPa, Young's modulus is 193000 MPa and thermal expansion coefficient is 1.93E-05 mm/mm/degC. Also, we should keep in mind that our rod doesn't buckles. Following quantities are calculated:

- (1) Direct stress
- (2) Bending stress
- (3) Max. shear stress
- (4) Stress due to eccentricity
- (5) Combined equivalent stress

Dimensions and properties of the rod provided by the customer are:

- (1) Length : 45 inches
- (2) Eccentricity : 0.01

Here, for the design to be OK, the Combined equivalent stress should be less than Proof stress and also, Critical-buckling load should be greater than Design compressive load. After calculating the above stresses, if any condition is not satisfied, we adjust stresses by changing dia or thickness by hit and trial method. The end result should also be checked from the catalogs of the industries producing parts like rods and rod ends.

Calculations for all this is done in excel sheets. The screenshot for which is provided in fig. 7 and 8.

4. RESULTS

After the hit and trial method, we got two sets of values of radii and thickness of rod i.e. inner radii 18mm and 8.49 mm, outer radii 20mm and 10.49 mm and thickness 1mm and 1mm for first and second cases respectively.

From the above calculations, the values of stresses are:

- (1) Direct stress: 27.72 N/mm² for first case and 11.27 N/mm² for second case
- (2) Bending stress : 0.00 N/mm² and 68.59 N/mm²
- (3) Max. shear stress: 0.00N/mm² and 59.242 N/mm²
- (4) Stress due to eccentricity: 27.7 N/mm² and 11.3 N/mm²
- (5) Combined equivalent stress: 27.72 N/mm² and 130.03 N/mm²
- (6) Factor of safety : 2.38 and 1.47

To match the customer's requirements and ease, we select the fixed length strut, which will have least designing complexities and also, will have the least chances of failure. In order to have our strut a bit adjustable, we use male rod ends and the rod has inner threading. Hold open rod works in very unfavorable conditions, bearing the weight of engine cowl and strong wind currents and inside the engine in high temperature ranges. Hence, we choose the material, which is easily available and can have high strength i.e. stainless steel 304.

5. 3D CAD MODEL

Now that the dimensions of our parts are known, we design two hold open rods in CATIA V-5. The hold open rod is designed with the help of CATIA V-5 software. CATIA or computer aided three dimensional interactive application is multi platform CAD/CAM CAE software developed by French company Dassault systems directed by Bernard Charles. It is written in the C++ programming language.

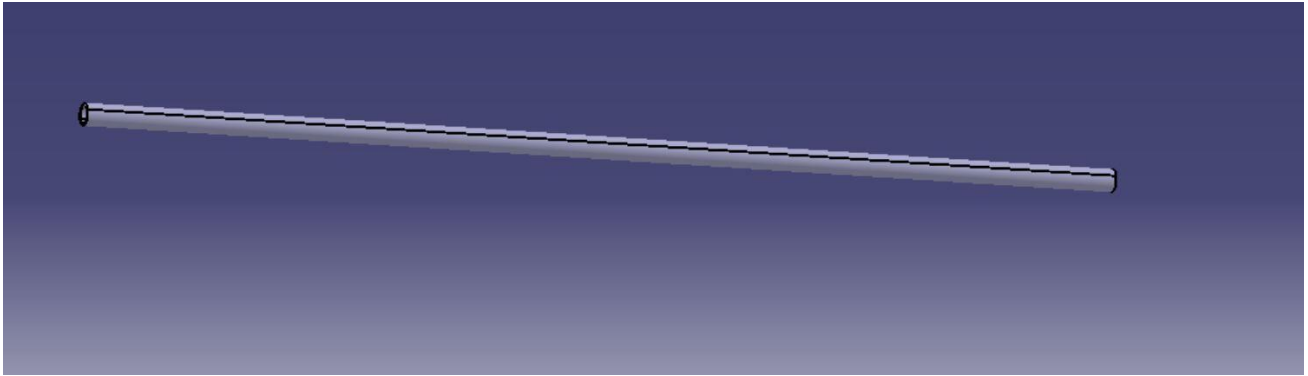


Fig. 4

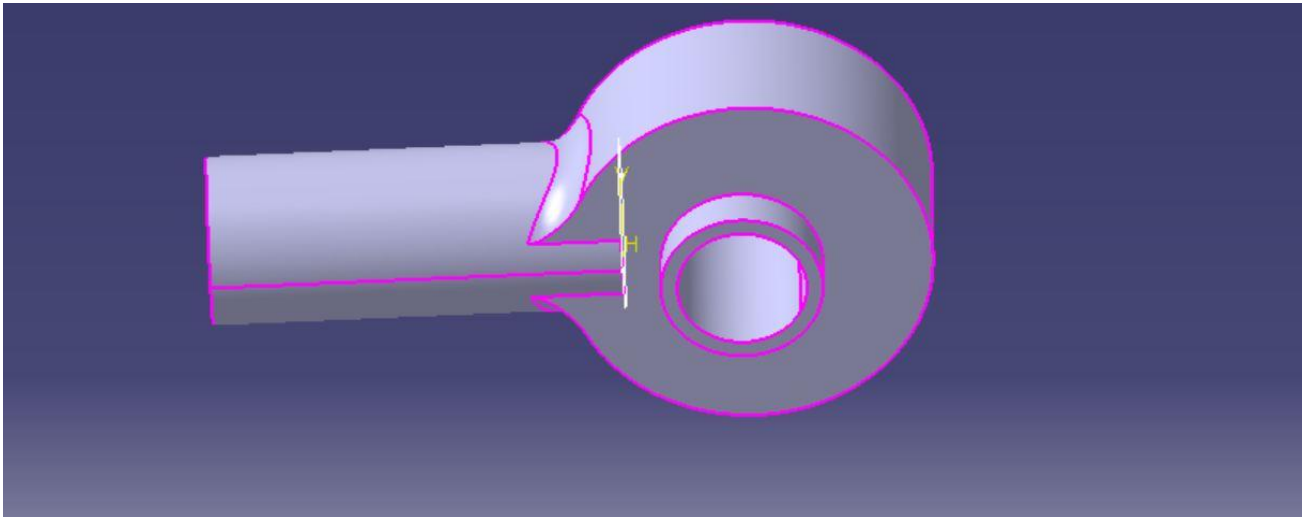


Fig. 5

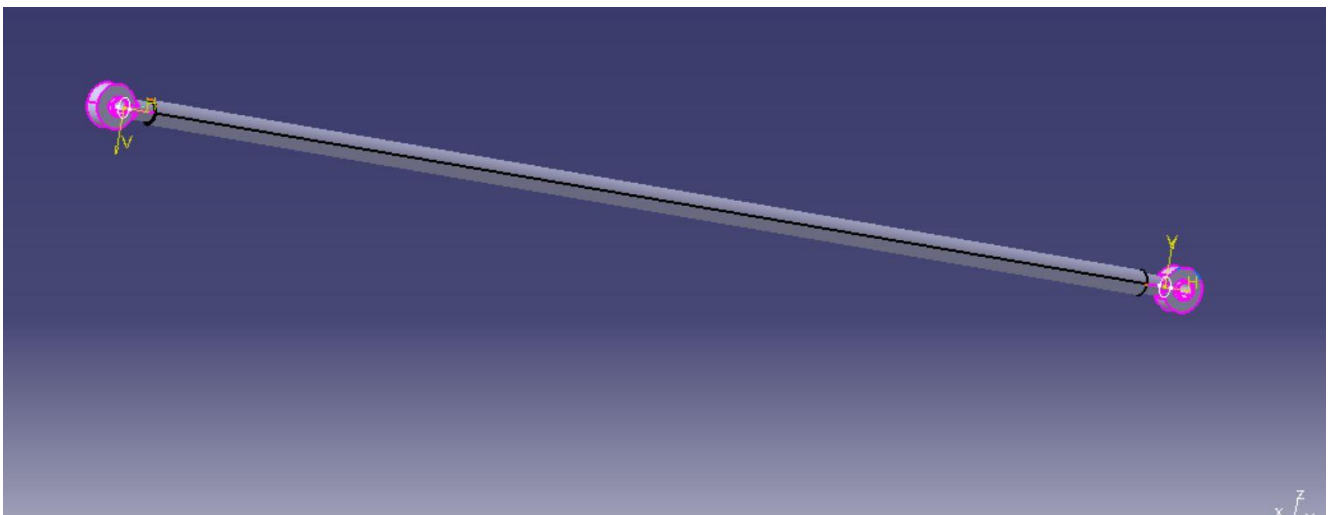


Fig. 6

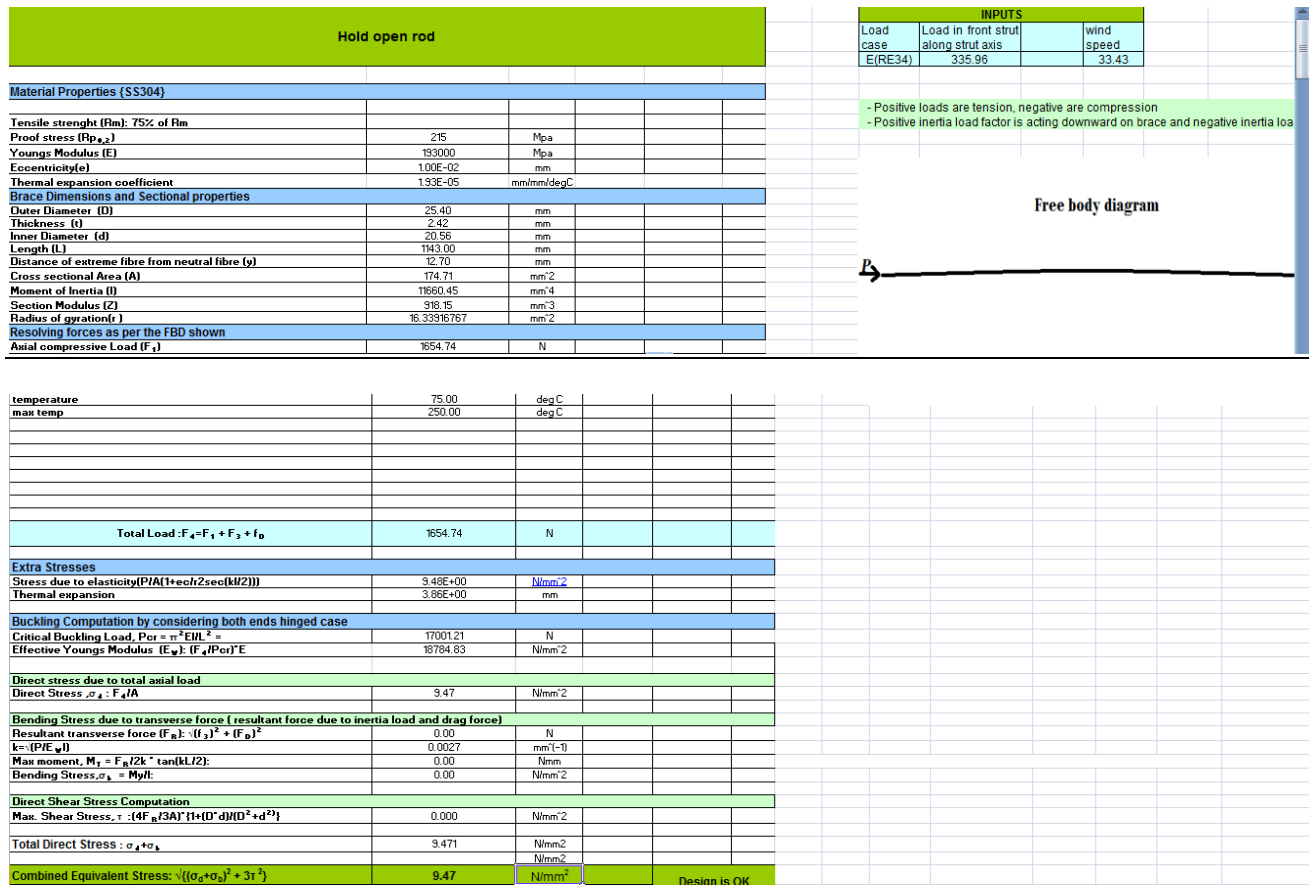


Fig. 7

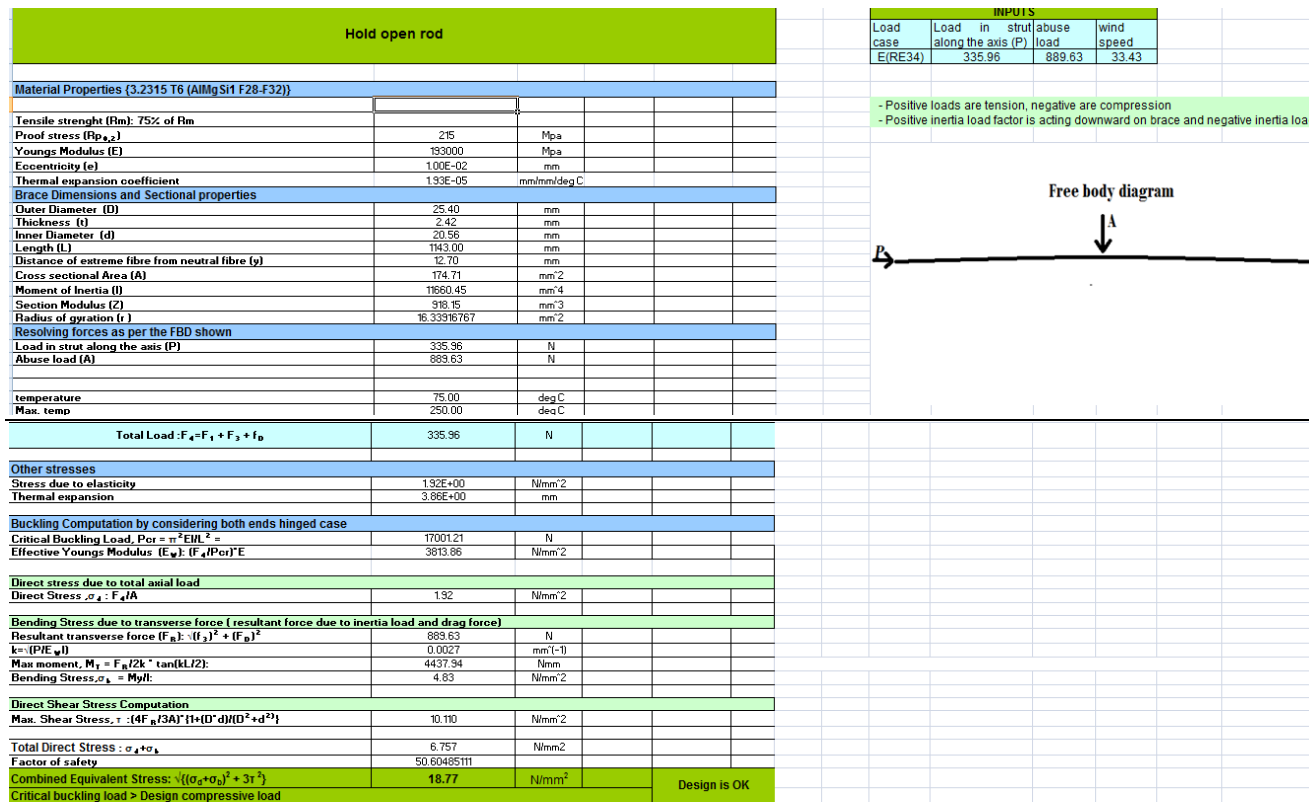


Fig. 8



6. REFERENCE

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- [3] Patent for mechanically dampening hold open rod; Patent WO2012024432A1 by Gary Mc Murtey and J Palma.
- [4] Aircraft Basic Science by Kroes.