Effects of process parameters on the dissimilar friction stir welded joints between aluminum alloy and Polycarbonate

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Introduction

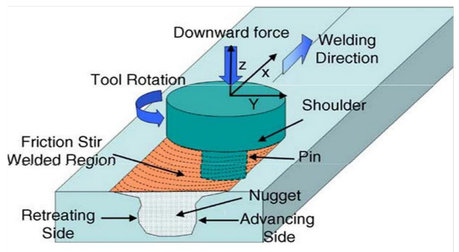


Fig.1 Friction Stir Welding Process

In this process, heat is generated from the friction between the rotating welding tool (including both the shoulder and the probe) and the material being welded, causing the material to soften at a temperature lower than its melting point.

Objective of the Study

- To investigate the effect of tool offset and material flow behavior on the weld quality of friction stir welded joints in aluminum alloy (AA2017) and polycarbonate (PC).
- In this study, the effects of process parameters on welded joints between aluminum alloy and polycarbonate were investigated to clarify the suitable condition for sufficient joint efficiency.

Design of Tool and Work-Piece

Aluminum alloy and polycarbonate with dimensions of 100 mm x 50 mm x 3 mm shown in Fig. 2(b) were joined via FSW in a butt configuration. Tapered cylindrical tool pin made of SKD11 tool steel with shoulder diameter of 18 mm and tool pin height of 2.7 mm was used as shown in Fig. 2(a).

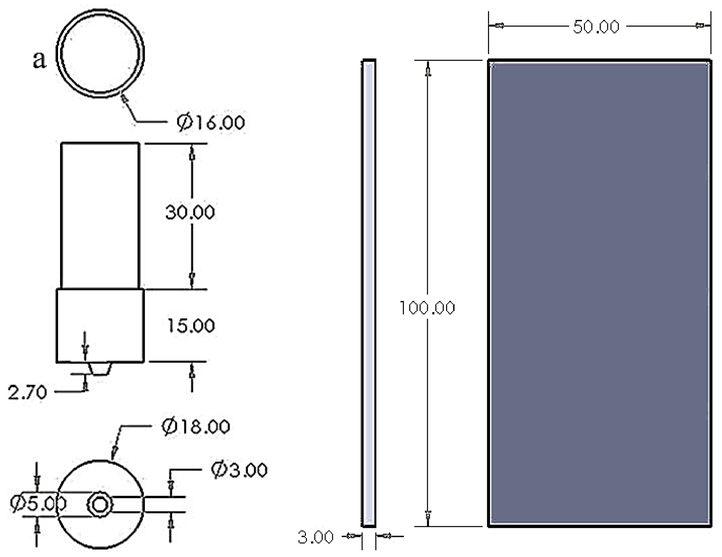


Fig. 2. Geometries of tool and workpiece (a) Geometries of Tool, (b) Geometries of work-piece.

FSW Process Parameters

Table 1. FSW process parameters with an ultimate tensile strength of joint.

Experimental condition	Tool offset (mm)	Tool Rotation speed (rpm)	Ultimate tensile strength (MPa)		
			(Start) Test 1	(Middle) Test 2	(End) Test 3
(a)	4	1760	4.49	3.70	3.80
(b)		1320	4.20	3.80	3.60
(c)	3	1760	5.60	4.60	4.40
(d)		1320	4.49	5.00	4.60
(e)	2	1760	33.10	4.80	4.49
(f)		1320	5.80	33.40	4.80

Table 1 shows the resulting ultimate tensile strength of joint to the process parameters of tool offset and rotational speed. It is observed that the tool offset of 3 and 4 mm leads to much lower tensile strength than the tool offset of 2 mm.

Results and Discussion

Experimental Conditions

(i) 4mm Tool offset Condition

- Fig.3 (a) and (b), show the shoulder influenced weld formation, due to the improper material fusion between the two dissimilar materials and reduced tool pin interaction at the weld zone, which has led to lower tensile strength.
- The lowest ultimate tensile strength 3.60 MPa were obtained from experimental conditions (b) in which the tool offset of 4 mm was used.

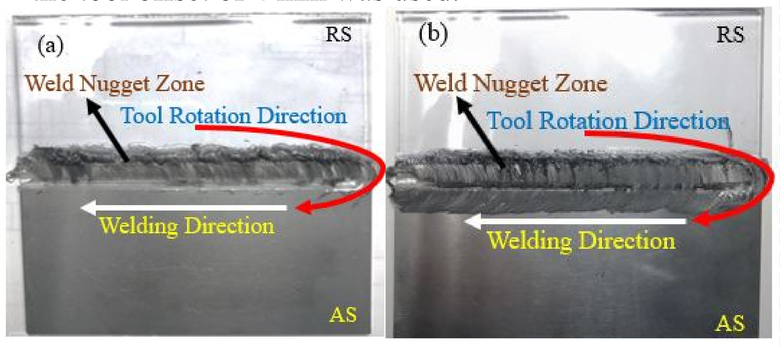


Fig. 3. Material flow at joint interface. (a) and (b) correspond to experimental condition (a) and (b) in Table 1.

(ii) 3mm Tool offset Condition

- Fig. 4 (c) has exhibited a tunnel like appearance throughout the weld joint due to tool pin progress. In Fig. 4 (d), regular weld formation is observed.
- This is mainly attributed to the discontinuity and non-uniform material flow with some of the defects, such as tunnels and voids along the weld line due to the instability in the welding process.

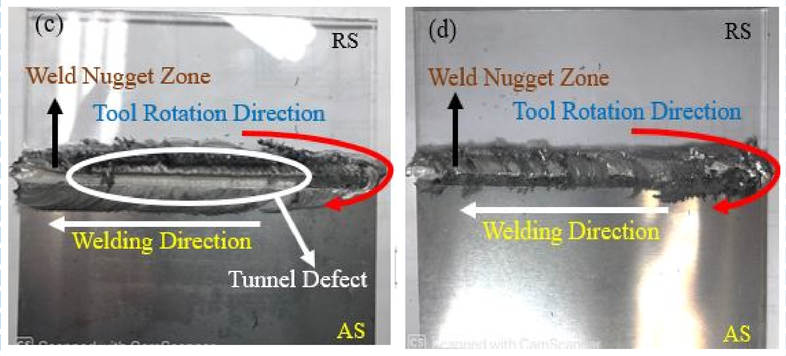


Fig. 4. Material flow at joint interface. (c) and (d) correspond to experimental condition (c) and (d) in Table 1.

(iii) 2mm Tool offset Condition

- The tool pin offset of 2 mm enhanced material flow along with the weld interface. From Fig.5 (e) and (f), non-uniform material flow along the weld zone due to high rotational speed and highly deformed material flow is observed.
- The highest ultimate tensile strength of 33.4 MPa were obtained from experimental conditions (f) in which the tool offset of 2 mm was used.

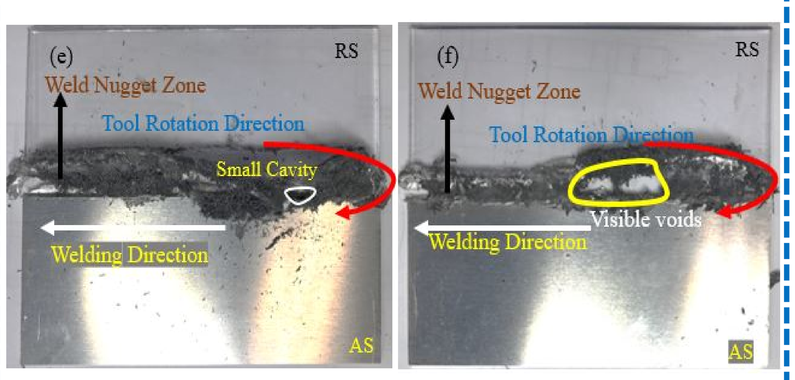
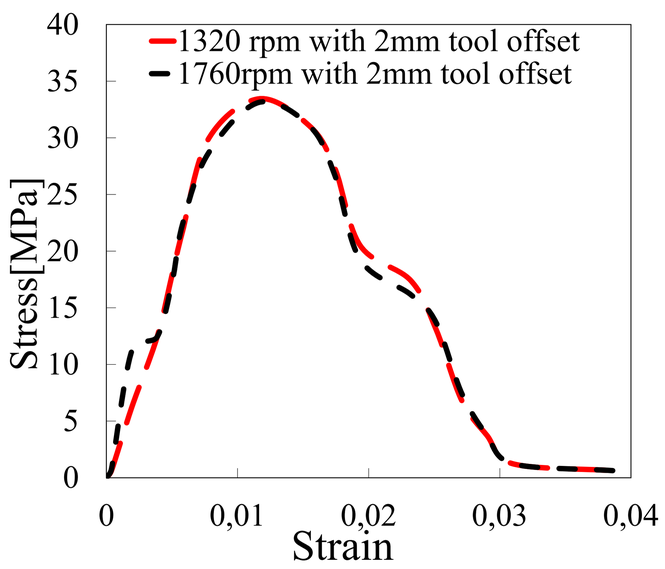


Fig. 5. Material flow at joint interface. (e) and (f) correspond to experimental condition (e) and (f) in Table 1.

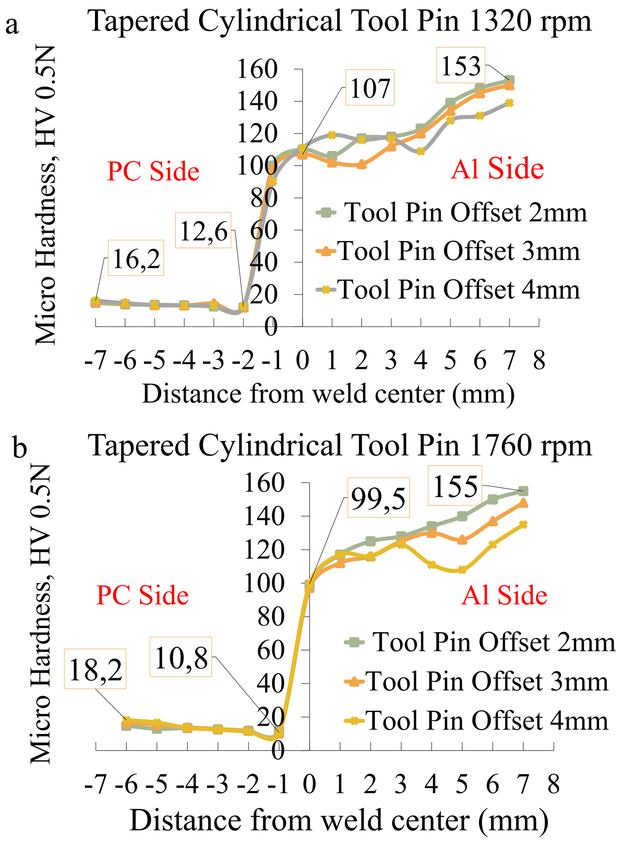
Mechanical Properties

Tensile Strength Analysis



Stress-strain curves formation for welded specimens using the rotational speed of 1320 and1760 rpm with 2mm tool offset.

Hardness profile of the joints



Conclusions

- ❖ The effect of tool pin offset on joint efficiency was evaluated based on the tensile strength of the welded samples. The results showed that the FSW with a tool pin offset of 2 mm, the rotational speed of 1320 rpm and travel speed of 60 mm/min recorded a higher tensile strength
- ❖ Since the tool shoulder and pin enhanced the heat transfer, the decrease of tool pin offset which in turn enhanced a smaller number of voids and defects in the weld surface and in terms increase weld strength.
- ❖ Tensile strength and hardness of the weld joints have lower values compared to the base materials owing to the presence of voids at the weld interface and highly influenced by welding parameters.

References

[1] H. A. Derazkola, M. Elyasi (2018) The influence of process parameters in friction stir welding of Al-Mg alloy and polycardonate. J. Manuf Process 35 : 88-98.
[2] R. Moshwan, M. Sahifulddin, and F. Yusof (2014) Dissimilar friction stir welding between polycarbonate and AA7075 aluminum alloy. Int. J. Mater. Res 105 : 1-9.