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Optimization of Power Transmission on Mechanical Forging Presses

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Abstract

Vertical crankshaft forging presses are designed for precision die forging and calibrating large series, large dimensions and power demanding forgings. Forming is carried out in several die cavities with increasing complexity, for example, intended for the aerospace and automotive industries. Transfer of vertical forging press workforce is realized between crankshaft and ram through the inserted connecting rod and coupling or sliding joint. The accuracy of these presses is directly related to their stiffness. Designers are therefore looking for ways to increase the stiffness. One of the possibilities is to increase the rigidity of the transmission of power from the crankshaft to the forging. The subject of this paper is comparing the conventional press with power transmission using the crank mechanism and the press with yoke mechanism.

Keywords: forming machines; forging press; FEM simulation

1. Introduction

Currently, great emphasis is placed on product quality, which results in increased demands on the design of forming machines. Together with the high quality and long-term reliability of forming machines, high energy efficiency of equipment and low cost is also very important.

Survey between producers and users of crank forging presses showed that it is necessary to upgrade these presses with regard to developing and changing technological requirements. These requirements must comply with innovative technical parameters of the machine, especially its greater rigidity [3]. Two proposals of the press

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configuration were designed. Efforts to modernize the existing concept were the basis of these proposals. Proposals were compared with regard to workspace stiffness and the total machine.

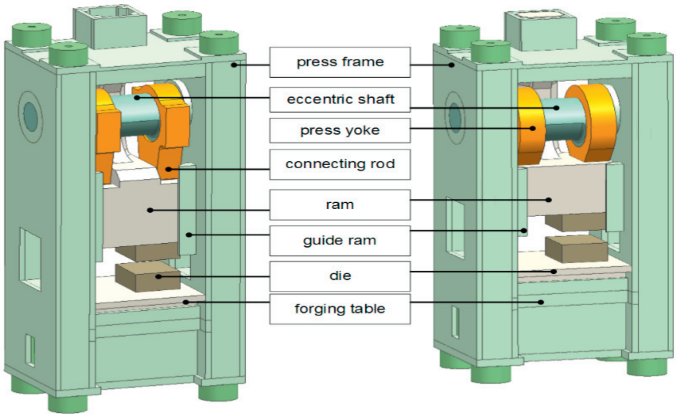

Fig. 1. (a) Mechanical forging press 25 MN with connecting rod - proposal 1, (b) Mechanical forging press 25 MN with press yoke - proposal 2.

Both proposals are consistent with the following parameters:

- Crankshaft is placed from left to right [4].
- Forging table size is 1400 × 1500 mm.
- Press ram has guidance also on the top of the press frame.
- Undivided press frame with anchors

In proposal 1, see Fig. 1a, transfer of power between the eccentric shaft and the ram is realized by two connecting rods. It is a two-point joint system. In proposal 1, see Fig. 1b, transfer of power between the eccentric shaft and the ram is realized by an embedded bearing ring with the sliding surface in contact with the ram. (yoke system of power transfer). This proposal allows height of the ram to be reduced by 600 mm [1, 2, 10].

2. Boundary conditions

Both variants were modelled for a power load 25 MN. Both variants were loaded with regard to the possibility of accurate comparison. The calculation was made for eccentric loading with eccentricity of 280 mm, see Fig. 2. Load by workforce was entered through an embedded element representing the tool.

The frame was anchored at the bottom of the frame through a circular area defined by the axis of the frame. All inserted parts of the press (eccentric shafts, connecting rod and yoke) were inserted by contacts. Prestressing was determined as 1.4 times the workforce. The gap in the guidance was determined to 0.2 mm [5, 8, 9].

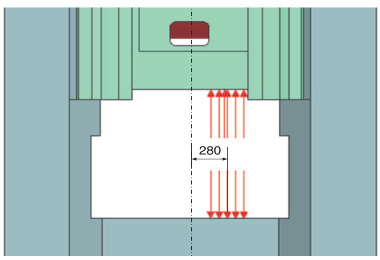

Fig. 2. Boundary condition, the loading force 25 MN with eccentricity 280 mm.

3. Calculation results

3.1. Version 1, Mechanical forging press 25 MN with connecting rod

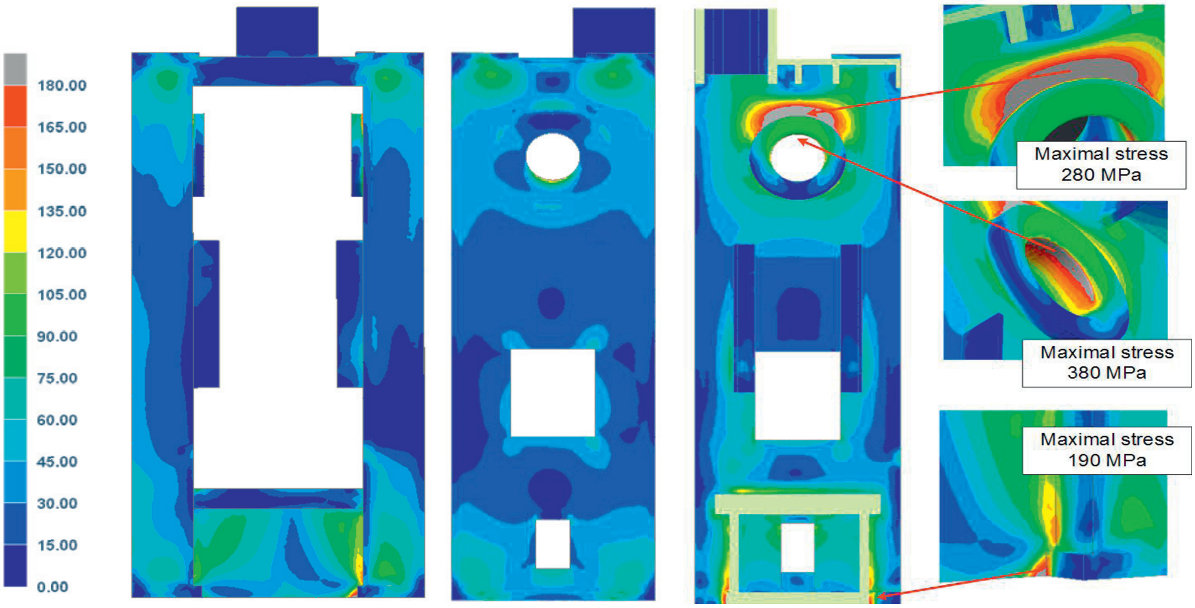

Fig. 3. Frame stress display, eccentric load with work force of 25 MN.

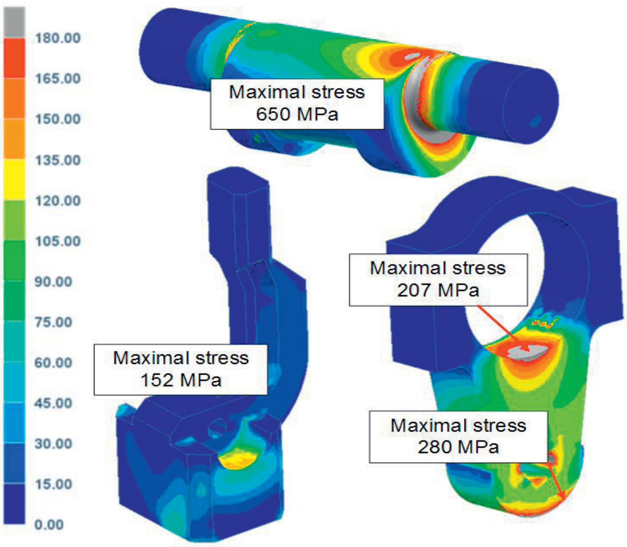

Fig. 4. Display of ram, eccentric shaft and anchoring rod stress, eccentric load with work force of 25 MN.

3.2. Version 2, Mechanical forging press 25 MN with connecting rod

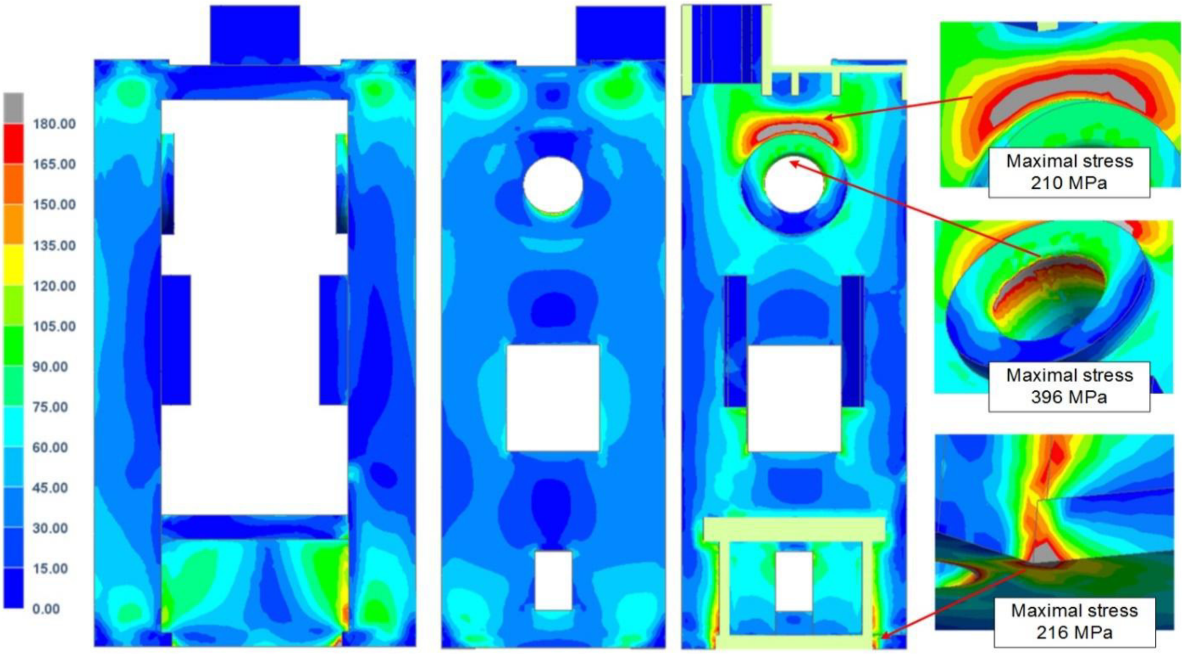

Fig. 5. Frame stress display, eccentric load with work force of 25 MN.

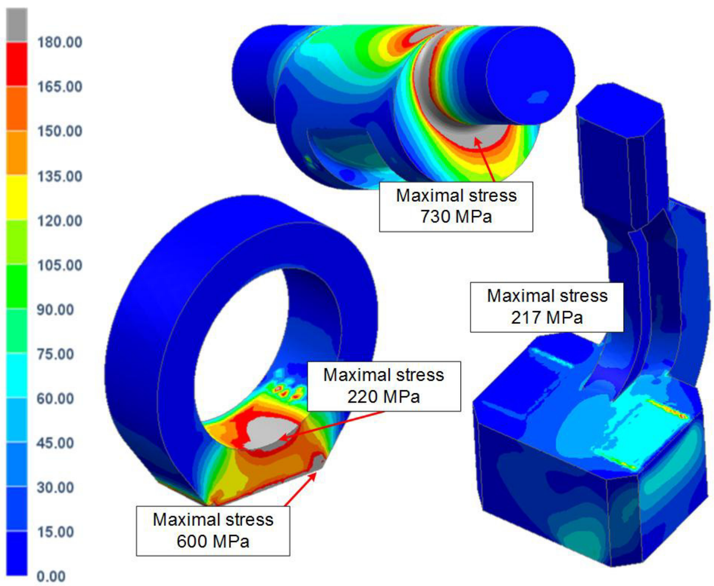

Fig. 6. Display of ram, eccentric shaft and yoke, eccentric load with work force of 25 MN.

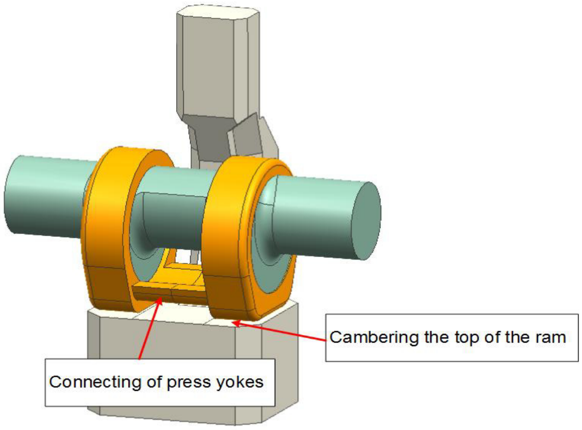

Fig. 7. Connecting of press yoke and cambering the top of the ram.

3.3. Version 2, optimization

Proposal 2 was further partially optimized in order to reduce stress in the yoke and eccentric shaft. It the press yokes were connected, see Fig. 7. 8, to reduce deflection of the eccentric shaft. Furthermore, the diameter of the eccentric shaft was extended.

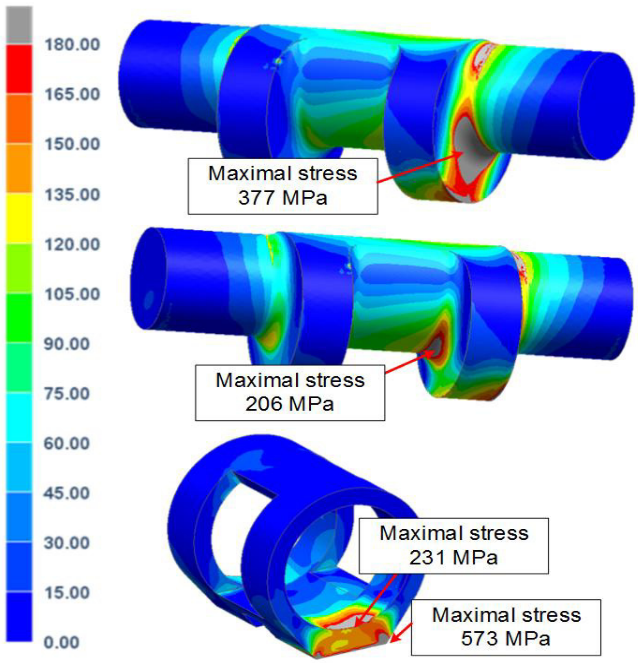

Fig. 8. Display of ram, eccentric shaft and yoke, eccentric load with work force of 25 MN.

To further reduce stress of the eccentric shaft and yoke cambering of the top surface of the ram was designed - the surface in contact with the yoke, see Fig. 7. 9, - with four different radiuses, namely: 50, 75, 100 and 125 m.

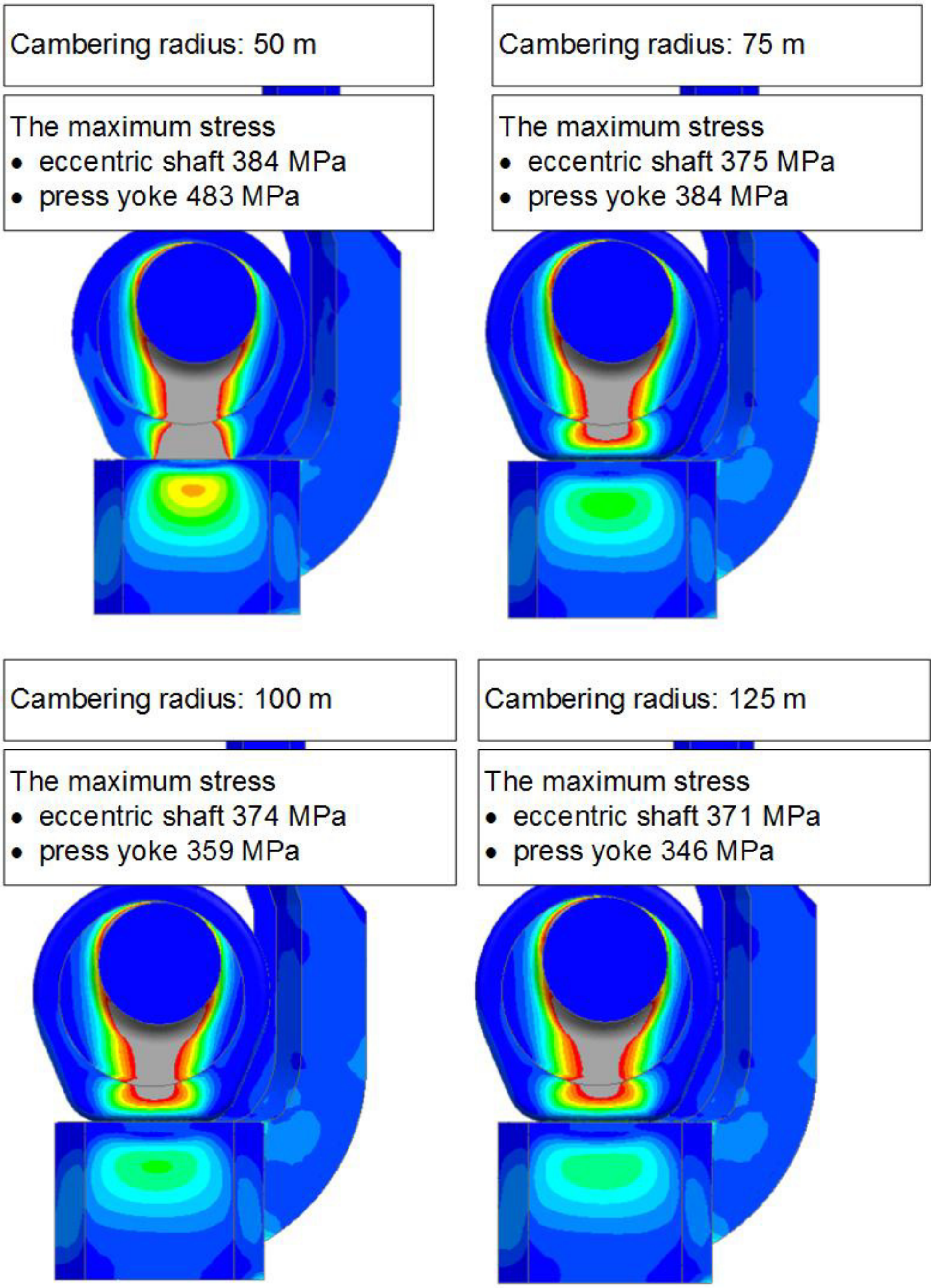

Fig. 9. Display of ram, eccentric shaft and yoke, eccentric load with work force of 25 MN.

3.4. Comparison of the variants

In proposal 1, with two connecting rods, the biggest stress is over the eccentric shaft bearing housing, up to 280 MPa. Increased stress is also under the anchors, about 220 MPa, see Fig. 3, 4.

In proposal 2, with the yoke, there is also increased stress over the eccentric shaft bearing housing, up to 210 MPa, see Fig. 5, 6.

In both variants we must also continue to solve the high stress generated between the pin and the eccentric on the crankshaft.

Proposal 2 is more rigid and lighter, so it can be recommended for further elaboration, see Table 1.

Table 1. Mass and stiffness comparison of proposals.

	Version 1	Version 2
Frame rigidity [N/mm]	18 629 000	20 016 000
Total weight [t]	87	79

4. Conclusion

The aim of this paper was to present solutions aimed at improving the technical parameters of mechanical forging presses.

The paper presents the results of calculations, stress distribution fields in the frames of both proposals of mechanical forging presses with working force 25 MN. The present results indicate that implementing the new design solution for transferring power from the crankshaft to the forgings would increase the stiffness of the press by 7.5% and reduce weight by 10%. Both values are an indispensable contribution to the improvement of the technical parameters of the machines (increased accuracy and reduced cost of production of the press). [6, 7]. In some places in the as yet non-optimized frame, there is very high stress, which should be removed by appropriate design modifications. Therefore, it will be necessary to complete the proposals to fully meet all operational requirements of modern forging presses.

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