

Mechanical Properties of Friction Stir Processed Al/Ti Composite Plates

Facai Ren¹, Bo Li¹ and Xiaoying Tang¹

¹Shanghai Institute of Special Equipment Inspection and Technical Research,
Shanghai Engineering Research Center of Pressure Pipeline Intelligent Inspection,
Shanghai 200062, China

Corresponding author e-mail: caifaren@163.com

Abstract. The mechanical properties of friction stir processed Al/Ti composite plates were investigated through mechanical property and micro-hardness test. The welding speed is 60 mm/min. The tool rotational speed is in the range of 1200-1800 r/min. The plunge depth is in the range of 0-0.5 mm. The influence of friction stir process parameters to the mechanical properties of Al/Ti composite plates are analyzed.

1. Introduction

Friction stir processing is a solid state metal joining technology. In this process, a solid body is used to join the two metals by excessive localized plastic deformation. The mechanical properties of composite plates fabricated via friction stir processing mainly depend on the plasticity and fluidity of composite metal during the process. In the past, some researchers investigated the mechanical properties of different alloys processed by friction stir processing.

Chen et al. [1] studied interface characteristics of lap joints of TC1 Ti alloy and LF6 Al alloy fabricated by friction stir welding. The results show that the amount of Ti alloy particles stirred into the stir zone decreases with the increase of welding speed or the decrease of tool rotation rate. Zhang et al. [2] studied the kinetics of the Al-Ti reaction during friction stir processing. Huang et al. [3] studied the effects of external water on the mechanical properties and microstructure of friction stir processed aluminum matrix composites. The results show that the external water can significantly reduce material flow and effectively inhibited grain growth. Huang et al. [4] proposed a novel method of friction surfacing assisted hybrid friction stir welding for joining of dissimilar Ti/Al joints. This technique can avoid the pin abrasion and improve the joint efficiency. Choi et al. [5] performed friction stir welding on the dissimilar materials of pure Ti and pure Al and investigated the effects of probe offset and tool rotation speed on the microstructure, mechanical properties and fracture behavior of the dissimilar joints.

In this paper, the mechanical properties of Al/Ti composite plates fabricated by the friction stir processing were investigated. The effects of different parameters on the mechanical properties were analyzed.

2. Material and Experimental

The chemical compositions of Ti-6Al-4V alloy and 5A06 aluminum alloy are shown in Table 1 and Table 2, respectively. The thicknesses of Ti-6Al-4V alloy and 5A06 aluminum alloy used in this investigation are 4mm and 2mm, respectively. The schematic representation of friction stir process is



shown in Fig. 1. The welding speed is in the range of 60 mm/min. The tool rotational speed is in the range of 1200-1800 r/min.

Table 1. Chemical composition of Ti-6Al-4V alloy (wt.%).

C	Al	V	N	H	O	Fe	Ti
≤0.10	5.5~6.8	3.5~4.5	≤0.05	≤0.015	≤0.20	≤0.30	bal

Table 2. Chemical composition of 5A06 aluminum alloy (wt.%).

Si	Cu	Mn	Mg	Ti	Zn	Al
0.40	0.10	0.5~0.8	5.8~6.8	0.02~0.10	0.20	bal

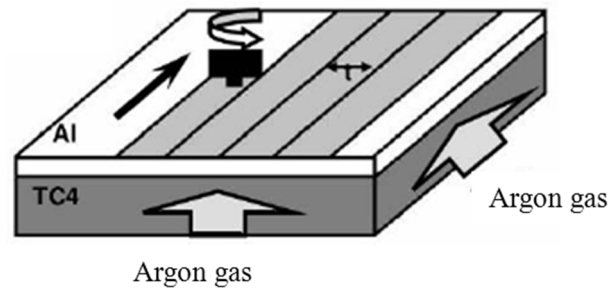


Figure 1. Schematic representation of friction stir process.

3. Results and Discussions

3.1. Micro-hardness of Al/Ti composite structure

The annealing temperatures of Al/Ti composite specimen are 400°C, 500°C and 600°C. The annealing time was 1 hour. The annealing process was performed in the resistance furnace in argon atmosphere. The micro-hardness distribution of Al/Ti composite structure fabricated by friction stir processing is shown in Fig. 2. It can be seen that the maximum micro-hardness value is about 750HV. The micro-hardness values of Al/Ti composite structure annealed at 600°C are relatively high compared with other annealing processing conditions. The micro-hardness value fluctuation range of Al/Ti composite structure annealed at 400°C is small within all the test points.

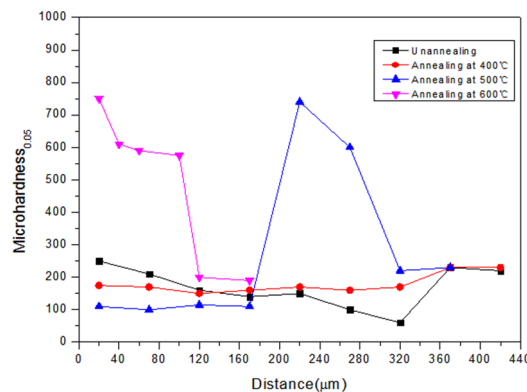


Figure 2. The micro-hardness distribution of Al/Ti composite structure.

3.2. Mechanical properties of Al/Ti composite structure

Some of the mechanical properties test specimens are shown in Fig. 3.

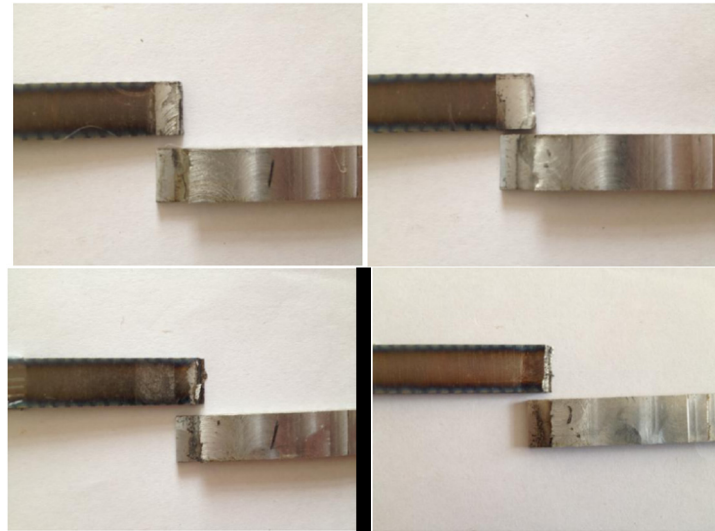


Figure 3. Mechanical properties test specimens.

The test result of Al/Ti composite structure under different annealing temperature is shown in Fig. 4. The maximum failure load value is 8.65 KN when the annealing temperature is 500°C. The minimum failure load value is 4.92 KN when the annealing temperature is 600°C. The maximum elongation value is about 3.63% without annealing. The minimum elongation value is about 0.65% when the annealing temperature is 600°C.

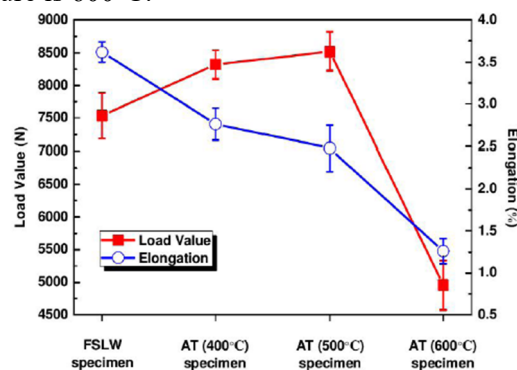


Figure 4. The test results of Al/Ti composite structure under different annealing temperature.

The failure load and elongation values of different process parameters are shown in Fig. 5. When the tool rotational speed is 1800 r/min and the traverse speed is 60 mm/min, the minimum failure load and elongation values are 4.3 KN and 1.16%, respectively. When the tool rotational speed is 1200 r/min and the traverse speed is 60 mm/min, the maximum failure load and elongation values are 6.37 KN and 2.25%, respectively.

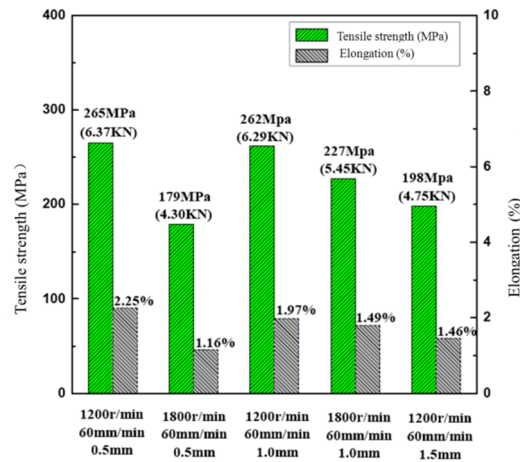


Figure 5. The test results of Al/Ti composite structure under different processing condition.

The failure load and elongation values of different plunge depth are shown in Fig. 6. The traverse speed is 60 mm/min. The tool rotational speed is 1200 r/min. When the plunge depth is 0.1 mm, the failure load is relatively high and the value is about 6.67 KN.

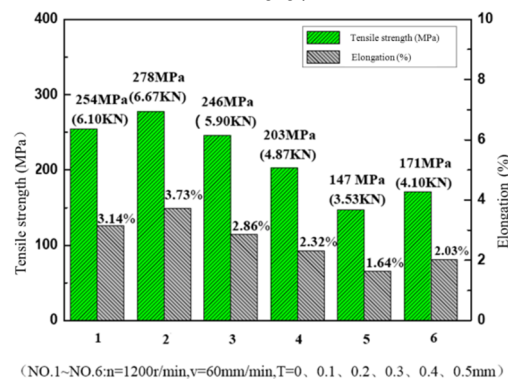


Figure 6. The failure load and elongation values of different plunge depth.

4. Conclusion

The mechanical properties of Ti-6Al-4V alloy and 5A06 aluminum alloy composite plates fabricated by friction stir processing have been studied by micro-hardness analysis and mechanical tests. The results show that the maximum failure load is 6.67 KN when the tool rotational speed is 1200 r/min, the traverse speed is 60 mm/min and the plunge depth is 0.1 mm.

Acknowledgments

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