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Friction stir welding of plastics

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Abstract

Friction stir welding (FSW) frequently produces a superior microstructure and mechanical properties than conventional methods for welding nonferrous materials and alloys. Plastic materials are used in many areas in industry because they offer excellent physical and corrosion properties, high degree freedom of processing and design. In this paper, the application of the FSW method in plastic materials is examined.

Introduction

The importance of joining materials in industrial applications has been gradually increasing. Electric power plants, the chemical, petrochemical and nuclear industries, space aeronautics and the electronic industry require materials of different properties to be joined [1–4].

FSW process firstly used for Al alloys (lower heat input than conventional joining methods) and invented at The Welding Institute (TWI) in UK (1991). Plastic materials are widely used in industry and FSW joining method firstly used at plastics at 1997. Plastics can be joined with various process methods like adhesives, solvents, hot plate, hot gas, extrusion, friction, ultrasonic, resistance (implant) and Friction Stir Welding (FSW) [5].

Choi et. al. [6] investigated dissimilar friction stir welding of pure Ti and carbon fiber reinforced plastic plates. They indicated that the silane coupling agent treatment helped to fabricate the sound dissimilar Ti/CFRP joint.

Vidakis et. al. [7] investigated optimization of friction stir welding parameters in hybrid additive manufacturing: weldability of 3d-printed poly (methyl methacrylate) plates. The feasibility of joining 3D-printed Poly (methyl methacrylate) (PMMA) specimens via FSW was verified in their work.

Rudrapati [8] investigated effects of welding process conditions on friction stir welding of polymer composites. They indicated that to achieve optimal welding economics in FSW of polymers, processing conditions such as tool rotation speed, welding speed, as well as precision tool design are the most significant factors to consider.

Wilkins and Strauss [9] investigated influence of tool thread pitch during friction stir welding of high-density polyethylene plate.

Material and Method

Schematic diagram of FSW process has shown in Fig.1. Pin geometry, tool rotation speed, shoulder geometry, traverse speed, offset diameter of materials to AS (Advancing side) or RS (Retreating Side) (if applied in dissimilar materials) are very important parameters in FSW to achieve good welding quality. FSW method don’t need preparation and have less total process time comparing to another plastic joining techniques. FSW method don’t need consumables and have lower cost than hot-plate, friction and ultrasonic welding methods (Table 1).

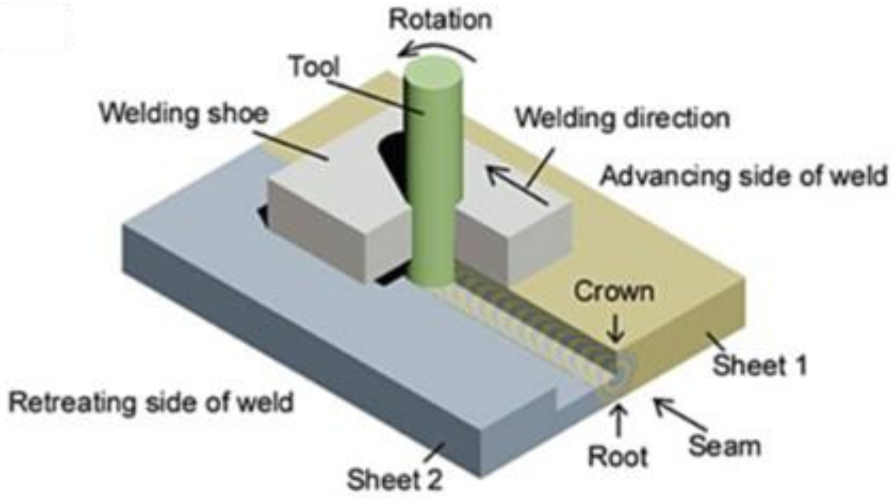

Figure 1. The schematic diagram of FSW process [10]

Table 1. Process requirement comparison of common plastic joining techniques [5]

Process	Preparation	Process Time	Total Time	Consumables	Machine/ Tool, consumable cost
Ultrasonic	energy directors	1-3 sec.	5-10 min.	none	$30000
Hot-plate	none	30-40 sec.	60-90 sec.	none	$47000
Hot-gas	v-groove	8-10 min.	15 min.	gas, filler	$3500
Extrusion	v-groove	8-10 min.	15 min.	gas, filler	$5500
Friction	flatten face	10-15 sec.	6-8 min.	none	$89000
Adhesives	clean	3 min.	2-3 hours	cleaner, adhesive	$3000
FSW	none	2 min.	3 min.	none	$11000

Conclusion

Industry needs faster welding speed, sound welding zone and good welding quality (without porosity, cracks etc.). FSW method is a new technique for joining plastics and is advantageous over other methods due to its low heat input and low costs. Researchers need to do more studies in order to become widespread FSW of plastics.

Appropriate selection of welding input parameters in FSW can enhance the properties of light-weight plastic weld joints. Process parameters selection plays important role to conduct FSW efficiently [8].

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