OPTIMAL DESIGN OF LINEAR HYDRAULIC MOTOR PLUNGER FROM HORIZONTAL HYDRAULIC PRESS – 2 MN

ŢĂLU D.L. ŞTEFAN[1*], ŢĂLU D.L. MIHAI[2]

[1] *Technical University of Cluj-Napoca, Romania*
[2]*University of Craiova, Faculty of Mechanics, Romania*

***Abstract*:** In this paper, the design optimization of the linear hydraulic motor plunger from horizontal Hydraulic Press – 2 MN is presented. The analysis of linear the hydraulic motor plunger of horizontal Hydraulic Press – 2 MN was made for determination of stresses, displacements, deformations, buckling and the factors of safety distribution. A three-dimensional model of the linear hydraulic motor plunger was generated based on the designed data. Finite element analysis was performed using COSMOSWorks software. The simulation results were evaluated and compared to the experimental data. Results show that the established FEM model provides useful information for the plunger optimal design.

***Keywords*:** horizontal Hydraulic Press, linear hydraulic motor plunger, finite elements method, displacements, deformations, buckling, factors of safety distribution

1. INTRODUCTION

The manufacturers and industrial designers to maintain competitiveness and rapidly release highly innovative products that meet stringent regulatory standards, must decrease design costs according market to demand.

Finite-element analysis (FEA) is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems and an integral part of the computer-aided engineering (CAE) environment, to predict and improve the performance of new designs or processes, to reduce time to market, and to reduce overall engineering costs [1, 2].

Mathematical modelling and numerical simulation of hydraulic components are powerful tools in analysis and synthesis of the hydraulic systems. The results from experimental research and numerical simulation can become a database with direct implications over the cost and duration of product manufacturing.

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.

2.2. Meshing of the linear hydraulic motor plunger

A three-dimensional model of the linear hydraulic motor plunger was generated based on the designed data (Figure 1). Finite elements analysis was performed using COSMOSWorks software.

[*] Corresponding author, e-mail: stefan_ta@yahoo.com

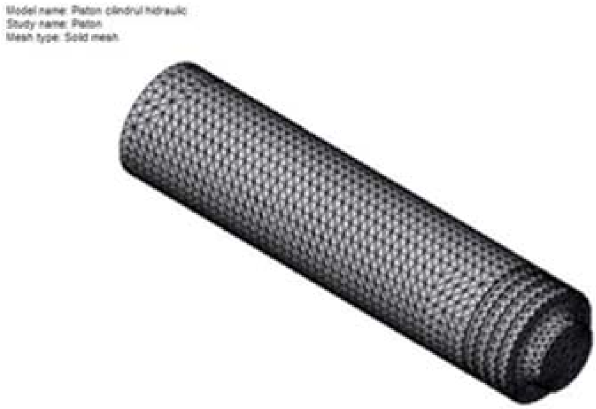


Fig. 1. 3D meshing of the linear hydraulic motor plunger.

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. Obtained results 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	1118	954	1233	0	0	0
MIN.	-1.14041E-05	-2.17484E-05	-1.21358E-06	0.0000	0.0000	0.0000
NODE	1205	3656	4365	0	0	0
MAX.	1.14029E-05	1.09956E-05	4.22225E-05	0.0000	0.0000	0.0000

MAXIMUM RESULTANT DISPLACEMENT

NODE 4421

MAX. 4.35566E-05

FOR REQUESTED (Global Cartesian Coord. System)

NODES	FX	FY	FZ	MX	MY	MZ
Total React.	-.9658E+02	0.4706E+04	-.1786E+07	0.0000E+00	0.0000E+00	0.0000E+00

TOTAL STRAIN ENERGY. . . . . = 0.249738E+03

MAXIMUM NODAL VON MISES STRESS

NODE 637

MAX. 0.47748E+08

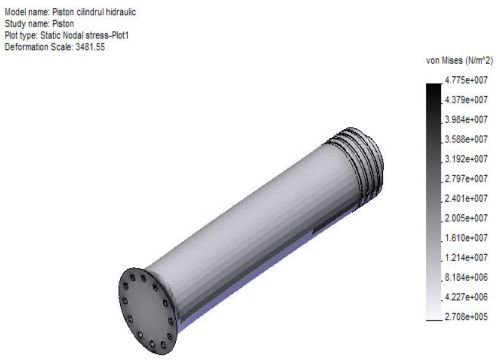


Fig. 2. The stress distribution.

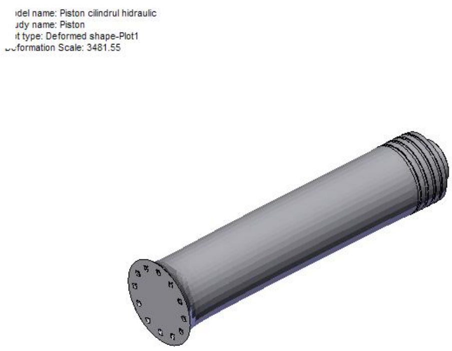


Fig. 3. The deformations distribution.

The stresses distribution of the linear hydraulic motor plunger determined according the theory of Von Mises is shown in Figure 2 and 3D deformations distribution is shown in Figure 3.

The resulting 3D displacement distribution is shown Figure 4 and the slipping result is shown in Figure 5.

Fig. 4. The diplacement distribution.

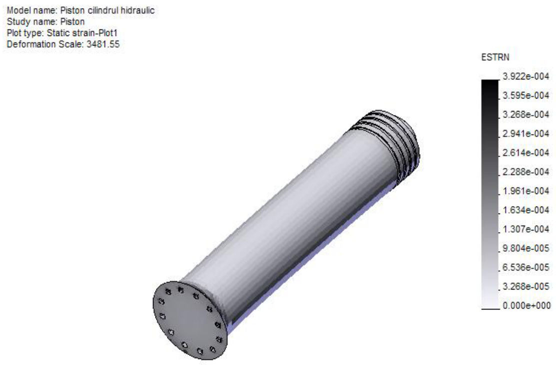


Fig. 5. The slipping result distribution.

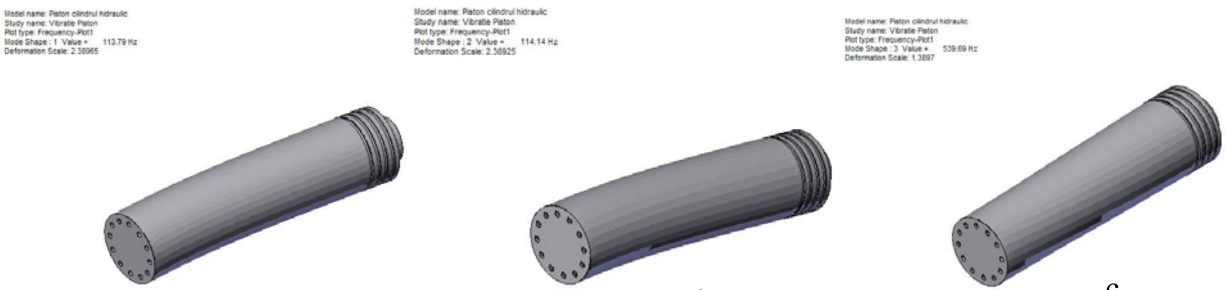
2.4. The vibrational analysis

The first 3 modes of natural vibration of plunger were studied. The program shows the following results:

F R E Q U E N C Y A N A L Y S I S by L A N C Z O S A L G O R I T H M

FREQUENCY NUMBER	FREQUENCY (RAD/SEC)	FREQUENCY (CYCLES/SEC)	PERIOD (SECONDS)
1	0.7149563E+03	0.1137888E+03	0.8788210E-02
2	0.7171439E+03	0.1141370E+03	0.8761402E-02
3	0.3390953E+04	0.5396869E+03	0.1852926E-02

Mode 1 is shown in Figure 6a, natural frequency of vibration is ν = 113.79 Hz, scale deformation is Kd = 2.38.
Mode 2 is shown in Figure 6b, natural frequency of vibration is ν = 114.14 Hz, scale deformation is Kd = 2.39.
Mode 3 is shown in Figure 6c, natural frequency of vibration is v = 539.69 Hz, scale deformation is Kd = 1.387.



a b c

Fig. 6. The vibrational analysis: a - Mode 1; b - Mode 2; c - Mode 3.

2.5. The buckling analysis

Deformation in buckling of the plunger, with the multiplier scale distortion of Kd = 8.29, is shown in Figure 7a, and the state of deformations for buckling is shown in Figure 7b.

a b

Fig. 7. The buckling analysis: a - deformation in buckling; b - the state of deformations.

2.6. Safety factors distribution

Graphical distributions for safety factors distribution are shown according:

- criterion: Max von Mises Stress; factor of safety distribution: Min FOS = 4.3 (Figure 8a);
- criterion: Mohr-Coulomb Stress; factor of safety distribution: Min FOS = 3.5 (Figure 8b);

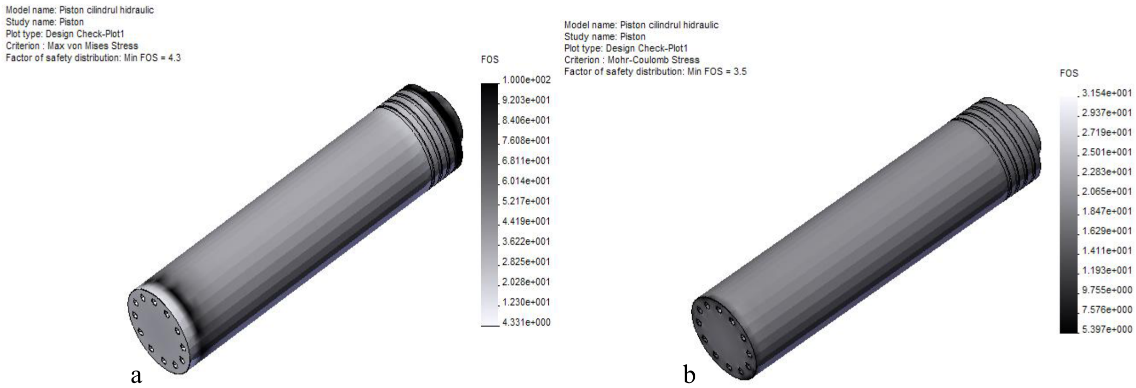


Fig. 8. The factors of safety distribution: a - criterion: Max von Mises Stress;
b - criterion: Mohr-Coulomb Stress.

3. CONCLUSIONS

The Finite Element Analysis using COSMOSWorks software for the linear hydraulic motor plunger from horizontal Hydraulic Press – 2 MN was made for determination of stress, displacements, deformations, buckling and the safety factors distribution. The simulation results were evaluated and compared to the experimental data. The obtained result provides useful information for the plunger optimal design.

4. ACKNOWLEDGEMENTS

This work has partly been funded by the Romanian Ministry of Education, Research and Youth, through The National University Research Council, Grant PN–II–ID–PCE–2007–1, code ID_1107, 2007 – 2010.

REFERENCES

[1] Braess, D., Finite Elements: Theory, Fast Solvers, and Applications in Solid Mechanics – Third Edition, Cambridge University Press, UK, 2007.
[2] Singiresu, S.R., The Finite Element Method in Engineering – Fourth Edition, Elsevier Inc., USA, 2005.