DESIGN OF MECHANICAL FORGING PRESS WITH MAXIMAL FORCE IN SIDE CAVITY

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This paper deals with design of crankshaft forging press for multi-cavity forging with maximal forging force in on of side cavities. As a tool was used optimization of structure, structural FEM analysis and geometrical modification of frame. Results are in more uniform stress distribution in whole structure of forging press. This design leads to optimized production and improved quality of final products. Forging press with this modification has higher durability and it has competitive advantage.

KEYWORDS

forming machine, mechanical forging press, structural FEM analysis, frame

1 INTRODUCTION

Forging presses are used nowadays mainly with maximal force acting in axis of machine. It is caused by maximal demands on productivity. This task is by designer solved in way that maximal force with eccentric loading is resulting in more robust structure and higher material consumption on structure of press.

For simulations is used eccentricity which is not fully corresponding with eccentricity achieved in side cavities during forging process. This eccentricity is highly depending on actual technological operation. This leads generally to higher loading of structure and components. High stress is in frame and this phenomenon is decreasing life time. Failures and destruction of machine can also occur. Our design is minimizing these problems.

Methods of technological process automatization for serial and mass production use more often forging from one side to the other. It is because easier manipulation and results is that cavity with maximal applied forging force is situated on side of press.

Our research is trying to solve this problem. Our aim is to design crankshaft forging press for multi-cavity forging with maximal force applied in one from the both side cavities. This design should reflect problems connected with this loading scenario. This solution should bring higher rigidity during forging process, lower tilting of tools and higher accuracy and quality of final product. Of course can be this design of press used for conventional forging technology without any special modification.

The nominal force of forging press is in our case not defined in central axis of machine, but in axis of side cavity (Fig.1 below). Although the design of this machine is highly specified, this machine is not considered as one-purpose machine. This machine can be described as machine with variable loading caused by technological forces.

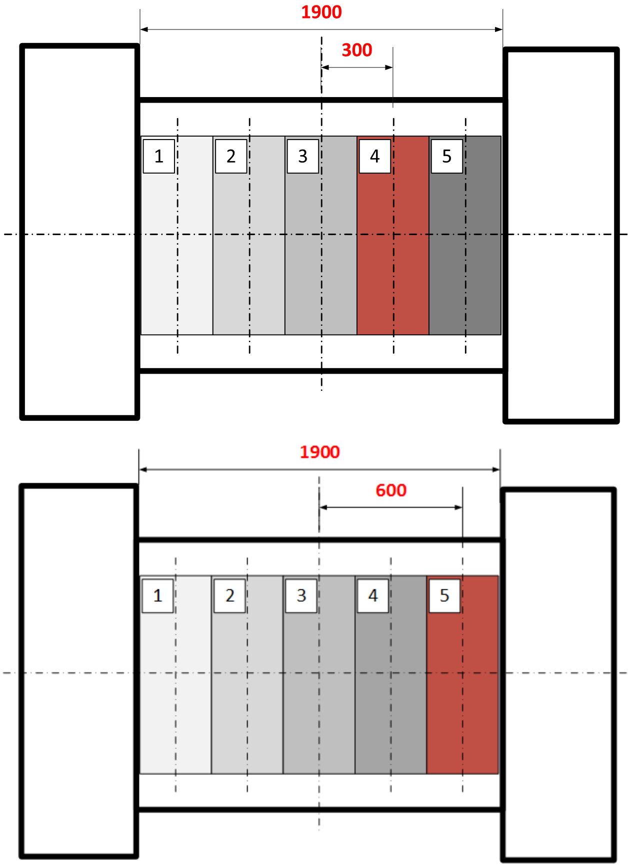

Figure 1 Multi-cavity forging

2 PROPOSED SOLUTION

The basic design of press is based upon conceptual solutions of mechanical forging press LMZ 2500 Smeral with application of components from performed state of art analysis in area of crankshaft presses [Cechura 2015]. This solution of press design was not published and also not used up to now.

The basic prerequisite for design is actual need of forging table for five forging cavities. This is caused by technological demands. The direction of automatic movement of forged part is applied from the left to the right with maximal force applied in fifth cavity (Fig.1). This movement is easier from manipulation point of view.

2.1 Design of eccentrically loaded machine

The current design of considered mechanical forging press in not well designed for eccentric loading in last cavity. This is obvious from performed FEM analysis. Main aim of analysis was to identify areas with higher stress. With grey colour (Fig.3) are marked areas, where maximal stress is over allowable limits.

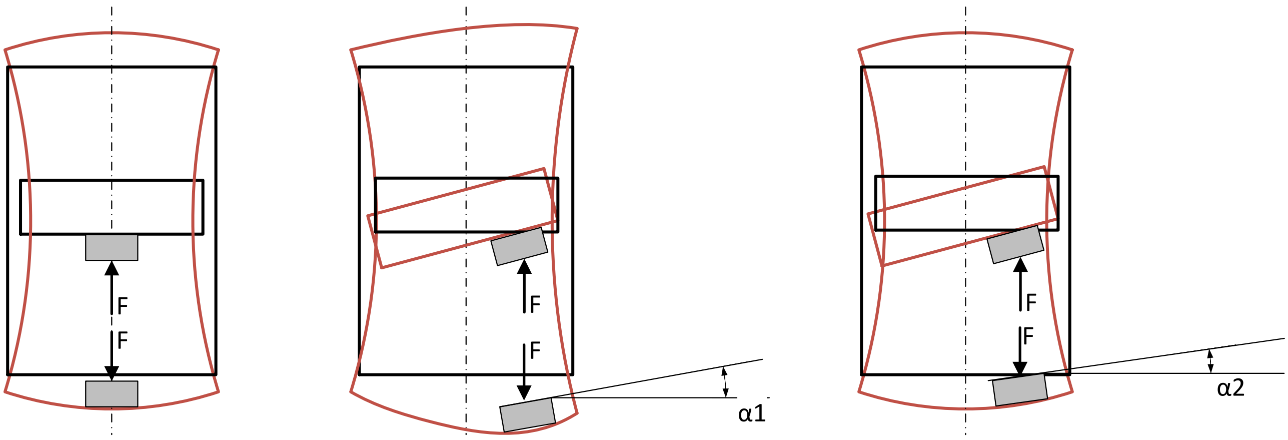

Figure 2. Tilting of tool under various loading- from the left is centric forging, eccentric forging on symmetrical frame and eccentric forging on non-symmetrical frame

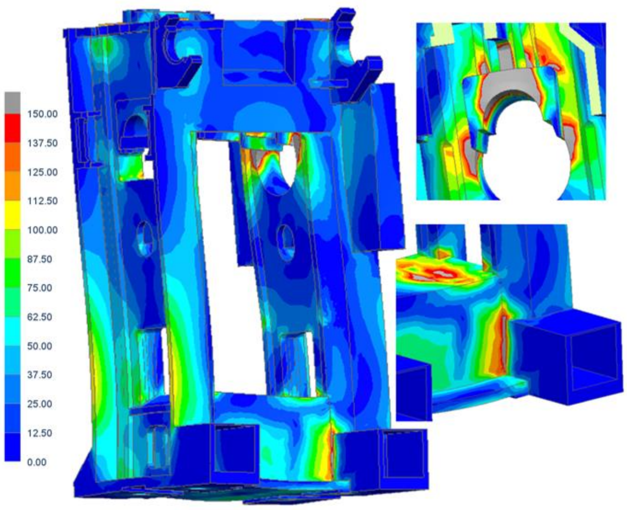

Figure 3. Extremely loaded frame during eccentric loading (original solution) (MPa)

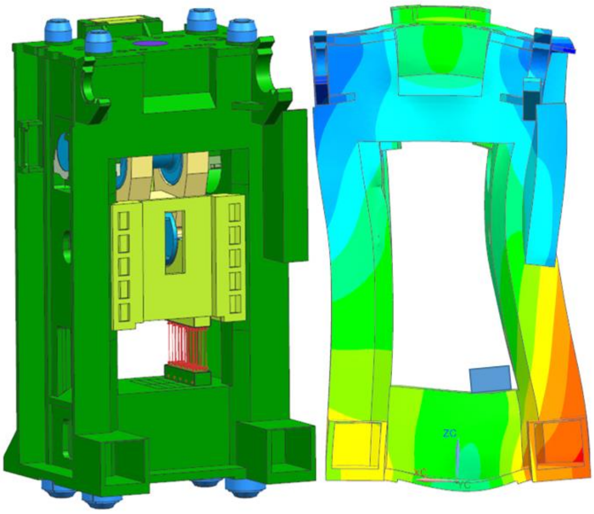

Figure 4. Tilting of tool (die) during eccentric loading (magnified deformation)

In order to ensure sufficient design of structure and dimensioning were performed following design changes (external dimensions of machine were maintained):

- Reinforcement of frame on side of force in order to get same deformation on both sides of frame. Also stresses will be more uniformly distributed.

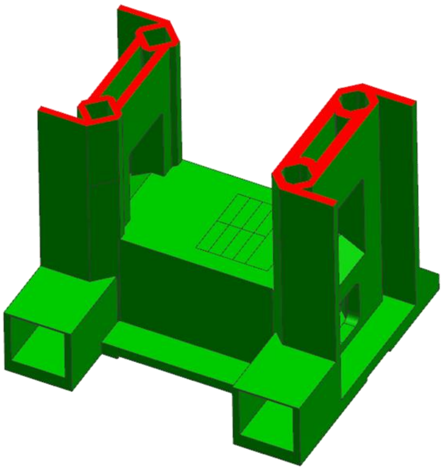

Figure 5. Reinforcement of frame on side of forging force

- Increasing of anchors and their preloading on side with higher force
- Table reinforcement in area of acting force in order to decrease stress and displacement
- Reinforcement of crankshaft and also bearing modification on side of acting force. This should lead to pressures and stresses changes on level which is corresponding with existing centric loaded solution.

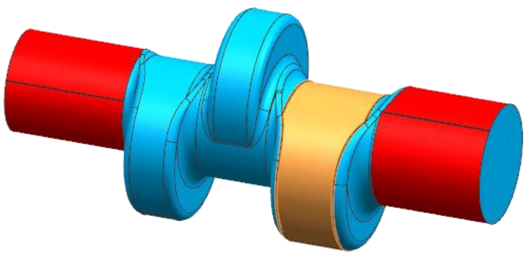

Figure 6. Cranskhaft reinforcement

- Reinforcement of ram and connecting rod on side of acting force

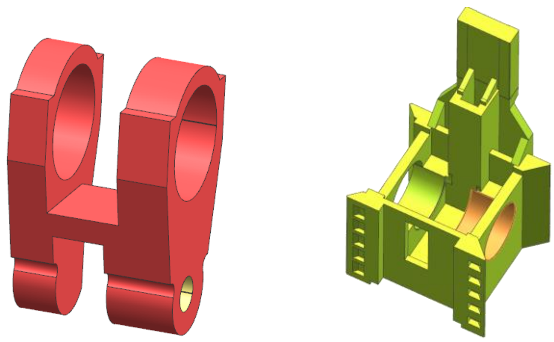

Figure 7. Reinforcement of ram and connecting rod

Dimensioning of forging press if performed in order to meet specification of maximal force 2500 t in side cavity. Also tilting of tool caused by deformation should be as small as possible. It means α2 < α1 (Fig. 2 and 4). [Zahalka 2014]

3 SIMULATION OF ECCENTRICALLY LOADED NON-SYMETRICAL FRAME

3.1 Boundary conditions of simulation

Static simulation was performed for eccentric loading with eccentricity 600mm and forging force 25 MN.

Fixing of frame was defined on face in bottom part of frame. There was defined circular face in axis of frame for that.

All parts (such as eccentric shaft, ram, pin, connecting rod and anchors) were considered in simulation with defined contact boundary condition. Clearance in guidance was set as 0,1mm, in bearings was used 0.2 mm. Material of all parts is steel. [Zahalka 2013]

As a simulation software was used commercial products Siemens NX10 as pre and post-processor. NX Nastran was used as solver. From obtained results was performed virtual diagnosing of stress distribution in investigated parts of machine. [Cechura 2013]

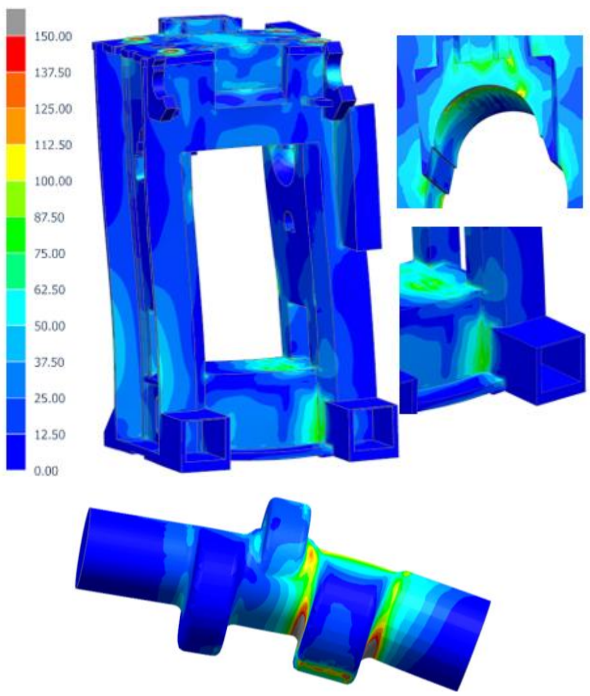

Figure 8. Stress distribution in parts of forging press

3.2 Comparing of new and existing design of press LMZ2500

In actual design and new design was examined displacement of all parts and evaluated individual contribution of this parts with respect to overall rigidity of machine. It is obvious in Fig. 9 and Fig. 10.

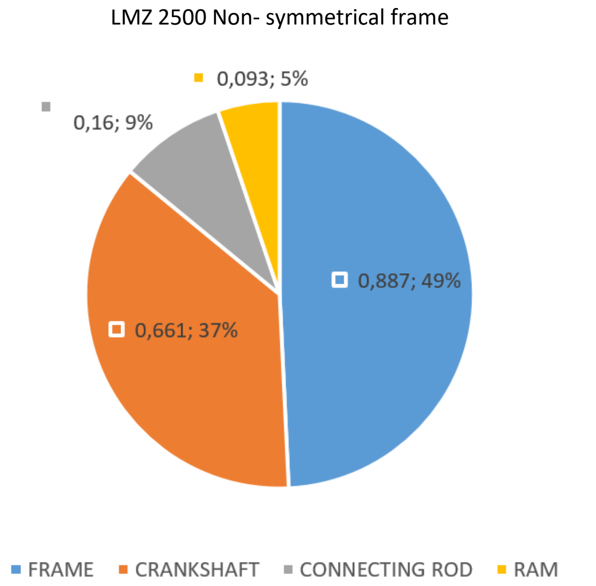

Figure 9. Representation of displacement in new design of forging press

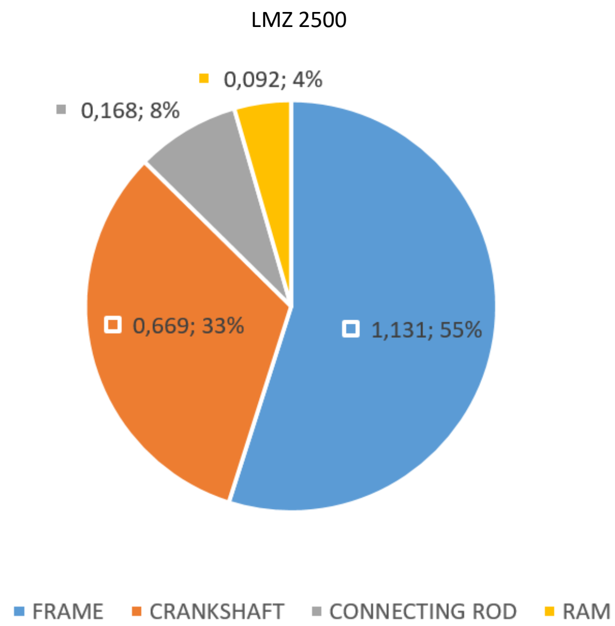

Figure 10. Representation of displacement in existing design of forging press

Fig. 11 shows displacement of ram (upper graph) and table (lower graph) during loading with eccentricity 600mm.

From picture is obvious, that major effect on tilting of tools has movement of ram. This movement is not possible to modify easily because of clearances in mechanical systems of press.

Points in tool are in red colour (eccentricity 600mm). Difference in displacement of points gives the overall tilting.

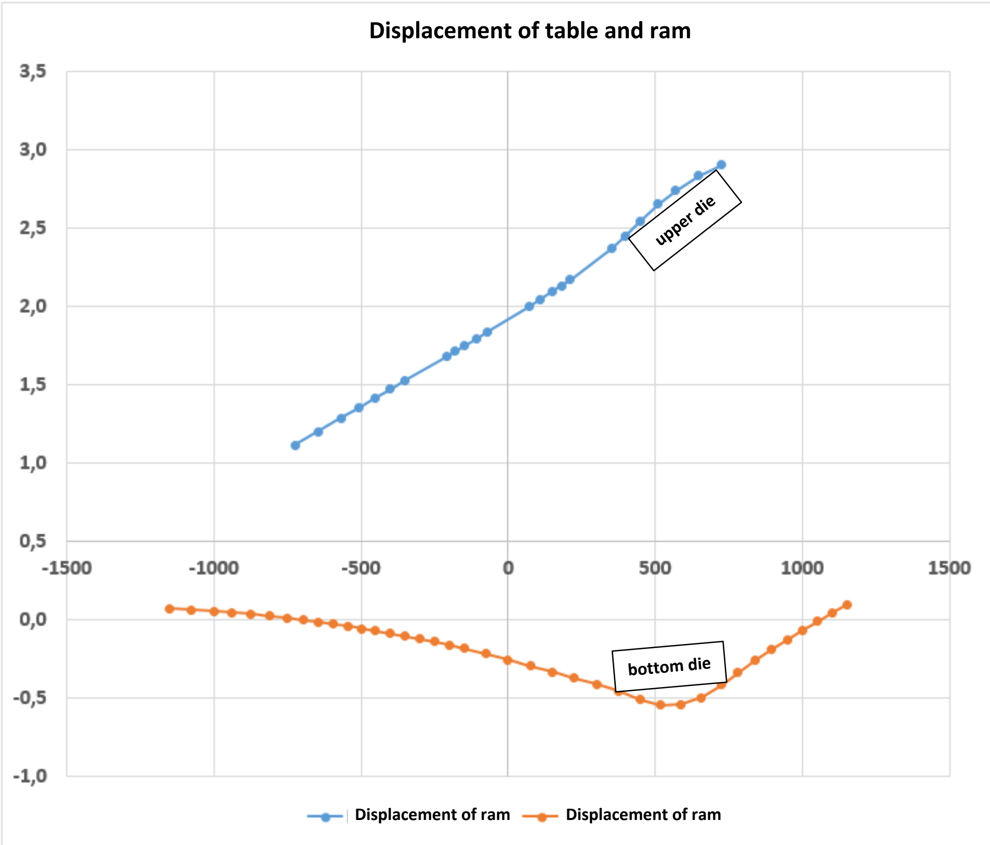

Figure 11. Displacement of table and ram (mm)

4 CONCLUSION

By performed changes of press and design were achieved following properties:

- Uniform distribution of stress in frame during eccentric loading
- Frame has comparable extension on both sides at time of last operation.
- Forging table has comparable deformation as in previous design
- Lower loading of guidance ram-frame
- Lower loading of crankshaft
- Contact pressure in bearing of crankshaft is lower
- Increasing of working area stiffness

Results described above were obtained with increasing of weight from 164t to 169t. The weight is considered with frame, anchors, crankshaft, connecting rods and ram.

Our solution is not single-purpose machine and can be used for various technological operations. During forging process have to be technology performed from the left to the right and maximal force can be located in central cavity and eccentric load in right-side cavity. For centric forging is more suitable use press with classical design. It is for that technology better because has more suitable tilting and accuracy during centric loading.

For wider usage of this press and for placing of cavities is suitable use diagram in Fig.11.

According value of displacement in individual points during described loading is possible to choose place on ram and position of cavity, where forged part has optimal accuracy. For each other loading scenario is possible to perform similar diagram as in Fig.11.

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