MECHANICAL ANALYSIS OF THE ROTATING DRAWING MANDREL WITH SELECTED BEARINGS CONFIGURATION

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ABSTRACT

Nowadays is important to increase power efficiency in the heat production sector. Tubes with shaped internal surface are one of the possibilities to improve efficiency of heat exchangers. In the fact of this is actual to look on the improvements of the process of forming from the perspective of the tool construction. Presented article is focused on mechanical analysis of the rotating mandrel for cold forming of tubes with shaped internal surface. As a proposed material of the tool was selected heat-treated tool steel. Analyses were performed with selected configuration of the bearings. One bearing was configured as radial and second bearing was configured as radial-axial. A result shows stresses in the mandrel and deformation of the mandrel under a load of forming pressure. Obtained results have potential to enhance knowledge in the area of construction of the forming tools.

Keywords: Forming, tube, mandrel, bearing, stress.

INTRODUCTION

In the process of drawing pipes, the forming drawing process is performed in several steps, in which the dimensions of the semi-finished products are determined by drawing tools - a drawing die and a drawing mandrel (Zajac, Beraxa, Michalík, Botko, & Pollák, 2016). It is precisely these drawing tools that are subject to high requirements in terms of dimensional accuracy, contact surface integrity and surface homogeneity, as any shortcomings of these properties are directly reflected on the final surfaces of the manufactured pipes, which is of course unacceptable in terms of quality and dimensional requirements (Pospiech, 1998). Keeping said traction tools in optimal condition for a long time means not only high demands on the material from which they are made, but also on the effectiveness of the necessary repairs after any damage to ensure further operation of the tool (Hsu, et al., 2016). This work is focused on the design of alternative materials for the production of drawing mandrels from tool steels produced by powder metallurgy, which would mean a reduction in investment costs in comparison with currently used carbide drawing mandrels. Alternative materials also mean a benefit in the efficiency of repairs of damaged mandrels, which is again reflected in the financial evaluation with a positive effect (Bella, Buček, Ridzoň, Mojžiš, & Parilák et al., 2016).

The mandrel itself is used for the production of tubes with shaped internal surface. The main principle is to draw the tube through the die and the self-rotating mandrel, while an internal shape is formed in the inner part of the tube. (Beraxa, & Parilák, 2018) The tube is clamped at one end and pulled over the mandrel, where the tube spins the shaped mandrel by its pulling. The mandrel is located in a die which has a conical shape of the passage. The bearings are used for a smoother rotation of the mandrel (Bella, Durcik, Ridzon, & Parilak, et al., 2018).

Tests of mechanical properties were performed with a free-rotating mandrel fitted with one radial and one axially radial bearing. Tool steel tempered to a hardness of 64 HRc was chosen as the tool material (Beraxa, Domovcová, & Parilák, 2014; Botko, Hatala, Beraxa, Duplak, & Zajac, 2018).

MATERIAL AND METHODS OF WORK

As a proposed material of the tool was selected heat-treated tool steel. Mechanical properties of the material are listed in Table 1.

Table 1. Mechanical properties of the tool material

Hardness HRC	Elasticity modulus [GPa]	Poisson's ratio [-]
63	210	0.29

Analysis were performed using software Autodesk Inventor. As can be observed from figure 1 analyzed forming tool (mandrel) was in configuration with one tapered roller bearing and one ball bearing. This means that on the one side with tapered roller bearing was radial axial bond and on the second side with ball bearing was only radial bond. As a load was selected pressure on whole outer surface of the forming tool, which corresponds with the process conditions.

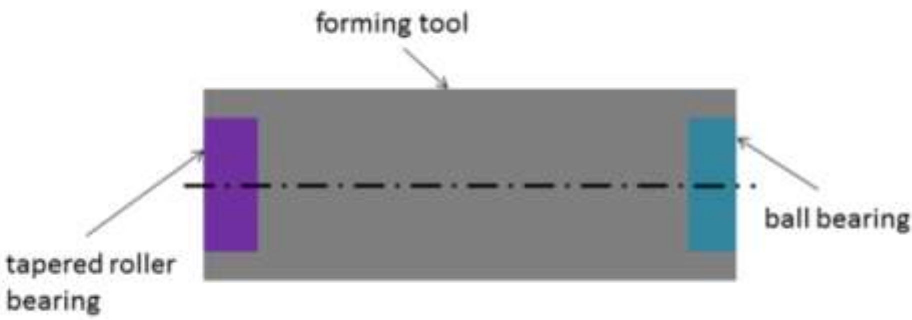

Figure 1. Configuration of analyzed mandrel

RESULTS AND DISCUSSION

From the figure 2. it is possible to define the course of the equivalent stress. As can be seen from von Misses analysis, no extremely stressed area on the forming tool is seen.

First principal stress (figure 3) also shows no extremely stressed area on the tested rotary forming tool. First principal stress represents the maximum compressive stresses that are present in the rotary forming tool under the load of the operating load.

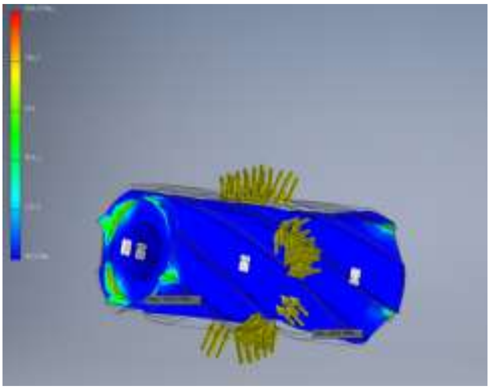

Figure 2. Von Misses stress

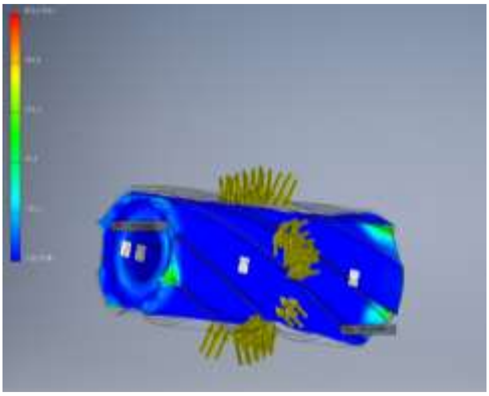

Figure 3. First principal stress

When monitoring third principal stress (figure 4), it can be seen that it reaches a value of 300 MPa. Third principal stress represents compressive stresses that arise in the body due to exposure to load. The default value is lower than the yield strength value for the proposed component material

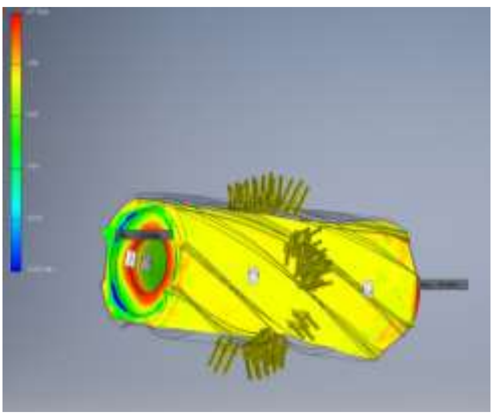

Figure 4. Third principal stress

Displacement x (figure 5) for the analyzed forming tool show no significant values. Thus, can be stated, that from the perspective of displacement x was forming tool designed correctly.

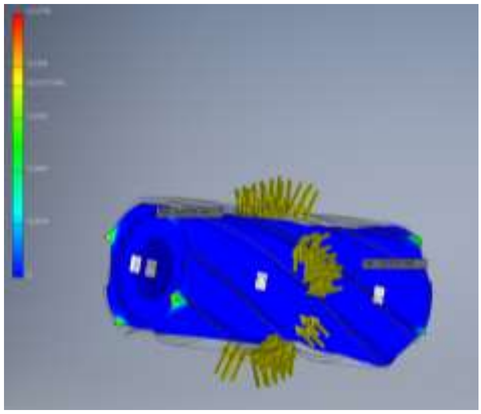

Figure 5. Displacement x

Displacement y (figure 6) and displacement z (figure 7) shows some weak areas in the bottom of the tool groves. For further analysis and real verification, it will be necessary to slightly change the geometry of the rotating tool to eliminate displacements y and z caused by process load.

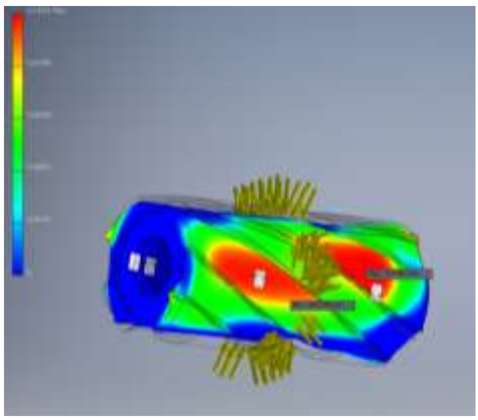

Figure 6. Displacement y

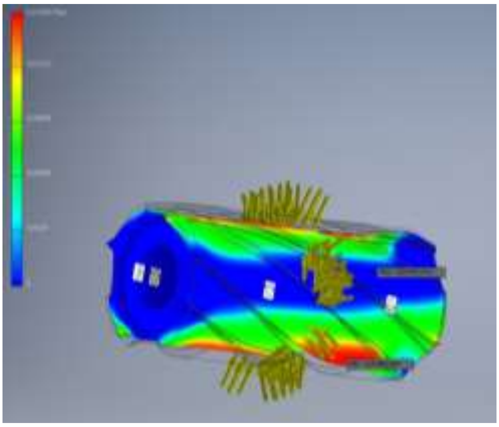

Figure 7. Displacement z

CONCLUSIONS

Simulation was performed on the forming tool during the actual technological process with one tapered roller bearing and one ball bearing. Results of the analysis show promising results for experimental verification of proposed configuration. Application of heat threated steel instead of sintered carbide gives opportunity for simpler production process of such tool. According to the performed analysis is proposed hardened steel of adequate strength and bearing configuration do not significantly affect overall strength of the forming tool. In the future there is a need to make verification of presented results in the production conditions. Development of the more efficient tools is very important for increasing of productivity and sustainable development of industry.

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