International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 05 | May 2023 www.irjet.net p-ISSN: 2395-0072

FEA Analysis of Hydraulic Cylinder using ANSYS

Vishal Yadav[1], Purushottam Sahu [2], Ghanshyam Dhanera [3]

[1]Research scholar, BM College of Technology, Indore, MP
[2]Professor and Head Department of mechanical engineering, College of Technology, Indore, MP
[3]Professor, Department of mechanical engineering, College of Technology, Indore, MP

---***---

Abstract -A hydraulic cylinder is a mechanical actuator that converts hydraulic energy into linear force and motion. It is a key component in many hydraulic systems used in various industries, such as construction, manufacturing, and transportation. The objective of current research is to investigate the structural characteristics of hydraulic cylinder using techniques of FEA. The modeling of hydraulic cylinder is conducted in design modeler and structural analysis is conducted using ANSYS simulation package. The FEA analysis results have shown that critical regions are obtained at the end support regions. The mid center region of the hydraulic cylinder is almost uniform. The equivalent stress at this region is nearly 96.3MPa. The hydraulic cylinder has safety factor of 1.08 which makes it feasible for the required application.

Key Words *- FEA, Hydraulic cylinder, Safety factor*

1. INTRODUCTION:

Actuators like hydraulic cylinders transform the potential energy of pressurised fluid into the mechanical energy of a rotary motion. An actuator's moving element (piston or plunger) experiences a force that is proportional to the fluid's pressure and the element's area. Figure 1 depicts a double-rod hydraulic cylinder.

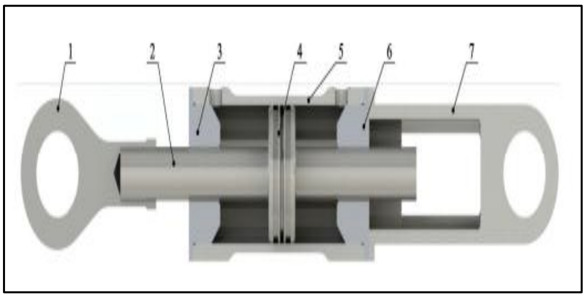

Figure 1: Double tie-rod hydraulic cylinder [1]

Front cap (1), piston rod (2), front cap (3), piston (4), barrel (5), rear cap (6), and tail joint (7) make up the parts [2]. Working pressures of up to 25 MPa are typical for standard hydraulic cylinders, with higher-pressure variants available on special order. Both the diameter and the pitch may range from a few millimetres [3,4] to several meters [5].

2. LITERATURE REVIEW

Composite cylinders with steel liners were the subject of a technique for designing strength and buckling proposed by Mantovani et al. [6,7]. An actuator with a working pressure of 35 MPa, an internal diameter of 300 mm, and a stroke of 1960 mm was used in the authors' study. The authors achieved this by adapting a solution to the Lame issue for anisotropic materials. The cylinder's initial strength, together with its circumferential and axial deformation, have been constrained in the design to provide optimal performance.

Piston and front cap were made from composite material reinforced with carbon fibre, and FEM analysis was done by Ritchie et al. [8]. The pieces were fabricated from prefabricated pipes using subtractive manufacturing techniques, which are not ideal for use with composites. The composite was deemed to have middling machinability, with poor surface quality and dimensional accuracy being the results. In both corrosion tests and a comparison of their respective weights, the composite material was clearly the victor.

In order to improve tribological conditions at the barrel-piston contact, Scholz and Kroll [9] investigated removing the steel liner from the interior of the barrel of a hydraulic cylinder and replacing it with a nanocomposite coating. The authors described techniques for nanocomposite coating production and stress calculation inside individual composite layers.

To combat this, Kumar and Lee [10] created hybrid piston rods that are made of steel at their core and a composite shell for added strength. Both finite element and experimental testing were conducted on a variety of components ranging in size from 7.5 mm to 30 mm in diameter and 650 mm in length. Depending on the kind of construction, the CFRP percentage might be anywhere from 0% (for solid steel rods) to 100% (for all-composite designs). There is evidence that increasing the element's composite content improves its buckling resistance.

3. OBJECTIVE

The objective of current research is to investigate the structural characteristics of hydraulic cylinder using techniques of FEA. The modeling of hydraulic cylinder is conducted in design modeler and structural analysis is conducted using ANSYS simulation package.

4. METHODOLOGY

The methodology process involves modeling of piston in design modeler of ANSYS as shown in figure 2. The hydraulic cylinder is modeled using sketch and extrude tool of design modeler.

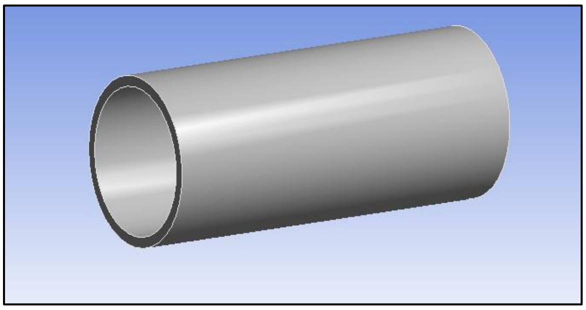

Figure 2: Design of hydraulic cylinder

After modeling of hydraulic cylinder, the model is checked for topological consistency and therefore meshed using hexahedral/brick element type as shown in figure 3. The model is meshed with fine relevance and adaptive size function.

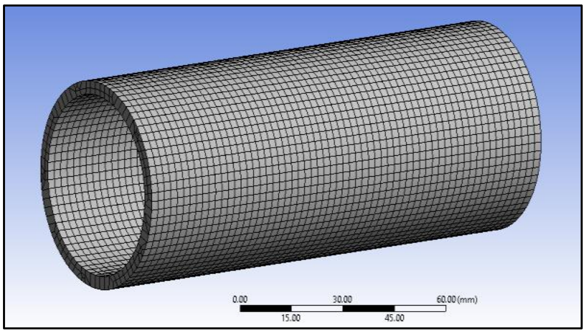

Figure 3: Meshed model of hydraulic cylinder

After meshing, the structural loads and boundary conditions are applied on the hydraulic cylinder as shown in figure 4. The structural loads and boundary conditions are applied on the hydraulic cylinder which includes applying displacement support at free ends and pressure of 20MPa on inner wall of hydraulic cylinder.

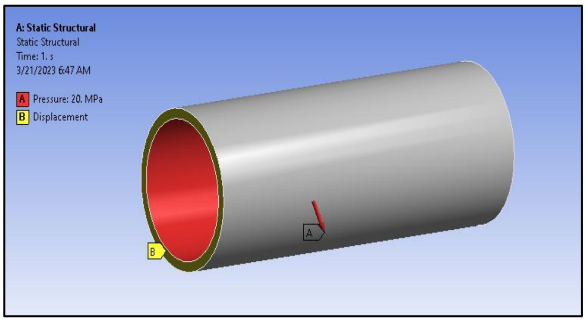

Figure 4: Structural loads and boundary conditions

After applying structural loads on the cylinder, the FEA simulation is run. The FEA simulation process involves formulation of element matrices and global stiffness matrix.

5. RESULTS AND DISCUSSION

From the FEA simulation, the deformation distribution plot and equivalent stress distribution plots are obtained as shown in figure 5 and figure 6 respectively. The maximum deformation is obtained at the center region of the cylinder with magnitude of more .017mm. The deformation is lower at the corner regions of the cylinder as shown in dark blue colored region.

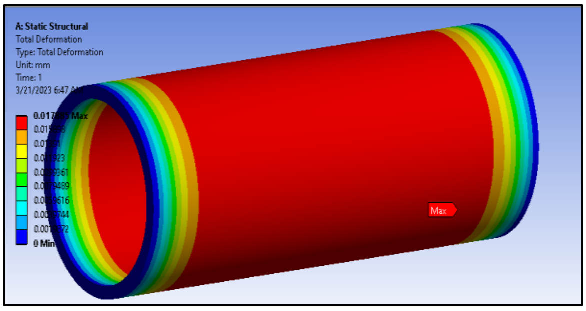

Figure 5: Deformation plot on cylinder

The equivalent stress distribution plot is obtained for cylinder as shown in figure 6. The equivalent stress distribution plot shows higher stresses at the inner surfaces of the cylinder. The stresses on inner surface of the hydraulic cylinder are 162MPa.

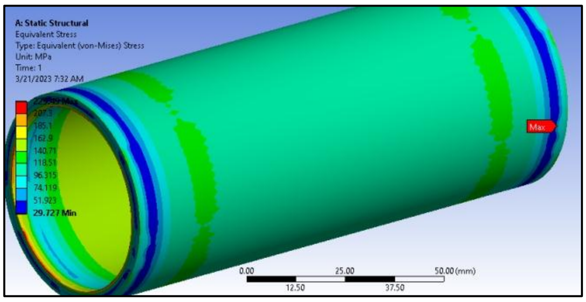

Figure 6: Equivalent stress distribution plot

The equivalent stress is lower at the corner regions wherein the stress value is 51.92MPa. The safety factor distribution plot is obtained and minimum safety factor is obtained at the end regions.

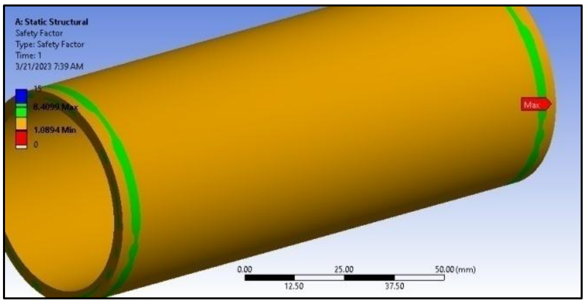

Figure 7: Safety factor distribution plot

5. CONCLUSION

The FEA simulation enabled to determine the critical stress regions of hydraulic cylinder. The FEA analysis results have shown that critical regions are obtained at the end support regions. The mid center region of the hydraulic cylinder is almost uniform. The equivalent stress at this region is nearly 96.3MPa. The hydraulic cylinder has safety factor of 1.08 which makes it feasible for the required application.

REFERENCES

[1] MarekLubecki[1] ,MichałStosiak[1], "Development of Composite Hydraulic Actuators: A Review" Actuators 2022, 11, 365. https://doi.org/10.3390/act11120365

2. Li, Y.; Shang, Y.; Wan, X.; Jiao, Z.; Yu, T. Design and Experiment on Light Weight Hydraulic Cylinder Made of Carbon Fiber Reinforced Polymer. Compos.Struct.2022, 291, 115564. [CrossRef]

3. Li, N. Multi-Degree-of-Freedom Manipulator Driven by Micro Hydraulic System. In Proceedings of the 2016 7th International Conference on Education, Management, Computer and Medicine (EMCM 2016), Shenyang, China, 29–31 December 2016; Atlantis Press: Paris, France, 2016.

4. Xia, J.; Durfee, W.K. Analysis of Small-Scale Hydraulic Actuation Systems. J. Mech. Des. 2013, 135, 091001. [CrossRef]

5. Truong, V.T.; Hwang, Y.L.; Cheng, J.K.; Tran, K.D. Dynamics Analysis and Numerical Simulation of Large-Scale Hydraulic Cylinder Actuators. In Engineering Tribology and Materials IV; Trans Tech Publications Ltd.: Zurich, Switzerland, 2020; Volume 900, pp. 14–19.

6. Mantovani, S.; Costi, D.; Strozzi, A.; Bertocchi, E.; Dolcini, E. Double Acting Composite Tube Cylinder for Fluid Power Applications: A Design Procedure. In Proceedings of the International Conference on Mechanical, Automotive and Aerospace Engineering, Kuala Lumpur, Malaysia, 17–19 May 2011.

7. Mantovani, S. Feasibility Analysis of a Double-Acting Composite Cylinder in High-Pressure Loading Conditions for Fluid Power Applications. Appl. Sci. 2020, 10, 826. [CrossRef]

8. Ritchie, J.; Mumtahina, U.; Rasul, M.; Sayem, A. Alternative Materials in Hydraulic Cylinder Design—Application Of Carbon Fibre Components. Mech. Eng. Res. J. 2013, 9, 43–47.

9. Scholz, S.; Kroll, L. Nanocomposite Glide Surfaces for FRP Hydraulic Cylinders—Evaluation and Test. Compos. Part B Eng. 2014, 61, 207–213

10. S P, P.K.; Lee, S.-S. Design and Experimental Analyses of Hybrid Piston Rods Used in Hydraulic Cylinders under Axial Load.Appl. Sci. 2021, 11, 8552.