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Original Article

Calculation, Design and Manufacturing Super Short Height Hydraulic Jack, Double Acting, Lifting Capacity of 30 Tons for Lifting Bridge Beam to Replace Bearings

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Abstract *- Almost every type of jack for lifting beams of bridges to replace bearings today is single-acting or has no mechanical locks. The purpose of this research is to design and manufacture a lifting capacity of 30 tons, double acting, including a mechanical lock and large lifting height hydraulic jack. This article presents the calculation, design method with Solidwork software and test fabrication of that type of hydraulic jack.*

Keywords *- Hydraulic jack, Solidworks, Manufacture and Experiment, Inspector equipment.*

1. Introduction

The super short-height hydraulic jack is essential equipment for repairing and upgrading old bridges. The jack has the commission to lift beams to replace bearings and repair other bridge parts. There are some studies of hydraulic jacks, including: [1] has studied hydraulic jacks with spring return, [2,3,4] has studied hydraulic single acting jack with a mechanical lock, [5,6] studies telescoping cylinder jack, [7,8] studies jack with an internal cylindrical guide, [9] studies double-acting jack. The authors above just stop at the design or calculation of some basic parameters of the click; The author [10, 11] applied Solidwork software to calculate the hydraulic design. However, the studies only calculated and designed each part of the double-piston rod jack; they have not calculated and designed a hydraulic double-acting super short height jack with a mechanical lock used for lifting beams to replace bearings. The article carries on calculation and design methods using Solidworks software, manufacture and experiment process of the jack.

For the type of slab beam, box girder, PCI girder and Super Tee girder…, according to the designed span and loads, they use bearings that have differences in structure and dimension. [12] total of height total of the pad bearing, denoted by H, is equal to (21÷192) mm, and pot bearing H is equal to (70÷390) mm. For the long-span bridge, the stronger the bridge's load capacity, the bigger the bearing dimension is and vice versa. The bearings do not directly attach to the top of the pier and the bottom of the beam but usually through the lower and upper pedestals. [13] The height of the bearing seat, denoted by t, equals (15÷20) cm, the distance from the edge of the bearing to the edge of the bearing seat, denoted by A, equals (15÷20) cm, distance from the edge of the bearing set to the edge of bend cap, denoted by B, equals (20÷50) cm. Thus, the dimensions of the space where the jack is put on are B x (H+t), Figure 1, Figure 2. The hydraulic jack mentioned in the paper has a capacity of 30 tons, and the collapsed height L of the jack, denoted by (H+t), equals 120 mm (Figure 3).

2. Contents

2.1. Specification of Basic Parameters

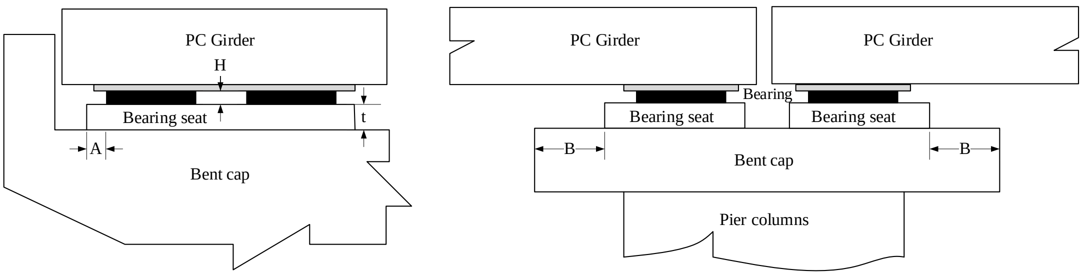

Fig. 1 Working space of the jack

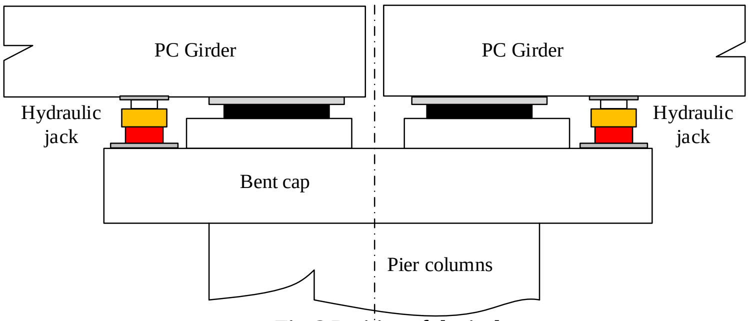

Fig. 2 Position of the jack

The layout of the jack is shown in Figure 3.

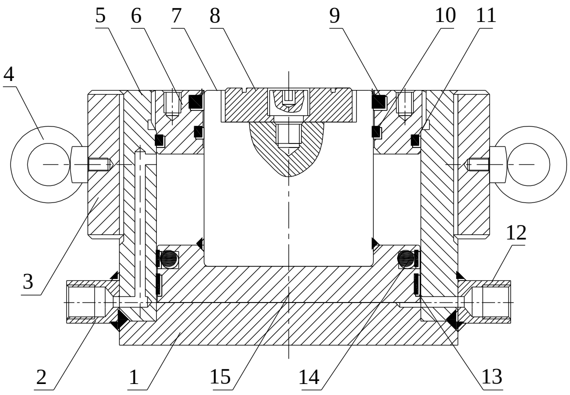

Fig. 3 Layout of the jack

1- Jack base; 2, 12- Oil joint coupling; 3- Mechanical lock; 4- hook handle; 5- Cylinder; 6- Guide tube; 7- Piston rod; 8- Flange of piston rod; 9- Dust seal; 10, 11- Rubber O ring; 13- Guide teflon; 14- SPGO seal; 15- Piston.

The article only presents stress and displacement of parts of jack. Basic parameters for calculation and design: Capacity: 30 (tons), Collapse height: 120 (mm), High pressure: 250 (kg/cm^2), Low pressure: 5 (kg/cm^2)

2.2. Building Model for Calculating

+ Using Solidworks software for creating parts and assembling.

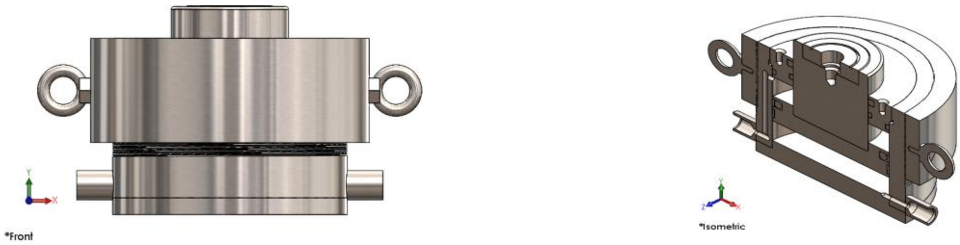

Fig. 4 3D model of the jack

+ Selection of materials: Material for the cylinder and piston rod is normalizing steels 40X, and it has the characteristics: Modulus of elasticity E = 2,05e5 (N/mm^2); Tensile strength σ_b = 980 (N/mm^2), Yield strength σ_c = 785 (N/mm^2). The material for the other ones is steel C45 has the following characteristics: Modulus of elasticity E = 2,05e5 (N/mm^2), Tensile strength σ_b = 598 (N/mm^2), Yield strength σ_c = 353 (N/mm^2).

2.3. Results and Discussion

- Calculation cases

+ Case 1: The piston is at up limitation.

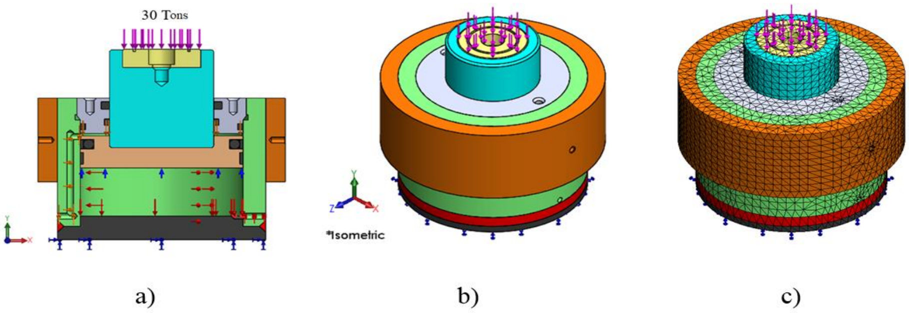

Fig. 5 Applying force on the model and meshing for case 1
a) Section view of the model, b) Full view of the model, c) Messing view

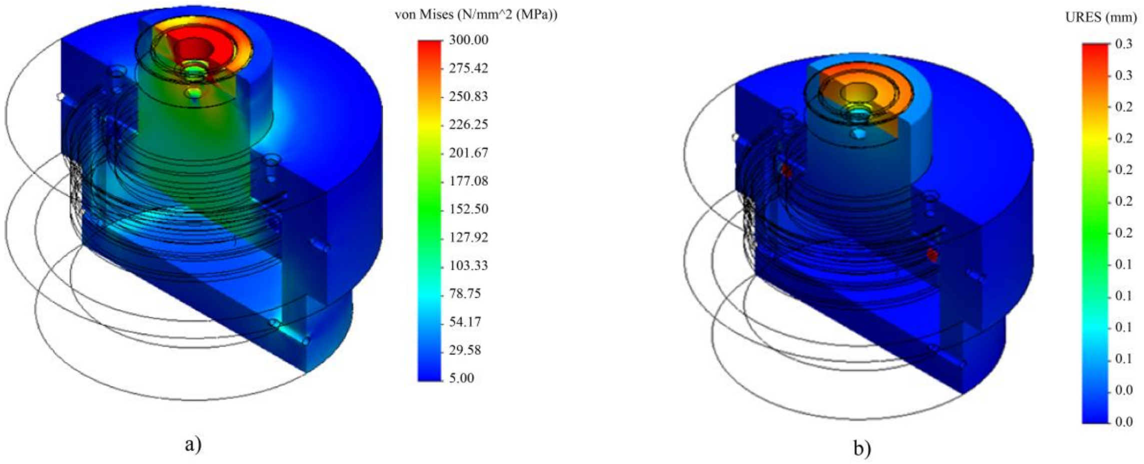

Fig. 6 Results in case 1
a) von Mises stress; b) Displacement (URES)

Reviews: The results show that the maximum stress and maximum displacement on the model are in the allowable limit [σ_{max} = 300 (N/mm^2), u_{max} = 0,3 (mm)]; consequently, the flange and other parts of the model can have enough loading capacity.

+ Case 2: The piston is at low limitation; loads completely apply on mechanical lock.

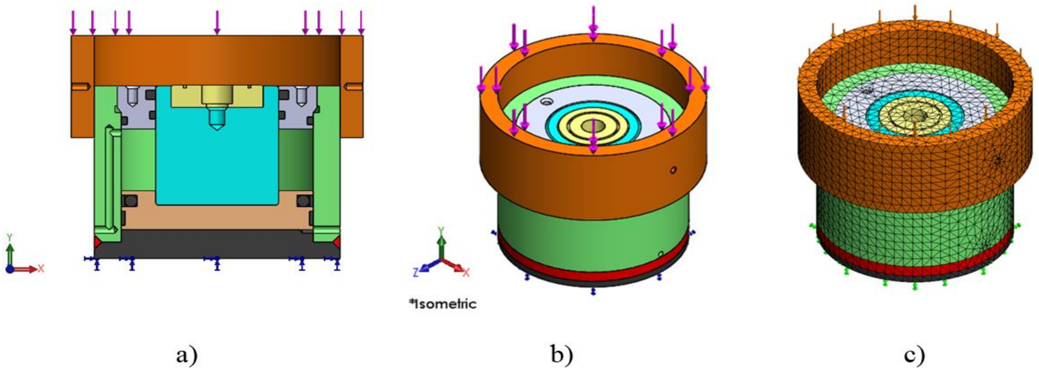

Fig. 7 Applying force on the model and meshing for case 2
a) Section view of the model, b) Full view of the model, c) Mesing view

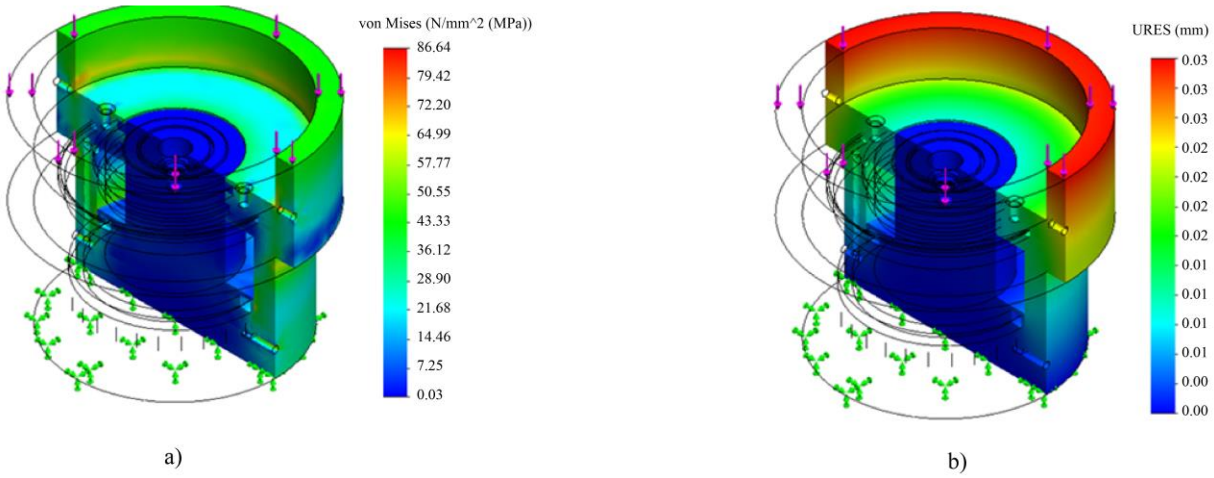

Fig. 8 Results in case 2
a) von Mises stress; b) Displacement (URES)

Review:

The results show that the maximum stress and maximum displacement of the mechanical lock are in the allowed limit [σ_{max} = 86,64 (N/mm^2), u_{max} = 0,03 (mm)]; as a result, the lock and other parts have enough loading capacity.

2.4. Images of Product Manufacturing and Testing

a) b) c)

Fig. 9 Product Manufacturing
a) Guide tube; b) Piston and piston rod; c) Cylinder

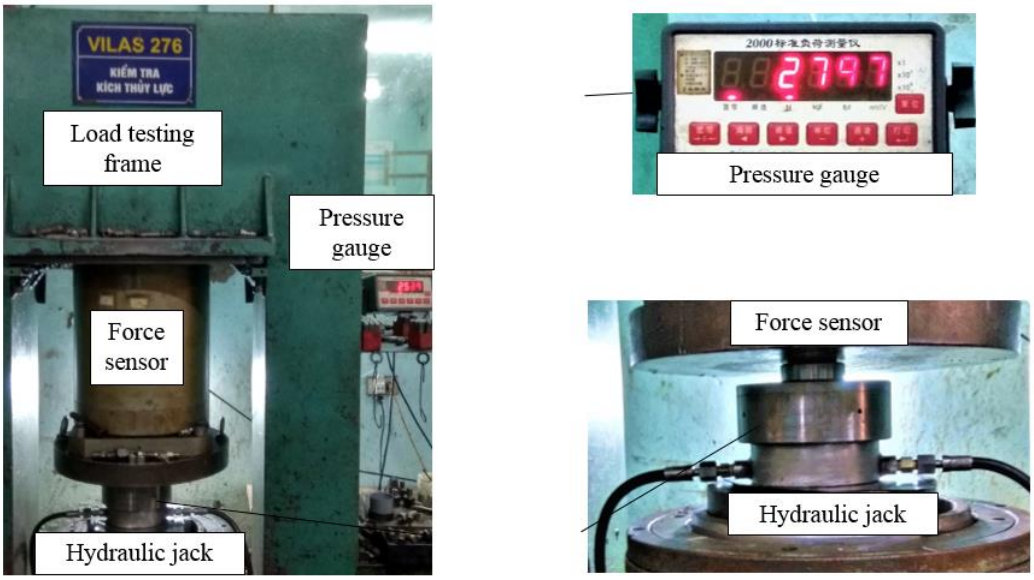

Fig. 10 Product testing

3. Conclusion

- The lifting capacity of 30 tons super short height of 120 mm double acting hydraulic jack was calculated and designed by Solidworks to have enough loading capacity in different load cases.
- The jack was manufactured and tested in the factory. Testing results show that the equipment can work well in heavy-load cases.
- The equipment was inspected by an independent legal agency, and the results are suitably calculated and designed parameters.
- The jack can be manufactured in bulk for lifting beams to replace bearings.

Acknowledgment

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