

An Overview Of The Development Of Friction Stir Welding

Rachna Pandey¹, Dr. R.S Jadoun²

Department of Industrial and Production Engineering^{1,2}, G.B.P.U.A&T, PantNagar-263145^{1,2}

Abstract - This review paper illustrates process, components, application and advancement of Friction Stir Welding (FSW) over conventional fusion welding processes. As compared to fusion welding, this welding technique significantly lowered the energy input and distortion which results as improved welding properties, offers less residual stresses, less distortion and fewer weld defects. Therefore, FSW welding technique minimizes the issues associated with other joining processes such as brazing, soldering and fusion welding. This paper emphasis on advantages of using FSW than conventional fusion welding and also its vital role in different industries such as automotive, aerospace and manufacturing industry to develop aluminium alloys and steel alloys joints.

Keywords - Friction Stir Welding, components, parameters and applications.

INTRODUCTION:

Over Last two decades, it has been observed that the Friction Stir Welding (FRW) has wider applications for fusion of two dissimilar alloys like Aluminium, Steel, Chromium, Zinc, Copper, Hafnium and Zirconium etc to enhance strength, reduction in weight and possibly corrosion resistant properties. FSW process was introduced and developed by Wayne Thomas in 1991 at TWI (The Welding Institute) in UK (W.M. Thomas 1991, C. Dawes 1995). FSW is classified as solid state welding in which non consumable tool rotates between two faces of workpiece to generate heat due to friction, ultimately resulting as intermixing and joining of two workpieces under mechanical pressure (Y N Zhang 2012, Mishra 2005, P.L Threadgill 2009). This process creates high-quality, high-strength joints with low distortion and is capable of fabricating either butt or lap joints, in a wide range of material thicknesses and lengths. Conventional welding techniques(not FSW) incorporates problems like(1)severe segregation of reinforcing particles during solidification and (2) undesired chemical reactions between the reinforcing particles and the molten matrix (Ellis 1996, Mishra 2005). welding methods is related to the advanced differences in melting temperature, thermal properties, and cooling rate after welding of both metallic alloys. Therefore, the joint strength affected by dissolution of precipitates, shrinkage, and different microstructure of the diverse materials at the weld zone (WZ) (T. Tanaka, 2009).

COMPONENTS OF FRICTION STIR WELDING:

TOOL:

Friction Stir Welding tool serves three primary functions: 1. heating of the work piece, 2. Movement of material to produce the joint and 3. Containment of the hot metal beneath the tool shoulder (Rajiv S. Mishra et al 2007). It used a rotating non-consumable tool, which rotates along the joint between two components to fabricate a high-quality butt or lap welds. Tool is commonly prepared with a profiled pin, which enclosed in a shoulder with a larger diameter than that of the pin, this shown in figure 1. In the case of butt joining the pin length approximates to the thickness of the workpiece (Stephan W. Kallee et al 2001). In this welding, a cylindrical shouldered tool with a profiled pin rotated and plunged into the joint region between two pieces of material. the parts have to be strongly clamped to avoid the joint faces from being forced apart. Frictional heat between the work piece and the wear resistant welding tool causes the later to soften without getting melting point, allowing the tool to pass through along the weld line. The plasticized material material, transferred to the trailing edge of the tool pin, is forged through close contact with the tool shoulder and pin profile. A solid phase bond is formed between the work piece during cooling (Sarang Shah et al 2012).

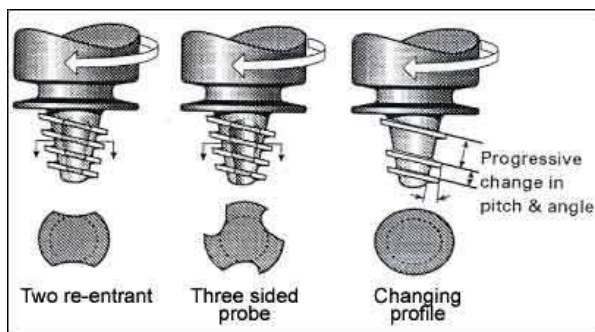


Fig1. Basic variants of TWI's new generation of Whorl TM type FSW tools for welding thick work pieces (Stephan W. Kallee et al 2001).

MATERIAL:

It is a solid state joining process, a thermo mechanical deformation process, which operates below the melting point of the workpiece material. With the help of this welding we can weld all aluminium alloys, including those that cannot usually be connected by conventional fusion welding techniques such as aluminium-lithium alloys. Dissimilar aluminium alloys can also be joined by this process. For the welding of aluminium alloys no shielding gas or filler is required. For aluminium alloys in the thickness range of 1.2 to 75mm TWI has developed this welding technique. The process can be applied to copper, magnesium alloys as well as to zinc and lead. An introductory study on Friction Stir Welding of 9.5 mm thick Elektron Magnesium alloy AZ61A has been effectively carried out at TWI (Stephan W. Kallee et al 2001, Backlund J et al 1998, Thousand Oaks 1999).

PARAMETERS:

The following parameters must be controlled while using the Friction Stir Welding:

Tool speed: It is a slower process as compared to arc or laser welding. Because the tool must turn to generate heat on the joint and then traverse the length of the joint transmitting that heat. The tool is tipped with a probe which rotates within the range of 200-2000 rotations per min (rpm). Effects of rotation speed are Frictional heat, "stirring", oxide layer breaking and mixing of material (15, Sarang Shah et al 2012).

Tool Tilt: Tilting of the tool can have major effect on the welding process. Usually the range of tilt is 2-4 degrees, from which the tool leans into the joint. The effects of the tool tilt is the appearance of the weld, thinning (15, Sarang Shah et al 2012).

Plunge Depth: It is the depth to which the shoulder of the tool sinks into the material. It is determined by rotating time. It needs to be properly set, both to ensure the necessary downward pressure is achieved and to ensure that the tool fully penetrated the weld (15, Sarang Shah et al 2012).

ADVANTAGES:

Friction Stir Welding has several advantages over fusion welding as problems associated with cooling from the liquid phase are avoided. Also issues such as porosity, solidification cracking, solute, redistribution and liquation cracking do not arise during this process. In it has been found to produce a low concentration of defects and is very tolerant of variations in parameters and materials. Though this welding process lead to significant reductions in distortion as the absence of fusion removes much of the thermal contraction associated with solidification and cooling, still, it is not a zero distortion technique. It can be easily automated on simple milling machines- lower setup costs and less training. With the help of friction stir welding we usually achieved good weld appearance hence reducing the need of expensive machining after welding. Low environmental impact. For aluminium alloys no shielding gas or filler wire is required. This process is very bendable in Joining in one, two and three dimensions, being applicable to butt, lap and spot weld geometries, welding can be conducted in any position (17, D. A. Price 2007, P L Threadgill 2009).

DISADVANTAGES:

Friction Stir welding cannot easily used for making fillet welds because the absence of a filler wire. Likewise, this process fully mechanised nature prevents its use for applications where access or complex weld shape is best suited to a manual process (P. L. Threadgill 2003, Y. Uematsu 2008, P L Threadgill 2009).

APPLICATIONS:

Commercial applications of Friction Stir Welding process have been reported across many industries which are aerospace, shipbuilding and offshore, automotive, general fabrication, rolling stock for railways, robotics, computers, casting, powder metallurgy etc. Friction Stir Welding used in production of butt welds although friction stir spot welds and lap welds are also being applied with increasing occurrence (P L Threadgill 2009).

CONCLUSION:

In this paper expounded the extensive effort on understanding the Friction Stir welding process, parameters of this process, materials etc. Friction Stir welding process can also be used for zinc, titanium alloys, lead, copper, magnesium as well as for steel and stainless steel. For the manufacturing of spacecraft made from high-strength aluminium alloys, the aerospace industry applies the process successfully. This welding process opening up completely new areas of welding daily. The process improves existing structural properties and leaves the weld "cold" (Stephan W. Kallee 2001, Sarang Shah 2012, D. Muruganandam et. Al 2015).

REFERENCES:

1. W.M. Thomas, E.D. Nicholas, J.C. Needham, M.G. Murch, P. Templesmith, C.J. Dawes, G.B. "Patent Application No. 9125978.8" UK, 1991.
2. C. Dawes, W. Thomas, TWI Bulletin 6, November/December 1995, p. 124.
3. Y.N Zhang, X.Cao, S. Larose, p. w ANJARA, Review of tools for friction stir welding and processing, Can. Metall. Q. 51 (3) (2012) 250-261
4. R.S. Mishra, Z.Y. Ma, Friction stir welding and processing, Mater. Sci. Eng. R Rep. 50 (1-2) (2005) 1-78.
5. P. Threadgill, A. Leonard, H. Shercliff, P. Withers, Friction stir welding of aluminium alloys, Int. Mater. Rev. 54 (2) (2009) 49-93.
6. M.B.D. Ellis, Int.Mater.Rev. 41(2)(1996)41-58.
7. R.S. Mishra, Z.Y.Ma, Mater.Sci.Eng. R50(2005)1-78.
8. T. Tanaka, T. Morishige, T. Hirata, Comprehensive analysis of joint strength for dissimilar friction stir welds of mild steel to aluminum alloys, Scr. Mater. 61(October (7)) (2009) 756-759
9. Stephan W. Kallee, E. Dave Nicholas and Wayne M. Thomas, TWI Ltd, Friction stir welding - invention, innovations and applications INALCO 2001 8th International Conference on Joints in Aluminium Munich, Germany, 28-30 March 2001.
10. Sarang Shah, Sabri Tosunoglu, Friction Stir Welding: Current State of the Art and Future Prospects, Florida International University Department of Mechanical and Materials Engineering Miami Florida
The 16th World Multi-Conference on Systemics, Cyber netics and Informatics WMSCI 2012 Orlando Florida July 17-20, 2012.
11. Rajiv S. Mishra, Murray W. Mahoney, Friction Stir Welding and Processing editors, p 1-5 DOI:10.1361/fswp2007p001.

12. Backlund J, Norlin A, Andersson A: Friction stir welding - weld properties and manufacturing techniques. 7th Inalco Conference, Cambridge, 15-17 Apr 98, <http://www.woodhead-publishing.com>
13. First International Symposium on Friction Stir Welding, Thousand Oaks, CA, USA, 14-16 June 1999.
- 14.1 st Int Symp on FSW, Thousand Oaks, CA, June 1999.
15. www.thomasnet.com/articles/
16. P L Threadgill, A J Leonard, H R Shercliff and P J Withers, Friction Stir Welding of aluminium alloys, International Materials Reviews, vol.54. no.2. March 2009. pp. 49-93.
17. <https://googleweblight.com/>
18. D. A. Price, S. W. Williams, A. Wescott, C. J. C. Harrison, A. Rezai, A. Steuwer, M. Peel, P. Staron and M. Kocak: Sci. Technol. Weld. Join., 2007, 12, 620-633.
19. P. L. Threadgill and M. E. Nunn: 'A review of friction stir welding: part 1 process overview ', TWI members report no. 760/2003, TWI, Abington, UK, 2003.
20. Y. Uematsu, K. Tokaji, Y. Tozaki, T. Kurita and S. Murata: Int. J. Fatig., 2008, 30, 1956-1966.
21. D. Muruganandam, C. Balasubramanian and B. Gokulachander, Review Paper on Friction Stir Welding of Aluminium and Magnesium Alloys, Indian Journal of Science and Technology, Vol 8(35), DOI:10.17485/ ijt/ 2015/v8i35/86774, December 2015.
22. Kumar Arya, Gourav Gupta, Atul Kumar Rajput, org, A Review on Friction Stir Welding for Aluminium Alloy to Steel Pradyumn, International Journal of Scientific & Engineering Research, Volume 7, Issue 5, May-2016 119ISSN 2229-5518IJSER © 2016<http://www.ijse>.

