FINITE ELEMENT ANALYSIS OF AXIAL PISTON PUMPS USING ANSYS

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Abstract: This paper highlights a finite element analysis for some mechanical components of the high-pressure hydraulic pumps by ANSYS software. The progress of hydraulic systems requires rising the working pressure. For reaching this requirement, it is necessary to raise the functional parameters of the hydraulic system components. Hence, it is essential to identify specific parameters that can be improved according to the suitable materials and technology. For the adjustable axial piston pumps, the parameters that can be improved must provide increased working pressure values by finding new materials for the cylinders block and pistons and a higher value for the maximum flow rate by increasing the swash plate angle.

1. INTRODUCTION

Increasing the working pressure there are many phenomena that occur in pump function. Due to the high pressure required for maintaining the functional gap between piston shoe and shoe bearing plate, a small deflection of the piston shoe can occur. This will allow a tilted operation of the piston shoe that can damage the carrying film. Another dangerous phenomenon is notified at the port plate level. Because some of the pistons work at high pressure and some at the low pressure, an unbalanced force occurs to incline the cylinders block against the port plate. Again the carrying film can be damaged and this can introduce high wear of the contact surfaces. For the pear composed from cylinders block and a piston, a proper pear of materials has to be chosen. These means that for cylinder block the material must be softer than the one of the piston. But there are moments when the piston operates inclined in the cylinder bore. Because of the instant unbalanced force, the bore can be damage and the total efficiency of the pump can be affected.

The main objective if this work is to study the displacements, strains and stresses that occurs in the structure during the steady state operation using a parametric model. The components studied with the ANSYS program are the hydrostatic bearing, the piston and the cylinder block. The gap between piston shoe and shoe bearing plate is taken into account for modeling the hydrostatic bearing. For the simulation, it was considered that a clearance exists between this two components and the contact pressure is to be done in a single point. Between piston and cylinders block a clearance also exists and for the first step the contact pressure is to be done in two opposite points. The main goal of the simulation is to establish the components deflection for modeling the real contact situations. The theoretical results are found in a good agreement with the experimental ones.

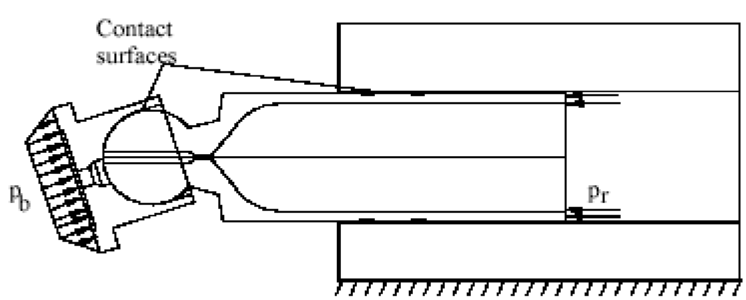

Fig.1 The model for moving assembly

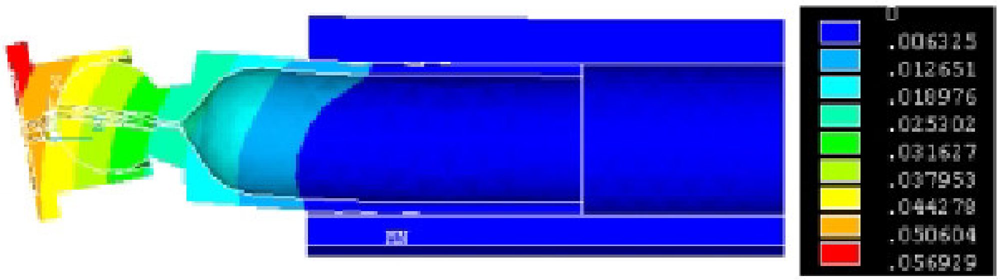

Fig.2 Global displacement of the assembly

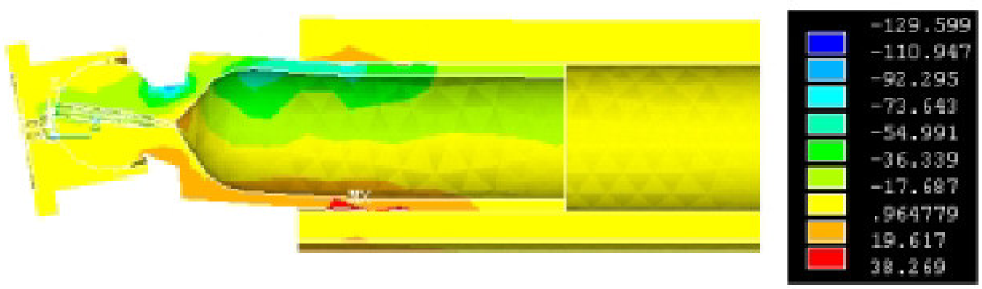

Fig.3 The axial stress for the assembly

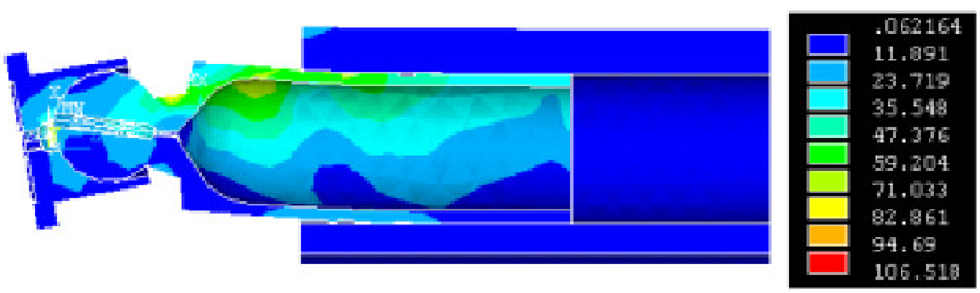

Fig.4 the Von Misses stresses for the assembly

2. METHODOLOGY

For the simulation, an adjustable axial pump was considered with inclined disc working at p_0=210 bar, with the cylinder block having a bronze sleeve (with 20 % Pb) and pistons made of nitride steel. In order to obtain more accurate results, all the complex geometrical forms, including the equal pressure channels, pressure resistance were included in the models. During the simulation, various type of finite element networks were used. The main criteria for choosing the pear of materials for the components being in contact is given by the pressure contact between piston and cylinder sleeve and the contact between piston and the slipper seat.

2.1. The Assembly

First simulated case had the main goal to see the behavior of the motion assembly made from the sleeper, piston and cylinder block. The working pressure taken into account is 210 bar. The outline of the model is shown in Fig.1. Pr is the outlet pressure of the pump and P_b is the pressure on the sleeper shoe, which is smaller the outlet one because the pressure resistance from the piston inside. The results are presented in the Fig- 2, 3 and 4.

As is shown in the diagram from Fig-2, the displacements have smaller values in the area of the contact between piston and cylinder block. The maximum values occur in the slipper shoe. The axial stress diagram presented in the Fig-3 reveal that the bending is the dominating phenomena for the piston. The von Misses stresses (Fig. 4) have values below the admissible stress, so the pump can works at a higher pressure.

2.2. The Piston

For a better view of the results, the piston was detached from the assembly. For emphasize the phenomena, the view of the deformed shape of piston (Fig. 2) was represented to an increased scale. As it was mentioned, the bending of the piston has induced small deflection and normal stresses. But the most important parameter is the contact pressure computed in the area where the cylinder block and the slipper seat meet. The value of the displacements is about the same size as the clearance. This could mean that on the certain portions, the clearance would be canceled and occurs a contact zone. For the simulation, it was taken into account the possibility of a contact between piston and the adjacent components, and the surface of the piston was modeled with contact elements. The friction was considered and it imposed a coefficient of friction between the components in contact. The admitted contact pressure is higher than the results presented in Fig-5; therefore there is no danger for the piston surface to be destroyed.

2.3. The Cylinder Block

The model contains the bore from the highest level at the moment when the piston begins the stroke and the pressure is at the maximum value. For viewing the stress in the contact area between piston and cylinder sleeve, the piston and the section of cylinder block were coupled using the contact element. The material of the cylinder sleeve is softer than the piston material. The displacements, and von Misses stress are represented in the Fig-6 and 7.

2.4. The Slipper

The slipper is one of the most stressed components because of the contact pressure from the piston end and the carrying pressure between the plate and slipper shoe. If the slipper is deforming, it can work inclined in comparison with the pump plate and damage the carrying film. The displacements, axial stresses and von Misses stresses of the slipper are shown in the Fig-8, 9 and 10.

3. Conclusions

This paper is concentrated to the computer analysis techniques in the development of the axial piston pumps. For obtaining some proper results, the real model of the loading diagram has been built. This gave the real load diagram for the moving piston and could represent proper load for the piston, slipper seat and cylinder block sleeve. The materials, which contribute the contact area between piston and slipper seat and between piston and cylinder block sleeve, were tested. The most important conclusion of the paper is the possibility of increasing the nominal operating pressure up to 420 bar, without changing the materials.

References:

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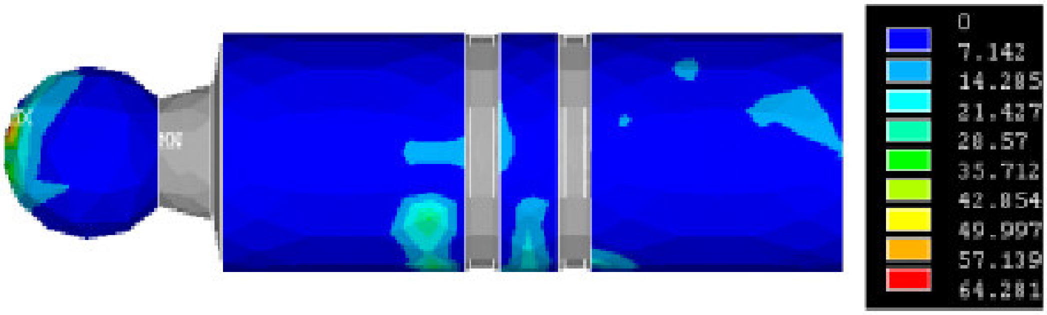

Fig.5 The contact pressures for the surfaces

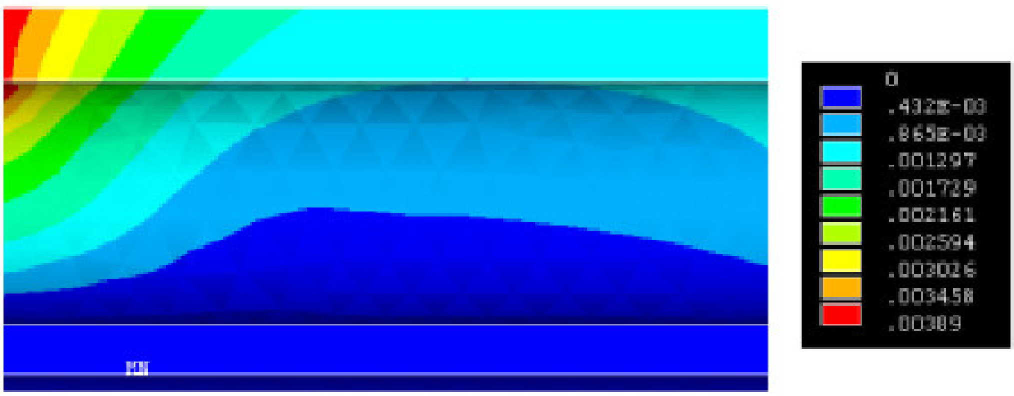

Fig.6 The displacement diagram for the cylinder block (cross-section)

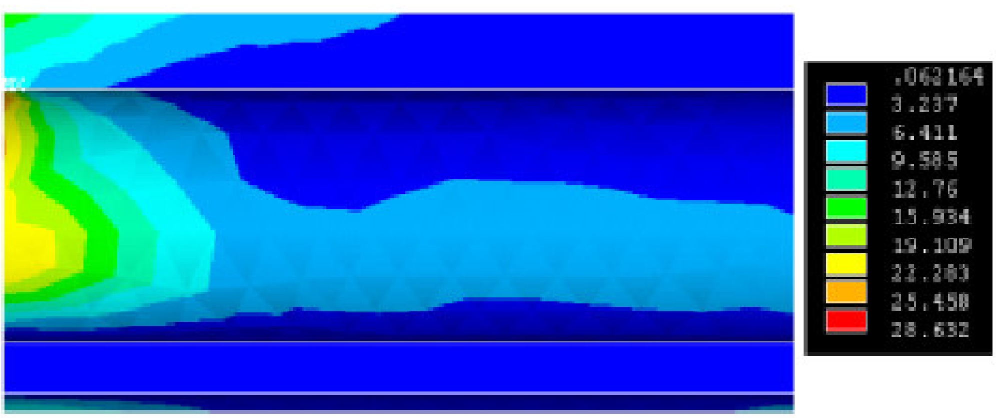

Fig.7 The Von Misses stresses diagram for the cylinder block

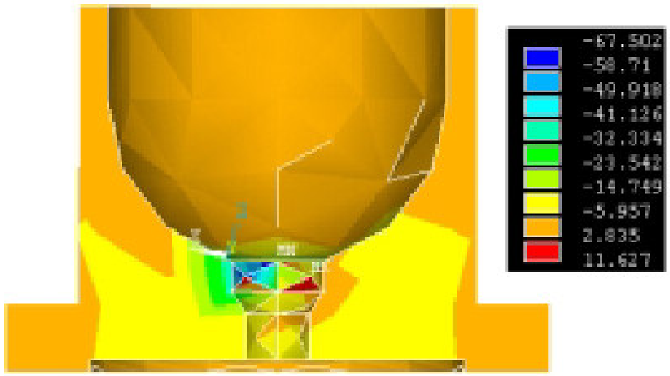

Fig. 8 The displacement diagram for the slipper

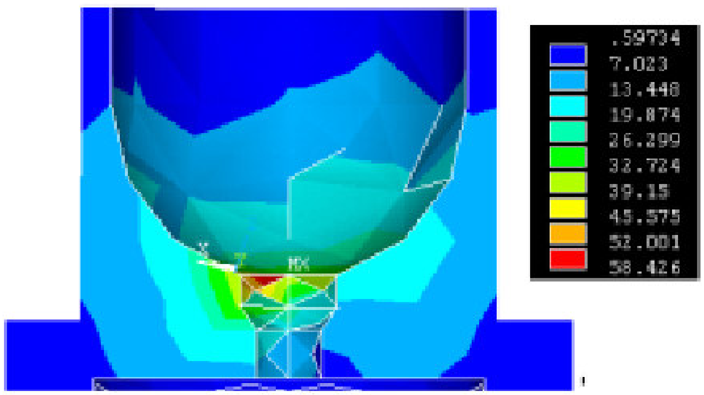

Fig.9 The axial stress diagram for the slipper

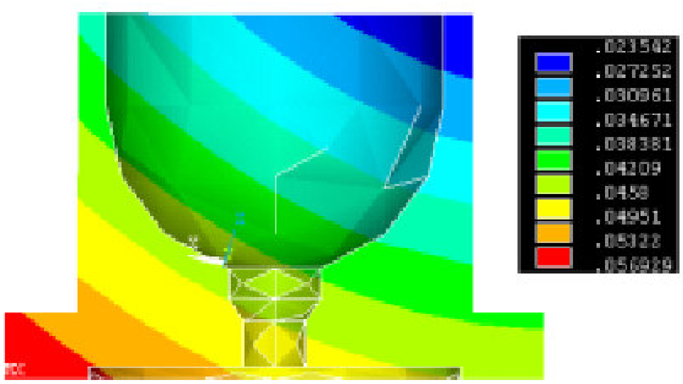

Fig. 10 The von Misses stresses for the slipper