IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁜ Vol. 9, Issue 3, March 2022

DOI: 10.17148/IARJSET.2022.9317

Analysis on Piston Rod of Hydraulic Cylinder With Different Materials

Lanke Revanth Kumar[1], Kodidasu Jaswanth[2], B Ashok[3], Kolusu Balaji[4]

[1,2,3,4]Student, Department of Mechanical Engineering, Vignan's Institute of Information Technology(A), Duvvada, Visakhapatnam, Andhra Pradesh, India

Abstract: This paper describes the comparative study of piston rod used in hydraulic cylinder made of two different materials by using Finite Element Method (FEM) and attempts to figure out which material gives less deformation under same loading conditions. The parameters used for the analysis are operating loads and material properties of piston rod. The specifications used for the study of these piston rod belong to hydraulic cylinder having stroke length 167mm. The dimensions are obtained and a 3-D CAD model on CREO 3.0 is prepared. Static structural analysis is performed by using ANSYS 19.2. The results predict the total deformation and critical region on the piston rod using FEA. The best material is then selected on basis of these results and a comparison is made with the structural steel and EN-19 to find out which material gives less deformation.

Keywords: Hydraulic cylinder, Piston rod, Deformation, Analysis.

I. INTRODUCTION

A. Hydraulic Cylinder:

The Hydraulic cylinders are actuation devices that use pressurized hydraulic fluid to produce linear motion and force. They are used in a variety of power transfer applications, and can be single or double action. A single action hydraulic cylinder is pressurized for motion in only one direction. Single action hydraulic cylinder consists of top port and bottom port for the rise of piston rod the pressurized fluid will be sent through bottom port and fluid is sent through top port for bring the piston down.

Parts of a hydraulic cylinder:

- Cylinder barrel
- Cylinder base or cap
- Cylinder head
- Piston
- Piston rod
- Seal gland
- Seals

Piston Rod

The piston rod is typically a hard chrome-plated piece of cold-rolled steel that attaches to the piston and extends from the cylinder through the rod-end head. In double rod-end cylinders, the actuator has a rod extending from both sides of the piston and out both ends of the barrel. The piston rod connects the hydraulic actuator to the machine component doing the work. This connection can be in the form of a machine thread or a mounting attachment. The piston rod is highly ground and polished so as to provide a reliable seal and prevent leakage.

B. Materials used for piston rod:

In this project we are using EN-19 and structural steel for comparison .

EN-19:

En19 steel is a high quality engineering alloy steel containing chromium and molybdenum. It falls in a class of low alloy steel. It has high fatigue strength, abrasion and impact resistance, toughness, and torsional strength. It can be heat treated in a number of ways to give it a combination of properties.

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TABLE I MECHANICAL PROPERTIES OF EN-19

Property	Value
Tensile strength	655 MPa
Yield strength	415 MPa
Bulk modulus	140 GPa
Elastic modulus	190-210 GPa
Poisson's ratio	0.27-0.30

TABLE II PHYSICAL PROPERTIES OF EN-19

Property	**Value**
Density	8.08 G/CM 3
Density	0.292 LB/IN 3
Melting point	1425 °C
Melting point	2600 °F

Structural steel

Structural steel is a carbon steel, meaning it has a steel. Increasing the amount of carbon in the composition of steel results in materials that have high strength and low ductility. Depending on how the steel will be used will determine the carbon level or content needed carbon content of up to 2.1 percent by weight. After iron, carbon is the most important element in carbon.

TABLE III MECHANICAL PROPERTIES OF STRUCTURAL STEEL

PROPERTY	**VALUE**
young's modulus	2E+11 pa
poisson's ratio	0.3
Bulk modulus	1.6667E+11 pa
shear modulus	7.6923E+10 pa
tensile yield strength	2.5E+08 pa

TABLE IV PHYSICAL PROPERTIES OF STRUCTURAL STEEL

PROPERTY	**VALUE**
Density	7850 kg m^-3
Density	7.85 g cm^-3

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II. DESIGN

This project design is done with the help of creo software.

A. Creo software:

Creo is a parametric CAD software. What this means is that you can tweak a single parameter of the design prototype to see the effect it will have on the other properties. This feature is very useful in companies that work in R&D. Since most automobile and aerospace industries need to be competitive, using Creo saves them development time of a new product. PTC Creo is a suite of design software that focuses on CAD prototyping. It includes a whole bunch of modules that provide scalable design solutions. Since it is robust, Creo maximizes innovation and enables designers to develop prototypes just the way they envision. The various modules and add-ons enhance the utility of the software. It allows product developers to produce high-quality product designs within the shortest time possible. Being a robust software, PTC Creo optimizes product development by allowing users to create, develop, and prepare for manufacturing using a single development environment.

A. Design of hydraulic cylinder in creo

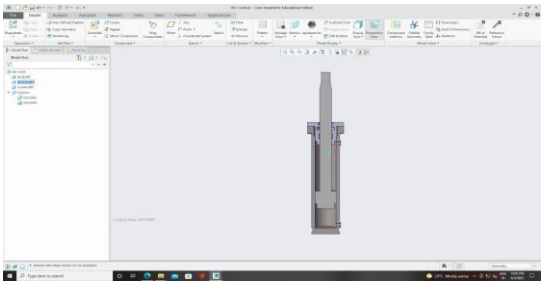

Fig.1 Design of hydraulic cylinder in Creo

B. Design of piston rod in creo:

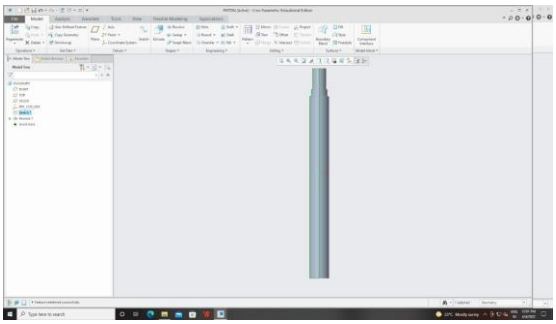

Fig.2 Design of piston rod in Creo

III. ANALYSIS

A. ANSYS Software:

ANSYS is one method to use the graphical user interface (GUI). This method follows the convention of a general-purpose, finite-element modeling package for numerically solving a wide variety of mechanical problems. These problems include static/dynamic, structural analysis, heat transfer, and fluid problems, as well as acoustic and electromagnetic problems. There are two methods to use ANSYS. ns of popular Windows and X-Windows-based programs. Another method is to use command files. The command-file approach has a steeper learning curve for many, but it has the advantage that the entire analysis can be described in a small text file, typically in less than 50 lines of commands.

B. Meshing:

Meshing is the discretization of the continuous body into a finite number of elements. Meshing is defined as the process of dividing the whole component or part or body into a number of elements so that whenever the load is applied on the component it distributes the uniformly called meshing. In the project we took hex dominant in method.

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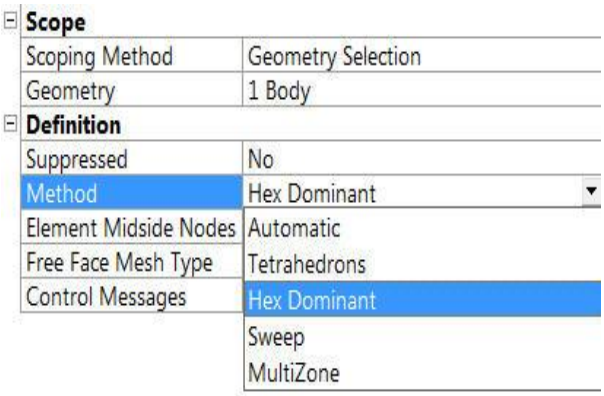

Fig.3

C. Mesh quality:

The quality of the mesh plays a significant role in the accuracy and stability of the numerical computation. The attributes associated with mesh quality are node point distribution, smoothness, and skewness. Regardless of the type of mesh used in your domain, checking the quality of your mesh is essential. In this project we are using orthogonal quality for checking mesh quality.

Orthogonal quality mesh metrics spectrum:

Fig.4 Orthogonal quality mesh

D. Meshing quality of piston rod

We have taken orthogonal quality from mesh metric to check the quality of mesh and we got good mesh quality.

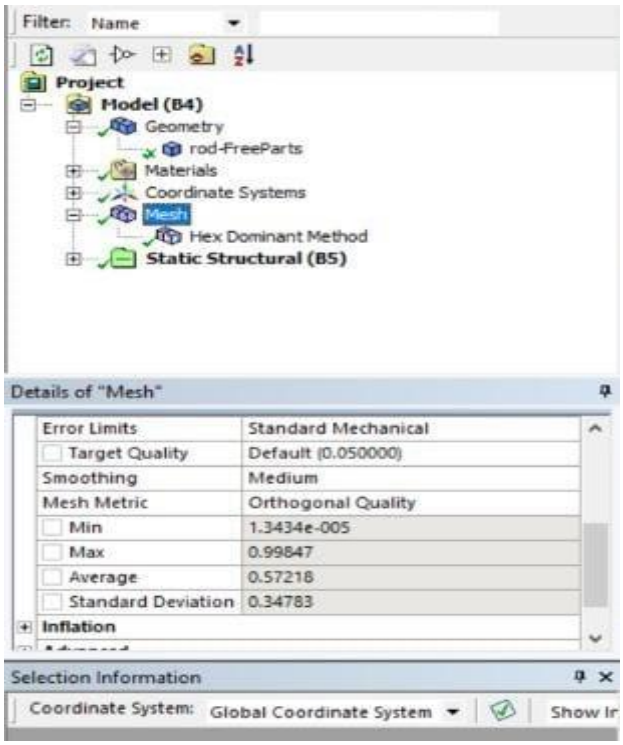

Fig.5

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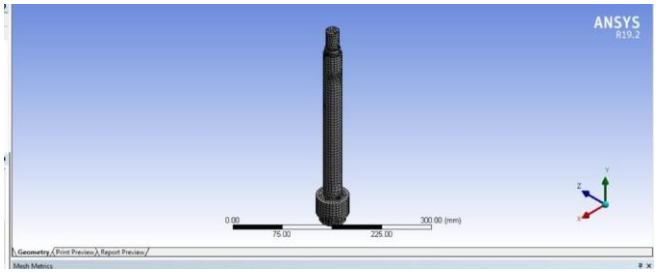

Fig.6 Hex dominant mesh of piston rod

E. Static Structural Analysis:

Structural analysis is the process of calculating and determining the effects of loads and internal forces on a structure, building or object. Structural Analysis is particularly important for structural engineers to ensure they completely understand the load paths and the impacts the loads have on their engineering design. It allows engineers or designers to ensure a piece of equipment or structure is safe for use under the estimated loads it is expected to withstand. Structural Analysis can either be performed during design, testing or post-construction and will generally account for the materials used, geometry of the structure and applied loads.

In this static structural analysis we had done the following steps to obtain results:

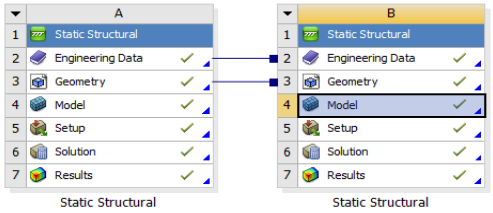

Fig.7

1. In engineering data we had given the properties of both structural steel and en-19 alloy.
2. After that we had imported the igs file of piston rod to the geometry.
3. In model we had done meshing and given fixed support to the piston face and given a load of 500kg (9806.6 N) on face of piston rod as boundary conditions.
4. Total deformation is assigned to the solution.

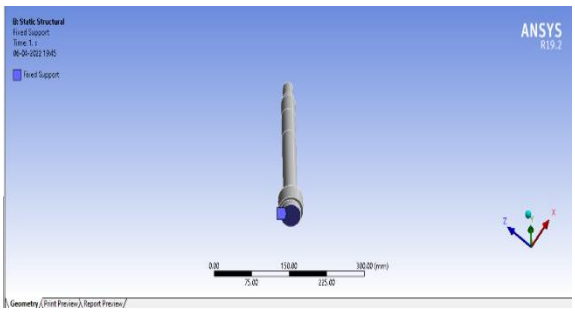

Fig.8 Direction of Fixed support

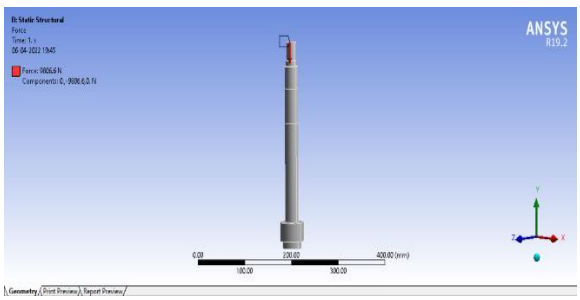

Fig.9 Direction of Load

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RESULTS

A. Total Deformation:

In this total deformation we will be knowing the range of deformation of both the material.

TABLE V RANGE OF DEFORMATION OF STRUCTURAL STEEL

RANGE	VALUE
MINIMUM	0 mm
MAXIMUM	0.028527 mm

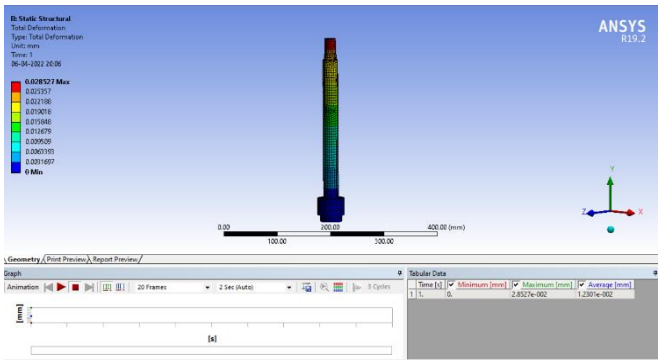

Fig.10 Total deformation of Structural Steel piston rod

TABLE VI RANGE OF DEFORMATION OF EN-19 ALLOY

RANGE	VALUE
MINIMUM	0 mm
MAXIMUM	0.028304 mm

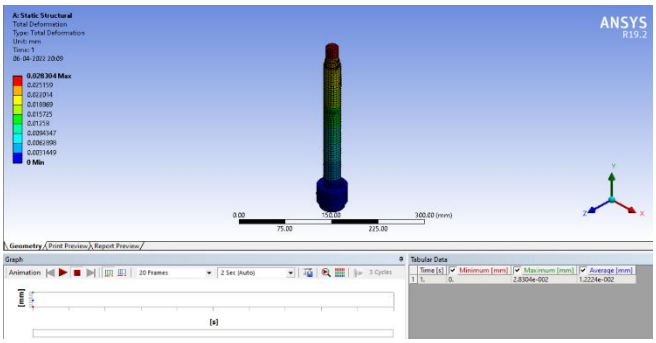

Fig.11 Total deformation of EN-19 piston rod

IV. CONCLUSION

After comparing both En-19 and Structural Steel, EN-19 gives less deformation when compared to structural steel. So, hereby we conclude that EN-19 is more suitable for piston rod.

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