NUMERICAL INVESTIGATIONS OF THE SEALING SEGMENTS DESIGN OF LINEAR HYDRAULIC MOTOR PLUNGER FROM HORIZONTAL HYDRAULIC PRESS – 2 MN

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Abstract: This paper describes optimal design of the sealing segments of the linear hydraulic motor plunger from horizontal Hydraulic Press – 2 MN. The analysis of the sealing segments was made for determination of stresses, displacements, deformations and the factors of safety distribution. A three-dimensional model of the sealing segments was generated based on the designed data. Finite elements analysis was performed using COSMOSWorks software. This software tool allows to quickly determine optimal design parameters using computational simulation. The simulation results were evaluated and compared to the experimental data. Results show that the established FEM model provides useful information for the sealing segments optimal design.

Keywords: horizontal hydraulic press, linear hydraulic motor plunger, sealing segments, finite elements method, displacements, deformations, factors of safety distribution

1. INTRODUCTION

The typical aim for a design process is to achieve the best possible performance within a given set of constraint. Computer models allow designs to be prototyped in software thus eliminating the need for the expensive cycle of build and test [1-3]. Computational simulation is a powerful tool for the design of parts and equipment in mechanical engineering [4-7]. The integration of computational analysis into the design process can reduce development time and costs while improving product performance [8-11].

Mathematical modelling and numerical simulation of hydraulic components is a powerful tool in analysis and synthesis of the hydraulic systems [12]. The physical processes that occur in the cylinder of a linear hydraulic motor are as complex as they are important for the resulting power produced.

The mechanical seal can be regarded as the main high-quality sealing element in use for the sealing of plungers. This rapid development of the mechanical seal as a machine element has only been possible through the continuous development of seal designs and through the systematic development of new and improved sealing ring materials.

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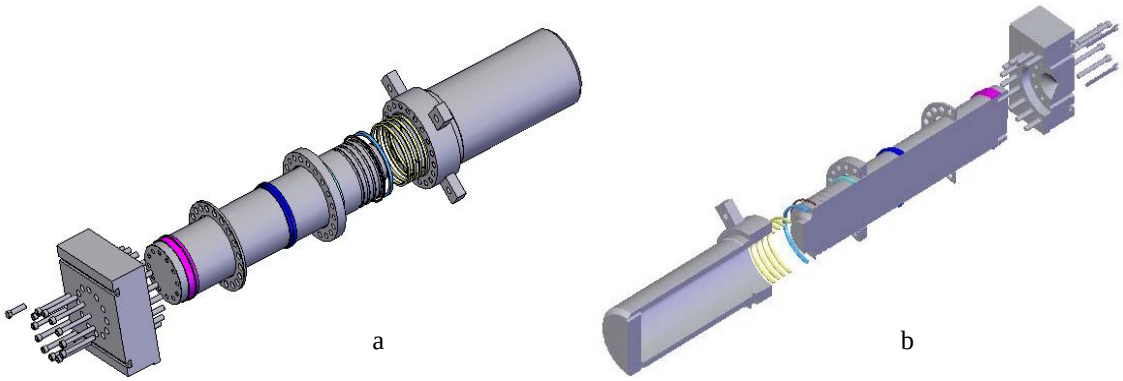
The machining quality of the sliding surfaces is decisive for the seal or leakage and the wear of the sliding rings. The sealing ring wear is influenced much more by the sliding pressure than the sliding speed.

2. MATERIALS AND METHODS

2.1. The linear hydraulic motor plunger from horizontal Hydraulic Press – 2 MN

The hydraulic element force from horizontal Hydraulic Press – 2 MN includes: a linear hydraulic motor, the clamping and restraint elements and the element to transmission force to piece. The assembly of linear hydraulic motor is set up by a hydraulic cylinder and a plunger (Fig.1).

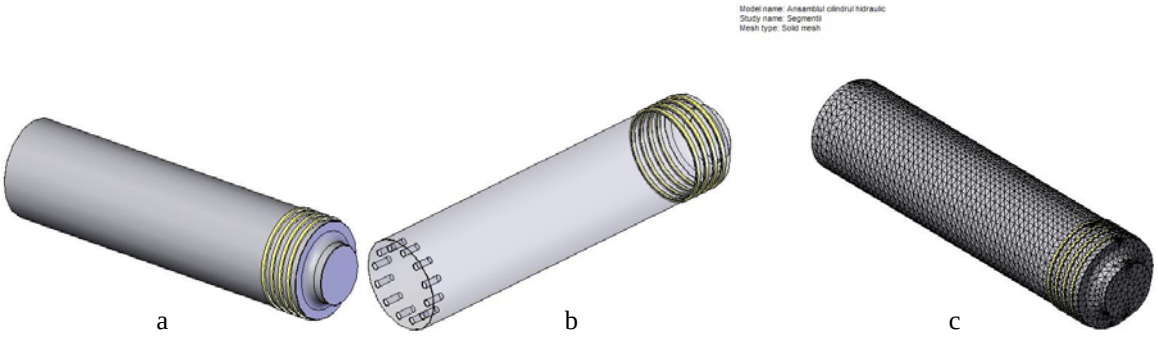


a b

Fig. 1. 3D exploded representation of: a) the hydraulic element force from horizontal Hydraulic Press – 2 MN; b) a longitudinal section in the hydraulic element force from horizontal Hydraulic Press – 2 MN.

2.2. Meshing of the sealing segments of the linear hydraulic motor plunger

A three-dimensional representation of the linear hydraulic motor plunger with the fitted sealing segments, generated based on the designed data, is shown in Figure 2: a) the normal mode; b) in transparency mode; c) 3D meshing. Finite elements analysis was performed using COSMOSWorks software.



a b c

Fig. 2. The linear hydraulic motor plunger with the fitted sealing segments: a) normal mode; b) in transparecy mode; c) 3D meshing.

2.3. The calculation of the stresses distribution and displacements

The linear hydraulic motor plunger is loaded at the designed nominal pressure p = 250 bar. The next representations are made only for sealing segments. It notes that the sealing segments are different loaded because there are different deformation of grooves displaced on the fitted ruling plunger. Results obtained are presented below:

D I S P L A C E M E N T S

NODE	X-DISPL.	Y-DISPL.	Z-DISPL.	XX-ROT.	YY-ROT.	ZZ-ROT.
MINIMUM/MAXIMUM DISPLACEMENTS						
NODE	2273	2244	14379	0	0	0
MIN.	-1.31394E-05	-1.31651E-05	-1.02320E-05	0.0000	0.0000	0.0000
NODE	4941	4932	7883	0	0	0
MAX.	1.32597E-05	1.32450E-05	3.10730E-06	0.0000	0.0000	0.0000

MAXIMUM RESULTANT DISPLACEMENT

NODE 4916
MAX. 1.43299E-05

FOR REQUESTED (Global Cartesian Coord. System)

NODES	FX	FY	FZ	MX	MY	MZ
Total React.	0.3658E+01	0.1149E+02	-.5557E+06	0.0000E+00	0.0000E+00	0.0000E+00

TOTAL STRAIN ENERGY. . . . . = 0.209920E+03

MAXIMUM NODAL VON MISES STRESS

NODE 4069
MAX. 0.75530E+08

The stresses distribution of the sealing segments determined according the theory of Von Mises is shown in Figure 3 and 3D deformations distribution is shown in Figure 4.

Fig. 3. The stresses distribution.

Fig. 4. The deformations distribution.

Fig. 5. The resulting slipping distribution.

2.4. The factors of safety distribution

Graphical distributions for factors of safety distribution are shown according:
- criterion: Max von Mises Stress; factor of safety distribution: Min FOS = 2.7 (Fig. 6a);
- criterion: Mohr-Coulomb Stress; factor of safety distribution: Min FOS = 1.4 (Fig. 6b).

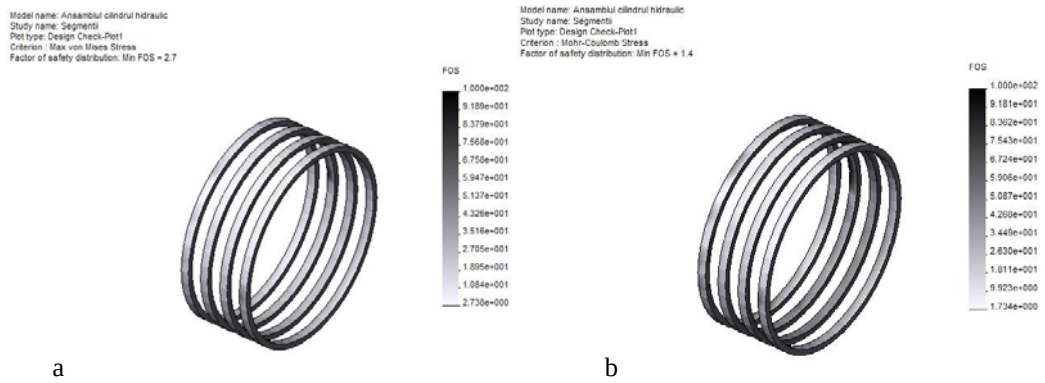


Fig. 6. The factors of safety distribution: a - criterion: Max von Mises Stress; b - criterion: Mohr-Coulomb Stress.

3. CONCLUSIONS

The Finite Elements Analysis using COSMOSWorks software for the sealing segments of the linear hydraulic motor plunger from horizontal Hydraulic Press – 2 MN was made for determination of stresses, displacements, deformations and the factors of safety distribution. The simulation results were evaluated and compared to the experimental data. Results show that the established FEM model provides useful information for the sealing segments optimal design.

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