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Preform design in hot die forging*

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A new opportunity for preform design for hot die forging is presented in this paper. The shape of preform is determined on the base of approximation of contour of cross section of forging with polynomial equation. As an example, the preform design of the axisymmetric part with "H" type cross section is performed. Computer simulation of forging processes in preform and final forging stage are done. Simulations with preforms, suggested from other autors are done too. The results are compared and analized.

1. INTRODUCTION

Forging is currently one of the most economical processes for the manufacture of parts for industry. Product quality and production costs are very significant factors for manufacturers today and determines their competitivness. The design of preforms, together with determination of the required number of transforming stages used in forging processes is an important aspect for improving the quality and reducing the costs. Preforming steps are necessery to achieve die filling without defects, high quality and high accuracy of the forged part, decrease of die wear, especially die wear in final impression.

There are very small numbers of decisions of the task about determining of necessity of preforming steps for hot die forging. Most of them are only general recommendation or particular decisions [1], [2], [3], [4]. In [5] Tomov offer a criteria for necessity of preforming stages based on the work done during the hot die forging. This method was successsful used for axisymmetric part with "H" type cross section in [6].

Different approaches about assignment of shape of preforming stages are proposed from autors like Brukhanov and Rebelsky [1], Biswas and Knight [7], Tomov and Wanheim [8], Zhao et al. [10], Biglari et al. [9].

2. PREFORM DESIGN METHOD

The preform design method used in this study applys technique on the base of the presentation of the contour of the shape of cross section of forging part with mathematical equation. The procedure starts with dividing of contour on the several basic parts, which are arcs and straight lines. Input data for approximation of the shape of contour are coordinates of

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endpoints and midpoints for every of this segments. Graphic view of the derived equation is used for construct of preform shape contour.

For investigated axisymmetric forging part with "H" type cross section, shown on fig.1, obtained polynomial equation is:

$$y = -2.10^{-7}.x^{6} + 5.10^{-5}.x^{5} - 0{,}0031.x^{4} + 0{,}0807.x^{3} - 0{,}7968.x^{2} + 2{,}3191.x + 6{,}6518 \quad (1)$$

Graphic view of (1) together with upper half of part contour is shown in fig.2.

Preform contour was constructed according to (1) and well known recommendations for preform design in hot die forging. Shape of preform stage is shown on fig.3.

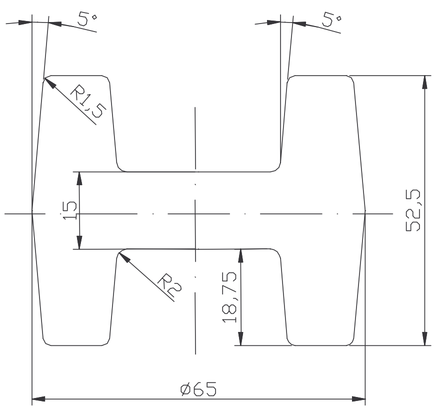


Figure 1. Investigated axisymmetric forging part with "H" type cross section.

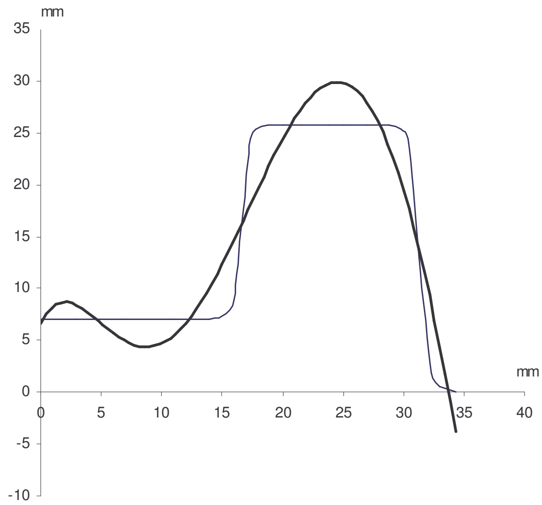


Figure 2. Part contour and graphic view of equation, obtained by approximation

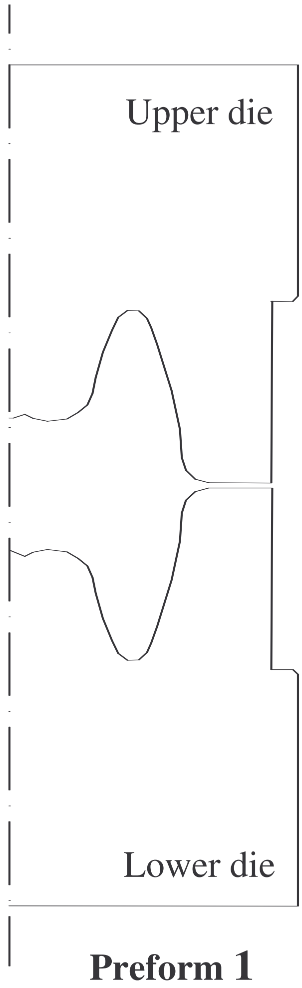
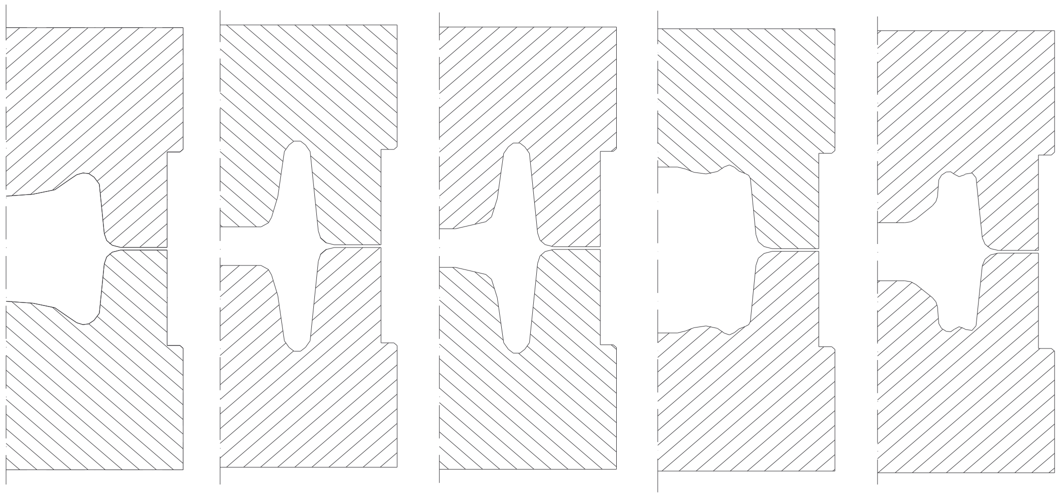


Figure 3. Shape of the dies for the preforming stage

3. EXPERIMENTS AND RESULTS

In this paper six different preform shapes, for forging part shown on fig.1, have been investigated by computer simulations. The first preform shape (**Preform 1**) is obtained by using design method introduced in this work. Preform shapes derived by manners, proposed from other investigators [1], [7], [8], [9] and [10] are studied too (fig.4). Software package for finite element analysis of metal forming processes was used. Low-carbon steel forged on hydraulic press with forging temperature T_F =1200°C has been chosen as deformed material for the analysis. The temperature of the die was T_T=300°C. The lubricant used for simulation was emulsion of graphite and water. The billet was with round cross section and dimensions ∅45X84.



Preform 2 [1] Preform 3 [7] Preform 4 [8] Preform 5 [9] Preform 6

Figure 4. Different preform shapes investigated by FEM simulation.

In oreder to investigate the effect of the preform shape on the forces and works done of the final impresion data for their values have been received. Results are shown in Table 1.

Table 1
Values of the forces and the works done for different cases of die forging

Preform	Forging in preform die		Forging in final die		Total values	
	F [MN]	W[kJ]	F [MN]	W[kJ]	F [MN]	W[kJ]
1	0,0888	3,7323	3,5282	4,8716	3,6170	8,6039
2	0,2688	3,3155	1,5676	5,5880	1,8364	8,9035
3	1,8139	9,0691	1,1523	2,5262	2,9662	11,5953
4	1,3818	8,3503	1,2689	2,6723	2,6507	11,0226
5	0,1081	1,9023	1,8151	7,1363	1,9232	9,0386
6	0,1421	4,2915	3,4948	4,8147	3,6369	9,1062

Comparing total works done for different preform dies, it is clearly, preform 1 ensure the smaller work done. Values of total works done for cases 2, 5 and 6 are higher, but still close to preform 1. Moreover, distribution of works done among preform and final impressions for preforms 1 and 6 are about equal. This corresponds to already vested forging practice.

Filling of final dies and effective strains distribution was studied in this work too. Deffect free forging in finishing impression was obtained for preforms 1, 5 and 6. Unfilling of die was the result of computer simulation for preforms 3 and 4, also in fewer grades for preform 2. This is a symptom for necessity of billet with larger volume than used. Obviously, this will bring bigger flash amount, which will provoke more intensive die wear and major consumption. Especially, this will be stronger asserted for cases 3 and 4. For example, the difference of total works done for forging with used in this study billet for preform 1 and preforms 3 and 4 come at 30435 %. This difference will increase if billet volume enlarge.

The values of effective strains for preforms providing filling of final dies are analyzed also in this study. Most equable is distribution of effective strains in final impression for forging with preform 1.

4. CONCLUSIONS

The result obtained applying the method of preform design for hot die forging based on the approximation of contour of cross section of forging with polynomial equation allow to conclude:

(i) it is suitable method for preform design for hot die forging. This manner ensures smaller work done, adequate die filling and equable distribution of effective strains. This defines decreasing of die wear and manufacturing expenditure.

(ii) it is necessity additional investigation about applying of this method for parts with other shape of cross section

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