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Effects of Welding Parameters on Mechanical and Microstructural Properties of AA6082–T6 Joints Produced by Friction Stir Welding

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Abstract

The effect of processing parameters on mechanical and microstructural properties of AA6082 joints produced by Friction Stir welding was analysed in the present study. Different samples obtained by employing rotating speeds of 710, 900, 1120 and 1800 rpm and welding speeds of 15, 40, 100, 160 mm/min were produced The mechanical properties of the joints were evaluated by the means of vicker hardness tester and it was found 63. 9 HV and the maximum tensile strength of about 136 N/MM^2 was obtained at tool rotational speed of 900 rpm and welding speed of 40 mm/min at room temperature. The microstructure of each sample showed very different features depending on thermal and mechanical conditions and complete mix of base metal in weld nugget is observed in tool rotational speed of 900 rpm and tool traverse speed of 40 mm/min.

Keywords: Friction Stir Welding; AA 6082 Al Alloy; processing parametres; Mechanical properties; Microstructure.

Introduction

Friction stir welding (FSW) technology is being targeted by modern aerospace industry for high performance structural applications [1]. In comparision to the traditional welding techniques, FSW strongly reduces the presence of distortions and residual stresses [2-4]. This technique was termed as “green “technology by many researchers due to its energy efficiency and environment friendliness [5]. In friction stir welding process, joining is done with the help of frictional heat generated at the faying surfaces of the two sheets to be joined with the specially designed rotating tool, which travels down the length of the contacting plates. This produces a highly plastically deformed zone through the associated stirring action. The localized thermo-mechanical affected zone is produced by friction between the tool shoulder and the plate top surface, as well as plastic deformation of the material in contact with the tool[6]. The probe is typically slightly shorter than the thickness of the work-piece and its diameter is typically slight larger than the thickness of the work-piece[7]. The FSW process is a solid state process and therefore solidification structure is absent in the weld ad the problem related to the presence of brittle inter dendritic and eutectic phases is eliminated[8]. The objective of this work are to develop an understanding of the microstructural development of friction stir welds on an AA 6082-T6 Al alloy, and to determine the optimum welding condition range without any defect in the welds and the mechanical properties of the welds.

Experimental Procedure

The material under investigation was a AA6082-T6 Al alloy which is a medium strength alloy with excellent corrosion resistance. Before the friction stir welding the weld surface of the base material was cleaned. The aluminum rolled plates of the size 100mm x 100 mm x 4 mm were welded along the rolling direction. The chemical composition of the AA6082-T6 Al alloy is given in below table.

Table 1 chemical composition of AA 6082-T6

Si	Cu	Fe	Mn	Zn	Cr	Ti	Other Elements	Al
0. 9%	0. 9%	0. 24	0. 7%	0. 04%	0. 06%	0. 05%	0. 15%	balance

The AA 6082-T6 Al alloy was friction stir welded for single pass using a H13 steel tool having a tapered cylindrical treaded with a shoulder diameter of 18 mm and 6 mm pin diameter and length 3 mm was used as shown Fig 1. a & b. The chemical composition of H13 steel is listed in table

Table 2 chemical composition of H13 steel

C	Mn	Si	Cr	Ni	Mo	V	Cu	P	S	Fe
0. 35%	0. 3%	0. 88%	5. 0%	0. 3%	1. 5%	1. 0%	0. 25%	0. 03%	0. 03%	balance

The FSW were conducted using vertical milling machine with four tool travel speeds and rotational speeds as follows in table

Table 3. Experimental Plan.

S. No	Welding Speed (Tool travel Speed mm/Min)	Tool RPM
1	15	710
2	40	900
3	100	1120
4	160	1800

These results show that these are optimum tool rotational speed in order to obtain defect –free weld. Vickers Hardness tests were calibrated on Vickers hardness tester Model No. Vm 50 Make: MCS. Tesile test Specimens are prepared as per ASTM E8 standard and transverse tensile properties Such as Tensile strength, Percentage of elongation and joint are evaluated using computerized(universal Testing machine) UTM.

For the microstructures the samples were cut in a direction perpendicular to the welding direction. These samples were then grinded successively on Sic papers of grit 220 to 600. After which they were polished with emery papers of grade 1/4, 2/4, 3/4, 4/4 respectively. Then these samples were polished on fine cloth using 1 μm diamond paste to obtain the mirror finish. The samples were then etched using Keller's reagent then used for optical microscopy of magnification 200X.

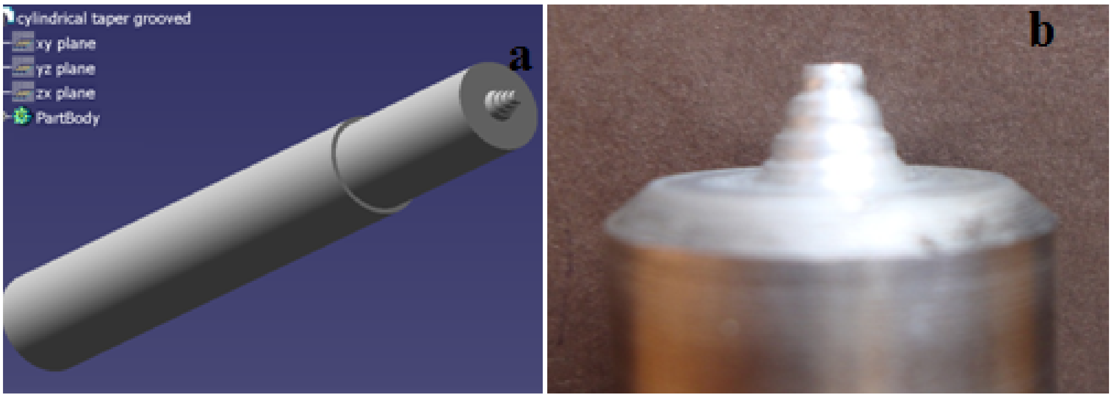

Fig. 1. (a) Tapered cylindrical grooved tool designed in CATIA; (b) Tapered cylindrical grooved tool (photograph).

Results and discussion

Influence of process parameters on mechanical properties

FSW is becoming a very effective tool in solving the joining problems in the aerospace industry where joints high ductility and tensile strength are required. In the present work, FSW welds of AA6082 –T6 sheets were successfully obtained by varying the process parameters. In table 3, the different parameters are used in this work are reported. It can be observed from table 4, 5 and fig 2, 3 that the mechanical properties have been considerably improved by friction stir welding. The mechanical properties are found to be lower at lower rotational speed (710 rpm). This is due to the insufficient deformation by poor stirring action and insufficient deformation by the tool pin may be the reasons for the decrease in the properties. Again from table 4, 5 it is clear that the tensile strength and hardness has been improved at rotational speed of 900 rpm.. Further increase in the rotational speed 1800 rpm has resulted in higher temperatures in the stirred zone than the optimal, leading to grain growth that ultimately decreased the tensile strength as well as hardness. Therefore, optimal rotational speed must be used to avoid grain growth and insufficient deformation. The best mechanical properties were obtained at a rotational speed of 900 rpm. Traverse speed also affects the mechanical properties of the weldements. A lower traverse speed (15mm/min) results slower cooling rate that allows sufficient time for grain growth leading to lower tensile and hardness. There is an optimum value of traverse speed to obtain better mechanical properties, In the present work, the best results were obtained at traverse speed of 40mm/min.

Table 4. Tensile results of friction stir welded joints

S. No	Process Parameter	UTS(N/mm^2)	UYS(N/mm^2)
1.	710rpm, 15 mm/min	126. 7	83. 2
2.	900rpm, 40 mm/min	136. 0	107. 1
3.	1120rpm, 100 mm/min	120. 1	83. 7
4.	1800rpm, 160 mm/min	103. 1	73. 7

Table 5. Hardness results of friction stir welded joints

Distance	710rpm, 15 mm/min	900rpm, 40 mm/min	1120rpm, 100 mm/min	1800rpm, 160 mm/min
-15	61. 3	59. 7	63. 6	61. 6
-5	61. 6	60. 0	62. 0	62. 9
0	61. 9	60. 3	63. 9	61. 3
5	61. 0	59. 7	63. 6	62. 9
15	61. 3	60. 3	63. 9	61. 6

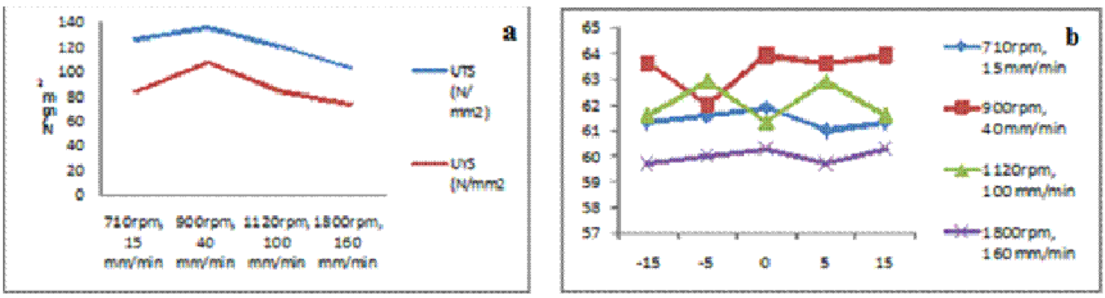

Fig. 2. a)Hardness Vs weld Distance for different Process parameters b) Tensile Strength Vs different Process parameters

Influence of process parameters on microstructure

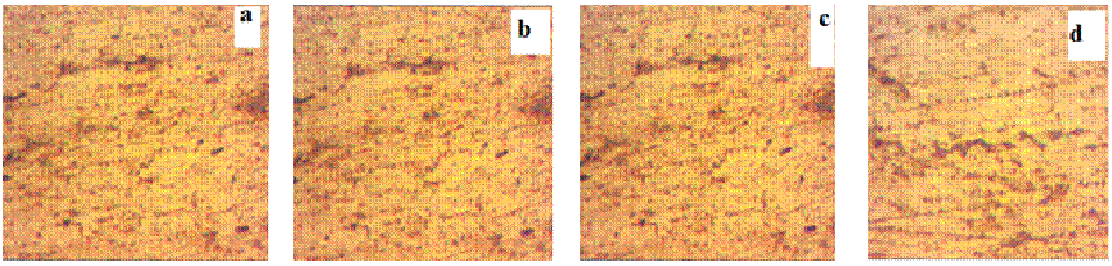

Fig. 3. Microstructures of the friction stir welded samples (a) 710rpm, 15 mm/min; (b) 900rpm, 40 mm/min; (c) 1120rpm, 100 mm/min (d) 1800rpm, 160 mm/min

The microstructures of friction stir weldments of AA6082-T6 alloy at various combinations of tool rotational speed and tool travel speed are observed under optical microscope size 200X and the observation are presented above. The mixing of the base metal into the weld nugget is low for the sample with 710 rpm and 15 mm/min. Good mix of the base metal into the weld nugget. The material flow is uniform and homogeneous for 900 rpm, 40mm/min. Irregular flow of base metal to weld nugget and the microstructure shows the non uniform and in homogeneous material flow for the sample with 1120 rpm and 100mm/min. smooth flow of the material can be observed for the higher tool rotational speed and traverse speed. Therefore the better metal flow with complete mix of base metal in to the weld nugget can be obtained at optimum process parameters at for 900 rpm and 40 mm/min.

Conclusions

In the present work, an attempt has been made to study the effect of process parameters on mechanical and microstructural properties of friction stir welded AA6082-T6 aluminum alloy. The following important conclusions are derived from this investigation.

1. The variation of the hardness across the weld was found to be uniform and homogeneous in nature due to the distribution of the interfaced strengthening of the newly formed grains in the aluminium matrix during the process with 900 rpm tool rotational speed as substantiated by the microstructures with smooth metal flow and good bonding between the plates.
2. The variation of the hardness across the weld was found to be non uniform and inhomogeneous in nature for 1800 rpm tool rotational speed because of high tool rotational speed leading weak bond formation with a number of FSW defects being observed.
3. The hardness increase with increase of rotational speed. This is because of heat input (generated by the friction between tool shoulder and base metal) increase with increase in tool rotational speed.
4. The tensile strength is found to increase with reduced tool translational speed

with a constant tool rotational speed, this is due to the reason that with increase in feed rate the frictional heat developed during the welding gradually reduces. The reduction in heat generation leads to a drop in plastic flow of the material and thus the metallurgical bond formed has a lesser strength.

5. Analysis on the mechanical and metallurgical properties of the AA 6082-T6 welded joints indicates that the mechanical stirring is the major metal flow mechanism in metallurgical bond formation.
6. Complete mix of Base metal in weld nugget is observed in tool rotational speed of 900rpm and tool travel speed of 40mm/min. Therefore, optimum mechanical properties are obtained at this process parameter.

References

[1] W. M. Thomas, E. D. Nicholas, J. C. Needam, M. G. Murch, P. Templesmith, C. J. Dawes, GB Patent Application No. 5460317, October 1995
[2] G. Bussu, P. E. Irving. the role of residual stress and heat affected zone properties on fatigue crack propagation in friction stir welded 2024-T351 aluminium joints, Int. j. fatigue 25(2003) 77-88.
[3] R. John, K. V. jata, K. Sadananda, Residual stress effects on near threshold fatigue crack growth in friction stir welded aerospace alloys, INt J. Fatigue 25(2003)939-948.
[4] K. V. Jata, K. K Sankaran, J. Ruschau, Friction stir wlding effects on microstructure and fatigue of aluminum alloy 7050-T7451, metal. Mater. Trans. 31A(2000)2181-2192
[5] R. S. Mishra, Z. Y. Ma, Mater. Sci. Eng. R 50 (2005) 1-78.
[6] M. Guerra, C. Scmidt, J. C. McClure, L. E. Murr, A. C. Nunes, Mater. Charact. 49 (2003) 95-101.
[7] P. Ulysse, Inter. J. Mach. Tools Manuf. 42(2002)1549-1557
[8] C. G. Rhodes, M. W. Mahoney, W. H. Bingel, Sccripta Mater. 36 (1997) 69-75.
[9] K. Kumar and Satish V. Kailas, " *The Role of friction stir welding and material flow and weld formation*"; Materials science and Engineering, A 485(2008).
[10] Thomas WM, Nicholas ED. "*Friction stir welding for the transportation industries*"; Mater Des 1997; 1 8:269–73.
[11] Prof. Dr. -Ing. K. U. Kainer Stephan W. Kallee, Wayne M. Thomas; E. Dave Nicholas Published Online; 15 MAY 2006 DOI: 10. 1002/3527607552. ch29