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Research on the bending formation technology of 6065 aluminum alloy tube

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Abstract. In this paper. aluminum alloy isothermal extrusion technology at the exit of extruding machine and new technology of aging treatment before bending were further studied. Results showed that isothermal extrusion was an ideal extrusion method of limiting and eliminating the structure in homogeneity, getting the higher the extrusion speed, avoiding the product defects, ensuring mechanical properties and improving the productivity; The new technology of aging treatment before bending forming could effectively improve the paragraph after elongation, reduce crack or fracture probability of aluminum alloy bending process and avoid the quality problem of the scratches.

Key words. aluminum alloy, isothermal extrusion,aging treatment.

1. Introduction

Aluminum has low density, high strength and good plasticity, and can be processed into a variety of profiles. Generally, aluminum bending tube is manufactured by cold bending tube, which requires higher surface quality and accuracy of bending material. The current conventional cold bending process technology is complex, money-consuming and low efficient, so to study new bending formation technology has important practical significance. [1–2]

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2. Isothermal extrusion technology of 6065 aluminum tubes

In order to improve the quality of tube bending, in addition to the production of tube with fine grains, the reasonable extrusion process is also crucial. In the conventional extrusion process of aluminum and aluminum alloys, the uneven temperature and deformation of metal result in defects in size, shape, organization, and performance of products. With the development and in-depth study of extrusion technology, many new types of extrusion techniques have emerged, such as hydrostatic extrusion, Conform continuous extrusion, isothermal extrusion, etc., among which isothermal extrusion is an ideal extrusion process to limit and eliminate the unevenness of extruded products. Isothermal extrusion is to conduct extrusion for aluminum ingot at a constant outlet temperature (± 5). The outlet temperature is a key factor in determining the quality of products, for uneven temperature will lead to uneven mechanical dimensions and mechanical properties. Throughout the extrusion process, the temperature of metal in the deformation zone around the die holes remains constant to maintain metal deformation resistance and the flow uniformity. This could not only improve the dimensional accuracy of aluminum alloy extrusion products, the uniformity of product properties, as well as the extrusion rate and productivity[3−6].

2.1. Experimental materials and methods

Put the 6065 aluminum alloy into the extruder to conduct extrusion and the displacement / speed sensor which is used to test the extrusion locations passes the extrusion rate to the control module. At the same time, the infrared thermometer at the outlet of the extruder detects the temperature of aluminum alloy and transmits it to the control system. The control module conducts recalculation and adjusts the extrusion speed according to the real-time feedback signal and the desired signal. If the outlet temperature is lower than the target temperature, increase the extrusion speed, and vice versa. This allows a stable temperature (solution temperature), so as to ensure the aluminum extrusion outlet temperature difference is in the range of±5 .

2.2. Experimental results and analysis

Examine the microstructure of samples were observed and the metallic phase of the extruded 6065aluminum alloy is as shown in Figure 1

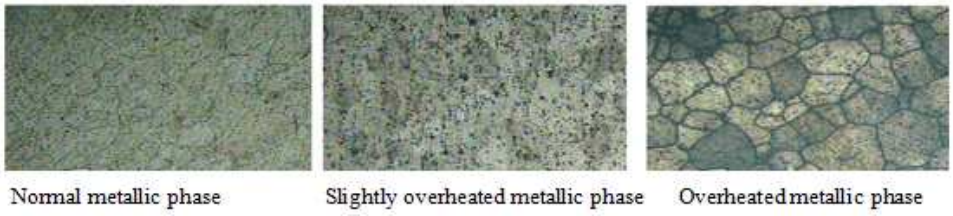

Fig. 1. Metallograph of 6065 aluminum alloy extrusion product

The metallographic structure in Figure 1 indicates that when the temperature at the extrusion outlet exceeds the target temperature, the metallographic grains of the extruded product have larger size and deteriorative uniformity. With the rise of temperature, the deterioration of the microstructure and properties of the extruded product deteriorate markedly. Although the extrusion rate is one of the important process parameters that influence the quality and production efficiency of extruded product and a higher extrusion speed is conducive to the production efficiency, this may easily lead to the over-high temperature of the extrusion product at the die exit, and cause cracks and other defects of products. While a lower extrusion speed will seriously affect productivity and reduce economic efficiency. Thus, using a control system to adjust the extrusion speed reasonably could ensure the isothermal extrusion at higher extrusion speed, thus avoiding the product defects, ensuring the mechanical performance and increasing productivity.

3. Aging treatment process of 6065 aluminum alloy tube

In the bending process of aluminum alloy tube, there are some defects in appearance such as wrinkle, reverse, cross-sectional deformation, inconsistency of the outer wall and inner wall of the bent profile, outer crack and inner collapse, etc. which may affect the quality of products and restrict their application. These defects are related to the bending capability of profiles. The bending capability refers to complexity to bend the profile to form a product without defects and with a certain curvature and angle. It is determined by the bending process, geometry, and curvature degree and material properties. In the production process, reasonable control of the bending process could reduce and avoid defects [7].

In the current process of bending tube machining, the traditional bending forming process generally adopts bending tube and then conducts aging treatment in order to avoid cracks. The aluminum alloy tubes with irregular shape stack in the aging oven, resulting in the waste of space in the aging treatment process, as well as the surface scratching, sectional deformation, rebound and cracking and other defects. This may affect the quality of products, reduce production efficiency and increase the processing cost.

The new aging treatment process of aluminum alloy cylindrical and bending tube is to place aging treatment process of aluminum alloy cylindrical tube before the bending tube technique. Put the aluminum alloy in the aging furnace for heat preservation at 155 for 5-6 hours. A comparative analysis of the traditional bending forming process and the new one indicates that molding parts with the new treatment technique have high dimensional accuracy and smooth surface and the rebound, cracking and other defects are reduced, and the strength indexes could meet requirements.

3.1. Experimental materials and methods

Take the 6065 aluminum alloy as an example to conduct artificial aging treatment after the high temperature molding and cooling. The heating temperature of the

aging furnace is 155 , and holding time is 5-6H. The ordinary aging process treatment is also conducted as the control with the aging processes as shown in table 1.

Table 1. Aging process parameters

	temperature	time
ordinary aging process	200	2-3H
improved aging process	155	5-6H

3.2. Experimental results and analysis

Conduct tensile test for the aged specimen. The performance measurements of the aluminum alloy under ordinary conditions are as shown in Table 2, and those under the improved technique are as shown in Table 3. (Tensile test, standard request, test results, tensile strength, non-proportional extension strength, elongation after fracture).

Table 2. Performance of aluminum alloy under the normal aging conditions

tensile test	standard request	test results
tensile strength	≥260 N/mm2	275 N/mm2
non-proportional extension strength	≥240 N/mm2	245 N/mm2
elongation after fracture	≥8%	8.50%

Table 3. Performance of aluminum alloy under improved aging conditions

tensile test	standard request	test results
tensile strength	260 N/mm2	275 N/mm2
non-proportional extension strength	240 N/mm2	245 N/mm2
elongation after fracture	≥8%	10.50%

The comparison indicates that the tensile strength of the specimen processed by the improved aging technique is up to 275 N/mm^2, the non-proportional extension strength is up to245 N/mm^2, and the elongation after fracture is up to 10.50%, which shows significant increase. Meanwhile, the cracks or fracture in the bending process are also reduced, as well as the starching problems. (Figure 2 is cracks of the appearance of aluminum alloy tube with the traditional technique and Figure 3 shows the appearance of aluminum alloy tube with the improved technique). Besides, aluminum alloy is put into the aging furnace for heat preservation at 155 for 5-6 hours, the lower temperature and longer holding time improve its performance. This indicates that the new technique in which the aging treatment is followed by

bend-shaping process is an ideal processing method for the plastic forming of 6065 aluminum bending profiles.

Fig. 2. Appearance of the traditional bending process

Fig. 3. Appearance of the new bending process

4. Conclusion

This paper focuses on isothermal extrusion technology and aging treatment technique of the bending forming technique of 6065 aluminum alloy. It develops a new technique in which the aging treatment is followed by bend-shaping process. The main conclusions and achievements are shown as follows:

(1) Higher extrusion speed is conducive to the increase of production efficiency, but may lead to over-high temperature of the extrusion product at the die exit, and uneven temperature will lead to uneven mechanical dimensions and mechanical

properties. Then, defects such as cracks may emerge. Therefore, using a control system to adjust the extrusion speed reasonably could ensure the isothermal extrusion at higher extrusion speed, improve the mechanical performance and productivity.

(2) A comparisive analysis indicates that the new technique where the aging treatment is followed by bend-shaping process could effectively improve percentage elongation after fracture. Meanwhile, the cracks or fracture in the bending process are also reduced, as well as the starching problems of aluminum alloy cylindrical tube.

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