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Investigation of Influence of Friction Stir Welding Parameters on Formability of Aluminum Tailor Welded Blanks

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ABSTRACT

Aluminum tailor welded blanks (TWBs) consist of two or more aluminum sheets joined together through some type of welding process. Because of high strength to weight ratio, aluminum TWBs are used in different industries like automotive industry. There are many different welding methods for aluminum welding, but melting methods cause to form brittle phases and decrease weld strength. Therefore, friction stir welding is a replacement method. Friction stir welding parameters have high influence on the welding quality. In the present study, some of the main parameters of friction stir welding are investigated. These parameters are type of welding tool, tool rotational speed and traveling speed of tool. Whereas tailor welded blanks are used in the out of plane forming processes, Erichsen formability test is used for weld quality investigation. Therefore, a design of experiment (DOE) is done using Tauguchi method and some aluminum tailor welded blanks are welded. Aluminum alloy of 6061 and 5182 are the base metal of tailor welded blanks. Results of study show that type of welding tool has a considerable influence on the weld quality. Weld quality and formability increase by increasing tool's rotational velocity.

KEYWORDS:

Aluminum Tailor Welded Blank, Friction Stir Welding (FSW), Erichsen Formability Test, Major Strain.

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1- Introduction

A Tailor-Welded Blank (TWB) is the result of joining sheet metal plates with the same or different thickness or strength, welded together to produce a single blank prior to the forming process. Automotive designers are always looking for new technologies to reduce vehicle weight and manufacturing costs in order to meet ever restricting fuel economy standards while remaining economically competitive. An opportunity to meet these seemingly conflicting requirements is through the use of Tailor-Welded Blanks (TWBs). The advantages of TWB technology can be summarized as (1) cost reduction by requiring less forming dies; (2) weight reduction by welding sheet material with different thickness or strength for performance requirements; (3) part dimensional consistency improvement by removing inaccurate spot welding processes; (4) corrosion resistance enhancement by eliminating lap joints; (5) strength improvement by substituting traditional spot welds with laser and mash seam welds [1].

Chien et al. [2] employed a bifurcation criterion to estimate the onset of failure in transversely loaded AA5754 TWBs. In their analysis, a FEM model, representing the geometrical configuration, was combined with an analytical model to predict failure. In previous works by the author the performance of different numerical criteria for FLD prediction in TWB was investigated [3]. The Second Derivative of Thinning (SDT) was found to be a good post-processing criterion for FLD prediction of TWB. The effect of the thickness ratio on the level of FLD for St12 TWB was also studied by the author in another work [4]. The results showed that the FLD level increased when the thickness ratio of TWB decreased.

In the present work effects of some parameters of friction stir welding (FSW) are investigated on the formability of aluminum tailor welded blanks (TWBs). Two types of aluminum of 5182 and 6061 were used as base sheets of aluminum TWBs. These parameters are: rotation speed of welding tool (rpm), transvers speed of welding tool (mm/min) and type of welding tool.

2- Methodologies

As mentioned above, in this study effects of some welding parameters such as rotation speed of welding tool (rpm), transvers speed of welding tool (mm/min) and type of welding tool were investigated on the formability of aluminum TWBs. Two types of aluminum of AA 5182 and AA 6061 with equal thickness of 1 mm were used as base metals of TWBs. For this purpose design of experiment was used based on the Tauguchi method. Two types of welding tool were used (A and B). Three levels were considered for rotation speed of welding tool and three levels for transvers speed of that. Table 1 shows the parameters and their levels. Therefore, L18 array of Tauguchi was used and 18 samples of aluminum TWBs were prepared using FSW. These samples were used in the out of plane forming test of Erichsen. Major strain of TWBs surface and forming load were used as criteria for formability investigation of aluminum TWBs. For determining the major strain of TWBs, specimens were grid marked with circles of 2.5 mm by an electrochemical etching method to measure major and minor strains calculations after deformation.

Table 1. Levels of welding parameters for TWBs welding

Welding Parameters	Level 1	Level 2	Level 3
Tool geometry	A	B	-
Tool rotation speed	800	1000	1200
Tool transvers speed (mm/min)	40	60	80

3- Results and Discussion

All welds exhibited smooth and striated surface without any defects, virtually no reduction in thickness, and with very good interaction between the material flow induced by the tool shoulder and the pin driven flow. Figure 1 shows the effects of welding parameters on the major strain of TWBs. This figure shows that using welding tool of B which has spiral geometry at the pole of tool, increases major strain in the weld position. Figure 1 also shows that major strain increases by tool rotation speed increasing.

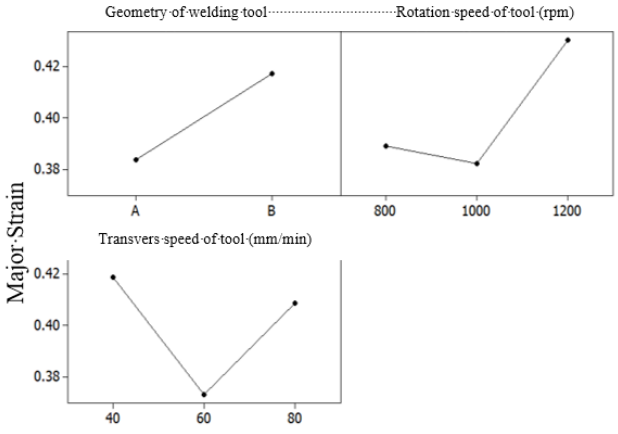

Figure 1. Effects of welding parameters on the major strain

4- Conclusion

In this study the effects of some of FSW parameters such as type of welding tool, rotation speed of tool and transverse speed of tool were investigated on the formability of aluminum TWB of AA 5182 and AA 6061. TWBs were used in the out-of-plane forming, Erichsen formability test was used in this study.

Results of present study show that using welding tool with spiral path on the pole (type B), because of improving tool and work piece connection and preventing tool vibration, produced a TWB with high strength and formability. Increasing of tool rotation speed cause enhancement of heat resulted from friction between tool and sheet and improved penetration, strength of weld and increased major strain of Erichsen test.

5- References

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