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Experimental study on process parameters in friction stir welding of AA4047 aluminium plates

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Abstract

Friction Stir Welding (FSW) is a solid state joining process that involves joining of metals without fusion or filler materials. In this paper, the effect of various process parameters such as rotational speed of tool, tool traverse speed (feed) and dimensions of tool pin (diameter) on tensile strength of the welded butt joints are investigated. The experiments were conducted on aluminum plates using FSW tools with straight cylindrical and tapered pins. Two tool profiles were used; one with straight cylindrical pin and the other with tapered cylindrical tool pin. Tool attachment was successfully designed for mounting the FSW tool on the milling machine. Results showed that straight cylindrical tool gave the better results for tensile strength of the welded work piece as compared to tapered cylindrical tool.
Keywords*: Friction Stir Welding; rotational speed of tool; tool traverse speed.*

I. Introduction

The friction stir welding (FSW) process was developed by The Welding Institute (TWI) in 1991 in Cambridge.TWI (The Welding Institute) is a world famous institute in the UK that specializes in materials joining technology. FSW is a solid state joining process that involves joining of metals without fusion or filler materials. The frictional heat is produced from a rapidly rotating non-consumable high strength tool pin that extends from a cylindrical shoulder. Shoulder is responsible for the generation of heat and for containing the plasticized material in the weld zone, while pin mixes the material of the components to be welded, thus creating a joint [1]. The heat and mass transfer depend on the material properties as well as welding variables including the rotational and welding speeds of the tool and its geometry [2]. In this paper, the effect of various process parameters

such as rotational speed of tool, tool traverse speed (feed) and dimensions of tool pin (diameter) on tensile strength of the welded butt joints are investigated.

II. Experimental set up

The present FSW was carried with selected values of tool rotational speed, feed speeds and pin diameter as shown in the Table 1**.** Two different rotational speeds at a fixed feed speed were used to fabricate the joints. Trial experiments were carried out to find out the working limits of welding parameters. Figure 1 shows the schematics representation of the FSW experiment carried during the present investigations.

Table 1:FSW parameters

Welding parameter	Symbol	Level 1	Level 2	Level 3
Tool Rotational Speed(RPM)	N	500	710	1100
Tool Feed (mm/min)	F	45	50	55
Pin Diameter (mm)	D	6	7	8

Figure 1: Schematic representation of FSW experiment

The FSW process is carried out at a tool rotational speed 500 rpm, tool traversed rate 45 mm/min and the pin diameter of 8 mm in the set up. The Figure 2 (a) shows the butt welded joint according to these process parameters. A tunnel like void is seen in the bottom portion of the weld at forwarding side. The Figure 2(b) shows the friction stir welded joint with tool rotational speed 710 rpm, tool traversed rate 50 mm/min and the pin diameter of 7 mm. With these process parameters

the void is minimized as compared to the process parameters in the previous case as shown in Figure 2(a) .This shows that increase in tool rotational speed and tool traversed rate the void in the stirring zone has been minimized. The Figure 2(c) shows the FSW joint with tool rotational speed 1100 rpm, tool traversed speed 55 mm/min and pin diameter of 6 mm which is the optimal values of the process parameters.

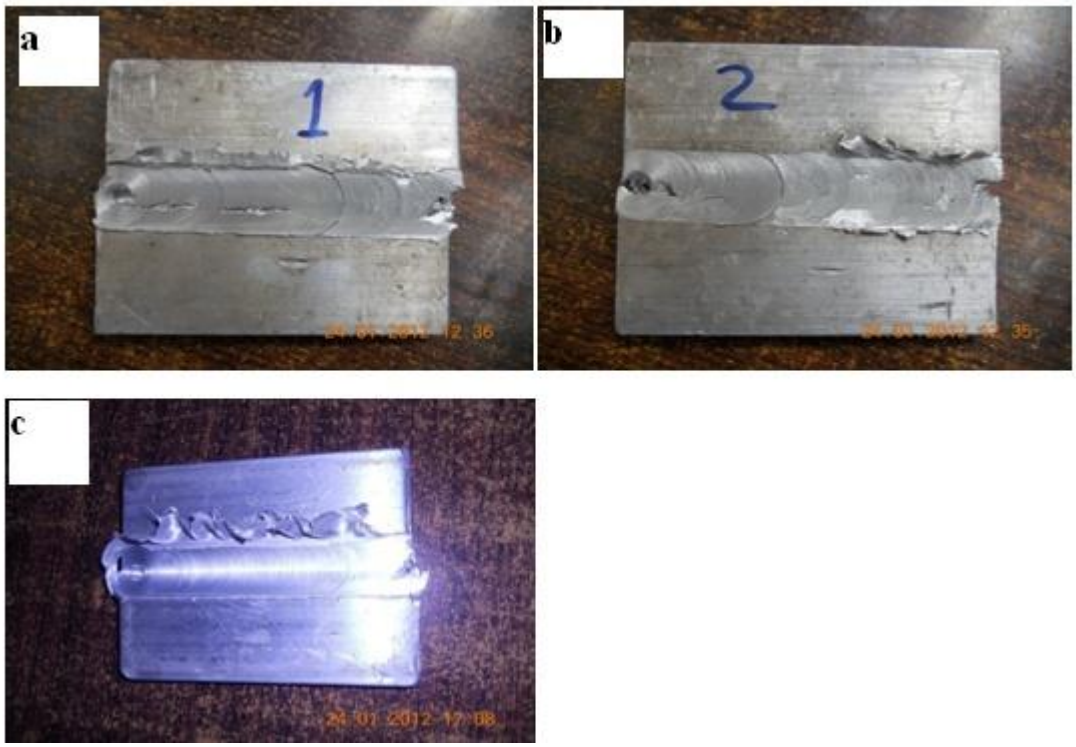

Figure 2: Different welding joint parameters used in experiment

III. Results

FSW process parameters, e.g. tool rotational speed, tool traverse speed (feed rate) and diameter of tool pin were considered as the input process parameters and Tensile Strength of the FSW welded work piece was considered as the response parameter. Each input parameters were set at three levels and respective experiments were performed to optimize the FSW parameters to obtain defect free high tensile strength work piece. From the experiment, the optimal combination for FSW parameters was found to be tool rotational speed of 1100 rpm; tool traverse speed of 55mm/min and tool pin diameter of 8 mm. The maximum tensile strength obtained was 41.82 MPa. Thus, it is clearly shown that the performance characteristics of the FSW process, in the present case; tensile strength of welded work piece is greatly improved by using this approach.

IV. Conclusions

Experimental investigations for study of the effect of FSW process parameters like tool rotational speed, tool traverse feed rate and tool pin diameter on tensile strength of the FSW but welded joint was performed. Two tool profiles were used; one with straight cylindrical pin and the other with tapered cylindrical tool pin. Tool attachment was successfully designed for mounting the FSW tool on the milling machine. Results showed that straight cylindrical tool gave the better results for tensile strength of the welded work piece as compared to tapered cylindrical tool. Thus, the weld quality was the best for straight cylindrical tool.

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