ISSN: 0975-766X
CODEN: IJPTFI
Available Online through Research Article
www.ijptonline.com

EVALUATION OF TOOLS FOR FRICTION STIR WELDING

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Received on 20-02-2016 *Accepted on 12-03-2016*

Abstract

The upgoing trend of research on joining of dissimilar alloys grown the interest on the study and analysis of Friction Stir welding. Joining of different steel groups and Aluminium has been on the research interest on the previous decade. Recent innovative research and development areas is on with Magnesium alloy groups. The Aluminium alloys and Magnesium alloys are investigated for the weld strength with respect to the change of welding parameters including tool geometry, the tool transverse speed, and the tool angular velocity. In this paper, the tools were compared for friction stir stir welding of butt joint using AA6061 and AZ61.

Keyword: Tools, FSW, Magnesium alloys and Aluminium alloys.

Introduction

FSW is a technique that allows aluminium alloys, lead, magnesium, titanium, steel, copper & other metals to be continuously welded without the use of any filter material [1].The tool rotates about its axis and also along the welding direction. This forms the joint. The characteristic like tool geometry i.e., shoulder diameter, tool shape, rotational speed, feed rate, shown in the Figure (1)vertical pressure caused by the tool pin & shoulder and eternal cooling affect the heat generated in the material [2].Tool pressure, rotational speed of tool, welding speed, geometries of tool pin & tool shoulder are very important key factors that control welding temperature & material flow [3].Poor alignment of the welding tool, a short pin and an inadequate plunge depth result in lack of penetration or disbanded surfaces which are major players in initiation of failure. The material being welded is partially deformed by the FSW tool [4].In FSW, the rotating tool causes a local plastic deformation [5].Functions of two main parts of the tool i.e., the shoulder& pin are to generate heat for material softening and flow control of material for a defect free weld .The profile of tool pin strongly influences the change of microstructure of the welded region and hence plays significant role in corrosion behavior. Previously studies were made on control geometry for choosing the tool pin profile with respect to microstructure and mechanical properties [6].Studies on tool profile on the microstructure and corrosion behavior of welds are scarce [7].The current investigation is aimed at studying the micro structural changes in various zones and the pitting corrosion behavior of our alloys . Friction Stir Welds made using four tool profiles (i) straight cylindrical (ii) straight threaded cylinder (iii) tapered (iv) threaded tapered. Pin geometry affects the weld nugget microstructure. The weld made using straight threaded cylinder tool profile shows very fine grain distribution when compared to the weld made using straight cylinder, tapered tool, and tapered threaded tool profiles. Very fine grains are formed by straight threaded cylinder profile due to dynamic recrystallyzation compared to weld nuggets made using the other three tool profiles .The shape of the weld nugget and the TMAZ zone is only dependent on the shape & the geometry of welding tool and not on the welding parameters .It is observed in a threaded cylinder tool that there was a relatively higher rate of dissolution of precipitates was observed in the heat affected zone of weld made. The reason behind this phenomena is higher amount of heat generation in the precipitation of FS welds using threaded cylinder tool profile..Earlier tool designs by “Mishra and Mahoney (2007)” revealed that they used simple tool geometries comprising a cylindrical, threaded and fixed pin with a concave shoulder machined from tool steel. As the tool advances, the newly deformed metal is pushed into the shoulder cavity where it is then directed back towards the pin. Shoulder with convex surface is ineffective as it pushes the material away.

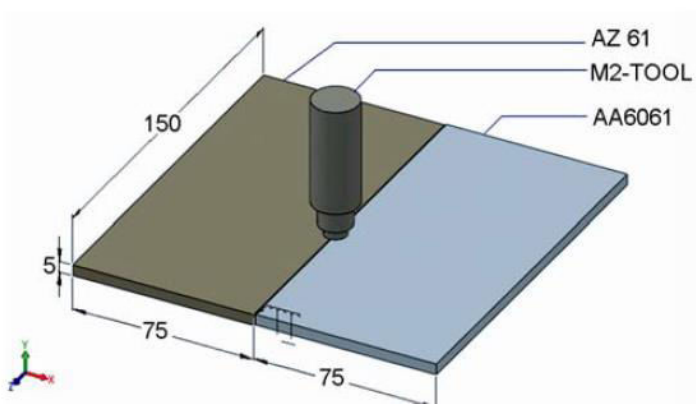

Figure .1. Schematic illustration of Friction Stir Welding of dissimilar alloys AA6061-AZ61.

Friction stir welding uses a non-consumable tool which allows to weld alloys of aluminium, magnesium, steel, titanium and copper [8]. Friction stir welding is a solid state welding process which comprises of a rotating which has a shoulder and a pin. The pin is plunged into the metal that has to be welded. A pre-determinedload or predetermined amount of force is applied on the weld metal or the plunges into the upper surface of the metal through a specific distance. Then the rotating tool is moved along a line at which the joint or weld has to be formed. During the rotation of the tool, frictional heat is supplied to the metal which plasticizes it allowing to flow under the influence of the shoulder and the pin. The heat produced due to friction and deformation of the metal and also the force applied by the shoulder of the tool helps in the plasticized bonding of the metal [9]. Thus the weld is completed behind the pin. The properties after the weld are affected by the process parameters which include the rotational speed of the tool, welding speed, plunging force, tilt angle of the tool and the geometry of the tool [10,11]. Most of the characteristics of the parent metals are retained after the welding. Friction stir welding is highly advantageous over other welding process in that it forms less pores, low distortion and less shrinkage and it also avoids cracking of the welded metal at the welded zone. Because of the absence of any fillers or filler materials the weld produced is less contaminated. The joints produced by the Friction stir welding show superior mechanical properties because of the recrystallized fine grains.Friction stir welding is environmental friendly, versatile and energy-efficient and also it is rapid and can be automated easily [12].

During the Friction stir welding process the maximum temperature which is produced at the welding zone is 0.6 to 0.9 times the melting point temperature of the metal that has to be welded. And hence,the use of larger temperature-gradient is avoided [13]. There is a smooth surface finish of the welded joints and the residual stresses are very low, the fatigue strength is also increased considerably due to its fine grained microstructure [14, 15].Friction stir welding is widely used in Defence and Aero-Space application [16], Railways [17], Ship building [18], bridge structures [19], and in automotive components [20].

Experimental Work:

In this experimental work, Friction stir welding (FSW) is carried out for thirty specimens with constant axial load and transverse speed. For three different Plunge Down Time(PDT), ten different Rotational speeds are selected as Variable parameters.

The three different combinations are selected due to the research interest on investigation of stronger side for Aluminium alloy and Magnesium alloy for advancing side and retreating side. Tool tilt is set for 0° and the AA 6061 - AZ 61, base metal of 150 mm weld length with 6 mm thick is Friction Stir Welded with Butt configuration.

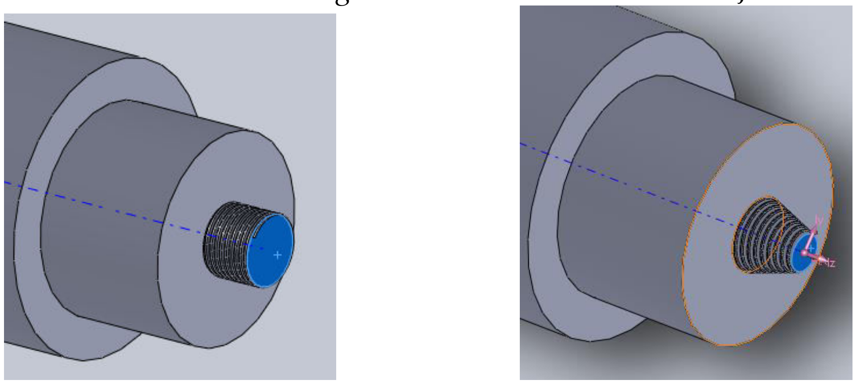

Figure 2 – Tool used for the friction stir welding.

Table-1: Composition of AA 6061 –and AZ 61.

Element (%)	Al	Mg	Si	Fe	Cu	Mn	Ni	Cr	Others
AA6061	96.2	1.0	0.6	0.5	0.3	0.1	0.04	0.3	0.96
AZ61	6.2	92.29	0.1	0.005	0.05	0.15	0.005	-	1.2

Table-2: Mechanical properties of AA 6061 – T6 and AZ 61.

Material	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Elongation (%)	Vicker's Hardness (0.5 kg)
AA6061	276	310	17	107
AZ61	230	306	16	68

The sample welded specimens are shown in Figure 2. The AA 6061 and AZ 61 plates for the current work is identified with the composition shown in Table 1. A common mechnical properties of AA6061 T6 and AZ 61 is shown in Table 2.

Result and Discussion

From the investigation in Friction Stir Weld on AA6061 – AZ 61 alloys, it was concluded that the taper threaded tool is best for the weld strength. The material flow mechanism determines the tensile strength based on the material kept at advancing side. The AA 6061 on advancing side reveals comparatively better weld strength. Apart from normal welding parameters such as rotational speed, transverse speed and axial load the Plunge Down time also is equally important.

Reference:

1. Thomas WM., Nicholas ED, Watts ER, Staines, DG, Friction based welding Technlogy for aluminium. In: Gregson PJ, Harris S. editors Material Science
2. Cam G. Friction Stir Welded structural materials beyond Al- Int Mtter Rev 2011; 56(1);1-48.Baragetti S, D'urso G. Aluminium 6060-T6 friction stir welded butt joints; Ftigue resistance with different tools and feed rates. J Mech Sci Technol 2014; 28(3);867-77
3. Cavaliere P, Campanile G, Panella F, Squillace A. Effect of welding parameters on mechanical and micro structural proper ties of AA6065 joints produced by Friction Stir Welding. J Mater Process Technol 2006;180(1-3):263-70.
4. Mishra R S, Mahoney M W. Friction Stir Welding and processing materials Park,O H: ASM International ; 2007.p.360p [ISBN-13-978-0-87170-840-3].
5. Li B, Shen Y, Hu w. The study on defects in aluminium 2219-T6 thick butt friction stir welds with the applications of multiple non-destructive testing methods. Mater Des 2011;32:2073-84.
6. Threadgill P.L, Leonard A J, Shercliff H R, Withers PJ. Friction Stir Welding of aluminium alloys. Int Mater Rev 2009;54(2):43-93
7. Mishra R.S., Mahoney M.W., 2007. Friction Stir Welding and Processing. ASM International Materials, Park O.H., pp.1-5, 7-28, 51-55.
8. . Thomas WM, Nicholas ED, Watts ER, Staines, DG. Friction based welding technology for aluminium. In: Gregson PJ, Harris S, editors. Material Science Forum 2002; 396-402:1543-8.
9. Friggard O, Grong O, Bjorneklett B, Middling OT. In: Proceedings in 1st International Symposium on friction stir welding. Thousand Oaks, CA, USA: TWI; June1999.
10. Mishra RS, Ma ZY. Friction stir welding -recent developments in tool and process technologies. Adv Eng Mater 2003; 5: 485-90.
11. Clark Lakshminarayanan A.K ,Balasubramanian V, Comparison of RSM with ANN in predicting tensile strength of friction stir welded AA7039 aluminium alloy joints, Trans. NonferrousMet. Soc. China. 19 (2009), 9-18.
12. Cook GE, Crawford R, Clark DE, Strauss AM, Robot: Int J 2004; 31(1);55-63.
13. Mishra RS, Ma ZY. Friction stir welding and processing, Material Science and Engineering. R 2005; 5; 1-78.

14. Lomolino S, Tovo R, Dos Santos J. On the fatigue behaviour and design curves of friction stir butt welded Al-alloys. Int J Fatigue 2005: 27(3); 305-16
15. Middling OT, Oosterkamp LD, Beesaas J. Friction stir welding aluminium process and applications. In: OgleMH, Maddok SJ, Threagrill PL; editors, seventh international conference INALCO'98. April 1998; Cambridge, UK, Cambridge: Woodhead publ; 1999. P.182-91.
16. Thomas WM, Nicholas ED, Needham JC, Murch MG, Temple Smith P, Dawas CJ. International patent application No. PCT/GB92/002203GB Pat appl no.9125978.8,Dec. 1991; US Oct 1995; Patet application no: 5460317.
17. Kawasaki T et al. Application of friction stir welding to construction of railway vehicles, special Issue Adv.Techno Exp Mech 2004;47(30), 502-11.
18. Pepe N. et al. Fatigue behaviour of ship building aluminium alloy welded by FSW, In: 9th international fatigue congress, Atlanta, USA, May 2006, P.11.
19. Vigh L.G, Okura I. Fatigue behaviour of friction stir welded aluminium bridge deck segment. Materdes 2013; 44; 119-27.
20. Smith CB, et al. Friction stir welding in the automotive industry 2001. http://www.frictionstirlink.com/publications/pub07FSWAutoIndTMSpaperpdf.

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