# THE FINITE ELEMENT ANALYSIS OF A HIGH PRESSURE PUMP

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***Abstract.*** *This paper analyse through the finite elements method (FEM) a high pressure pump. The analysis of high pressure pump was made for determination of stresses distribution, displacements and deformations. A three-dimensional model of the high pressure pump with a complex geometry was generated based on the designed data. The Finite Elements Analysis was performed using SolidWorks 3D CAD Design and COSMOSWorks software. Results predicted by the finite element method show the method presented is efficient and accurate and in good agreement with the theoretical and experimental values. Results from the current analysis can be used for further studies in designing of the high pressure pump.*
***Keywords:*** *high pressure pump, finite elements analysis, stresses, displacements, deformations*

## 1. INTRODUCTION

High pressure pumping systems are used in a wide range of industrial processes. Careful selection of the pumping system components is important for optimum safety and reliability [1].
There are a number of design criteria that are important to ensure that the pump is a quality fit for the application. Key parameters in pump design include seal integrity, materials of manufacture and accurate assessment of the stresses that the pump and associated equipment will experience in service [2].
CAD and finite element analysis (FEA) play a key role in the design of the pump itself [3 - 9].
Finite element analysis allows designs to be analyzed, optimized, and revised quickly and accurately. Virtual testing and optimization is conducted early in the design cycle, thereby saving both time and money and assuring a consistent product each production run. It is essential to have a quality pump at the heart of the high pressure pumping system, for optimum safety and reliability.

## 2. MODELLING OF HIGH PRESSURE PUMP ASSEMBLY

### 2.1 The high pressure pump

The analyzed high pressure pump with piston, ensures a nominal working pressure p = 1750 bar.
A three-dimensional model of the high pressure pump assembly with all components, with a complex geometry, was generated based on the designed data and performed using SolidWorks 3D CAD Design.
The 3D of component parts of high pressure pump are: body pump (Fig. 1, Fig. 2); piston (Fig. 3); action rod (Fig. 4, Fig. 5); threated bush (Fig. 6, Fig. 7); bush (Fig. 8); spherical element (Fig. 9); pellet compression (Fig. 10) and washer pintle (Fig. 11).
The high pressure pump assembly and a longitudinal section in it is shown in Fig. 12 and Fig. 13.

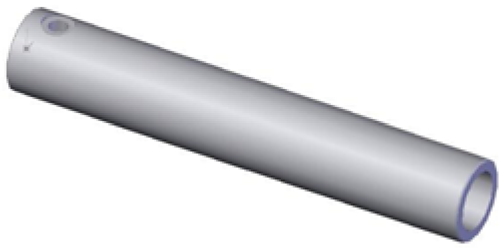

**Figure 1. The body pump.**

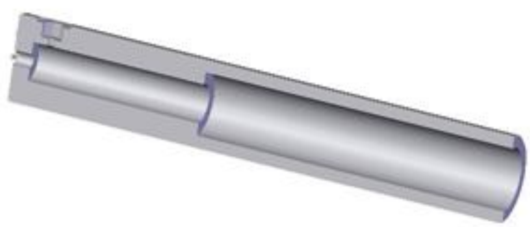

**Figure 2. The body pump section.**

**Figure 3. The piston.**

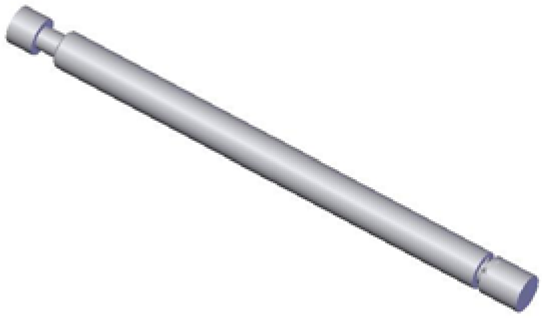

**Figure 4. The action rod.**

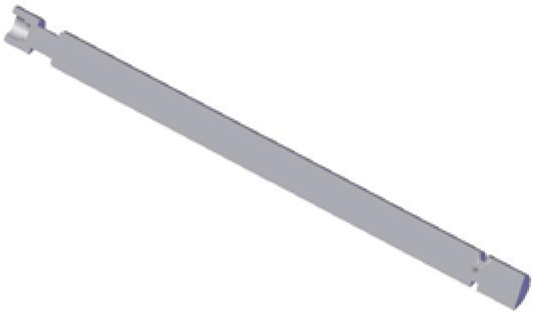

**Figure 5. The action rod section.**

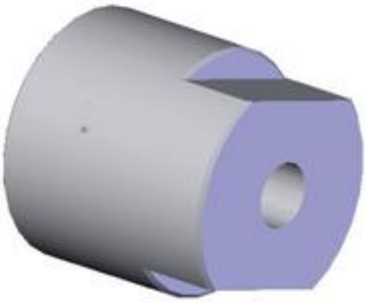

**Figure 6. The threaded bush.**

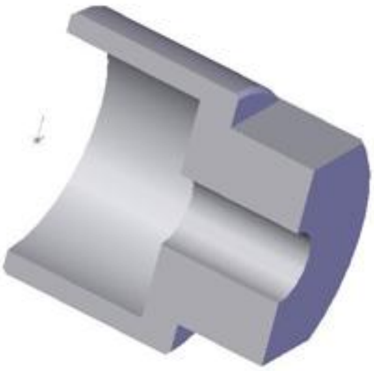

**Figure 7. The threaded bush section.**

**Figure 8. The bush.**

**Figure 9. The spherical element.**

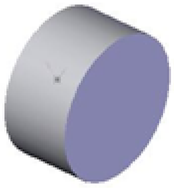

**Figure 10. The pellet compression.**

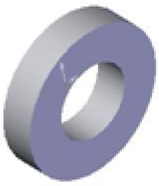

**Figure 11. The washer pintle.**

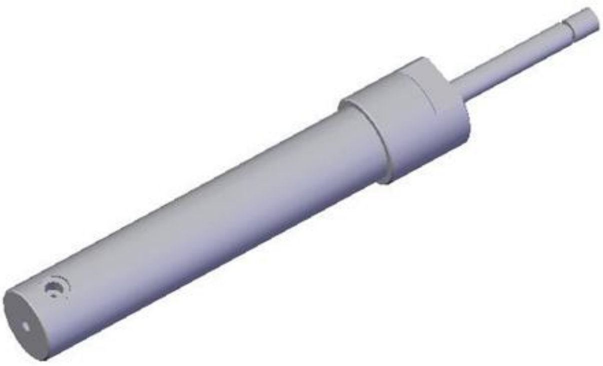

**Figure 12. The high pressure pump assembly.**

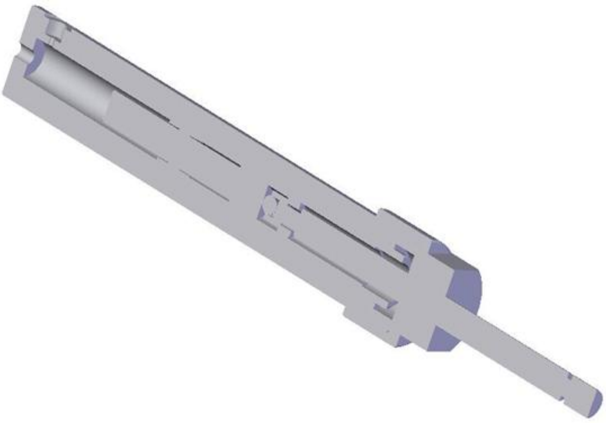

**Figure 13. A longitudinal section of high pressure pump assembly.**

## 3. THE FEM ANALYSIS OF HIGH PRESSURE PUMP ASSEMBLY

### 3.1 Meshing of high pressure pump

The high pressure pump will be analyzed at a nominal working pressure p = 1750 bar.

Finite elements analysis was performed using COSMOSWorks software.

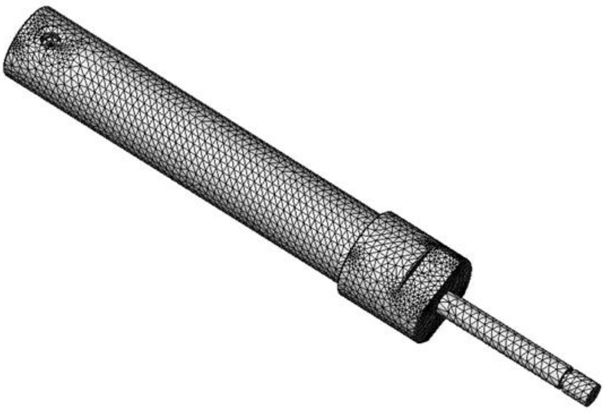

**Figure 13. A 3D meshing of high pressure pump assembly.**

### 3.2 The calculation of the stresses distribution, displacements and deformations

The obtained results are presented with a deformation scale 1: 818 to emphasize the distortions of high pressure pump components.

Results obtained are presented below:

MAXIMUM NODAL VON MISES STRESS

Node: 23352

Max.: 2.1552e+008

MINIMUM/MAXIMUM DISPLACEMENTS

| | X-displ. | Y-displ. | Z-displ. |
|---|---|---|---|
| Node: | 4254 | 6352 | 46872 |
| Min.: | -3.8910e-006 | -3.2512e-006 | 0.00000 |
| Node: | 3763 | 6565 | 2167 |
| Max.: | 3.196e-006 | 3.468e-006 | 4.744e-005 |

MAXIMUM MAGNITUDE OF DISPLACEMENT

Node: 11927

Max.: 6.4755e-005

COMPONENTS OF TOTAL REACTION FORCE

| Fx | Fy | Fz |
|---|---|---|
| -2.4657 | 8.1027 | -67983 |

Graphical distribution of normal stresses on the direction of the main axes of inertia and resultant are shown in Fig. 14, Fig. 15, Fig. 16 and Fig. 17 (deformation scale is k = 818).

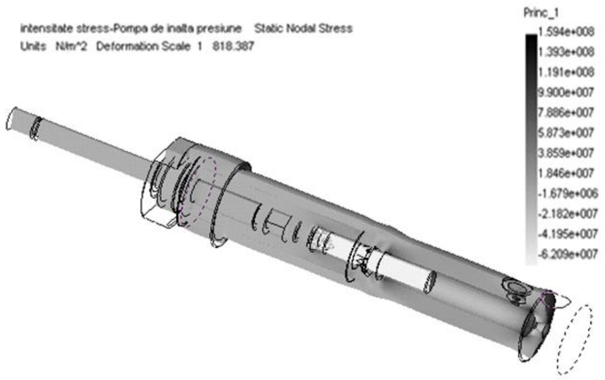


**Figure 14. The stresses distribution on the main axis of inertia 1.**

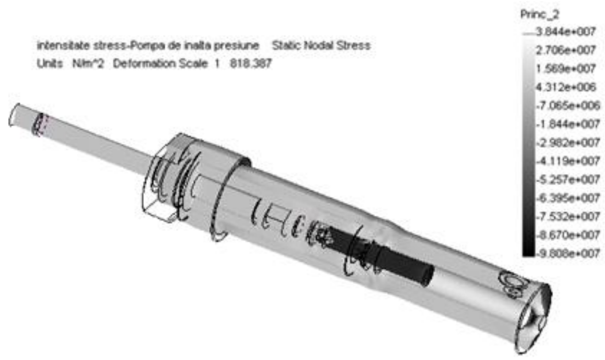


**Figure 15. The stresses distribution on the main axis of inertia 2.**


**Figure 16. The stresses distribution on the main axis of inertia 3.**

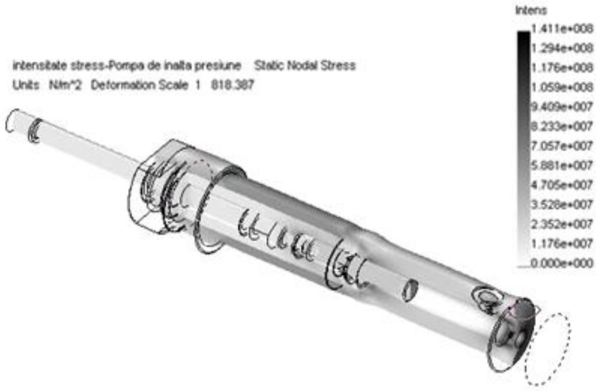


**Figure 17. The resultant stresses distribution.**

Graphical distribution of displacements distribution by axes Ox, Oy, Oz and resultant are shown in Fig. 18, Fig. 19, Fig. 20 and Fig. 21 (deformation scale is k = 818).

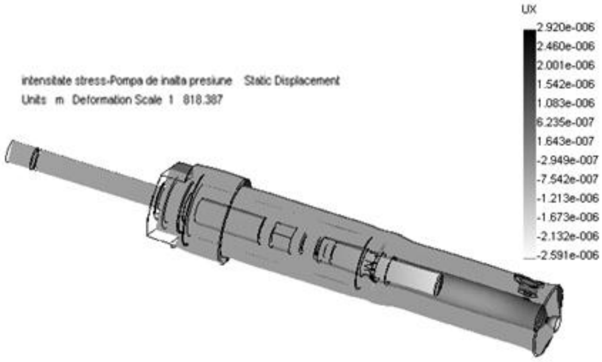


**Figure 18. The displacements distribution by Ox axis.**

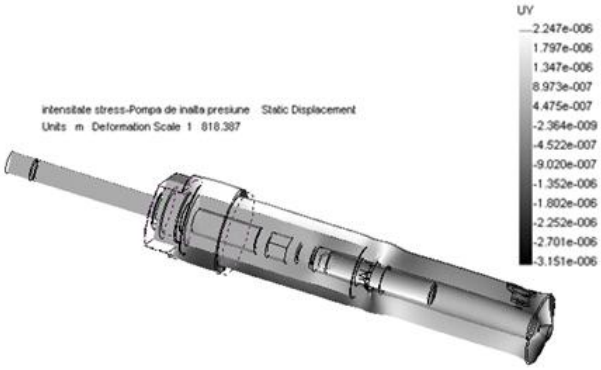


**Figure 19. The displacements distribution by Oy axis.**


**Figure 20. The displacements distribution by Oz axis.**


**Figure 21. The resultant displacements distribution.**

## 4. CONCLUSIONS

The Finite Elements Analysis using COSMOSWorks software for high pressure pump was made for determination of stresses distribution, displacements and deformations. Results predicted by the FEM show the method presented is efficient and accurate and in good agreement with the theoretical and experimental values. Results from the current analysis can be used for further studies in designing of the high pressure pump.

## 5. ACKNOWLEDGMENTS

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.

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