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AN INFLUENCE OF SOME PROCESS PARAMETERS ON LATERAL FORCES IN FORGING DIES

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Abstract

The lateral forces are relatively high in production of nonsymmetrical or extended forgings what results in an offset of the upper and lower dies. Two industrial forging processes for the bracket lever and the valve lever were analyzed. MSC/SuperForge software based on finite volume method has been used in numerical modeling of the processes. Combined thermo-mechanical numerical analysis took into account all stages of the forging processes. Changes in the inclination of parting line of dies and geometry of preforms resulted in considerable changes in distribution of force components. The results of calculations have been very helpful in finding the process parameters for which the lateral forces were relatively low.

Key words: forging die, lateral force, numerical modeling

1. INTRODUCTION

Development of hot forging processes has resulted in the increase of dimensional accuracy of forgings. However, a commonly used analysis of material flow has become insufficient for planning of the demanding processes. Additional detailed analysis of die deformation or die wear has been crucial to design new dies. The die cavity is usually subjected to complex loading with lateral and horizontal components of load. The lateral forces are relatively high in production of nonsymmetrical or extended forgings what results in an offset of the upper and lower dies. These displacements introduce geometrical inaccuracies into forgings or increased wear of some parts of die cavity. Advanced software opens the possibility to deal with such problems (Kocanda et al., 2005). Hence, the examples of numerical analysis of the processes with calculation of lateral forces in forging dies have been presented in this paper.

2. NUMERICAL ANALYSIS

Two industrial forging processes for the bracket lever and the valve lever were chosen for the analysis. MSC/SuperForge software based on finite volume method has been used in numerical modeling of the processes. Geometrical models were prepared by means of Solid Works software. The dies were assumed as stiff bodies. Combined thermo-mechanical numerical analysis has taken into account all stages of the forging processes.

2.1. Bracket lever

The forging of the bracket lever, shown in figure 1, was performed on a crank forging press. The lever was made of medium carbon dispersion hardening ferritic-pearlitic steel. In industrial practice, this bracket has been forged in several steps from a round bar of 20 mm in diameter. The operation in the final impression has been examined. The inclination α

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Fig. 1. Bracket lever.

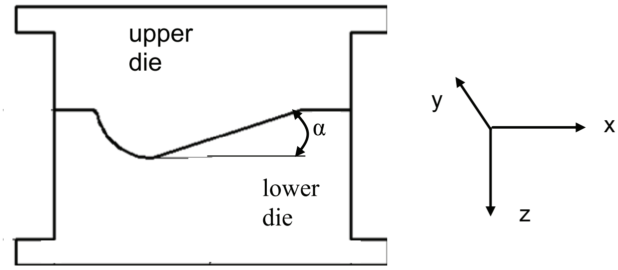

Fig. 2. Schematic presentation of dies for forging of bracket lever; α - the inclination of parting surface.

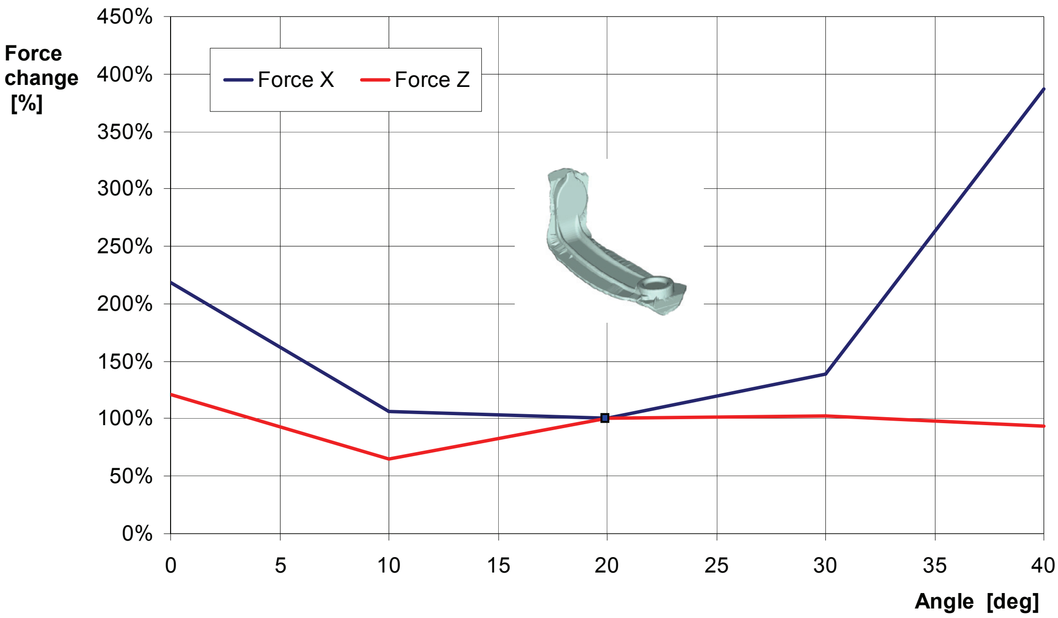

Fig. 3. Influence of parting surface inclination on changes (%) in lateral X and vertical Z forces (forging of bracket lever).

of parting surface of lower and upper dies corresponding to 0, 10, 20, 30 an 40 degrees was a variable for the analysis of forging process, figure 2. Initial temperature of the workpiece was 1100 degrees C and the dies were preheated to 300 degrees C. Friction conditions were defined by Coulomb's law with friction coefficient 0.1. A change in the inclination α of the main part of parting surface from 0 to 40 degrees resulted in changes in the lateral force F_x as shown in figure 3. Calculated force components were presented as relative values, i.e. the values of lateral force F_x=2 MN and forging force F_z=28.4 MN found for the inclination α=20 degrees were assumed as 100% for each of the forces. It should be pointed out that the smallest lateral force F_x has been just for this angle. Values of the angle α lower or higher than 20 degrees caused considerable increase of F_x. On the other hand, the forging force F_z was the smallest for α=10 degrees. Generally, the values of lateral force F_x were up to about 10% of the values of forging force F_z . These calculated data open the possibility to design tools in a proper way. For example, if a lateral force F_x is crucial for tool design and forging quality then the inclination of parting surface should be about 20 degrees. If both forces F_x and F_z should be as small as possible than α=10 degrees would be the best solution.

2.2. Valve lever

Geometry of medium carbon steel preform was a variable for the forging process of the valve lever. Forging process was performed on a forging hammer MPM 10000. Initial temperature of the preform was 1100 degrees C and the dies were preheated to 250 degrees C. Friction conditions were defined by friction parameter 0.3.

The upper and the lower dies were designed as to have fuller, blocker and finisher impressions, figure 4. The full process consisted of the following stages:

- Initial upsetting (1 blow),
- Fullering (2 blows),
- 90^o counter-clockwise (case I – figure 4) or clockwise (case II – figure 4) rotation of preform and additional fullering (2 blows),
- Forging in the blocker impression to get the general final shape (3 blows),
- Forging in finisher impression to get the final overall shape (1 blow).

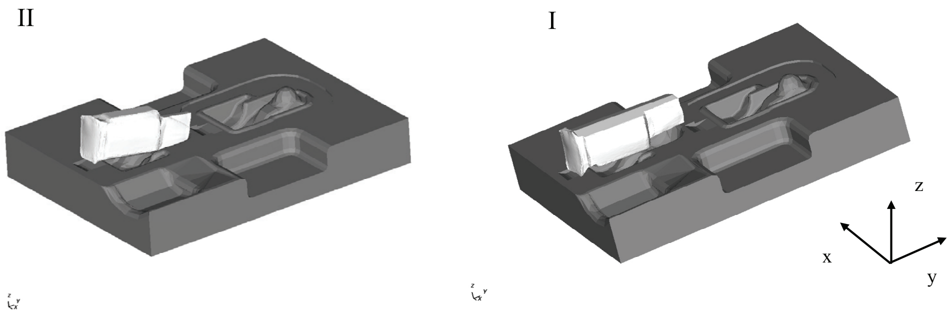

Fig. 4. Positioning of the preform in the blocker impressions of the lower die for forging of valve lever; I – counter-clockwise and II – clockwise rotation of preform after fullering.

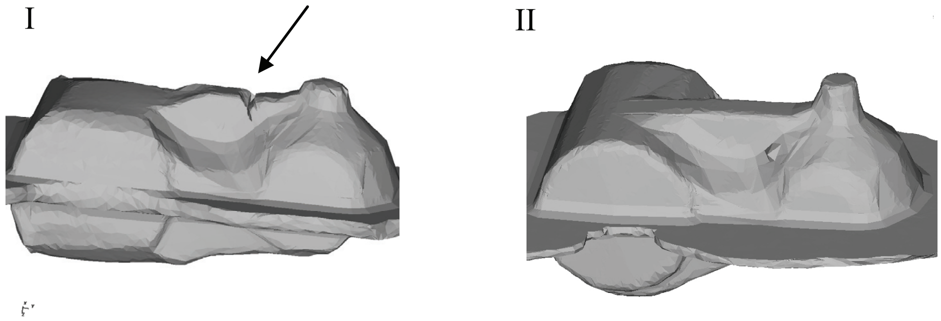

Fig. 5. A forging with overlapping (case I) and a forging without any defect (case II).

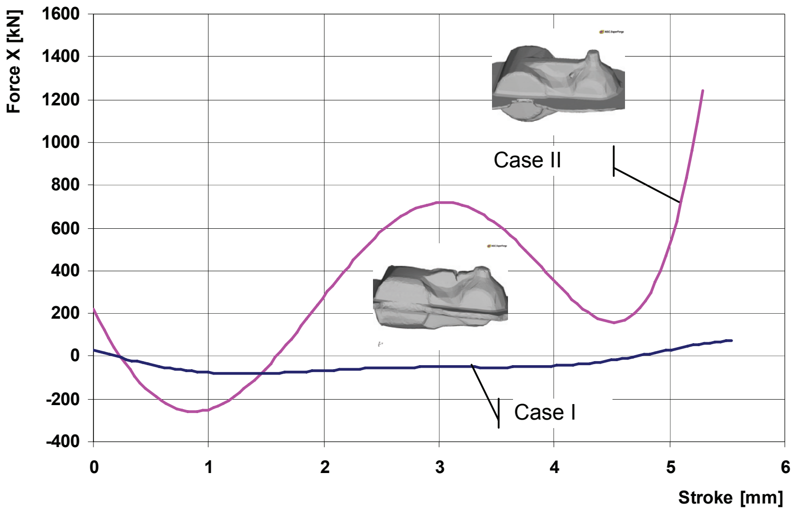

Fig. 6. Changes of the lateral force in X direction for two cases of preform orientation.

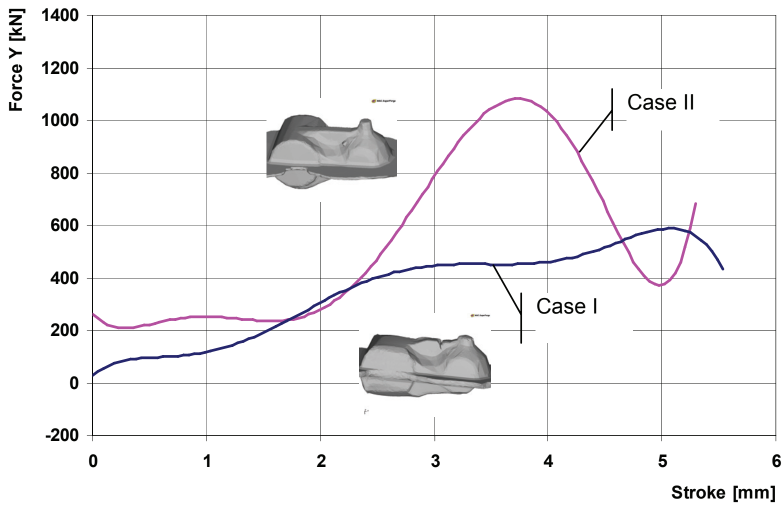

Fig. 7. Changes of the lateral force in Y direction for two cases of preform orientation.

As an example, forging in the blocker impression has been chosen for analysis. All of the previous stages and number of blows were taken into account during numerical simulation. Geometrical changes and temperature fields have been imported for all subsequent stages. The forging obtained after deformation of preform characterized by case I showed a forging defect in the form of overlapping, figure 5. As for the case II, the forging did not show any defect. Figure 6 and 7 present changes in lateral forces X and Y as a function of upper die stroke (third blow). The lateral forces for the case I have been much smaller than for the case II. It means that the necessity to change the preform positioning for getting the forging without overlapping lead to a considerable increase in values of lateral forces (case II).

3. CONCLUSIONS

1) Numerical modeling of the bracket lever forging for various inclinations of the parting surface has been helpful in minimizing the lateral force. The lowest values of lateral force F_x and forging force F_z have been found for the inclination angle of about 10 degrees.
2) The necessity to avoid the overlapping defects by changing preform positioning in valve lever forging lead to a

considerable increase in values of lateral forces. This effect requires careful die design to minimize an offset of dies during forging.

3) Generally, the ratio of lateral to vertical forces was up to about 10% in the two analyzed forging processes.

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WPŁYW WYBRANYCH PARAMETRÓW KUCIA NA ROZKŁAD SIŁ POPRZECZNYCH W WYKROJACH MATRYCOWYCH

Streszczenie

Przy kuciu odkuwek wydłużonych i niesymetrycznych występują w wykrojach matryc znaczne siły poprzeczne, które mogą doprowadzić do wzajemnych przesunięć matryc dolnych i górnych, a tym samym – wad geometrycznych odkuwek. W referacie przedstawiono analizę dwóch przemysłowych procesów kucia dźwigni ze stali średniowęglowych. Przeprowadzono modelowanie komputerowe tych procesów metodą objętości skończonych (program MSC SuperForge). Złożona analiza termo-mechaniczna uwzględniła wszystkie etapy procesów. Zmiany w położeniu powierzchni podziału matryc i zmiany geometrii przedkuwek miały duży wpływ na rozkład sił w matrycach. Wyniki obliczeń były bardzo pomocne w określeniu takich parametrów procesów, przy których siły poprzeczne okazały się najmniejsze.

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