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Analysis f Transient Flow and Fluid Flow Over a Mono Directional Hydraulics System.

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ABSTRACT

Mechanical motions within machines, like the sprayer, are typically controlled with hydraulic systems instead of pneumatics due to the higher power density of the less compressible hydraulic oil. The motion control provided by these hydraulic systems can be divided into two sub-categories, rotational motion and linear motion. While rotational motion can be generated by hydraulically with motors, linear motion control is typically accomplished using hydraulic cylinders. In the present paper, a static structural analysis on the hydraulic system was performed. The static structural analysis is considered to determine deformations, stress and strains at different loads. Similarly, by using transient structural analysis of hydraulic at different loads, motion of hydraulic system is defined.

Keywords: Static analysis, fluid dynamics, Hydraulic System.

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1. INTRODUCTION

The principles that provide the basis of fluid power were being developed as early as the 1600's[1]. However, the hydraulic portion of the fluid power industry, as we know it today, has mainly been developed within the last century, particularly since a hydraulic system utilizing oil instead of water was used to control guns on the USS Virginia in 1906 [2]. The economic impact of the fluid power industry still remains strong today; based on 2013 U.S. Census Bureau data, sales within the fluid power industry surpassed $22 billion and provided jobs for 71,000 people. After taking a broader view of the industry and including ten key industries that utilize fluid power components, the employment numbers increase to over 874,000 people with payroll figures exceeding $54.4 billion [3]

Figure 1: Multiple sectors of industry incorporate fluid power components.

Recent developments in the fluid power industry have focused on the incorporation of sensing and control technology to develop systems that have the potential to increase machine productivity and efficiency. For instance, automating certain machinery such as an agricultural sprayer can allow for more efficient application of agricultural chemicals and a reduced environmental impact. Achieving improvements in the efficiency and productivity of equipment like the sprayer requires improved motion control of the mechanical systems involved in the machine's operation.

Mechanical motions within machines, like the sprayer, are typically controlled with hydraulic systems instead of pneumatics due to the higher power density of the less compressible hydraulic oil. The motion control provided by these hydraulic systems can be divided into two sub-categories, rotational motion and linear motion. While rotational motion can be generated by hydraulically with motors, linear motion control is typically accomplished using hydraulic cylinders.

While linear motion control can be conducted through alternative methods using mechanical and electrical systems, a hydraulic cylinders ability to transmit power is limited only by the structural strength of the materials used in machining the cylinder[4]. The immense power and force capabilities of a hydraulic cylinder can, however, be detrimental when the moving piston is permitted to impact the case at the end of stroke.

To address the issues regarding damage and unwanted motion due to impact, hydraulic cylinder cushions have been developed to decelerate the piston and rod assembly as it approaches the end of the stroke[5]. Piston deceleration is achieved by metering the fluid as it exits the cylinder causing a pressure increase in either the cap or rod end, depending on direction of motion (Figure 1). By increasing the pressure in these volumes on the back side of the piston, a force resisting the motion of the piston is developed causing the piston to decelerate.

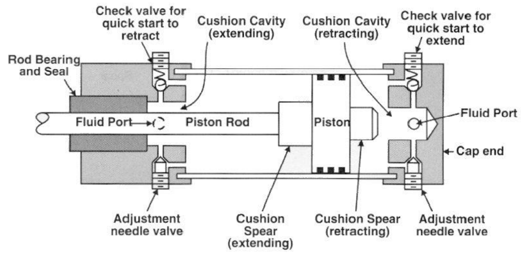


Figure 2: Hydraulic cylinder with cushioning spears to meter flow out of fluid port.

Various approaches to metering the fluid for cylinder cushions have been implemented. One approach diverts the outlet flow through needle valves as the cushion spear enters the cushion cavity (Figure 2). An alternative approach utilizes a cushioning spear or collar that either contains a varying outer diameter or internally bored orifices to variably meter the outlet flow as a function of insertion depth of the spear into the cushioning cavity (Anon, 1973). This research paper focused on the second approach.

The objectives of this work are to:

1. Develop a dynamic model that can predict the velocity and pressure performance of a hydraulic cylinder cushion.
2. Support the developed dynamic model through analytical analysis.
3. Utilize the dynamic model to analyze the performance of cushioning spear types commonly found in industry and compare those spears to the analytically developed spear type.
4. Implement a cushion design optimization procedure to find cushioning spear profiles which best achieve a predetermined velocity profile.

2. LITERATURE REVIEW: Hydraulic cylinders are used extensively in industry to provide linear motion control. These cylinders are composed of cylindrically shaped metal case with a piston rod assembly (A and B respectively in Figure 2) that moves back and forth within the case. The piston and rod assembly separates two different volumes inside the cylinder case. For a single rod cylinder, these two volumes are called: the rod end volume, where the rod end is the end of the cylinder from which the rod protrudes, and the cap end volume, where the cap end does not have a rod. As these volumes are pressurized, hydrostatic forces due to the pressurized fluid act on the surfaces of the vessel containing the fluid.

Thus, the forces acting on the piston-rod assembly cause it to move, extending the rod out of the cylinder case or retracting the rod into the cylinder case (Figure 3 shows a cylinder in retraction). An external load can be attached to cylinder rod, and as the piston-rod assembly moves, a force is exerted on the load causing the load to move along a linear path. For a cylinder in retraction, the flow leaving the cap end exits through the cushioning cavity E before returning to the rest of the hydraulic circuit through the cylinder port I. The cylinder stops when the piston reaches the end of its stroke, or when the piston makes contact with the end cap, H. The components labelled F and G are the cylinder cushion spear and collar that decelerate the piston before it contacts the end cap in either retraction or extension, respectively.

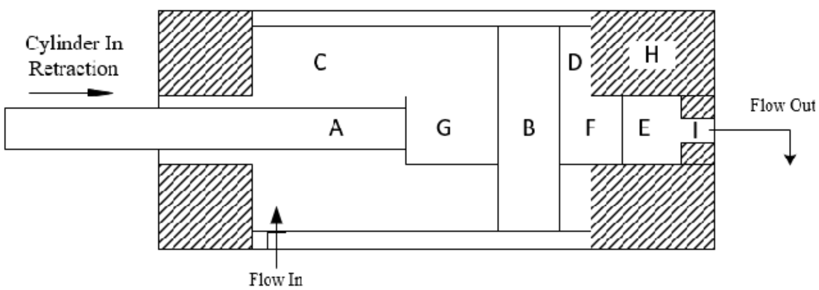


Figure 3: Hydraulic cylinder in retraction with main functional components.

Hydraulic cylinders provide high power density for moving heavy loads, but if the cylinders are allowed to reach end of stroke at full speed, sudden deceleration can cause excessive impact (Esposito, 2003). Therefore, a cushioning mechanism was designed to decelerate the cylinder piston and reduce the speed at which impact occurs.

Cylinder cushions meter the flow leaving the cylinder case causing pressure to increase. When the area of the piston is exposed to this accumulating pressure, a force develops that opposes the motion of the piston-rod assembly causing deceleration[7]. With the importance of accurately metering the fluid leaving the cylinder to create a resisting force, there is value in predicting the pressure response, i.e. the cushion pressure as a function of time, generated when the fluid is metered by the cushioning mechanism orifice.

In approaching the development of a mathematical model to describe the performance of a hydraulic cylinder and cylinder cushion, it was necessary to investigate how other researchers had treated similar systems. In their general approach to describing the system, other researchers seemed to choose one of two methods: an energy based model, or a model based on the principle dynamic equations. The earliest research efforts tended to lean towards the energy approach that required less complicated mathematics.

In more recent investigations, with the assistance of computer-based analysis, numerical simulation provided more insight into the response of the system. The details of how various researchers applied both of these methods, the energy approach and that based on principle equations, were reviewed and are detailed in this work.

3. PART MODELING: In this, we will be able to:

Understand the design modeller workshop, Draw sketches, Convert sketches into 3d models, Understand views of the model in 3d space, Apply constraints and relations.

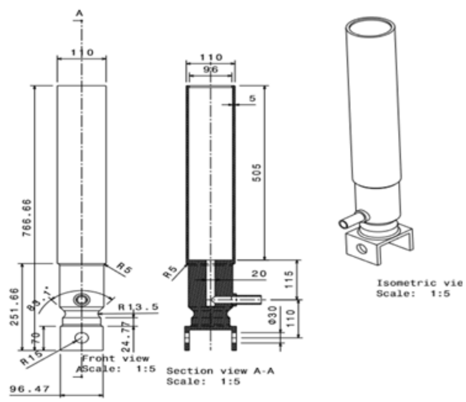


Fig 4.1 part diagram

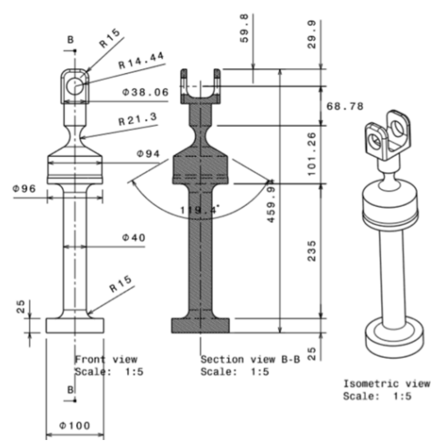


Fig 4.1 part diagram

4. STATIC STRUCTURAL ANALYSIS

In this work, we will be able to define total deformation and stress, etc

- Create the static structural analysis system
- Apply different types of materials
- Applying of boundary conditions

- Apply a different type of constraints
- Apply different loads
- Generate the results as per required

In this work, we imported the geometry of the component show the dimensions for the component with respect to the load applications. The material to be applied on the model is Stainless Cast iron. Next, you will run the analysis under two conditions and evaluate the Total Deformation, Directional Deformation, Equivalent Stress, Maximum Principal Stress, and Minimum Principal Stress.

The Static Structural analysis is one of the important analyses in ANSYS Workbench. It is available as Static Structural analysis system under the Analysis System toolbox in the Toolbox window, this system analyses the structural components for displacements (deformation), stresses, strains, and forces under different loading conditions. The loads in this analysis system are assumed not to have damping characteristics (time dependent). Steady loading and damping conditions are assumed in this type of analysis system.

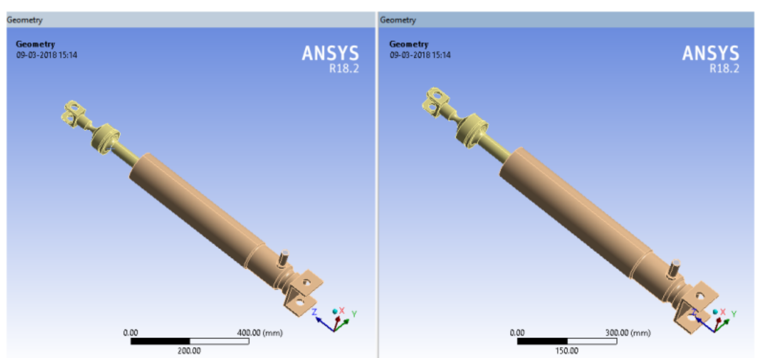
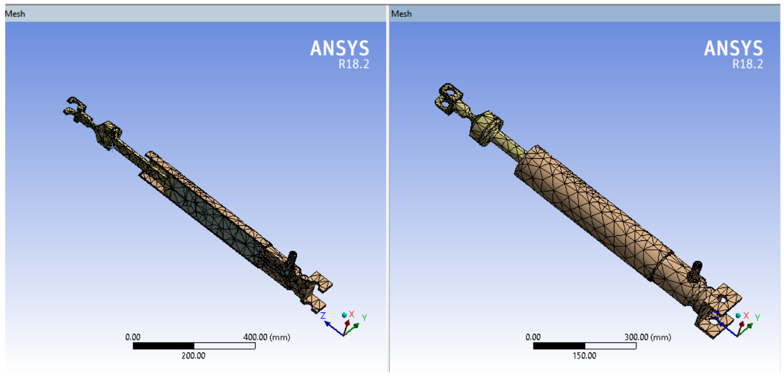


Fig 6.6 Modal in static structural analysis

After the model is created in the Design Modeler window, we need to generate the mesh for the model in the Mechanical window.



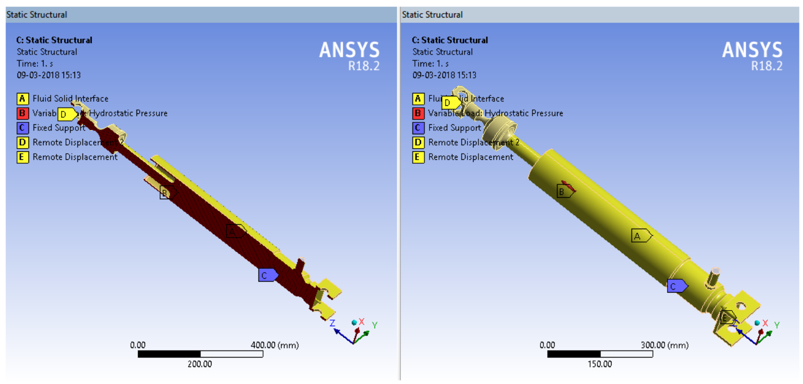


Fig 6.9 The violet and red color face of the model displaying the Fixed support and forces

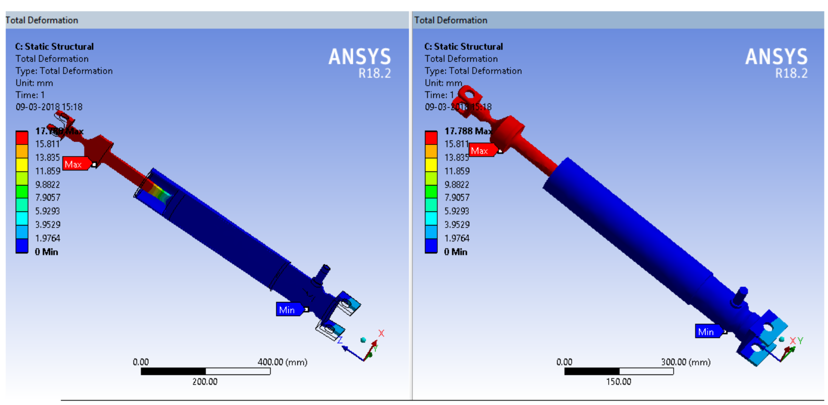


Fig 6.10 Total deformation of the hydraulic system and its selection view

The value that is displayed next to each color is the Total Deformation in the region which is depicted by that particular color in the model. The blue color in the model represents the lowest value of the Total Deformation, whereas the red color denotes the maximum value of the total Deformation.

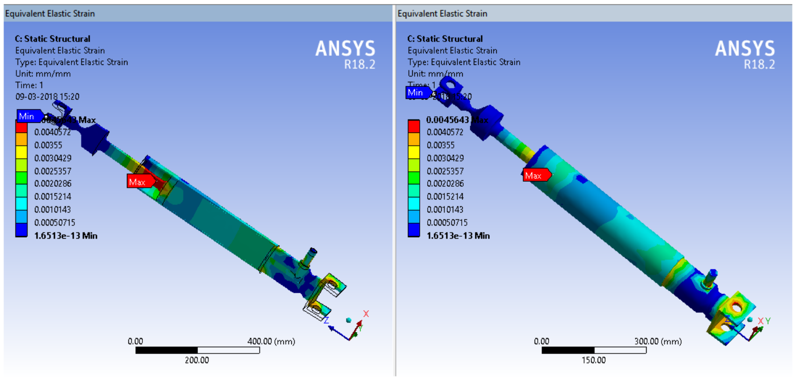


Fig 6.11Equivalent strain of the hydraulic system and its selection view

The value that is displayed next to each color is the equivalent strain in the region which Is depicted by that particular color in the model. The blue color in the model represents the Lowest value of the equivalent strain, whereas the red color denotes the maximum value of The equivalent strain.

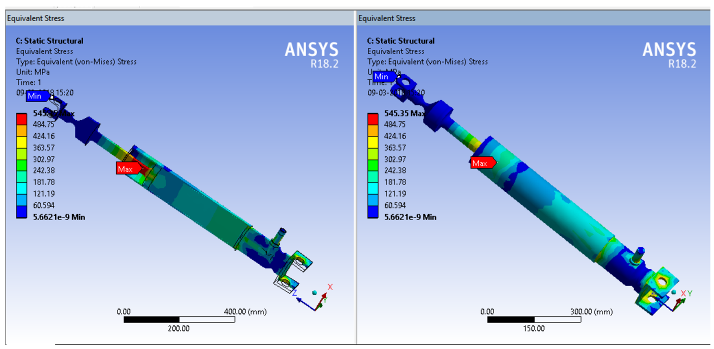


Fig 6.12 Equivalent stress of the hydraulic system and its selection view

The value that is displayed next to each color is the equivalent stress in the region which is depicted by that particular color in the model. The blue color in the model represents the lowest value of the equivalent stress, whereas the red color denotes the maximum value of The equivalent stress.

5. Results for aluminum alloy; if hydraulic system is made up of aluminum alloy

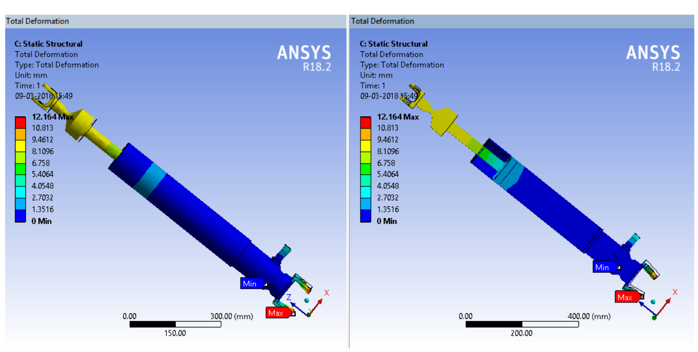


Fig 6.13 Total deformation of the hydraulic system and its selection view

The value that is displayed next to each color is the Total Deformation in the region which Is depicted by that particular color in the model. The blue color in the model represents the lowest value of the Total Deformation, whereas the red color denotes the maximum value of The Total Deformation.

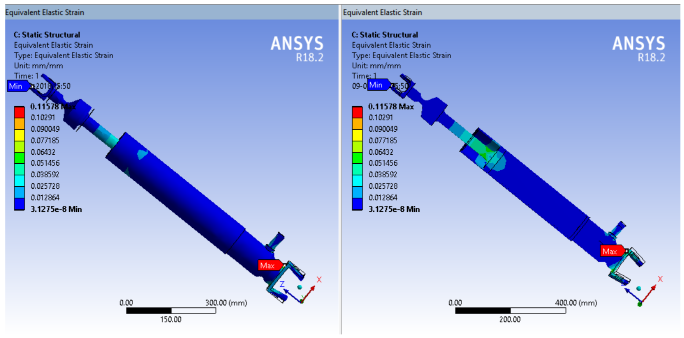


Fig 6.14 Equivalent strain of the hydraulic system and its selection view

The value that is displayed next to each color is the equivalent strain in the region which is depicted by that particular color in the model. The blue color in the model represents the lowest value of the equivalent strain, whereas the red color denotes the maximum value of the equivalent strain.

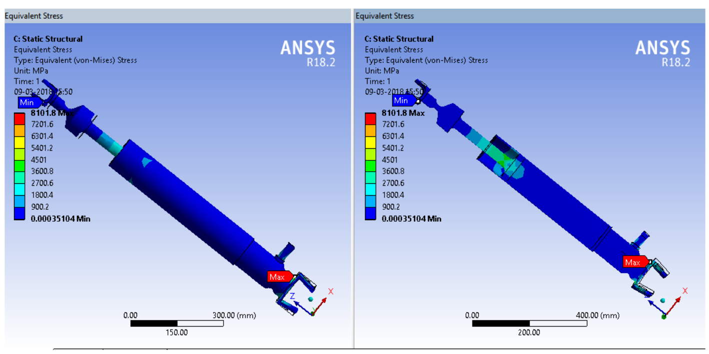
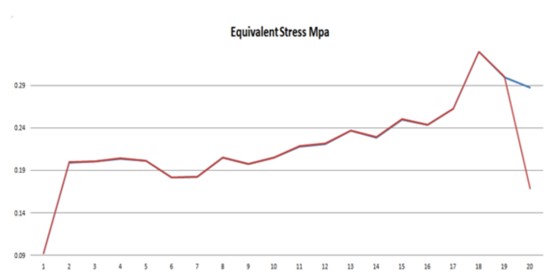
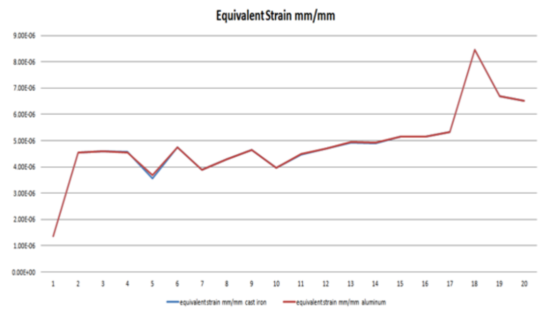


Fig 6.15 Equivalent stress of the hydraulic system and its selection view

The value that is displayed next to each color is the equivalent stress in the region which is depicted by that particular color in the model. The blue color in the model represents the lowest value of the equivalent stress, whereas the red color denotes the maximum value of the equivalent stress.



Graph 1: graph from the transient structural analysis



Graph 2: Graph from the transient structural analysis

6. CONCLUSIONS:

In this work, the analysis of the hydraulic system is done. By performing the static analysis on the hydraulic system, the motion of piston in hydraulic is obtained because of the fluid intake or pump into the hydraulic cylinder.

As per the above analysis, increasing of the fluid makes the increase of the pressure, the stress and the strain in the chamber. As the results state that the piston sliding is due to the pressure built in the chamber.

The process of the transient structural analysis is carried out by change of materials like cast iron (general material for the hydraulic) and aluminum alloy (light material for the manufacturing) and in process the difference in between the pressures, the stress, and the strains are found to be small.

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