Effect of Tool Plunging Downforce on Friction Stir Welding of ADC12 Die Cast Alloy†

KIM Young Gon*, NAKATA Kazuhiro**, MURAKAMI Taichi***, KOMAZAKI Toru**** and USHIO Masao**

Abstract

Friction Stir Welding (FSW) has been attracting attention as a useful joining process for casts with superior characteristics to conventional fusion welding. It is well known that arc welding of aluminum die cast alloy is very difficult because of the formation of blowholes and cracks. In this research, the effect of the tool plunge downforce on FSW joints of ADC12 was evaluated for establishing the range of the optimum welding conditions in FSW. The range of the optimum FSW conditions for sound joints expanded with increasing tool plunge downforce, because the area of contact of the tool shoulder with the workpiece increased and plastic metal flow was activated.

KEY WORDS: (Friction Stir Welding), (Aluminum Die Cast Alloy), (Structure), (Hardness), (Tensile Strength)

1. Introduction

The basic principle of Friction Stir Welding (FSW), which was developed as a new joining process by The Welding Institute (TWI) [1], is relatively simple. Fusion welding of aluminum die cast alloys is difficult due to the formation of blowholes and cracks in the weld metal. On the other hand, being solid state welding process, FSW enables the joining of these cast alloys [2]. FSW joints are governed by three main parameters; i.e., the tool rotation speed, the welding speed and the tool plunge downforce with fixed tool geometry. The tool rotation speed and the welding speed are easily controlled. However, the adjustment of the tool plunge downforce is extremely difficult, because it is governed by the contact area of the tool shoulder with the workpiece and the plunge depth of the tool.

In this research, the effect of the tool plunge downforce on FSW joints in aluminum die cast alloy ADC12 has been evaluated for establishing the range of optimum FSW condition.

2. Experimental

Aluminum die cast alloy plate ADC12, 4mm in thickness, was used. The tool plunge downforce was changed from 6.86 to 14.21 kN. The tool rotation speed and the welding speed were changed from 500 to 1500 rpm and from 250 to 1000 mm/min, respectively. The value of the tool plunge downforce was set as the total of the cylinder pressure and the machine head weight. A tool dimension of 15 mm shoulder diameter and 5mm probe diameter was used. The tilt angle of 3 degree was kept constant. Visual and X-ray radiography inspections of FSW joints were performed to reveal weld defects at the surface and inner zones in the welded joint.

3. Results and Discussions

Figure 1 shows the relationship between the FSW parameters and the sound FSW joints. In all condition of the tool plunge downforce, a sound joint without groove-like defects and voids [3] was obtained at the appropriate tool rotation and welding speeds. At the high tool plunge downforce of 14.21 kN, the optimum range of the welding condition was wider than with any other condition. It is considered that the plastic metal flow becomes active because of increasing heat input to the FSW joints due to expanding the contact area of the tool shoulder with the workpiece. The optimum range at the tool plunge downforce of 11.76 kN was almost same as that for 14.21 kN. At the lower tool plunge downforce of 6.86 to 9.36 kN, however, the optimum range became

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* Ph. D. Student
** Professor
*** Post Doctoral Research Fellow
**** Ryobi Limited

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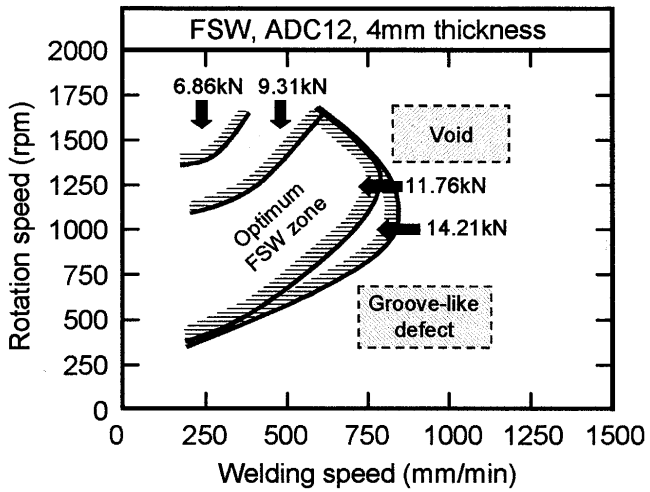

Fig.1 Optimum FSW conditions (ADC12, 4mm thickness).

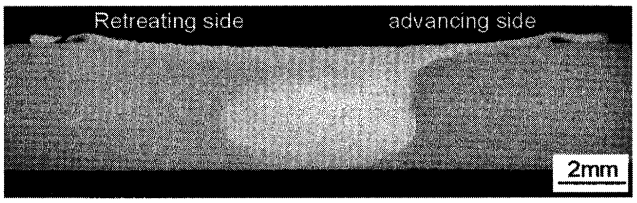

Fig.2 Macrostructural feature of defect free joint (ADC12, 4mmt, 1500rpm-250mm/min-11.76kN)

narrow, because the contact area was not enough for the sufficient plastic metal flow at the lower tool rotation speed and the higher welding speed.

Figure 2 shows the macroscopic structure of a cross section of a FSW joint with optimum FSW conditions. A defect free joint was obtained.

4. Conclusions

The conclusions in this research are summarized as follows.

(1) The tool plunge downforce in FSW of ADC12 aluminum die cast alloy affected the range of the optimum FSW condition for obtaining a sound joint.

(2) The optimum range expands with increasing the tool plunge downforce. At the tool plunge downforce of 14.21 kN, the widest range of the optimum welding condition was obtained.

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