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Finite Element Analysis on New Compound Extrusion for Straight Tube of 7A04 Aluminym Alloy

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Finite Element Analysis on New Compound Extrusion for Straight Tube of 7A04 Aluminum Alloy

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Abstract. A method of new compound extrusion is introduced. The process for the straight tube of 7A04 aluminum alloy was simulated by DEFORM-3D finite element software. The deformation process and force was discussed. The results showed that new compound process can effectively reduce the load.

1. Introduction

The tubular member is a common product in industrial applications. According to its shape characteristics, traditional production processes include casting and machining. The casting process is prone to defects such as coarse grain, uneven structure, composition segregation and low mechanical properties, which will greatly reduce the performance of subsequent products. The mechanical processing method has a large amount of machining, which will result in materials and energy waste. Therefore, it has been proposed to obtain a straight tube [1] of a desired size by a method of back-extrusion. Wang Xianwen [2] analyzed the reverse extrusion process of EW75 magnesium alloy, and obtained the best process deformation to 500 °C and extrusion speed of 5 mm/s. Wang Xiaobin [3] and others simulated the forming of TC6 alloy tubular parts and obtained the distribution of stress and strain under different process parameters. Research on metal forming under the new reverse extrusion process is rare.

Future-oriented metal extrusion processing technology must be more refined, more economical, and cleaner [4]. In order to improve the problem of large deformation and uneven deformation of ordinary anti-extrusion, Y. H. Kim [5] proposed reverse torsion method. The test results show that the conventional back-extrusion can reduce the forming force by about 30%; at the same time, achieve more uniform deformation. Wang Qiang [6] et al. proposed a hollow billet reverse extrusion labor-saving forming method, which can save about 25% of labor, and the deformation of the bottom of the cylinder is more uniform, improving the mechanical properties. V. Shatermashhadi et al. [7] developed a new compound extrusion process and experimented with high-purity lead, indicating that



the forming force can be reduced and the mechanical properties of the product are improved. Based on this process and Deform3D software, the forming process of 7A04 aluminum alloy tubular parts was simulated, and the deformation process and force during forming were analyzed. This study has certain theoretical guiding significance for the actual production of 7A04 aluminum alloy in the future.

2. Process introduction

In the new compound extrusion process, the mold device comprises three parts, a concave mold, a fixed punch, and a moving punch. The mold structure of the conventional back extrusion and radial-reverse composite extrusion is shown in Fig. 1(a) and (b). In the conventional back-extrusion process, the blank is placed in the die, the punch moves downward, and the metal flows out through the gap of the die. In the radial-reverse composite extrusion process, the blank is placed in a fixed punch with a through hole, and then the moving punch is moved downward to press the blank, and the blank is first radially extruded, filled with the fixed punch and The bottom cavity between the female molds is then subjected to reverse extrusion, and the metal flows out through the sidewall gap formed by the convex and concave molds.

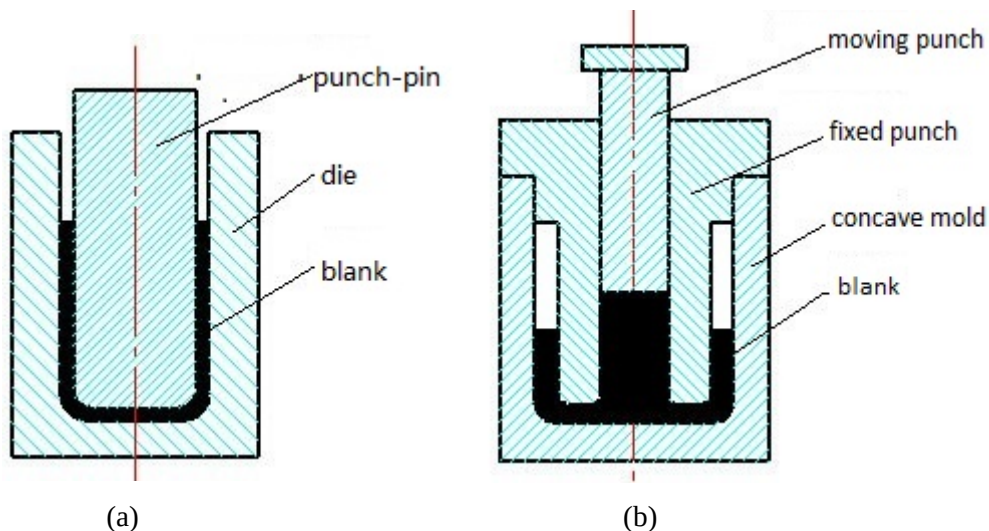


Figure 1. The schematic view of backward extrusion and new compound extrusion.

3. Numerical simulation

3.1 Establishment of a rigid shape finite element geometric model

A three-dimensional solid model of the blank, the moving punch, the fixed punch and the die is built in the proe three-dimensional software, as shown in Fig. 2. In the simulated back-extrusion process, regardless of the force and deformation of the punch and the die, the moving punch, the fixed punch and the die are defined as rigid bodies, and the blank is defined as a plastomer.

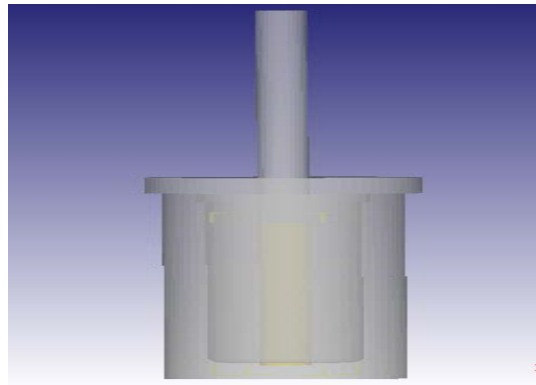


Figure 2. Geometrical model for simulation.

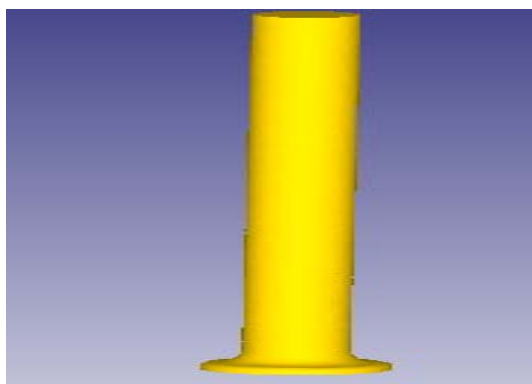
3. 2 Simulation conditions and parameter settings

The blank material is 7A04 aluminum alloy. In order to avoid cracks caused by the temperature difference between the material and the mold, isothermal forming was used, and the material and mold temperature were selected to be 460 °C. The billet and the mold have a friction factor of 0. 25 and the punch moves at a speed of 1 mm/s. The punch stroke is 250 mm, the step size is 0. 15, and the number of steps is 1778 steps. The grid uses a tetrahedral unit with a unit number of 35, 000.

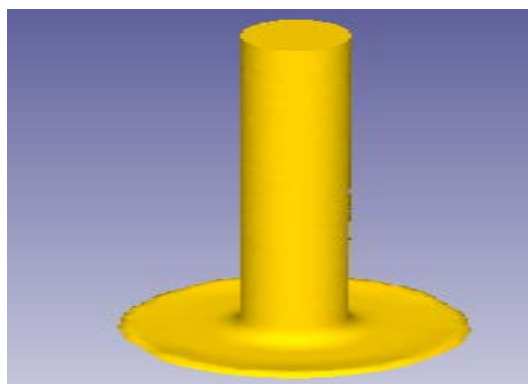
4. Numerical simulation results and analysis of new compound extrusion process

4. 1 Analysis of deformation process

Fig.3 shows the flow of metal during the new compound extrusion of the material. The moving punch moves downward, and under the pressure, the bottom metal begins to generate radial flow, filling the bottom gap of the fixed punch and the die, as shown in Fig. 3(a). As the punch continues to move down, the metal fills the bottom gap, as shown in Fig. 3(b). The punch continues to extrude the blank, and the metal begins to flow through the second fillet region of the fixed punch and the die, and the sidewall gap formed along the fixed punch and the die begins to be reversely pressed, as shown in Fig. 3(c). Under the action of the pressing force, more metal is extruded and the height of the wall is continuously increased until the extrusion process is completed, as shown in Fig. 3(d).



(a)120 step



(b)340 step

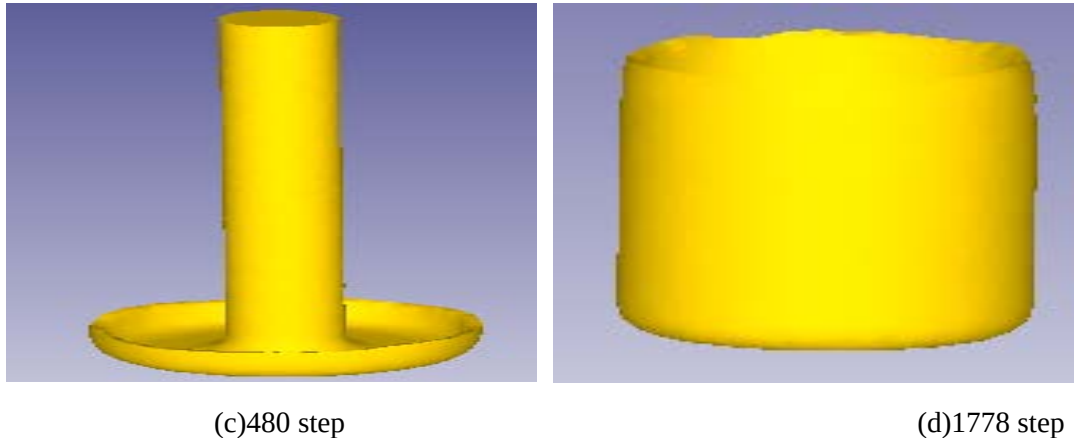


Figure 3. Metal flow in new compound extrusion

4. 2 load stroke curve

The load-stroke curve of the new compound extrusion process is shown in Figure 4(a). It can be seen that the pressing force changes with the stroke of the punch, and is roughly divided into three stages. The first stage: at the beginning of the extrusion, the blank is moved downward by the punch, and the compression deformation occurs. The bottom metal has a tendency to generate radial flow. At this time, the blank is elastically deformed, and the positive extrusion occurs. The load and stroke are Linear relationship, the stroke is short in this stage, and the pressing force rises quickly. The second stage: the punch continues to move downward, and the bottom metal flows radially through the fixed punch and the first rounded corner of the die. Due to the transition of the fillet, the pressing force is gentler than before; then the blank follows the plane diameter To the diffusion flow, the load fluctuates within a certain range without increasing; the metal gradually fills the cavity at the bottom of the convex and concave mold, the blank begins to pass through the fixed convex mold and the second round corner of the concave mold, and the metal changes the flow path again, and the load increases significantly. However, the growth rate is slower than when the first rounded corner is passed, and the load is kept in a stable state during the filling of the gap at the rounded corner. The third stage: the metal begins to contact the inner wall of the die and enters the reverse extrusion. As more metal is extruded, the contact area between the blank and the inner wall of the die is continuously expanded, and the friction is getting larger and larger. The pressure rises in a band and the load fluctuates within a certain range. The maximum load is 59960KN. The conventional back-squeezing load stroke curve is as shown in 4(b), and the maximum load is 325231KN. It can be seen that the load under the new compound extrusion process is only 18% under the conventional process, which greatly reduces the forming force.

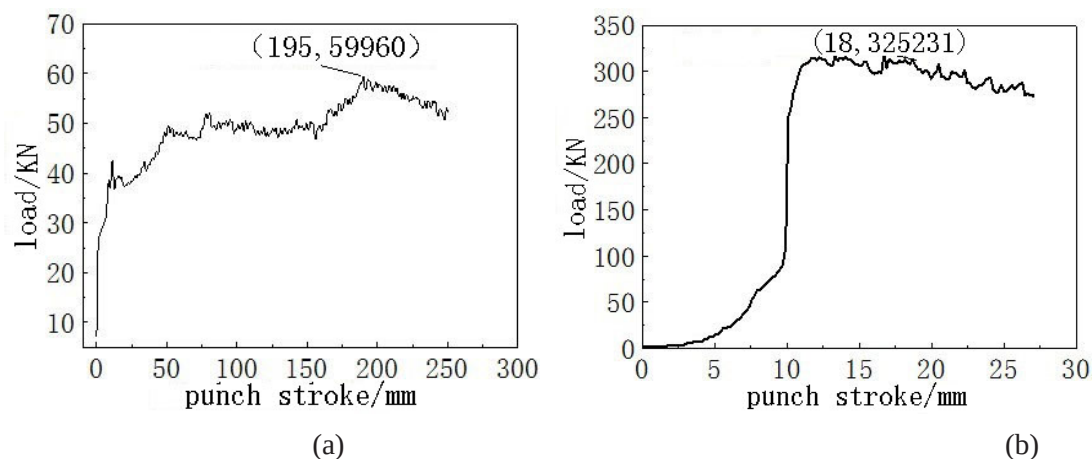


Figure 4. The Load-stroke curves at new compound Extrusion and Backward Extrusion.

5. Conclusion

Based on Deform-3D software, the forming process of 7A04 aluminum alloy tubular parts under new compound extrusion process was simulated, and the deformation process and load variation were analyzed. The maximum load of the tubular member produced by this process is about 18% of the conventional reverse extrusion process, which greatly reduces the forming force. It provides theoretical guidance for the application of this process in the production of aluminum alloy tubular parts in the future.

References

- [1] X. K. Li et al., Research on Force Saving of Anti-extrusion of Straight Tube [J]. Hot Working Technology. 41 (2012) 92-94.
- [2] X. W. Wang et al., FEM Simulation of Backward Extrusion Process of EW75 Magnesium Alloy [J]. Hot Working Technology. 41 (2012) 88-90.
- [3] X. B. WANG et al., Deformation Analysis of TC6 Titanium Alloy Cylinder in Backward Extrusion [J]. Hot Working Technology. 42 (2013) 97-100.
- [4] Y. Wang. Frontier review of plastic processing technology [J]. Journal of Plasticity Engineering. 10 (2003) 1-4.
- [5] Y H Kim, J H Park. Upper bound analysis of torsional backw ard extrusion process [J]. Journal of Materials Processing Technology. (2003) 735-740.
- [6] Q. Wan, Z. M. Zhang. Investigation on backward extrusion of hollow billet with force saving [J]. Journal of Plasticity Engineering. 17(2010) 22-26.
- [7] V. shatermashhadi, B. Manafi, K. Abrinia, et al., Development of a novel method for the backward extrusion[J]. Materials and Design. 62(2014) 361-366.