Flow characteristics of brass rod during continuous extrusion

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Abstract

Continuous extrusion forming technology has much excellence as high production efficiency, saving energy and so on, however the flowing uniformity of the billet is the key of affecting the product quality of brass alloy rod in continuous extrusion. The flow characteristics of the brass rod billet were obtained based on continuous extrusion process, and then two kinds of forming channel shapes were designed in this paper. The results show that the grain size of the brass alloy rod is fine and uniform after continuous extrusion. For the process of round-table shaped channel, the flow velocity of the billet is nonuniform, the product appears circular microstructure, which make the performance and microstructure of product uneven. For the process of table-cone shaped channel, the flow velocity is more uniform, and the circular microstructure disappears, which make the performance and microstructure of brass alloy rod more uniform. The research results show that the product of brass alloy rod with uniform grain and excellent properties is obtained based on the table-cone shaped channel during continuous extrusion.

Keywords: Brass rod; Continuous extrusion; Flow characteristics

1. Introduction

Continuous extrusion (also named CONFORM) technique is widely used in copper and copper alloy processing. The brass alloy rod is one of such copper alloy products, which is widely used in electrical field. The continuous extrusion process is being most widely adopted for its superiority of pre-heating-free, high extrusion ratio, post-treatment-free and so on. The continuous extrusion process is mainly driven by extrusion wheel, when the billet...
meets the abutment, where the billet will be generated the right-angle deformation, and then entering into chamber, in the end passing the die to form the product.

For continuous extrusion process, Song et al. (1990) studied the technologic parameters for CONFORM process and the three-dimensional photoplaticity at high temperature (Song et al 1998). Kim et al. (2000) applied the upper bound and optical design method to study the CONFORM process. Cho et al. (2000) adopted the parametric investigation method to study the surface defect occurrence and curling phenomenon in CONFORM process (Cho et al. 2001). Menninen et al. (2006) analyzed the flash formation in continuous rotary extrusion in continuous rotary extrusion of copper. Wu et al. (2007) studied the effect of extrusion wheel angular velocity on continuous extrusion forming process. Zhao et al. (2013) analyzed the effect of deformation speed on the microstructure and mechanical properties of AA6063 during continuous extrusion process.

However, regarding to flow characteristics of brass rod during continuous extrusion any remarkable study has not been presented. In this paper, we aimed at the understanding of the flow characteristics for brass alloy rod. Since the flow rules influenced the microstructure and the performance of the product directly in the process of continuous extrusion, it had very important practical significance to study the flow characteristics which would be able to meet the production requirements.

2. Experimental procedures

The extrusion experiment is based on TLJ400 continuous extrusion machine, whose extrusion wheel diameter is 400 mm. The experimental material is H62 brass alloy, whose chemical compositions includes Cu 62.5%, Fe 0.15%, Pb 0.03%, Ni 0.5% and Zn others. The obtained samples of round-table shaped channel and table-cone shaped channel are shown in Fig. 1 and Fig. 2 based on continuous extrusion experiment. From the Fig. 1 and Fig. 2, it is easy to find that the two samples have the same entrance and the different exit channel. The cross section (a)-(c) are the regions which would be used to observe the macrostructure and microstructure.

3. Results and discussion

3.1. Macrostructure discussion

During the continuous extrusion process, the extrusion wheel and the guide roller are rotary with constant velocity while the other components are stationary. The rod feedstock is driven under the friction of the rotation extrusion wheel groove, as the billet meet the abutment, the billet could not move forward and would be forced passing the right-angle bend extrusion region, and then forming the product.

The flow process of the brass rod passing the round-table shaped channel are shown in Fig. 3(a)-(c), which from
the entrance of the chamber to the middle cross-section, and the extruded product. As described in Fig. 3(a), it can be seen that some streamlines in the cross-section of entrance of the chamber are from the bottom to two sides of the cross-section, some of which concentrate in the top side because of the effect of friction. After entering the chamber the streamlines focus in the circumference direction, as shown in Fig. 3(b). Due to the friction between the brass billet and the chamber, the flow of the edge of cross-section is slow. The outside of the billet would form the dead zone for the block of the die broadside. The streamline layer thickness is different in the whole cross-section and the flow of the center region is faster than the edge one. The macrostructure of the cross-section of product is illustrated in Fig. 3(c). It can be seen that there are some streamlines existing in the circumferential direction, which will affect the uniformity of product properties.

![Fig. 3. Macrostructure of the sample of round-table shaped channel. (a) Cross-section of the entrance of chamber, (b) cross-section of the middle of chamber and (c) cross-section of the product.](image)

The macrostructure of the sample of table-cone shaped channel is described in Fig. 4. The Fig. 4 (a)-(c) show the different sections, and the observing flow region is the same with the round-table sample. The Fig. 4(a) is the cross-section macrostructure in the region of the entrance of chamber, which can be seen that the flow is stability. The Fig. 4(b) shows the macrostructure in the middle of chamber, which shows that the width of dead zone and the amount of streamlines are smaller than ones of the round-table channel product. The Fig. 4(c) shows the macrostructure in the region of die exit, which can be seen that the streamline disappeared. During the table-cone channel process, the flow behaviour of the billet is improved, and the material flows more smoothly and uniformly than the round-table process, and better performance products will be produced.
3.2. Microstructure discussion

The microstructure of the product based on the round-table channel is shown in Fig. 5. The Fig. 5(a) is the streamline microstructure of the product obtained by the round-table channel, which can be seen there are some streamlines in the microstructure map. The Fig. 5(b) is the magnified streamline microstructure map, which can be observed that the streamlines is obvious, which will affect the uniformity of the product. Such product would occur layering and break during the following deformation process, for instance, drawing.
Fig. 6 shows the microstructure of the product based on the table-cone channel. The Fig. 6(a) is the microstructure map of the product, which can be seen the grain size is uniform and fine. The Fig. 6(b) is the magnified microstructure map, which can be observed that the grain size is fine and the streamline disappears.

Fig.6. Microstructure of the product based on the table-cone channel. (a) Microstructure map and (b) magnified microstructure map.

4. Conclusions

The brass rod was obtained by continuous extrusion experiment. Two different samples are obtained based on one channel of round-table, and the other channel of table-cone. For the two different samples, the macrostructure and microstructure are observed, and then the flow rules of the deformation billet are obtained. The results show that the grain size of the brass alloy rod obtained by table-cone process is more fine and uniform, which will make the brass alloy rod with excellent properties during continuous extrusion.

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