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Hold Open Rod Analysis

Goldy Singh Sodhi
Student
Gurukul Vidyapeeth Institute Of Engineering And Technology
Sodhigoldysingh@gmail.com

ABSTRACT

This articles describes the Hold open rod model and the complexity in its study due to its features and requirements involved (analysis, temperature effect, loads). A hold open rod also known as engine cowler 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 loads such as abuse loads too so as to avoid any accidents during cleaning, repairing or checking of engine.

1. INTRODUCTION

The optimum structural design of a hold open rod is important in holding engine cowler in place while performing maintenance tasks by labor and preventing any damage to engine cowler and engine. After calculating the precise dimensions of rod, the design is tested i.e. it is analyzed in various situations which the rod has to withstand. Thus, durability and credibility of this part is important. Due to this hold open rod has been the topic of research for different aspects such as its types, design, structural strength, etc such as :

M Wood, J Palma in 2009 published a patent for the telescoping type of hold open rod with the functioning of outer and inner tube to give variable length.

JR Metz, J Koskelowsky, J Luterman in 2010 published a patent with hold open rod with rotatably mounted pawls locking members and snubber.

In 2011, Ryan A. Wheeler and Julio Palma published a patent for reinforced plastic locking dogs.

Gary Mc Murtey and J Palma published a patent for mechanically dampening hold open rod.

Mr. J.D. Ramani, Prof. Sunil Shukla, Dr. Pushpendra Kumar published article did FEM analysis of rods of IC engines for material optimization.

A340-600 FAN COWLS FINITE ELEMENT MODEL: USING MSC.Nastran TO MODEL CFC SECONDARY STRUCTURES WITH CONTACT BOUNDARY CONDITIONS. 2001-43 Sofía Ponce Borrero, Juan Pablo Juste Mencía Stress Department Engineering Division EADS CASA.

2. PROBLEM DESCRIPTION

The hold open rod has an application for supporting engine cowling for maintenance and other mechanical purposes. It is mounted on the engine casing at one end and on the engine cowl cover at the other end by ball joints. There are various kinds of hold open rod that are used in the cowling support purpose. Example of some are the telescoping hold open rod (small and large), scissor or folding hold open rod, and fixed length hold open rod. In the case studied, we have used the fixed length hold open rod. The design of the hold open rod is to be such that it could withstand various abusive loads and other conditions such as thermal, wind etc. The cases or conditions studied are the abusive loading, Axial loading, and thermal conditions.

3. LOADING CONDITIONS

Customer has 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

4. MATERIAL DESCRIPTION

Material is to be such that it withstands all the conditions and cases without failure. Other conditions such as rusting due to stress, moisture are also a challenge for choosing the right material. On keeping all the above conditions in account, the suitable material which could withstand all the above is SS-304 (stainless steel). This material is to be used for both the hold open rod and the rod endings/ball joints.

5. BOUNDARY CONDITIONS

The hold open rod is fixed or mounted on the engine casing by rod endings (permanently fixed) and on the engine cowling cover by rod endings on the other end (temporarily fixed on usage). The point of application of axial load is at the two ends of the rod giving compressive force. For the abusive load this point is at the center of the rod, normal to the rod.

6. CALCULATIONS

Calculations are done in two excel sheets for the first two cases.

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

(1) Length : 45 inches

(2) Eccentricity : 0.01

To match the customer's requirements and ease, we have selected the fixed length strut which will have least designing complexities and also, will have the least chances of failure. 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 has high strength i.e stainless steel 304.

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. After the hit and trial method, the resulting diameters we get for all of the cases are inner dia being 22.98 mm and outer dia being 25.4mm and the thickness is 2.42mm.

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7. FEA OF HOLD OPEN ROD

Finite element analysis has become common place in recent years, and is now the basis of a multibillion dollar per year industry. Numerical solutions to even very complicated stress problems can now be obtained routinely using FEA, and the method is so important that even introductory treatments of mechanics of materials such as these modules should outline its principal features. In spite of the great power of FEA, the disadvantages of computer solutions must be kept in mind when using this and similar methods, they do not necessarily reveal how the stresses are influenced by important problem variables such as materials properties and geometrical features, and errors in input data can produce wildly incorrect results that may be overlooked by the analyst. Finite element codes are less complicated than many of the word processing and spreadsheet packages found on modern microcomputers. ANSYS FEA tools also offer unparalleled ease of use to help product developers focus on the most important part of simulation process: understanding the results and impact of design variation of the model. In ANSYS static structural analysis, the fidelity of results id achieved through the wide variety of material models available, the quality of elements library, the robustness of the solution algorithm, and the ability to model every product.

Based on the calculations that are done, keeping in account the loads and stresses, hold open rod is designed in CATIA V5 workbench. Here, the dimensions calculated as the results of calculations in excel sheets are used. The parts designed are rod and two rod ends having male and female threading respectively. Threading is done to avoid stress due to thermal deformation. The product thus formed is our CAD model. This CAD model is imported in ANSYS for the analysis of the rod and hence, total deformation and equivalent stress are calculated.

Case 1 (without abuse load):

The static structural analysis for this case gives the following observations:

1) The equivalent stress of the hold open rod has values of maximum 4.8067 MPa and minimum 0.000359 MPa.
2) The total deformation of the hold open rod has values of maximum 0.0072443mm and minimum is 0mm.

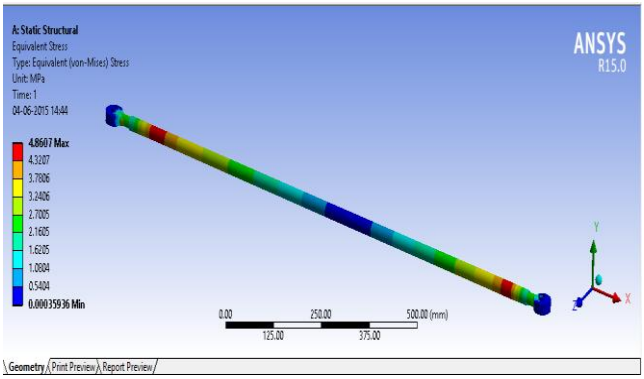

Fig. 1

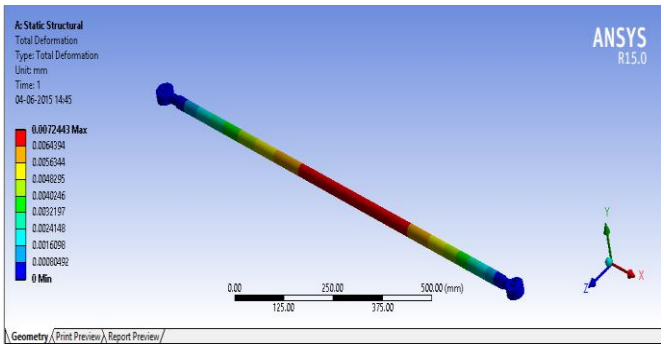

Fig. 2

Case 2 (with abuse load):

The static structural analysis for this case gives the following observations:

1. The equivalent stress of the hold open rod has values of maximum 116.77MPa and minimum 0.054437MPa.
2. The total deformation of the hold open rod has values of maximum 2.1584mm and minimum 0min.

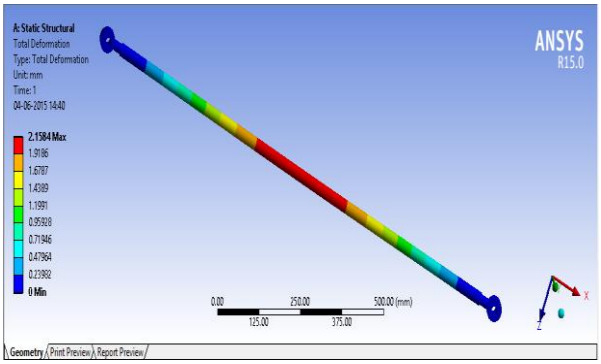

Fig. 3

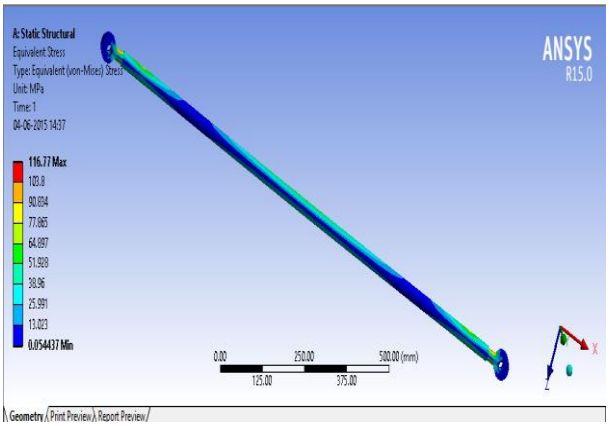

Fig. 4

Case 3(Thermal condition):

The static structural analysis for this case gives the following observations:

1. The equivalent stress of the hold open rod has values of maximum 1517.5MPa and minimum 21.89MPa.
2. The total deformation of the hold open has the values of maximum 0.10085mm and minimum 0mm.

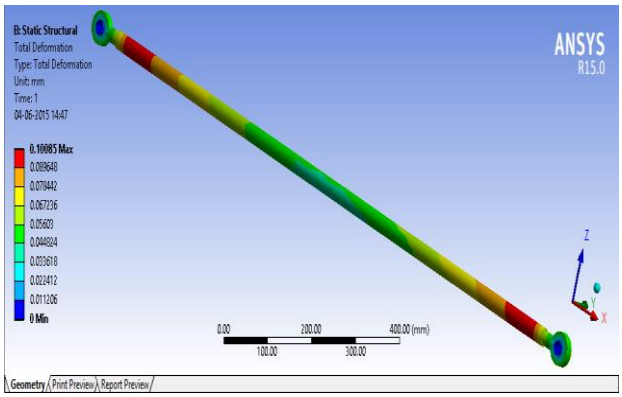

Fig. 5

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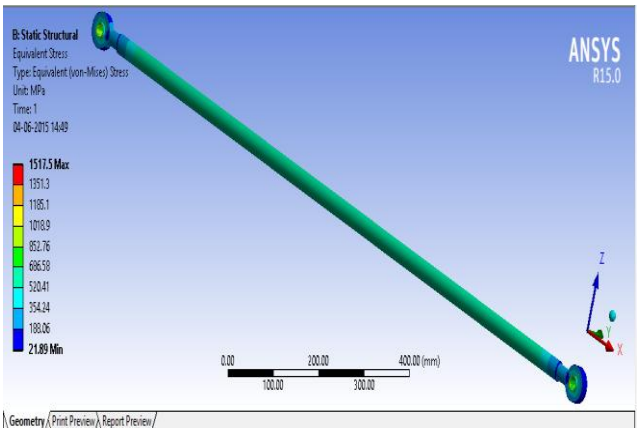

Fig.6

8. CONCLUSION

Here we have studied the loads and stresses undertaken by a hold open rod and hence the apt radii and thickness are calculated. The Cad model is designed in CATIA software which is used for the analysis in ANSYS software. Static structural analysis of this model is done thus, giving us the equivalent stresses and deformations of the hold open rod in different cases. Form these results we conclude that this model is correct and apt for three different cases specified by the customer i.e. it can withstand loads by wind, abuse load and thermal stress.

9. REFERENCES

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