© 2016 IJSRSET | Volume 2 | Issue 2 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Friction Stir Welding of 5xxx series Aluminium Alloys A Literature Survey

Rohit Thakur, Prabhdeep Singh Bajwa

Department of Mechanical Engineering, LRIET, Solan, Himachal Pradesh, India

ABSTRACT

As the concept of Friction stir welding is relatively new, there are many areas, which need thorough investigation to optimize and make it commercially viable. In order to obtain the desired mechanical properties, certain process parameters, like rotational and translation speeds, tool tilt angle, tool geometry etc. are to be controlled. Aluminum alloys of 5xxx series and their welded joints show good resistance to corrosion in sea water. Here, a literature survey has been carried out for the friction stir welding of 5xxx series aluminum alloys.
Keywords : 5xxx series Aluminum alloys, Friction Stir Welding, Mechanical Properties.

I. INTRODUCTION

Modern aerospace concepts demand reductions in both the weight as well as cost of production of materials. Under such conditions, welding processes have proven most attractive, and programs have been set up to study their potential. Car manufacturers and shipyards are also evaluating new production methods. Increasing operating expenses are driving manufacturers to reduce weight in many manufacturing applications, particularly in aerospace sector. The goal is to reduce the costs associated with manufacturing techniques to result in considerable cost and weight savings by reducing riveted / fastened joints and part count. One way of achieving this goal is by utilizing a novel welding technology known as Friction Stir Welding (FSW). Friction stir welding is a solid-state joining process developed and patented by The Welding Institute (TWI) in 1991 by Thomas et al and it is emerged as a welding technique to be used in high strength alloys for aerospace, automotive and marine applications that were difficult to join with conventional techniques. This technique is attractive for joining high strength aluminum alloys since there is far lower heat input during the process compared with conventional welding methods such as TIG or MIG. This solid state process leads to low distortion in long welds, excellent mechanical properties in the weld and heat-affected zone, no fumes or spatters, low shrinkage, as well as being energy efficient. Furthermore, other cost reductions are realized in that the process uses a non-consumable welding tool. The process was developed initially for aluminum alloys, but since then FSW was found suitable for joining a large number of materials.

In FSW, A non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of sheets or plates to be joined and traversed along the line of joint. The parts have to be suitably clamped rigidly on a backing bar to prevent the abutting joint faces from being forced apart. The length of the pin is slightly less than the required weld depth. The plunging is stopped when the tool shoulder touches the surface of the job. The tool shoulder should be in intimate contact with the work surface. The function of tool is heating of work-piece, and movement of material to produce the joint. The heating is accomplished by friction between the tool and the work-piece and plastic deformation of work-piece. The localized heating softens the material around the pin and combination of tool rotation and translation leads to movement of material from the front of the pin to the back of the pin Here a substantial forging force is applied by the tool to consolidate the plasticized metal behind the tool. The welding of the material is facilitated by severe plastic deformation in the solid state involving dynamic recrystallization of the base material. As the tool is moved along the seam the desired joint is created**.**

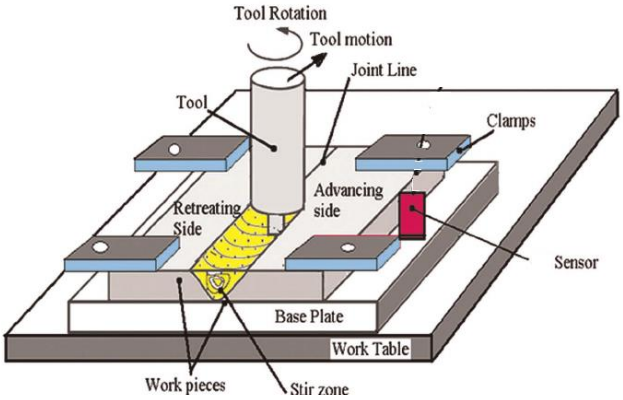

Figure 1 Schematic illustration of friction stir processing

Among weldable Al-alloys suitable to plastic working the group of Al-Mg alloys (of 5xxx series) of good weldability and relatively good service conditions are still the most popular in marine industry. 5xxx series aluminium alloys are used for a wide variety of applications such as shipbuilding, transportation, pressure vessels, bridges and buildings. The aluminium alloys that contain magnesium as a major alloying element are identified as AA5xxx (Al-Mg), non-heat-treatable alloys. AA5xxx alloys obtain their strength from solid solution strengthening and strain hardening. The mechanical properties of these alloys increase with the increase of magnesium content and work hardening rate. AA5052, AA5059, AA5083, AA5086 aluminium alloys are some of popular 5xxx series aluminum alloys.

II LITERATURE REVIEW

Thomas (1997) focuses on this study the relatively new joining technology, friction stir welding (FSW). Friction stir welding can be used to join most aluminium alloys and surface oxide presents no difficulty to the process. On the basis of this study it was recommend that number of lightweight materials suitable for the automotive, rail, marine and aerospace transportation industries can be fabricated by FSW.

G. S. Frankel (1999) studied the susceptibility of welded and unwelded samples of Al 5454 (UNS A95454) in the -O and -H34 tempers to pitting corrosion and stress corrosion cracking (SCC) in chloride solutions. Welded samples were fabricated using the relatively new friction stir welding (FSW) process as well as a standard gas-tungsten arc welding process for comparison. Pitting corrosion was assessed through potentiodynamic polarization experiments. U-bend and slow strain rate tests were used to determine SCC resistance. The FSW samples exhibited superior resistance to pitting corrosion compared to the base metal and arc-welded samples. U-bend tests indicated adequate SCC resistance for the FSW samples.

Xu et al. (2004) focused on the effect of welding parameters and tool shoulder diameter on the thermal histories of friction stir welded aluminum magnesium alloy 5083-H116. The study found that as the feed rate of the tool increases, the heat generated by the shoulder decreases and the heat generated by the pin increases. The heat generated by the shoulder was found to be also affected by the diameter of the shoulder; an increase in the shoulder diameter causes an increase in the heat generated. The shoulder: pin heat generation ratio revealed in the study ranges between 60%: 40% to 30%: 70% depending on the welding parameters discussed earlier.

Hirata et al., (2007) explained the relationship between the microstructure of stir zone and the mechanical properties of FS-welded 5083 aluminum alloy. The microstructures of the stir zones consisted of fine equiaxed grains at various FSW conditions. The grain size of the stir zone decreased with the decrease in friction heat flow during FSW. The results shown that the micro structure and mechanical properties of the FS-welded 5083 Al alloy joints were improved by the refinement of grain size of the stir zone.

G. Cam (2008) performed friction stir welding of Al-5086 H32 plates with a thickness of 3 mm using different welding speeds at a tool rotational speed of 1600 rpm. The experimental results indicated that the maximum tensile strength of the joints, which is about 75% that of the base plate was obtained with a traverse speed of 200 mm/min at the tool rotational speed at 1600 rpm, and the maximum bending angle of the joints can reach 180º.

Wang et al., (2008) reported the effect of welding processes (FSW and TIG) on the fatigue properties of 5052 aluminum-welded joints was analyzed based on fatigue testing. The results show that the fatigue properties of FSW welded joints are better than those of TIG welded joints.

Lombard et al., (2008) presented a systematic approach to optimizing FSW process parameters (tool rotational speed and feed rate) on 5083-H321 aluminum alloy. Eleven experiments were conducted by varying the tool rotational speed and welding speed. The tensile strength of the joint was increased from 289 to 313 MPa by varying the tool rotational speed from 400 rpm to 200 rpm at the constant welding speed of 85 mm/min. The tensile strength of the joint increased from 254 MPa to 315 MPa by varying the tool rotational speed from 635 rpm to 254 rpm at the constant welding speed 135 mm/min. The work indicates that the tool rotational speed is the key parameter governing the tensile strength.

Zhao et al., (2010) analyzed mechanical and metallurgical properties of FSW and TIG welded joints of Al–Mg–Sc alloy plates. The results shown that the mechanical properties of FSW welded joint are much better than those of TIG welded joint. Moreover, tensile strength and yield strength of FSW joint are 19% and 31% higher than those of TIG joint, respectively.

Klobcar et al. (2012) studied the effect of heat input in friction stir welding by varying the rotational speed and feed rate. Aluminum alloy 5083 was used as the material of this study. At the microscopic level, the higher heat input achieved larger grains compared to samples with lower heat input. The samples welded at relatively high and low heat input achieved a slightly lower tensile strength; whereas, the samples that welded at medium heat input achieved higher tensile strength compared to base material. The sample welded with low heat input attained the highest hardness compared to the other samples while welding at high heat input resulted in the lowest hardness.

Z. Barlas et al (2012) determined the effects of friction stir welding (FSW) parameters, which are the tool rotation speed, tool tilt angle, and tool rotation direction, on the macrostructure and microstructure, plus mechanical properties of butt joint AlMg3 aluminum Alloy (Al 5754) sheets. The macroscopic and microstructure examinations and tensile test results indicated that the joint properties were significantly affected by FSW parameters. A sound and defect-free weld was achieved with a tool rotation speed of 1100 rev/min and tool tilt angle of 2 deg, when the tool was rotated counterclockwise. The maximum tensile strength of the joint fabricated with FSW parameters was 217 MPa, which is 14% lower than that of the Al 5754 base metal. In this weld, closer to a symmetrical micro hardness distribution was measured, and hardness values of the weld nugget zone slightly increased and reached about 82 HV. A softened heat-affected zone was not detected by the microhardness testing.

III CONCLUSION

As the concept of FSW is relatively new, there are many areas, which need thorough investigation to optimize and make it commercially viable. In order to obtain the desired mechanical properties, certain process parameters, like rotational and translation speeds, tool tilt angle, tool geometry etc., are to be controlled.

IV REFERENCES

[1] Thomas W. M, Nicholas E. D., (1997) "Friction stir welding for the transportation industries', Materials & Design 18(4-6), pp. 269-273.

[2] Xu, J., Vaze, S.P., Ritter, R.J., Colligan, K.J., Pickens, J.R., (2004) "Experimental and numerical study of thermal process in friction stir welding," Joining of advanced and specialty Materials 4, pp. 10-19.

[3] Hirata T., Oguri T, Hagino H, Tanaka T, Wook Chungb S, Takigawa Y, Higashi K., (2007) "Influence of friction stir welding parameters on grain size and formability in 5083 aluminium alloy" Materials Science and Engineering 456, pp. 344-349.

[4] Cam, G., Gucluer, S., Cakan, A., Serindag, H.T., (2008), "Mechanical properties of friction stir butt-welded Al-5086 H32 plate," Journal of Achievements in Materials and Manufacturing Engineering, Vol. 30(2), pp. 151-156.

[5] Wang, X., Wang, K., Shen, Y., Hu, K., (2008) "Comparison of fatigue property between friction stir and TIG welds," Journal of University of Science and Technology Beijing, Mineral, Metallurgy, Material, 15, pp. 280-284.

[6] Lombard, H., Hattingh, D.G., Steuwer, A., James, M.N., (2008) "Optimizing FSW process parameters to minimize defects and maximize fatigue life in 5083-H321 aluminium alloy," Engineering Fracture Mechanics, 75, pp. 341-354.

[7] Zhao J., Jiang F., Jian H., Wen K., Jiang L., Chen X., 2010. Comparative investigation of tungsten inert gas and friction stir welding characteristics of Al–Mg–Sc alloy plates. Materials & Design, Vol. 31(1), pp. 306-311.

[8] Klobcar, Ladislav Kosec, Adam Pietras, Anton Smolej, (2012) "Friction-stir welding of aluminium alloy 5083, Materials and technology", Vol. 46, Issue 5, pp. 483-488.

[9] Z. Barlas, U. Ozsarac (2012) "Effects of FSW Parameters on Joint Properties of AlMg3 Alloy" Vol.16, pp. 16-22