Survey of Joining of Two Dissimilar Aluminium Alloys for Aerospace Application

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Abstract:-In this investigation an attempt has been made to study the experimental comparison of friction stir welding process two (AA6082-T6 & AA7075-T6) dissimilar aluminium alloy joints. Most commonly used method for welding of aluminium alloy is TIG welding process. TIG welding process produces the sound joints but the newly developed method friction stir welding process gives better joints than TIG welding process. Of the natural aging times studied, the stir zone of all welds showed the highest kinetics of micro-hardness and strength recovery. Its effect increased considerably in the heat input per unit length decreased.

Keywords:- Dissimilar Aluminium alloy, Friction stir welding, TIG welding.

I. INTRODUCTION

Aluminium is one of the lightest engineering metals, having strength to weight ratio superior to that of steel. The components made from aluminium and its alloys are vital to the aerospace industry. But the welding of aluminium and its alloys is difficult due high of thermal conductivity, high hydrogen solubility, high oxygen reactivity etc. The most common method used for welding of aluminium alloy is TIG welding but the recently developed method for welding of aluminium alloy is Friction-stir welding. The FSW is a solid-state joining process where coalescence occurs by the heat generated between the tool and the work piece material[11].In aerospace structures, the joining technology of laserbeam welding is widely used. This technology enables the effective joining of thin and filigree components for lightweight structures with sufficient stiffness [8].

Previous studies have investigated the effect of FSW process variables on dissimilar joining of aluminum alloys. Cole et al. studied the influence of weld temperature during dissimilar friction stir welding of AA6061 and AA7075. They reported that weld tool offsets on the retreating side of AA7075 increased the tensile strength and decreased the average weld temperature of dissimilar joints. Sarsilmazet al. considered the effect of tool shape and welding speed on the mechanical and fatigue behavior of dissimilar friction stir welded AA7075-AA6061 joints. They reported that the welds done using a treated cylindrical pin tool have the best properties. In the present work, an attempt has been made to understand the effect of tool pin profiles and welding speed on microstructure and mechanical property of dissimilar friction stir welded AA6082-T6/AA7075-T6 joints [12].

To do so, dissimilar FSW experiments under different welding conditions are performed and then developed microstructures in the weld zone and their mechanical properties are studied employing tensile testing together with optical metallographic.

Alloy	Zn	Mg	Cu	Mn	Si	Fe	Ti	Cr	Al
AA6082-T6	0.20	1.12	0.14	0.91	1.20	0.34	0.08	0.04	Balancing
AA7075-T6	5.21	2.30	1.32	0.10	0.21	0.37	0.12	0.18	Balancing

Table 1: The Alloys Chemical Composition.

Alloy	Yield stress (MPa)	Tensile strength (MPa)
AA6082-T6	288	337
AA7075-T6	498	560

Table 2: Mechanical Properties of Base Material from Tensile Tests.

II. LITERATURE REVIEW

A.B.Harman,investigate the study of fatigue durability of bonded joints representative of repairs to aircrafts structural with and without the presence of a clad layer was investigated by testing aluminium alloy7075-T6 double lap shear joints specimens[1].

V.InfantE, investigates the study of FSW process parameters have also proven to affects the tensile strength of the welded dissimilar plate which have shown to be about 66% of the tensile strength of the aluminium alloy[2].

Pratik Kikani, deals with analysis of various mechanical properties like hardness, tensile strength, compressive strength[3].

S.J.Maddox, presents a review of methods and corresponding codes and standards for the fatigue of welding aluminium structures and assessed the viewpoints of original design and estimate of the residual lifeof existingstructures[4].

S.Hanke, compares two aluminium alloys 5083 and 6082 were deposited by friction surfacing under the same process conditions. Process characteristics including torque and forces, temperatures and deposit microstructure were compared in this paper[5].

J,I.Ahuir-Torres, studies the effects of laser on the corrosion and wettability of AA2024-T3 using an IR Nd;vanadate picosecond laser was studied. The results revealed that ultra short laser surfacing texturing did not modify the corrosion behavior of AA 2024-T3 in the test[6].

R.Hermann, investigate the failure in 7000 series aluminium alloy welds due to liquation cracking has been investigated. In AL-Zn-Mg alloys, as rapid cooling tends to limit the extent of solute diffusion, liquation cracks form in the white zone[7].

J. Weibesiek investigated the multi-axial behavior of laserbeam-welded joints made from artificially hardened aluminium alloy AlSi-Mg-Mn T6 (EN AW 6082 T6) and self-hardening aluminium alloy AlMg3.5-Mn (EN AW 5042) under combined proportional and non-proportional axial with constant amplitudes in the range of 2×10^4-1×10^7 cycles[8].

Sonia Meco,describes about joining steels of aluminium the reaction between atoms and iron and aluminium during the joints process from brittle intermetallic compounds. The mechanical strength of the joints is limited by the presence of these IMCs and therefore the amount of these compounds should be minimized [9].

MuminSahin, conducts experimental study, 5083 aluminium alloys, which were exposed to severe plastic deformation, were joined with FSW. At the time of transfer of metal from liquid phase to solid phase, atoms are according to the interior structure property of the material [10].

III. EXPERIMENTAL DETAILS

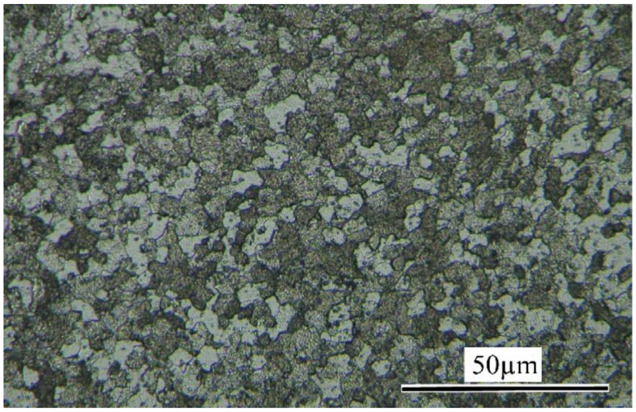
The FS welds werecarried outon 8 mmthick platesof AA 6082T6 and AA 7075-T6 with the chemical compositions and mechanical properties listed in Tables 1 and 2 respectively. All plates were cut before welding into dimensions measuring 300 mm long and 100 mm wide. The single-pass friction stir butt welds were conducted using a friction stir welding machine in load control. The AA6082-T6 aluminum alloy was located in the advancing side whereas AA7075-T6 in retreating side. The temperature profiles were in situ measured using K-type thermocouples with a 0.25mm diameter wire. Two thermocouples were inserted in the advancing side and retreating side at distance of 4 mm from the weld line. Microstructural analysis was carried out using an optical microscope Olympus PME3 incorporated with an image analyzing software (Clemex–Vision) and by transmission electron microscopy (TEM). A reagent composed of 3 ml HNO3, 6 ml HF, 6 ml HCl and 150 ml H2O was employed to etch the AA6082 and AA7075. The grain sizes were determined based on ASTM: E112-13 and the general intercept procedure. The tensile test specimens were prepared in transversal and longitudinal directions along the weld line.

IV. RESULT

A. Microstructural analysis

Fig. 1 shows the influence of the tool pin profile on the microstructure of the stir zone. The fine equiaxed grains in the stir zones of all samples means that both AA6082 and AA7075 alloys experienced dynamic recrystallization. Fig. 1 indicate that the grain size of the stir zone on the AA7075 side was finer than that of the AA6082 side. Similar results for stir zone grain size in the dissimilar FSW for AA6xxx–AA7xxx has been previously reported [13]. Dynamic recrystallized grain size is strongly affected by the rate of deformation and by temperature [15] and second phase particles [18]. Although AA7075 shows higher flow stress than AA6082, the lower temperature on the retreating side and second particles such as MgZn2 and Al3Zr in the AA7075 [17] can result in finer recrystallized grains on the retreating side. Decreasing the weld pitch (ratio of welding to rotational speed) results in a higher rate of deformation and peak temperature [16]. Mishra et al. [14] and Humphreys et al. [15] reported that an increase in the rate of deformation and a decrease in peak temperature generated fine recrystallized grains.

AA6082, Advancing Side



AA7075, Retreating side

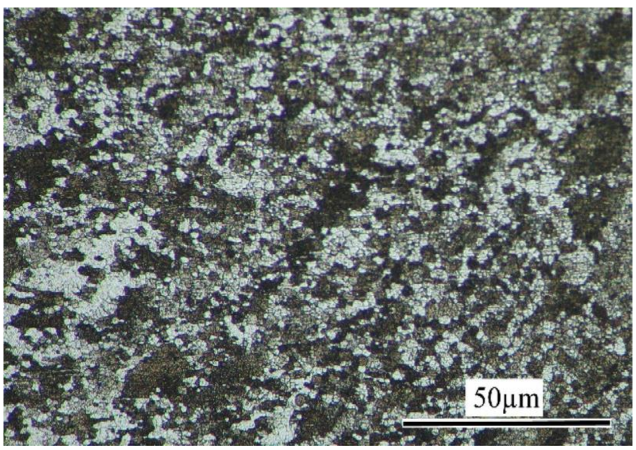


Fig.1: Optical Metallographic Images of the Stir Zone

B. Tensile Testing

The effect of natural aging on longitudinal and transverse tensile test. As seen, the longitudinal show lower yield and tensile strengths than the base materials. A comparison of the micro-hardness profiles and longitudinal tensile strengths indicate that there is a correlation between the tensile strength of longitudinal specimens and the micro-hardness in different regions in the weld, since the stir zone shows less hardness and strength than the base materials. The longitudinal tensile specimens show greater strength than the transverse tensile specimens. All transverse tensile specimens fractured in the TMAZ of the AA6082 side show decreased micro-hardness. As mentioned, the peak temperature and micro-hardness profiles of the joints made at the same traverse and rotational speeds show little difference.

V. CONCLUSIONS

The influence of friction stir welding parameters on microstructuresand mechanical properties of dissimilar friction stir weldedAA6082–AA7075 was analyzed using optical microscopy and tensile testing. The following results were obtained:

1. The peak temperature in the welded joints made by the tool with a conical probe with three grooves was higher than for those made by the tools with square frustum probes.
2. In all welds, the decrease in hardness was sharper on the AA7075 side than that on the AA6082 side. The variation in hardness variation on the AA6082 and AA7075 sides mainly depended on the size, volume fraction and distribution of precipitates in the weld line and the adjacent heat affected zone as well as the aging period after welding.
3. In each series of welds made using different tools, a decrease in weld pitch resulted in decreased strength of the welds and coarser grain sizes in the weld nugget. Samples welded using a square frustum probe showed finer recrystallized grains and samples welded using a conical probe had larger sized grains.
4. The zinc distribution across the weld shows that atomic diffusion does not occur at the interface of materials and that mixing of the materials is mechanical. The mixing of materials in the weld nugget of samples welded using the tool with a square frustum probe was more uniform than that in the other samples.

REFERENCES

[1]. A.B.Harman, A.N.Rider. On the fatiguedurability of clad 7075-T6 aluminium alloy bonded joints representative of aircraft repair 44 (2013) 144-156.
[2]. V.Infante, D.F.O. Braga, P.M.G. Moreira, F. Duarte, M. de Freitas, P.M.S.T. de Castro. Study of the fatigue behavior of dissimilar aluminium joints produced by friction stir welding 82 (2016) 310-316.
[3]. Pratik Kikani. Analysis of process parameters for dissimilar metal welding using MIG welding: A Review. joMME (2016) 38-41.
[4]. S.J. Maddox. Review of fatigue assessment procedure for welded aluminium structures. 25 (2003) 1359-1378.
[5]. S. Hanke, J.F. dos Santos. Comparative study of severe plastic deformation at elevated temperature of two aluminium alloys during friction surfacing. 247 (2017) 257-267.
[6]. J.I. Ahuir-Torres, M.A. Arenas, W. Perrie, G. Dearden, J. de Damborenea. Surface texturing of aluminium alloy AA2024-T3 by picosecond laser. 321(2017) 279-291.
[7]. R. Hermann, S.S. Birley, P. Holdway. Liquation cracking in aluminium alloy welds A212 (1996) 247-255.

[8]. J. Wiebesiek, K. Storzel, T. Bruder, H. kaufmann. Multiaxialfatigue behavior oflaserbeam-welded thin steel and aluminium sheets under proportional and non-proportional combined loading. 33 (2011) 992-1005.
[9]. Sonia Meco, luiscozzolino, SupriyoGanguly, Steward Williams, norman McPherson. Laser welding of steel to aluminium: thermal modeling and joint strength analysis. 247 (2017) 121-133.
[10]. MuminSahin, H. ErolAkata, KaanOzel. An experimental study on joining of severe plastic deformed aluminium material with friction welding method. 29 (2008) 265-274.
[11]. Gurmeet Singh, Amardeep S. Kang, Kulwant Singh, Jagtar Singh. Experimental comparison of friction stir welding process and TIG welding process for 6082-T6 aluminium alloy. 4 (2017) 3590-3600.
[12]. HamedJamshidiAval. Microstructure and residual stress distribution in friction stir welding of dissimilar aluminium alloys. 87 (2015) 405-413.
[13]. Chakrabarti DJ, Laughlin DE. Phase relations and precipitation in Al–Mg–Si alloys with Cu additions. Prog Mater Sci 2004;49:389–410.
[14]. Mishra RS, Mahoney MW. Friction stir welding and processing. 1nd ed. Materials Park (Ohio): ASM International; 2007.
[15]. Humphreys FJ, Hatherly M. Recrystallization and related annealing phenomena. 2nd ed. Oxford: Elsevier; 2004.
[16]. ZhangZ, ZhangHW. Material behaviors and mechanical features infrictionstir welding process. Int J AdvManufTechnol 2007;35:86–100.
[17]. Guo JF, Chen HC, Sun CN, Bi G, Sun Z, Wei J. Friction stir welding of dissimilar materials between AA6061 and AA7075 Al alloys effects of process parameters. Mater Des 2014;56:185–92.
[18]. McNelley TR, Swaminathan S, Su JQ. Recrystallization mechanisms during friction stir welding/processing of aluminum alloys. Scr Mater 2008;58:349–54.