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Applied Positioning-controlled Friction Welding Process of Aluminum Alloy

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This study is carried out to clarify the effect of process parameters on the mechanical properties of positioning controlled joints of aluminum alloy, A6061, in the case of a square cross-section. In addition, the effect of geometry on friction welding is demonstrated in comparison with an ordinary round bar. As a result, the positioning-control process is successfully performed, and mechanical properties are almost equivalent to the conventional friction welding process when sufficient upset distance is applied. A higher upset load and longer friction time make for a sufficient contact area in the weld interface, which results in a larger upset distance eliminating weld imperfection.

INTRODUCTION

Friction welding is one of the solid-state welding processes that use friction heat to join members. Aluminum alloy exhibits a preferable performance due to its high specific strength, but it seems to be difficult to assemble by fusion welding processes. Friction welding has superior characteristics for mechanical properties and production performance. However, this process is limited to joining only round bar materials due to the lack of positioning-control capability. The restriction due to geometry results in limiting industrial application.

The method of joining noncircular components by using friction heat has been developed. For example, there is linear motion friction welding that joins members by causing frictional heat because of the orbital motion, and linear motion friction welding by frictional heat because of the linear motion. Further, it can be said that friction stir welding (FSW) is also a type of method of joining noncircular components using frictional heat. However, in these joining methods, there are weak points, such as the inability to stop at an arbitrary main spindle rotation stop position, and the device for joining becoming complex.

This process limitation has been overcome by introducing servo systems, not a mechanical method. A computerized controlled AC servomotor makes positioning control possible. Positioning control means governing the stopping position of the main rotating spindle at any particular position when the joining is completed.

We propose 2 kinds of application examples using positioning-controlled friction welding. First is the component that decides the relative position of 2 materials despite their having a circular section—for example, torque rod and propeller shaft. As for the components in such application examples, the joint performance equals that of the conventional friction welding of the oil-pressure type by controlling the rotation stopping, that is, setting the stopping time appropriately. The best stopping time provides the joint with few twists near the weld interface. We have reported that it was possible to exactly join a round bar by a positioning-controlled friction welding machine. Another example is the noncircular component. However, there is no report of positioning-control friction welding for a noncircular component using a servo system, and little is known about how phenomena occur when noncircular components are welded by positioning control.

The purpose of this study is to clarify the effects of process parameters on the mechanical properties of positioning-controlled joints of aluminum alloy, A6061, in the case of a square cross-section. In addition, the effect of geometry on friction welding is shown in comparison with an ordinary round bar.

Principle of Friction Welding

Fig. 1 shows the principle of basic friction welding.

(1) One side of the materials to make it join is fixed, and the other material is rotated by rotational speed N.

(2) The material is touched by friction pressure P_1 with the other material rotated, and frictional heat is caused at the weld interface. The temperature of the material rises, transform becomes possible axially by the frictional heat, and the flash is formed. At this time, the oxide film and the pollutant on the friction surface are exhausted outside the joint area with the flash.

(3) The rotation is stopped with the brake after friction time t_1 passes, upset pressure P_2 is given during upset time t_2, and a joint completion is effected.

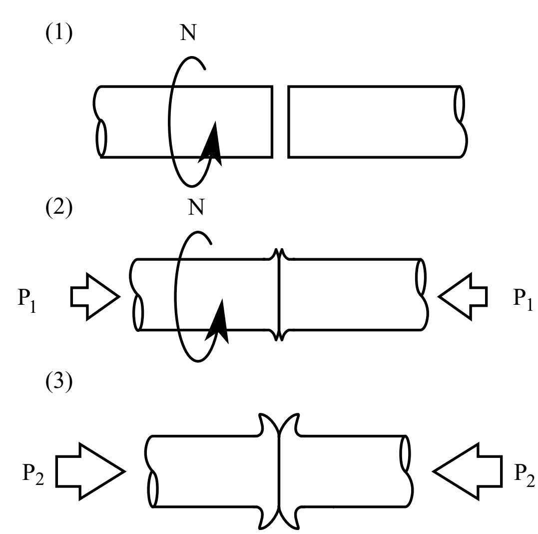

Fig. 1 Basic steps in friction welding process

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