

Minimisation of maintenance actions through design analysis of hydraulic cylinder for trailer

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Abstract- Trailers are used to transport commodities from one place to another place. Multistage hydraulic cylinders are powerful components and can be thought of as the “muscles” of the hydraulic system making light work of lifting, lowering, moving or “locking” heavy loads. In this paper, the basic structure of the two-stage hydraulic cylinder was introduced. A three-dimensional model was carried out for the hydraulic cylinder by using SOLIDWORKS15, the finite element analysis to the severe hydraulic condition while hydraulic cylinder working by using ANSYS13 software and the distribution of the stress and strain of two-stage hydraulic cylinder was derived from it. It optimized the design of the two-stage cylinder effectively and saved the cost. Numerous type of failure occurs; causes & trouble shootings in the hydraulic cylinder are discussed briefly.

Keywords- ANSYS, Hydraulic cylinder, SOLDWORKS, Trailer, failures.

1. INTRODUCTION

There are various sectors where trailers are used for transportation of logistics and agriculture products for one place to another place. These trailers classification based on types of wheel and specification function of trailers. In India, trailers play an important role because of their dependency on agriculture. The main part of tractor trolley is chassis. It is the most important part that provides stability and strength under different load conditions of the vehicle [1]. The hydraulic cylinder is a key device of the trailers which plays an important role in the unloading process. The second part, hydraulic cylinders are powerful components and can be thought of as the “muscles” of the telescopic hydraulic system makes work of lifting, lowering, moving or “locking” heavy loads. In trailer hydraulic system is used to unloading the material with less time. The lifting mechanism consists of the hydraulic cylinder, piston, seal, rod, tubes, hoses, and braking system etc. The quality of the hydraulic cylinder is directly related to the safety of the trailer. It also has some influence on the loading efficiency, work efficiency, reliability, and maintenance cost. So the design and development of multistage hydraulic cylinder are very important in the whole design of trailer. Generally, the working environment of the trailer is severe; therefore the hydraulic cylinder needs high performance. In trailers, the two-stage cylinder is used which has a long stroke length and a short retracted length. When the telescopic cylinder extends, all the sections move together until the external

part is prevented from extension by its stop rings. Failures of the hydraulic cylinder due to seal leakage, contaminated fluid, internally corroded barrel, chemical attack, and extreme temperature condition. The optimum design will help to reduce chances of the failures so fewer maintenance actions.

2. LITERATURE REVIEW

These studies discuss the various design material for the cylinder of dumper trucks i.e. Stainless steel, en8 steel, carbon fiber. With the help of ANSYS authors derive the various mechanical properties (total deformation, equivalent elastic strain, stress) of these materials and compared to each other. According to results, EN8 and carbon fibers have less deformation value and almost the same [2]. The author conducted a test to determine the effect of loading on the actuator response under some simulated faults. Lab view, a graphical language, was used to create a program for data acquisition and analysis. Most of the faults occur in the seals, maintenance actions according to vibration signature analysis [3]. In this paper author performed computer analysis of the strength analysis by fatigue life analysis and finite element method (FEM) by using fatigue life prediction method (FLP) was carried out. Wöhler fatigue graphs for different values of operating average pressure and stress concentration factor were presented [4]. Ansys analysis of multi-stage hydraulic cylinder and determination of various stresses. Allowable stress of the three-stage cylinder was maximum at barrel [5]. In this paper analysis of fatigue crack propagation in the hydraulic cylinder using damage mechanics approach is performed. This method allows indicating zones where fatigue cracks were initiated. Fatigue crack was the external side of the tube and direction was perpendicular to the cylinder wall.[6].In this paper, the analysis of the hydraulic cylinder of the linear hydraulic motor from horizontal hydraulic press – 2 MN made for determination of displacement and deformations. Finite element analysis was performed using cosmos works software. The stress formation occurred at the edge of the cylinder [7]. This paper shows the methods of how brakes can apply in the trailer. The author describes the importance of braking system in the trailer. (a)To reduce tire wear. (b) Better controllability. (c)less maintenance cost. The author

suggests fitting a hydraulic load sensor in the trailer and an electro controller system which will allow the braking system [8]. In this study, the author considers the problem of dynamic modeling of the brake system and develops a dynamic model for a hydraulic brake valve. The effects of varying design parameters (brake valve, accumulator and so on) and the different operating conditions were analyzed. At the same pressure of the oil supply system and when the input and output circuits are cut off respectively, the braking speed of each leftover single circuit was fast [9]. A finite element package used to predict the effect of surface texture parameters on the generated stresses in the thick-walled cylinder stainless steel grade 630 under the action of internal pressure. The hoop stress increase as hole diameter and depth increases. The concentration of stresses occurred at the hole root due to the sharp edge of the notched end [10]. In this paper, a hydraulic press PSPR 18 (60 TON HYDRAULIC PRESS) is selected based on failure history. FMEA (failure modes and effects analysis) concept is applied to find the high prone failure components. The Rod and Piston seal is to be replaced at an interval of 11 lakh cycles [11]. For the development of the telescopic cylinder combination of analytical and finite element analysis (FEA) methods was utilized and the bursting pressure, longitudinal stress piston rod and piston diameter, barbell thickness was determined and analyzed and the FEA analysis carried out on the hydraulic cylinder provided credible validation for the reliability, functionality, and safety of the hydraulic cylinder designed [12]. Computer-aided design and analysis software ANSYS and APDL language of the ANSYS software is used for creating the model and performing the analysis of this study. The maximum displacement values increase as the damping values become smaller [13]. This paper performed the ANSYS modeling analysis on the hydraulic cylinder. The author analyzed the key parts of a hydraulic cylinder with finite element static analysis module. The maximum deformation occurs at the pressure part. Deformation didn't exceed 0.01mm [14]. Two types of finite element buckling analysis were used in this research: a linear analysis based on Eigenvalue solution and nonlinear analysis based on the nonlinear static solution including material and geometry nonlinearity. The self-weight of the structure had a negligible effect on the critical buckling load [15]. This paper presented the finite element analysis of u type elastomeric seals of the hydraulic cylinder. The seal was made of TPU (thermoplastic polyurethane). The modal was created APDL batch file for ANSYS system. An axisymmetric 2d modal was used for ANSYS analysis. Von Mises stress distribution was 16Mpa and seal deformed radially. Due to higher contact pressure, abrasive wear may occur [16]. The parametric modeling of the two-stage hydraulic jack is carried out. They were subjected to large side forces. Steel, EN-24, is used as the working

material in this research. In all parts generated stress was below than yield stress [17]. This paper summarises the vibration analysis of the hydraulic cylinder under different loading application and different boundary conditions. The main cause of the vibration in the hydraulic cylinder is stick-slip phenomenon between piston and cylinder which is also responsible for the failure of a sealing material and reduces the fatigue life and the performance of the telescopic hydraulic system. Imperfection angle is directly related to the load bearing capacity like; 5% of wear on the guide ring had reduced the cylinder load capacity by approximately 10% [18]. This paper describes how to develop an optimum design for the trailer. The author finds out the value of load on the rod by numerical methods. The author creates a practical modal to show the design of the trailer [19]. In this research work design analysis of a small dumper was done with help of ansys. The objective of this paper was the design of conceptual trolley & system for Tata ace which would help in unloading material with much easy. Design & selection of hydraulic cylinder, Design of pins for hydraulic cylinder, the design of pins for the trolley. Analysis of trolley by using ansys. With the help of Ansys modal was analyzed various parameters i.e. Deformation, stress. In this paper, only modeling was performed and the author gives suggestion to use such type design to save work and time [20]. In the paper, the geometric model is made in Catia Software and imported to hyper work for focalized Finite element method and examination. Stretch and relocations distinctive water driven cylinders are figured by utilizing Ansys programming [21]. In this paper the hydraulic machine's tie rod frame i.e. 4 columns support frame. The tie rod to withstand the load capacity under the hard chroming after the machining and the model and assembly of the part in modeling create in CatiaV5 [22]. This paper reveals the cause of the failure of a hydraulic cylinder. Further, wear analysis, oil measurement analysis, and piston backward-forward motion test was performed. The reasons for seal failure are following. Improper seal installation, Side loading of the cylinder, contaminated fluid, chemical causes. In this paper fault identification of hydraulic cylinder was performed. Author find the cause of failure and eliminate it [23].

3. Methodologies

In this research, the finite element method is used to conduct the analysis of two-stage cylinder. The software used is ANSYS; it is a comprehensive general-purpose finite element computer program that contains over 100,000 lines of codes. A two-stage cylinder is modelled in. The element size used is determined by conducting a mesh density study. Primary input data collected online resources as well as an offline resource like the agricultural industry. Normally in India, two-stage

Hydraulic cylinders are used in trailers. The design load on the trailer is 15000kg. All dimensions of the hydraulic cylinder were taken from Sealum Industries Limited [24]. Dimensions of hydraulic cylinders are shown in Table 1.

Table -1: Dimensions of the hydraulic cylinder under study.

Sr. No.	Parts	Internal dia	Outer dia	length
1.	barrel	123.65	146.05	430.786
2.	First stage	95.25	123.65	430.06
3.	Rod	-	95.25	441.6

The performance requirements of the two-stage hydraulic cylinder are 20MPa rated pressure and 1282.446mm stroke length. So, considering stability, compact structure, intensity, and safe reliability, the front lifting-up pulling two-stage hydraulic cylinder is chosen in the hydraulic cylinder design. When oil supply starts, all levels of cylinders overhang in order. When oil supply stops, under load or weight, the cylinders retract in order. Double Y type of gasket ring is adopted in the cylinder end of the two-stage hydraulic cylinder, and double O type of gasket ring is adopted in the cylinder bottom, which improves the sealing reliability. The clearance fit is adopted between the piston and cylinder tube, which decreases the inner processing difficulty of the cylinder tube. With SOLIDWORKS15, the parametric design of the two-stage hydraulic cylinder is done, and the three-dimensional digital parametric model is established. The main parts are shown in Figure 1 to Figure 3.

According to the features of SOLIDWORKS15 and ANSYS, the three-dimensional model established in SOLIDWORKS15 was imported into ANSYS accurately. The element type of the two-stage hydraulic cylinder was defined, and the ANSYS model was meshed. As shown in Figure 4, the restriction was applied to the trunnion surface of the cylinder bottom.

The surface load was applied to the section of the rod of the cylinder.

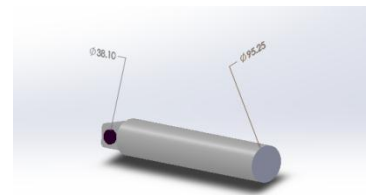


Fig 3. Second stage rod.

EN8 STEEL (C-0.44%, Si-0.4%, Mn-1%, S-0.05%, Ph-0.05%) was used [2]. After resolving, the deformation and stress were shown from Figure 5 to Figure 7.

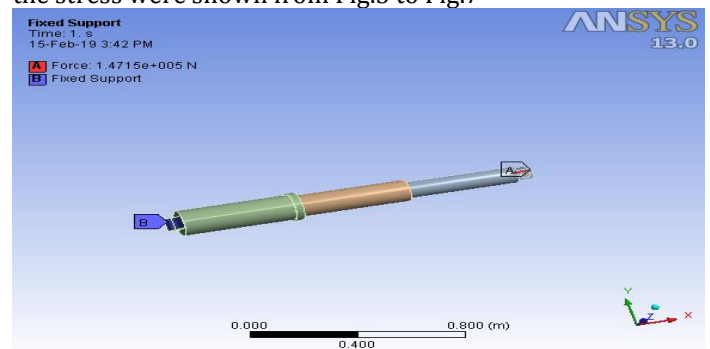


Fig 4. Force on cylinder

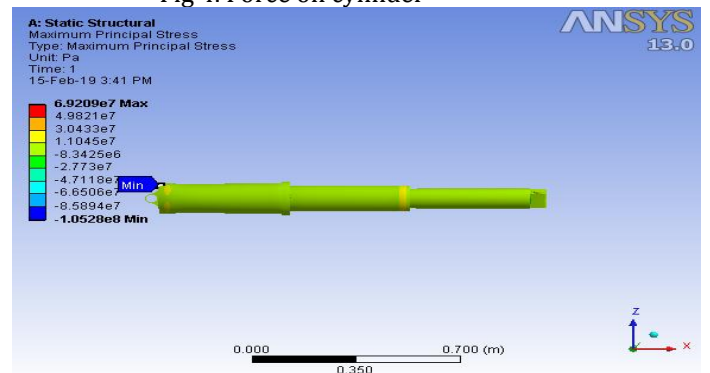


Fig 5. Principal stress.

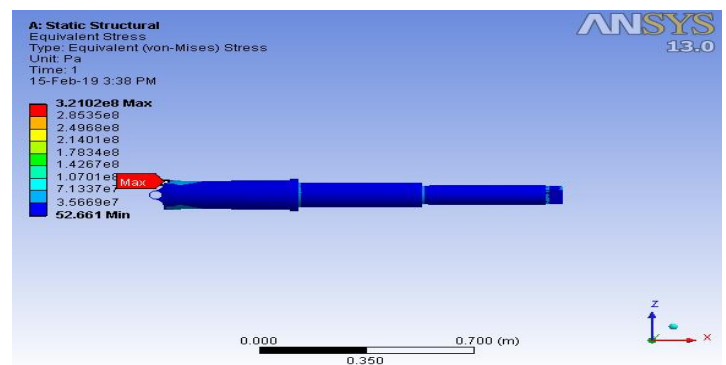


Fig 6. Equivalent stress.

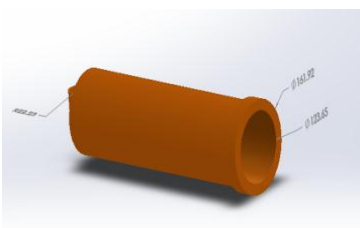


Fig 1. Barrel.

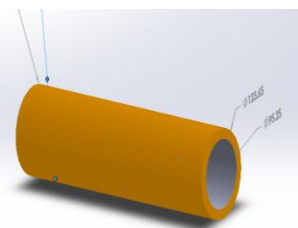


Fig 2. First stage tube

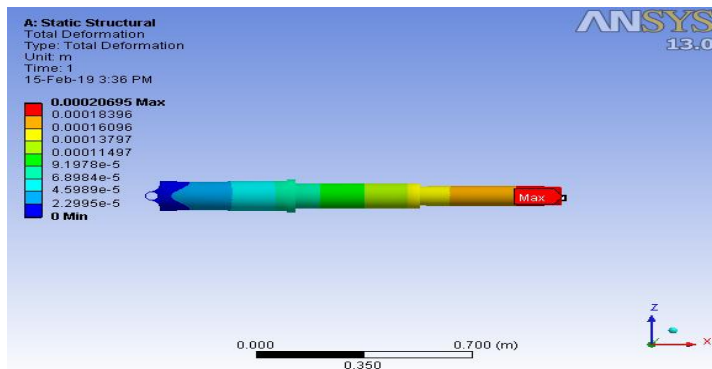


Fig 7. Total deformation

4. Failures :-

These are the following list of failures and troubleshooting [25].

Table -2 list of failures and trouble shooting.[25]

Sr. no.	failures	Causes	Trouble shooting
1.	Ruin of bearing surfaces	Moment load between steel body and hydraulic oil.	Sufficient design of bearing surface and proper service.
2.	Wear and tear of piston skirt	Not proper assembling and abrasive particles.	Tight sealing and routine maintenance.
3.	Leakage	Clearance due to friction between seals	change seals after a definite time
4.	Creeping	rough surface of piston and sleeve	Enough cooling required
5.	Jam	1.lack of oil 2.deformation of assembly due to deformation	adjusting the valve port
6.	Buffer out of order	Due to shock waves	adjust the vibration to simulate

According to the above failure mode analysis, we could establish the failure modules based on commercial software and analyze their performance under some failure occurrence.

5. Results and discussion:-

1. As is shown in the stress nephogram, allowable stress of the two-stage cylinder barrel is 321.2

Mpa and the maximum stress is 69.2 Mpa. So the hydraulic cylinder is safe.

2. As is shown in the displacement nephogram, the lateral stiffness of the two-stage hydraulic cylinder can satisfy the requirement of stability and the deformation is less and meets the operating requirement.
3. The stress on the trunnion and cylinder bottom is bigger. The simulation results above are corresponding to the actual situation. The structure design and mechanical analysis of the virtual prototype illustrated that the design and selection of multistage hydraulic cylinder used in trailers are reasonable.

6. Conclusions:-

1. The two-stage hydraulic cylinder designed in this paper can greatly fulfill the lifting force, shorten the stroke per cylinder and increase the total strokes. Meanwhile, it can ensure the lateral stiffness and stability of the hydraulic cylinder. So there will less chance of failures that leads to the decrement of maintenance actions.
2. Based on the SOLIDWORKS and ANSYS, the task of design and development of hydraulic cylinder used in trailers can be completed quickly and efficiently. This method has high practical value because it can greatly shorten the product research cycle.
3. ANSYS provides efficient analysis and reduces the chance of failure to reduce the cost by minimizing breakdown, repair maintenance and improve the efficiency of an enterprise.

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