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Research Paper

DESIGN, ANALYSIS AND FABRICATION OF A HYDRAULIC DIE EJECTOR FOR A POWDER METALLURGY COMPONENT

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The proposed project work attempts to design and develop a Hydraulic power pack of 1.2 Ton capacity for lifting a powder metallurgy component Die. Design of the components in the assembly are done considering the explicit conditions by the industry and the implicit conditions, i.e., inherent to all hydraulic units design and powder metallurgy components. The parts will be modeled in Solid Works and the core components will be subjected to structural analysis in ANSYS. As a result of design and analysis, the dimensions are finalized with the tolerances and mating conditions. The designed components of Hydraulic Die ejector will be manufactured in lathe machines as per the given specifications. The components will be assembled and tested in practical environments of the industry. The design and fabrication is considered to be cost effective.

Keywords: Powder metallurgy component die, Hydraulic power pack, Design, Analysis, Manufacturing, Assembly, Testing

INTRODUCTION

Powder Metallurgy

Powder metallurgy (PM) is the process of blending fine powdered materials, pressing them into a desired shape or form (compacting), and then heating the compressed material in a controlled atmosphere to bond the material. The powder metallurgy process generally consists of four basic steps: powder manufacture, powder blending and sintering. Compacting is generally performed at room temperature, and the elevated-temperature process of sintering is usually conducted at atmospheric pressure. The use of powder metal technology bypasses the need to manufacture the resulting products by metal removal processes, thereby reducing costs.

POWDER COMPACTION

Powder compaction is the process of compacting metal powder in a die through the

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application of high pressures. Typically the tools are held in the vertical orientation with the punch tool forming the bottom of the cavity. The powder is then compacted into a shape and then ejected from the die cavity.

Application of high pressure to the powders to form them into the required shape:

- The conventional compaction method is pressing, in which opposing punches squeeze the powders contained in a die.
- The work part after pressing is called a green compact, the word green meaning not yet fully processed.

Figure 1: A View of Powder Compaction Material

HYDRAULIC DIE EJECTORS

Hydraulic die ejector gets their power from pressurized hydraulic fluid, which is typically oil. The cylinder consists of a cylinder barrel, in which a piston connected to a piston rod is moving. The barrel is closed by the cylinder bottom and by the cylinder head where the piston rod comes out of the cylinder. The piston has sliding rings and seals. The piston divides the inside of the cylinder in two chambers, the bottom chamber and the piston rod side chamber. The hydraulic pressure acts on the piston to do linear work. A hydraulic cylinder is the actuator or "motor" side of this system. The "generator" side of the hydraulic system is the hydraulic pump that brings a fixed or regulated flow of oil into the system. The piston pushes the oil in the other chamber back to the reservoir. If we assume that the oil pressure in the piston rod chamber is zero, the force on the piston rod equals the pressure in the cylinder times the piston area. If the oil is pumped into the piston rod side chamber and the oil from the piston area flows back to the reservoir without pressure, the pressure in the piston rod area chamber is Pull Force/(piston area-piston rod area). In this way the hydraulic cylinder can both push and pull.

DESIGN AND ANALYSIS

Design of Hydraulic Die Ejector

The proposed project work attempts to design and develop a hydraulic die ejector of 1.2 Ton at 100 bar pressure for lifting a powder metallurgy component. Design of the components in the assembly are done considering the explicit conditions by the industry and the implicit conditions, i.e., inherent to all the hydraulic units design and powder metallurgy components.

For the design of hydraulic die ejector, the selection of materials is the important task in finding the best quality of materials.

Bill of Materials of the Hydraulic Die Ejector

The properties and the theory of the bill of materials of hydraulic die ejector are explained below:

EN8 Alloy for Making Cylinder and Piston Rod

EN8 also known as 080M40, unalloyed medium carbon steel. EN8 is a medium

Table 1: Bill of Materials

S. No.	Parts of the Hydraulic Die Ejector	Material	Quantity
1.	Cylinder	EN 8 alloy	1
2.	Piston	EN 8 alloy	1
3.	Cover plate	Mild steel	1
4.	O-rings	Synthetic rubbers	3
5.	Bolts	M6 x 20 mm counter shunk screws	4

Table 2: Chemical Composition of EN8

Element	Min	Max
Carbon, C	0.35%	0.45%
Manganese, Mn	0.60%	1.0%
Silicon, Si	0.5%	0.35%
Sulphur	–	0.6%
Phosphorus	–	0.6%

Table 3: Mechanical Properties of EN8

Condition	Yield Stress	Tensile Stress MPa	Elongation %
Normalized	280	550	16
Cold drawn (thin)	530	660	7

Table 4: Analysis of EN8

Carbon	0.35-0.45%
Manganese	0.60-1.00%
Silicon	0.05-0.35%
Phosphorous	0.06% max
Sulphur	0.06% max

strength steel, good tensile strength. EN8 is supplied as round drawn/turned, round hot rolled, hexagon, square, flats and plate.

ISO 68 Grade Hydraulic Oil Used for Hydraulic Die Ejector

Hydraulic fluids are a large group of fluids used as the motive medium in hydraulic machinery. In this designed project, for hydraulic die ejector. ISO 68 grade hydraulic oil is filled in the hydraulic cylinder by hydraulic pump, due to the pressure the piston moves up. To lower the piston valve is provided by which the liquid grade oil returns to the hydraulic tank.

Table 5: ISO 68 Grade Hydraulic Oil Properties

Property	Value in Metric Unit
Density at 60 °F (15.6 °C)	0.880×10^3 kg/m^3
Kinematic viscosity at 104 °F (40 °C)	68.0 centistokes (millimeter^2/second)
Kinematic viscosity at 212 °F (100 °C)	10.2 centistokes (millimeter^2/second)
Viscosity index	135
Flash point	204 ºC
Pour point	–40 ºC

O-Rings of the Hydraulic Die Ejector

An O-ring, also known as a packing, or a toric joint, is a mechanical gasket in the shape of a torus; it is a loop of elastomer with a round cross-section, designed to be seated in a groove and compressed during assembly between two or more parts, creating a seal at the interface.

The O-ring may be used in static applications or in dynamic applications where there is relative motion between the parts and the O-ring.

Mild Steel Material Used for Cover Plate

Mild steel is also known as plain-carbon steel, is the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications, more so than iron. Low-carbon steel contains approximately 0.05-

0.320% carbon making it malleable and ductile.

Table 6: Mechanical Properties of Mild Steel	
Max Stress	400-560 n/mm^2
Yield Stress	300-440 n/mm^2 Min
0.2% Proof Stress	280-420 n/mm^2 Min
Elongation	10-14% Min

Table 7: Chemical Composition of Mild Steel	
Carbon	0.16-0.18%
Silicon	0.40% Max
Manganese	0.70-0.90%
Sulphur	0.040% Max
Phosphorus	0.040% Max

Theoretical Calculations for Hydraulic Die Ejector

The proposed project needs to develop a Hydraulic power pack of 1.2 Ton capacity for lifting a powder metallurgy component Die.

Specifications given for Hydraulic Die ejector are:

Internal Diameter of the Cylinder = 30 mm = 3 cm

Applied Pressure to the Die = 100 bar = 100 kg/cm^2

For 1st Hydraulic Die ejector

Pressure = Load/Area

Load 1 = Pressure x Area

= 100 Kg/cm^2 x ®D^2/4

= 100 Kg/cm^2 x ®$(3)^2$/4 cm^2

= 100 Kg/cm^2 x 7.065 cm^2

= 706.5 Kg = 0.706 Ton

For 2nd Hydraulic Die ejector

Load 2 = Pressure x Area

= 100 Kg/cm^2 x ®D^2/4

= 100 Kg/cm^2 x ®$(3)^2$/4 cm^2

= 100 Kg/cm^2 x 7.065 cm^2

= 706.5 Kg = 0.706 Ton

Therefore, Load 1 + Load 2 = 0.706 Ton + 0.706 Ton = 1.41

As per design developed and the required amount of Hydraulic power pack of 1.2 Ton capacity for lifting a powder metallurgy component Die is theoretically calculated.

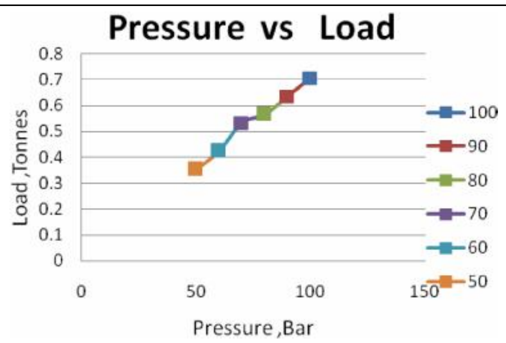
Calculated Theoretical Values of The Hydraulic Die Ejector

Table 8: Theoretical Values of Pressure and the Load

S. No.	Pressure (Bar)	Load (Ton)
1.	100	0.706
2.	90	0.635
3.	80	0.565
4.	70	0.532
5.	60	0.423
6.	50	0.353

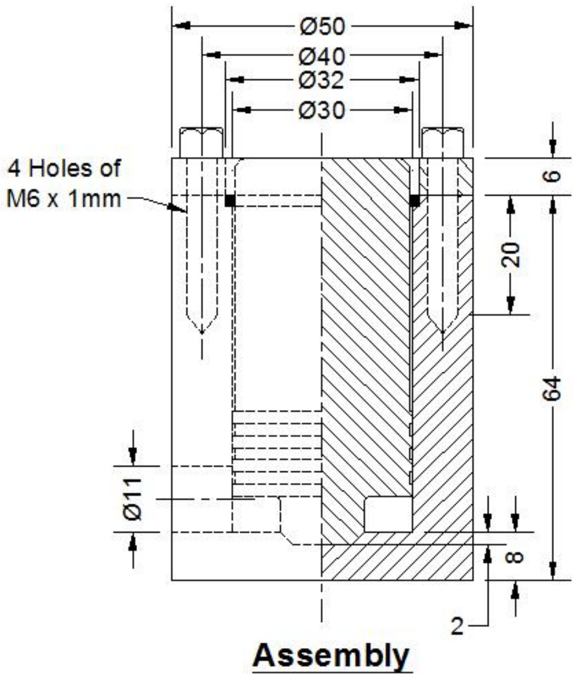
Graph Plotted Between Pressure And Load

Figure 2: Curve Plotted Between Load and Pressur



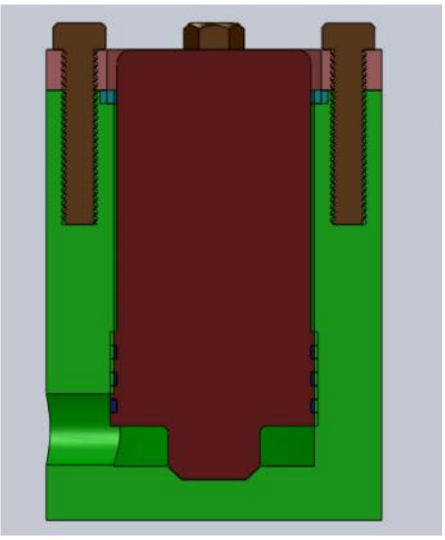
Hydraulic Die Ejector in 2D Drafting (Autocad)

Figure 3: 2D Drafting of Hydraulic Die Ejector Assembly



Components of Hydraulic Die Ejector in 3D Solid Modeling (Solid Works)

Figure 4: Solid Model of Hydraulic Die Ejector



FEA Implementation on Hydraulic Die Ejector

Figure 5: Deformation of the Cylinder at 50 bar Pressure

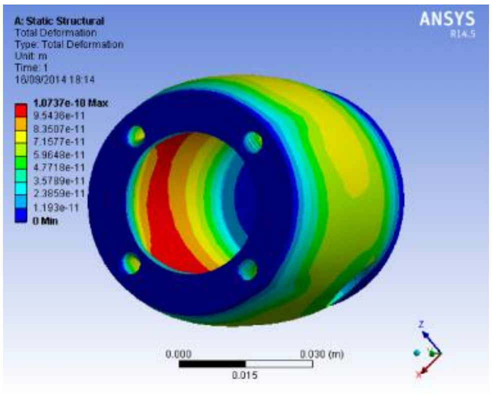


Figure 6: Analysis of Strain at 50 bar Pressure

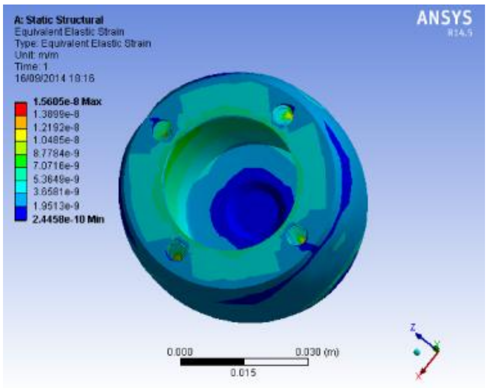


Figure 7: Analysis of Stress at 50 bar Pressure

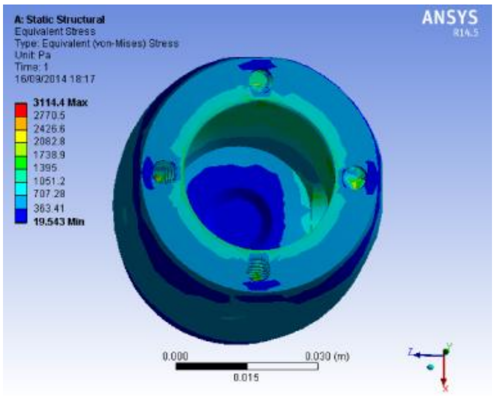


Figure 8: Analysis of Piston Rod Deformation at 50 bar Pressure

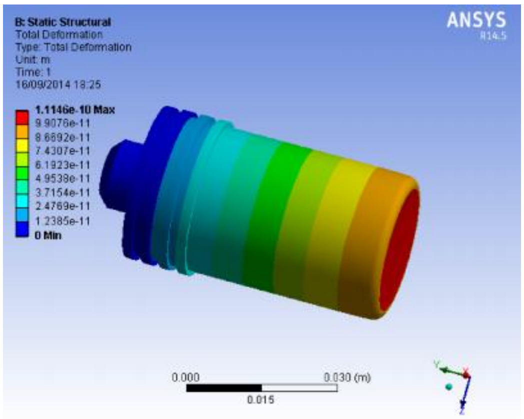


Figure 9: Analysis of Piston Rod Strain at 50 bar Pressure

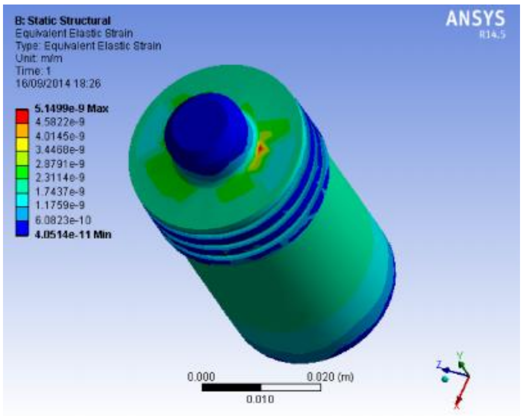


Figure 10: Analysis of Piston Rod Stress at 50 bar Pressure

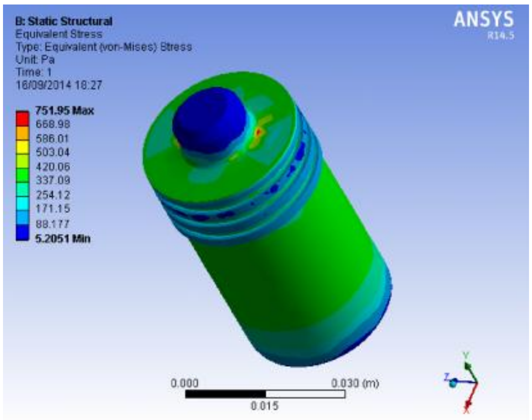


Figure 11: Deformation of the Cylinder at 60 bar Pressure

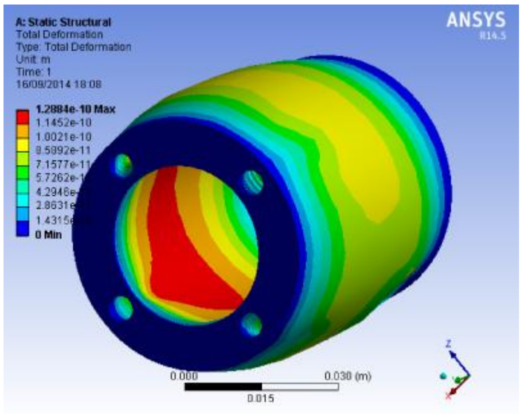


Figure 12: Analysis of Cylinder Stress at 60 bar Pressure

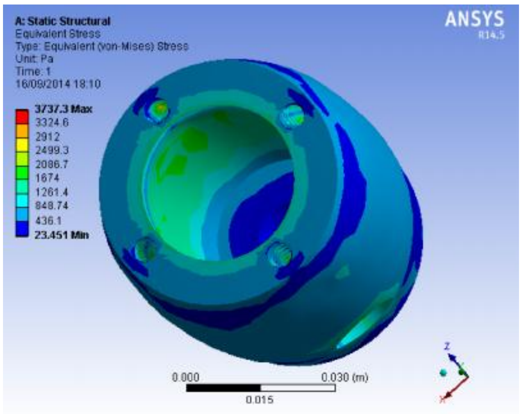


Figure 13: Analysis of Cylinder Strain at 60 bar Pressure

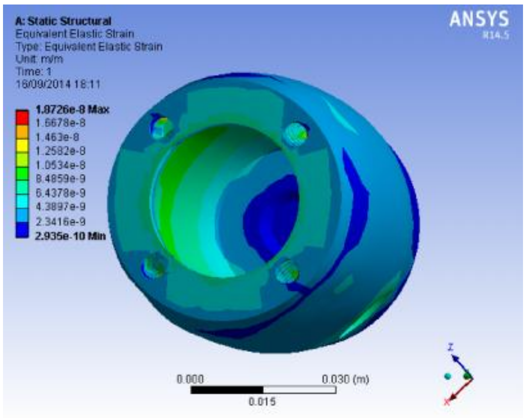


Figure 14: Analysis of Piston Rod Deformation at 60 bar Pressure

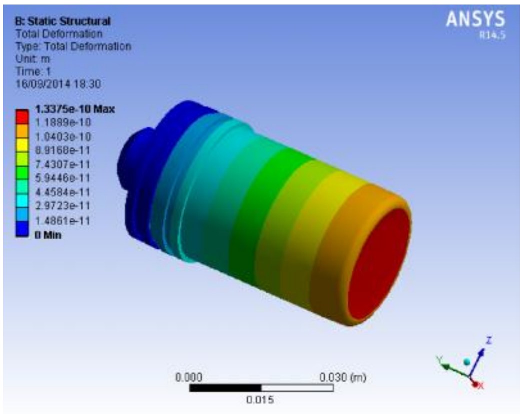


Figure 15: Analysis of Piston Rod Strain at 60 bar Pressure

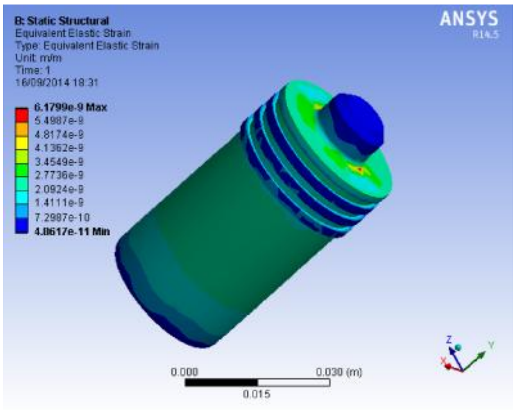


Figure 16: Analysis of Piston Rod Stress at 60 bar Pressure

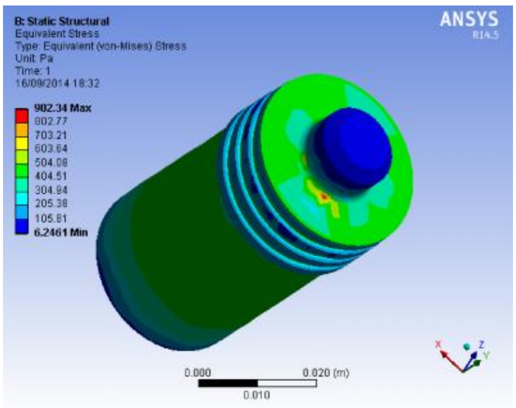


Figure 17: Deformation of the Cylinder at 70 bar Pressure

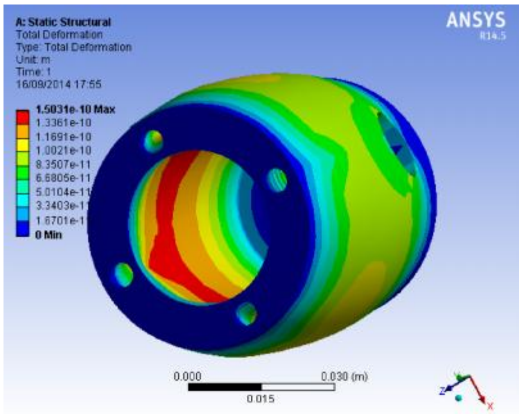


Figure 18: Analysis of Cylinder Stress at 70 bar Pressure

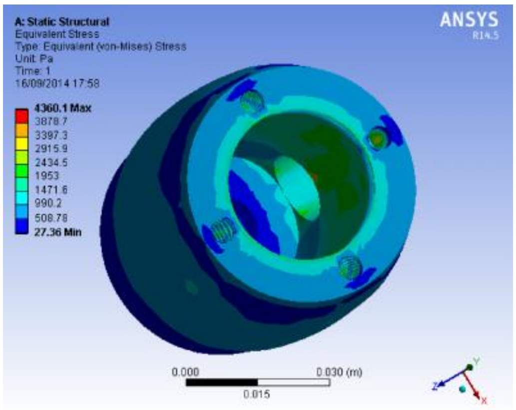


Figure 19: Analysis of Cylinder Strain at 70 bar Pressure

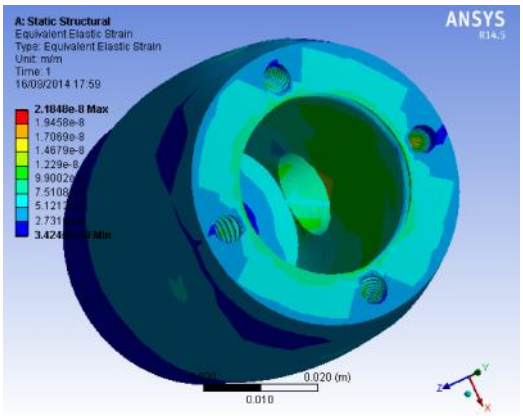


Figure 20: Analysis of Piston Rod Deformation at 70 bar Pressure

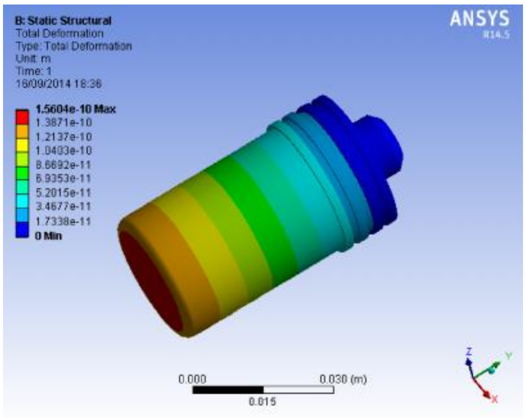


Figure 21: Analysis of Piston Rod Strain at 70 bar Pressure

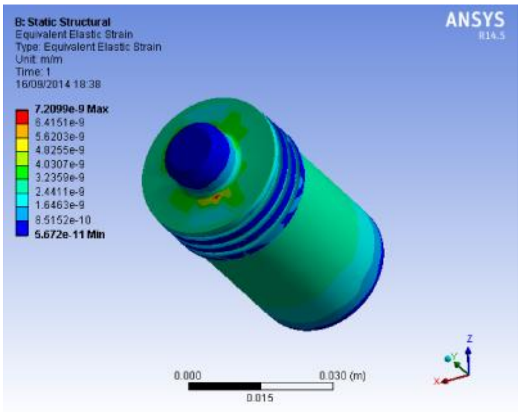


Figure 22: Analysis of Piston Rod Stress at 70 bar Pressure

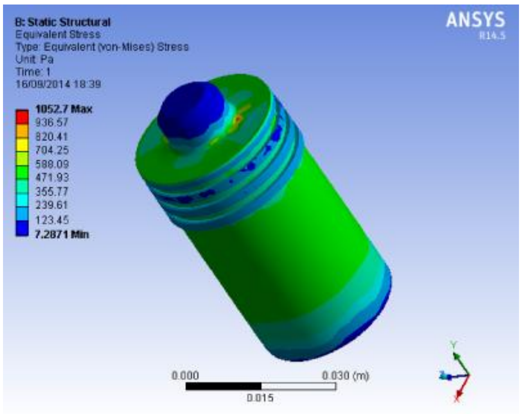


Figure 23: Deformation of the Cylinder at 80 bar Pressure

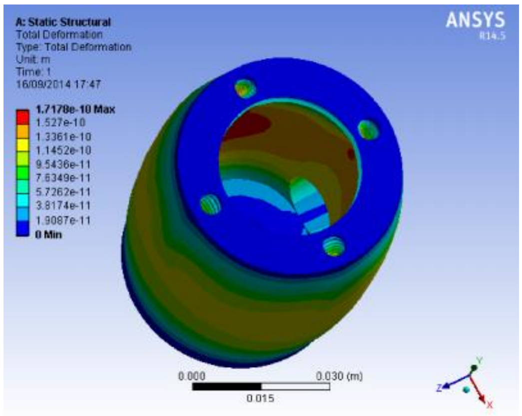


Figure 24: Analysis of Cylinder Strain at 80 bar Pressure

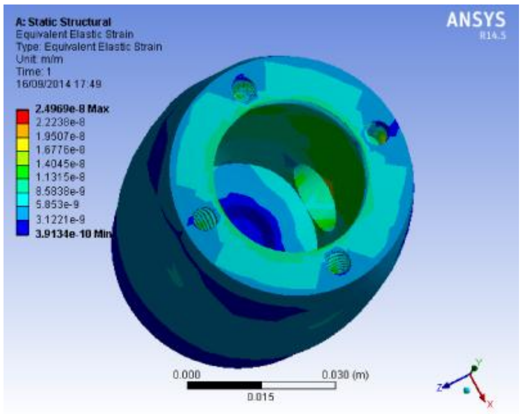


Figure 25: Analysis of Cylinder Stress at 80 bar Pressure

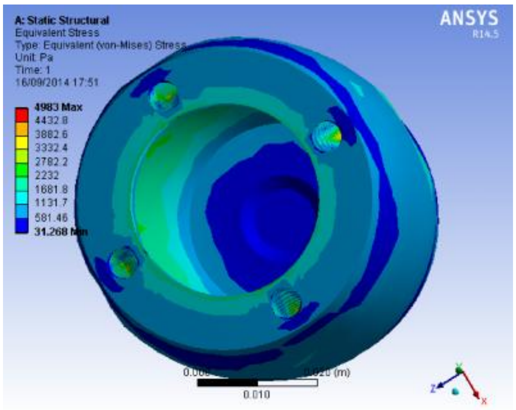


Figure 26: Analysis of Piston Rod Deformation at 80 bar Pressure

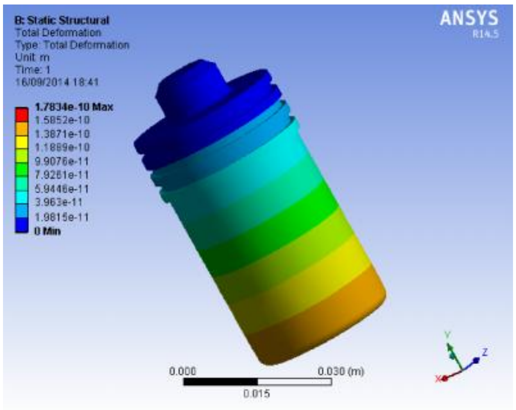


Figure 27: Analysis of Piston Rod Strain at 80 bar Pressure

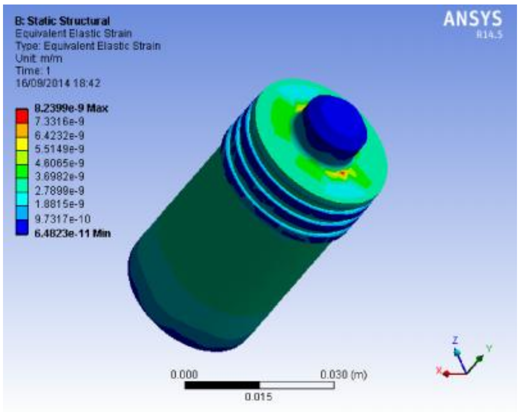


Figure 28: Analysis of Piston Rod Stress at 80 bar Pressure

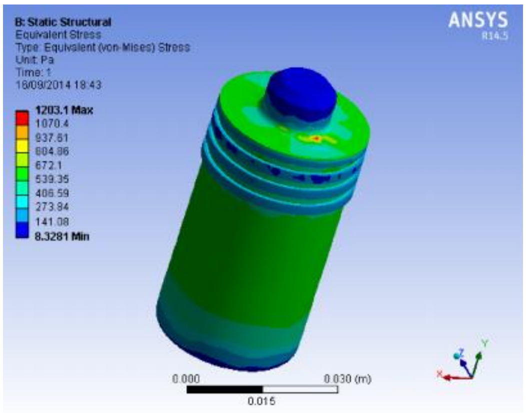


Figure 29: Deformation of the Cylinder at 90 bar Pressure

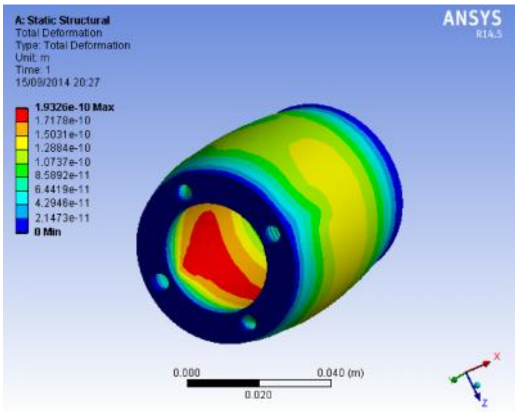


Figure 30: Analysis of the Cylinder Stress at 90 bar Pressure

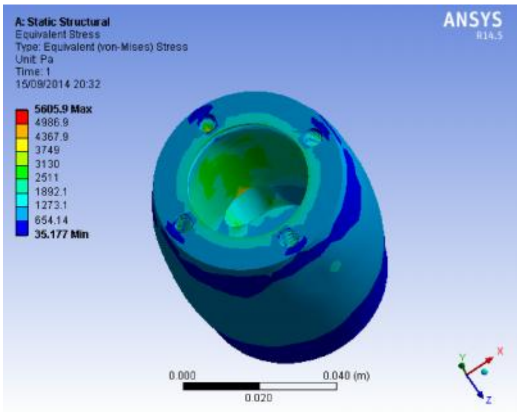


Figure 31: Analysis of the Cylinder Strain at 90 bar Pressure

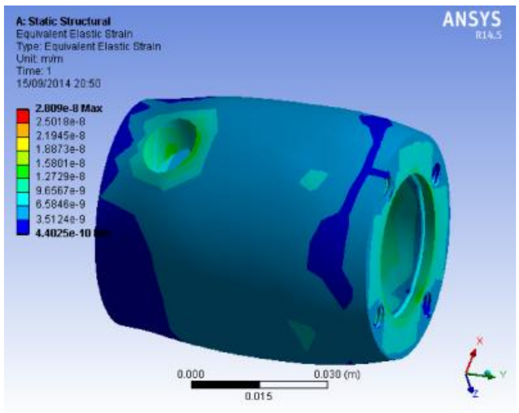


Figure 32: Piston Rod Deformation at 90 bar Pressure

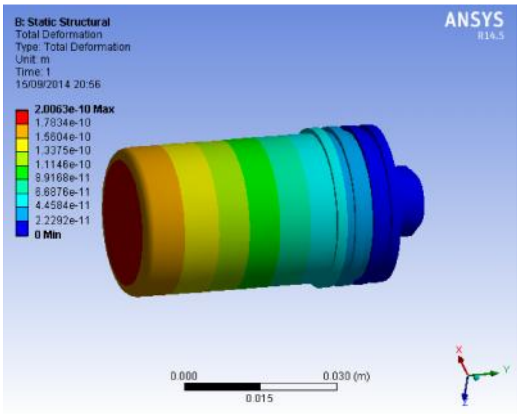


Figure 35: Analysis of Strain of Cylinder at 100 bar Pressure

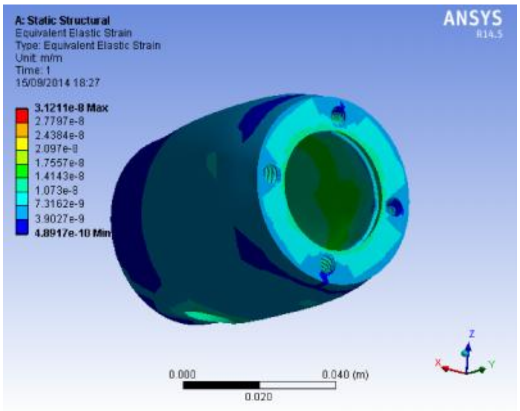


Figure 33: Analysis of Piston Rod Stress at 90 bar Pressure

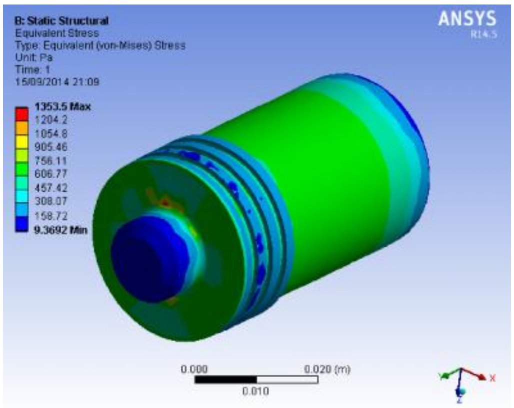


Figure 36: Analysis of Stress of Cylinder at 100 bar Pressure

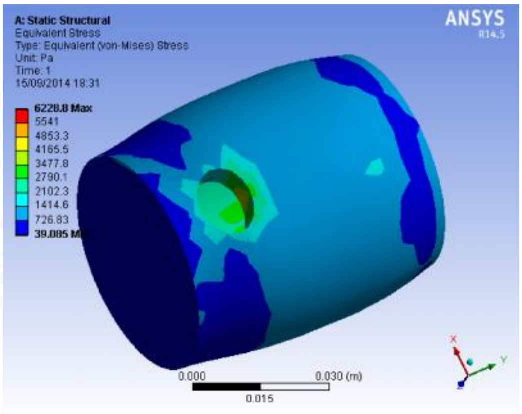


Figure 34: Analysis of Deformation of Cylinder at 100 bar Pressure

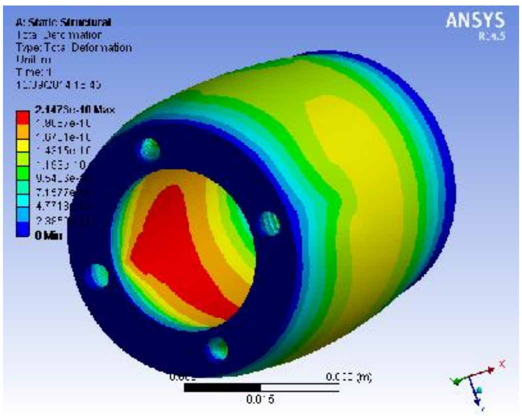


Figure 37: Analysis of Piston Rod Deformation at 100 bar Pressure

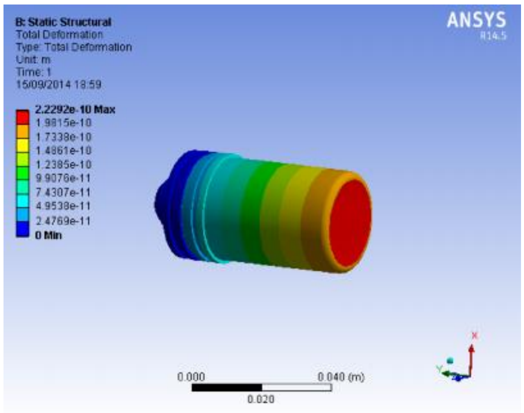


Figure 38: Analysis of Piston Rod Strain at 100 bar Pressure

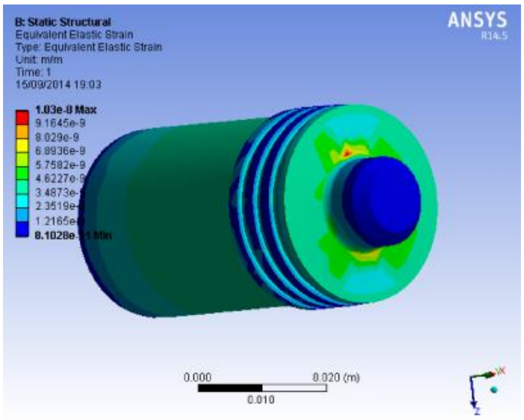
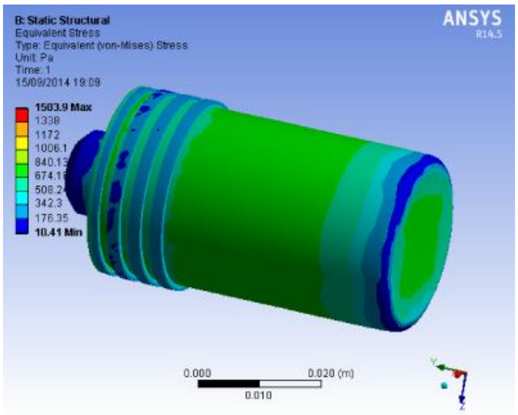


Figure 39: Analysis of Piston Rod Stress at 100 bar Pressure



FABRICATION AND TESTING

Fabrication Process of Hydraulic Die Ejector

Step wise fabrication process of hydraulic die ejector:

1. Material selection of the hydraulic die ejector is selected with the industry conditions and the properties of the materials.

2. As the material is selected, the dimensions are marked on the material and the required amount of material is taken for fabrication of hydraulic die ejector.

3. After the marking of dimensions and with the help of 2D drafting the required cylinder, piston rod and the cover plate of hydraulic die ejector are manufactured in the lathe machine operation. Turning, Drilling, Grooving, Step turning, Chamfering, Boring and Tapping operations are done to fabrication of hydraulic die ejector.

4. All the operations are processed with the help of 2D drafting, dimensional constraints and considering the limits and tolerances of manufacturing conditions.

5. Surface grinding and Surface finishing operations are processed for achieving the assembly (mating of parts) of the hydraulic die ejector.

6. Synthetic O-rings are purchased and are selected with hydraulic fluid constraints and conditions.

7. After the manufacturing of all the parts with industrial conditions, which are mentioned in the bill of materials. The final assembly of hydraulic die ejector is achieved with transition fit of the cylinder and the piston rod.

8. The final design which as developed, drafted in 2D and 3D solid modeled with the space constraints and dimensional constraints is manufactured with the implicit and explicit conditions.

9. The design and the fabrication is manufactured with reasonable cost as per the industry environments.

Testing of Hydraulic Die Ejector

With the design, analysis and fabrication, the hydraulic die ejector is manufactured by considering the dimensional constraints and space constraints on the machine.

Figure 40: Powder Compaction Machine

The hydraulic die ejector is tested in the industry.As per the requirement of two hydraulic die ejectors with dimensional constraints and space constraints are tested on the Powder compaction machine which produces the powder metallurgy components. These two die ejectors are placed on the sides of the compact unit and to the die ejectors where a 10 mm hole is made for the inlet of hydraulic oil from the hydraulic pump motor. As the Pascal principle states that the pressure in a closed container is the same at all points. When hydraulic oil from the comes with 100 bar pressure through inlet of the hydraulic die ejector, the piston rod area moves upward and lifts the load. The proposed project work attempts to design and develop a hydraulic die ejector of 1.2 Ton at 100 bar pressure for lifting a powder metallurgy component.

Pictures of Hydraulic Die Ejector While Fabrication

Figure 41: Pictures Showing the Fabrication Work of Hydraulic Die Ejector

Figure 42: Pictures Showing the Designed and Fabricated Hydraulic Die Ejector

RESULTS AND DISCUSSION

Performance of the Hydraulic Die Ejector

The project attempts to design and develop a hydraulic die ejector of 1.2 Ton at 100 bar pressure for lifting a powder metallurgy component. Design of the components in the assembly are done considering the explicit conditions by the industry and the implicit conditions, i.e., inherent to all the hydraulic units design and powder metallurgy components. As per the calculated theoretical values by considering the given specifications of the die, the overall capacity for lifting the powder metallurgy component is 1.41 Ton at 100 bar pressure. The loads are calculated with varying pressures and achieved a considerable amount of capacity for lifting the powder metallurgy components. From the analysis of 3D solid modeling, the approximate load capacity for lifting the compaction units is achieved and the less amount of deformation is analyzed with ANSYS at mechanical conditions.

CONCLUSION

- The proposed project work attempts to design, analyze and fabricate a new device called hydraulic die ejector which aims to lift the load capacity of Tons at different pressures.
- The all new design is needed in the market and industry where the hydraulic die ejector mainly focused with the space constraints and dimensional constraints almost of 70 x 50 mm.
- Finite element analysis has to be carried out properly taking care of each and every step of implementation.

- I believe in my work and efforts that the design will be helpful for the industries.
- The overall cost of the hydraulic die ejector is much lesser than the other market hydraulics.
- The die ejector is designed, analyzed and tested with utmost care of limits and tolerances of mating parts to achieve the target of load.

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