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EFFECT OF PROCESS PARAMETERS ON VOLUME LOSS OF ONE-SIDED HEAD OF 42CrMo BILLET CROSS WEDGE ROLLING

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A three-dimensional rigid-plastic Finite element model(FEM) for cross wedge rolling of square billet was established by using DEFORM finite element software. The influence of forming angle, broadening angle and section shrinkage on the volume of one-sided blank head was analyzed based on orthogonal experiments of three factors and three levels. It is concluded that the influence degree of forming angle, section shrinkage and broadening angle on the volume of one-sided blank head decreases in turn, and the influence degree of corresponding process parameters in different sections is also different. The results of this study can provide references for expanding the types of cross wedge rolling billets and choosing reasonable process parameters in square billet rolling.

Key words: steel 42CrMo, square billet, cross wedge rolling, FEM, volume loss

INTRODUCTION

Cross wedge forming technology is a near net forming rolling technology, which is widely used in related fields with high efficiency, high material utilization and high automation [1].

With the deepening and popularization of cross wedge rolling technology, the requirements for cross wedge rolling blanks are becoming wider and wider. At present, the research on cross wedge rolling at home and abroad has been stuck on the rolling basis of circular billet, but the research on cross wedge rolling of non-circular billet is less. Relying solely on the traditional round billet will limit the popularization of cross wedge rolling to a certain extent, especially for some large parts such as train shafts, which are difficult to obtain such large round bars. Therefore, it is very necessary to carry out research on the cross wedge rolling forming process based on non-circular billet. If the axle is formed by cross wedge rolling of square billet, the process of forging square billet into round billet will be omitted, which greatly shortens the production time and saves the production cost.

Ma Wenyu of Beijing University of Science and Technology also used DEFORM - 3D finite element software to analyze the stress and strain in square billet rolling process, and studied the influence of forming angle, broadening angle and square billet size on rolling force and determined the reasonable process parameters [2].

However, there are few reports on the quality of the end of the rolled piece. In actual production, process parameters are important factors affecting the head of the piece. Therefore, it is necessary to discuss the influence of process parameters on it.

In this paper, the influence of main factors on the volume loss of blank head of non-step end rolling and the order of influence of each factor are studied by the finite element numerical simulation method.

ESTABHLISHMENT OF FINITE ELEMENT MODEL

Firstly, the geometric models of roll, roll piece and guide plate are built and assembled in CREO software to determine the position relationship. The STL format is saved separately and imported into DEFORM - 3D software for simulation. Because of the symmetry of the model, in order to save the simulation calculation time, a 1/2 rolling model is adopted and symmetrical constraints are set on the boundary of the symmetrical surface; Since the rolling time is very short, it is considered

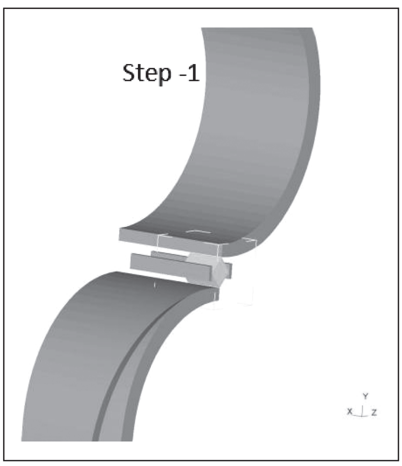

Figure 1 FEM of square billet cross rolling

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that the temperature of the rolled product remains unchanged ; Ignore the elastic deformation of the mold as a rigid body, the blank is regarded as a plastic body, the billet rolling temperature is 1 100, the material is AISI - 4140 [70 - 2 200 F(20 - 1 200 ° C)], the tetrahedral mesh is used and the mesh number is set to 50 000; The roll rotation speed is 0,42 rad / s, the friction coefficient between the roll and the blank is set to 2, and the friction coefficient between the baffle and the blank is set to 0,01, both of which are shear friction. The Finite element model (FEM) is shown in Figure 1.

CALCULATION METHOD OF SINGLE SIDE HEAD OF ROLLED PARTS

In order to accurately calculate the head volume of the rolled workpiece, it is first necessary to calculate the concave center value of the axle end of the rolled workpiece after rolling deformation. Twenty-five nodes are selected at the end section center of the rolled piece after rolling. The center point of the end section of the tied piece is offset due to the radial compression and the lateral expansion deformation during the cross rolling process, the center point of the blank cross section is not necessarily the center point of the end concave center of the rolled piece. The offset distance of the center point is usually not more than 0,2 mm. For this reason, the center point of the cross section of the billet and 12 uniformly distributed nodes on two circles with the center point as the center of the circle and the radius of the circle as 0,1 mm and 0,2 mm are selected[3]. Set the axially coordinate of the symmetrical center of the rolled piece to be 0. The node position diagram is shown in Figure 2.

$$V = \frac{1}{2}V_0 - \frac{\pi}{4}d_1^2 \cdot \frac{1}{25}\sum_{i=1}^{25}\omega_i \quad (1)$$

In the formula: V is the volume of the head of the rolled piece mm³; V0 is the original volume of the blank mm³; d1 is the rolled diameter of the rolled piece mm; ωi is the axial coordinate of the i point mm.

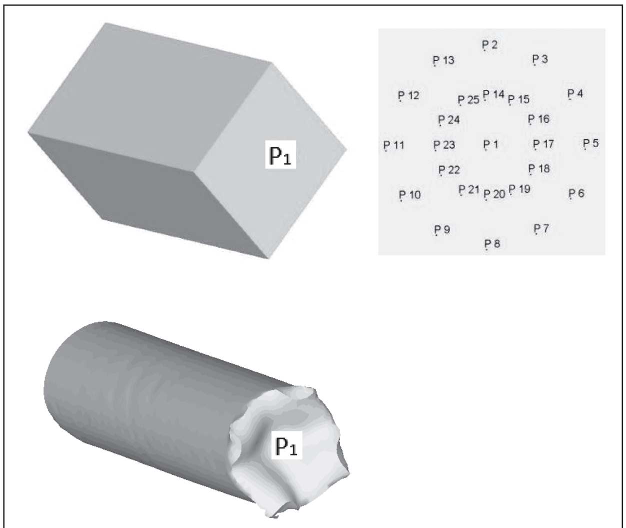

Figure 2 Node location map

INFLUENCE OF PROCESS PARAMETWRS ON THE VOLUNE OF ONE-SIDE MATERIAL HEAD OF ROLLING STOCK

Taking the volume of the one-side material of the rolling stock as the test index, the forming angle, the broadening angle and the section shrinkage were selected as the investigation factors, each factor has three levels. The Finite element simulation of the experimental group is carried out by using DEFORM - 3D finite element simulation software. The orthogonal experimental design scheme and results are shown in Table 1.

Table 1 **Orthogonal experimental design scheme and results**

Number of groups	α / °	β/ °	ψ/ %	V /mm³
1	26	8	40	3 434,7
2	26	9	50	16 301,7
3	26	10	60	6 557,3
4	28	8	50	12 392,1
5	28	9	60	15 154,0
6	28	10	40	19 030,0
7	30	8	60	27 380,1
8	30	9	40	11 251,5
9	30	10	50	15 268,3
t1	8 764,6	14 402,3	11 238,7	
t2	15 525,4	14 235,7	14 654,0	
t3	17 966,6	13 618,5	16 363,8	
Excellent level	1	3	1	
R	9 202,0	783,8	5 125,1	

α The forming angle; β The broadening angle; Y The section shrinkage

The factors in the table have the same number of occurrences at all levels and have the same effect on the volume of one-sided head. Therefore, the difference of the volume of one-sided head of each factor can be used to reflect the difference of factors at all levels. Taking the horizontal number as the abscissa and the mean value t1, t2, t3 of the sum of the volumes of the unilateral heads of each group as the ordinate, the influence trend of each factor on the volume of the single-side material head can be obtained.

The forming angle has a significant influence on the deformation of the rolling stock during the rolling process, which in turn affects the volume of the single-side material head after the rolling. Figure 3 shows the effect of α on the volume of the single-side material of the 42CrMo billet at 26 °- 30 °. It can be seen from the figure that the volume of the single-side material increases with α. When the forming angle is increased from 26 ° to 28 °, the volume increase of the single-side material is 77,14 %; when the forming angle is increased from 28 ° to 30 °, the volume increase of the single-side material is 15,72 %.

The increase of α leads to the increase of the axial component of the force between the die and the square billet in the deformation zone, which increases the metal flow in the axial direction, and thus leads to the increase of the non-uniformity of the axial deformation between the surface and the center of the rolled piece. With the further increase of α, the trend of compression at the center of square billet increases, which improves the non-uniformity of axial deformation between the surface and the center metal of the rolled piece, and weakens the influence of forming angle on the volume of one-sided blank head.

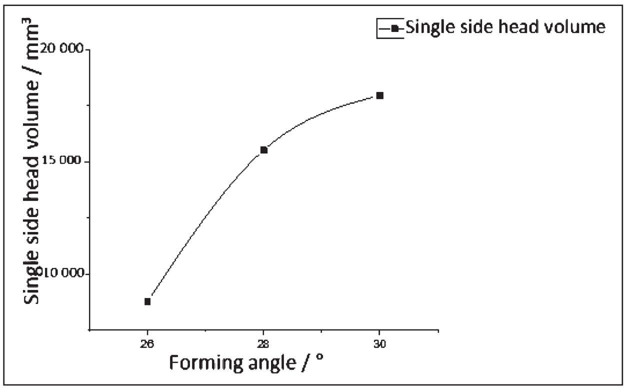

Figure 3 The relationship between the size of forming angle and the volume of one-sided blank head

Figure 4 shows the effect of β on the volume of a single-side material roll of 42CrMo square billet at 8 °- 10 °. When the broadening angle is increased from 8 ° to 9 °, the volume of the single-side material is reduced by 1,16 %. When the broadening angle is increased from 9 ° to 10 °, the volume of the single-side material is reduced by 4,34 %.

Because with the increase of β, the wedge side area of the rolled piece contacting with the die along the axis decreases, while the contact area along the radial direction increases, resulting in the decrease of the axial metal flow and the increase of the metal flow along the radial and transverse directions. Furthermore, with the increase of the broadening angle, the whole rolling time is greatly shortened, which reduces the time of non-uniform deformation between the surface metal and the core metal of the square billet.

Figure 5 shows the effect of Y on the volume of the single-side material of 42CrMo square billet rolling at 40 %- 60 %. With the increase of Y, the amount of metal deformation increases, the surface metal flow along the axis of billet is easier, and the non-uniformity between surface metal and core metal is aggravated. When is more than 50 %, the increase of the volume of the unilateral material head slows down. The reason is that under the action of large, the metal deformation gradually penetrates into the center of the billet, which improves the axial flow of the metal in the center. At the same time, the surface metal is hindered by the friction force of the die.

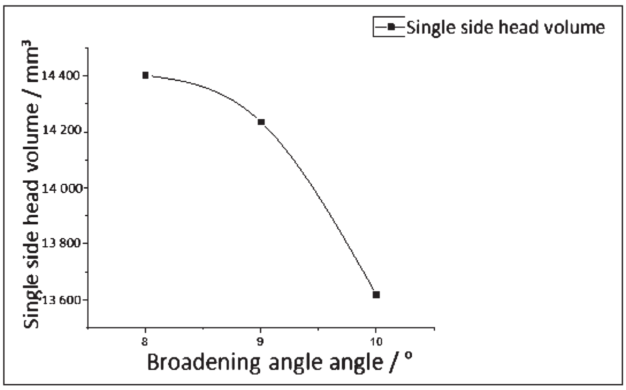

Figure 4 The relationship between the width of the widened angle and the volume of one-sided blank head

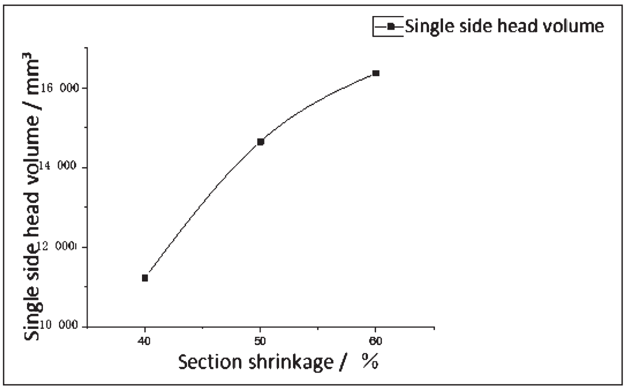

Figure 5 The relation between section shrinkage and the volume of one-sided blank head

COMPARISON OF SIDE HEAD VOLUME BETWEEN BILLET ROLLING AND ROUND BILLET ROLLING

The cross section size of the billet is 50 × 50 mm and the length is 80 mm. The round billet of the same volume and cross-sectional area is now used for rolling, and the diameter of the round billet is about 56,42 mm. Select the second set of conditions in Table 1 for finite element simulation. The simulation results are shown in Figure 6.

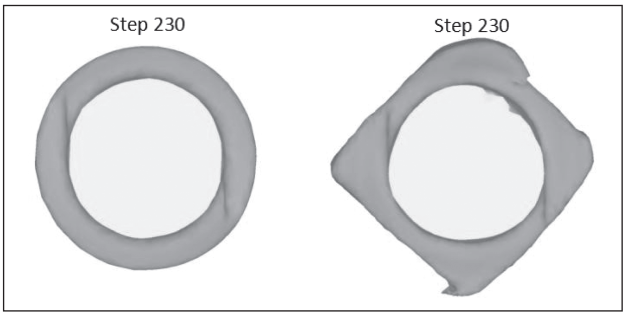

Figure 6 Simulation results of round billet and square billet

By calculating formula (1), it is concluded that the volume of one-sided blank head rolled by round billet is 14 571,1 mm^3 and that of one-sided blank head rolled by square billet is 16 301,7 mm^3.

It can be seen that the loss degree of the billet rolling head is not much different from that of the round billet. The loss of the billet head can be effectively reduced by appropriately changing the mold parameters. By comparative analysis, the cross wedge rolling of the square billet is feasible.

CONCLUSION

Within the range of the selected process parameters, the volume of the unilateral blank head of 42CrMo billet after cross wedge rolling increases rapidly with the increase of forming angle at first, the range is about 77,14 %, and then increases slowly, the range is 15,72 %. With the increase of the broadening angle, it gradually decreases, but the decrease is not significant; With the increase of the section shrinkage, the first increase is 30,39 %, and then the flat increase is 11,67 %.

The influence of forming angle, section shrinkage and broadening angle on the volume of one-sided blank head of 42CrMo billet by cross wedge rolling decreases in turn, and the influence degree of corresponding process parameters in different intervals is also different.

The simulation results show that the billet rolling scheme is feasible, and the comparison with the round billet rolling shows that there is little difference between the two schemes on the loss degree of the head of the rolled piece.

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Note: The responsible translator for the English language is Y. Chang, Ningbo, China