Modeling And Analysis Of Friction Stir Welding On Al Alloy 6061

Mohammed Ilyas Hamid
Asst. Professor, Mechanical Engineering Department
AHCET
Chevella, India

Mohd Muzammil Uddin
Asst. Professor, Mechanical Engineering Department
DCET
Hyderabad, India

Mohammad Khaja Yousufayan
Asst. Professor, Mechanical Engineering Department
NSAKCET
Hyderabad, India

***Abstract*— Aluminum alloy 6061 is widely accepted for the production of light weight structures which has high strength to weight ratio. Compared to fusion welding processes which is commonly used for welding structural aluminum alloys, friction stir welding process is a revolutionary solid state joining process in which the material which is being welded neither melts nor recast. This process utilizes non-consumable tool in order to generate frictional heat between the butting surfaces. The welding parameter such as tool pin profile plays a vital role in deciding the welding quality.**

In this work, a trail is conducted in order to understand the effect of welding speed as well as tool pin profile upon FSP zone formation in Aluminum alloy 6061. Two types of tool pin profiles are used to analysis the welding joints. Those profiles are 1.Straight cylindrical, 2.Tapered cylindrical. In this work we are also conducting coupled field analysis for cutting tools as well as welding plates.

We conducted experimental work upon milling machine. Fixture, cutting tools and plates are prepared. Major parameters taken for this project include Cut feed, spindle RPM.

Machine that is used for the experimental work is FN2 semiautomatic machine. For modeling we used Pro/Engineer software and for analysis ANSYS10.

Keywords*— *Friction stir welding, Pro-E, Aluminium alloy 6061, ANSYS

I. Introduction

Friction stir welding (FSW) is a solid-state welding process that gained much attention in research areas as well as manufacturing industry since its introduction in 1991. FSW has been used in high technology applications such as aerospace to automotive till high precision application such as micro welding. The main feature of a solid-state welding process is the non-melting of the work material which allows a lower temperature and a lower heat input welding process relative to the melting point of materials being joined.

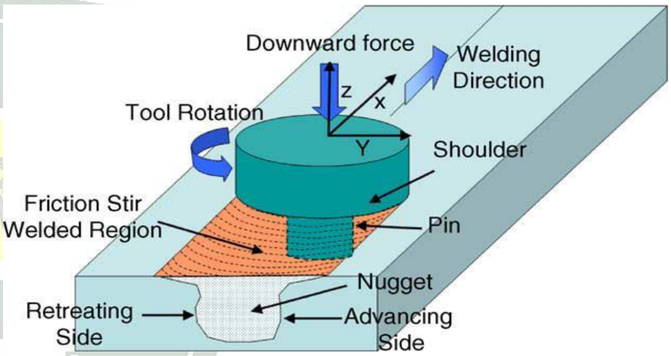

Fig. 1. Schematic Drawing Of FSW.

A. Parameter of FSW experiment

TABLE I. Experimental Parameters

Properties/parameter	**Values**
Work material dimension	100×50×3
Shoulder radius , mm	20
Pin radius, mm	2.5
Pin height ,mm	3
Pin conical angle ,◦	2
Tool angle	2
Work piece material	6061
Tool material	H.S.S

B. Introduction to Al alloys

Aluminium alloys are alloys in which aluminium (Al) is the predominant metal. The alloying elements constitute copper, magnesium, manganese, silicon, and zinc. There are mainly two classifications such as casting alloys and wrought alloys. Each of these alloys is further subdivided into the categories such as heat-treatable and non-heat-treatable. Aluminium alloy compositions are registered with The Aluminium Association many organizations publish more specific standards in order to manufacture of aluminium alloy, including the Society of Automotive Engineers standards organization, specifically its aerospace standards subgroups, and ASTM International.

TABLE II. AA 6061 COMPOSITION

Component Elements:	Metric
Aluminium, Al	95.8 - 98.6 %
Chromium, Cr	0.040 - 0.35 %
Copper, Cu	0.15 - 0.40 %
Iron, Fe	< 0.70 %
Magnesium, Mg	0.80 - 1.20 %
Manganese, Mn	< 0.15 %
Other, each	< 0.050 %
Other, total	< 0.15 %

Aluminium alloy AA6061 is a medium strength alloy with excellent corrosion resistance. It has the highest strength of the 64430 series alloys.

II. METHODOLOGY

A. Experimental Procedure

Rolled plates of 3mm in thickness were cut into the required size (100mm x 50 mm x 3 mm) by power hacksaw cutting and milling. The experiments were conducted on the aluminium alloy IS 64430.Rolled plates of 3mm in thickness were cut into the required size (100mm x 50 mm x 3 mm) by power hacksaw cutting and milling. The experiments were conducted on the aluminium alloy IS 64430. The process was repeated for tool travel rate of 90 mm/min for the tool speeds of 1400rpm. The plates where then subjected to mechanical testing.

B. Work Piece And Tool Modelling

Pro/ENGINEER Wildfire is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Pro/ENGINEER CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products. Customer requirements may change and time pressures may continue to mount, but your product design needs remain the same - regardless of your project's scope, you need the powerful, easy-to-use, affordable solution that Pro/ENGINEER provides.

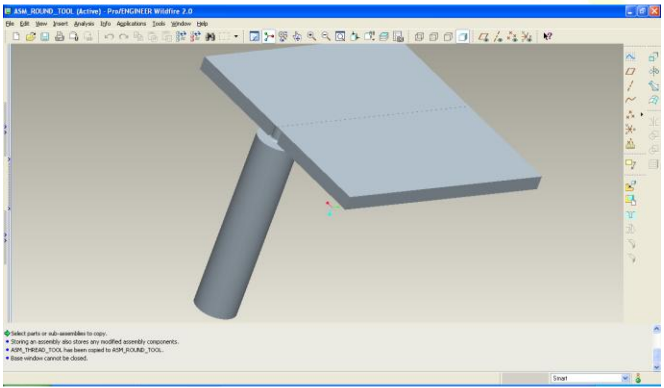

Fig. 2. Pro-E Round Tool Model.

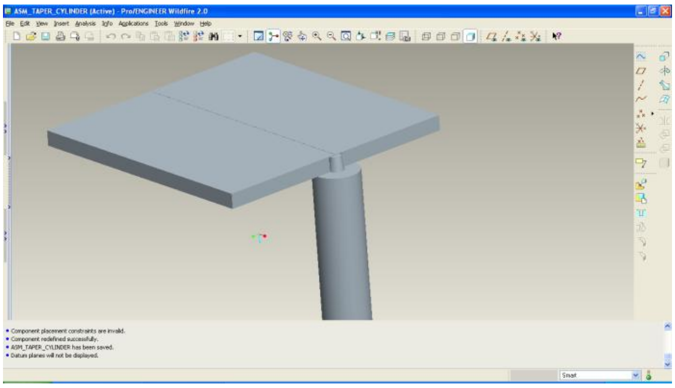

Fig. 3. Pro-E Tapered Tool Model.

Fig. 4. After Welding Workpiece.

Fig. 5. Tools Of Friction Stir Welding.

III. ANALYSIS REPORTS

A. Report Of AA 6061 at 1200 RPM

- Temperature – 703K.
- Pressure – 19.68Mpa.

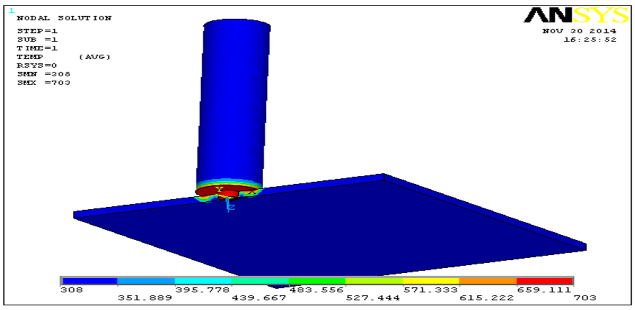

Fig. 6. Temperature distribution at 703oC: for round tool.

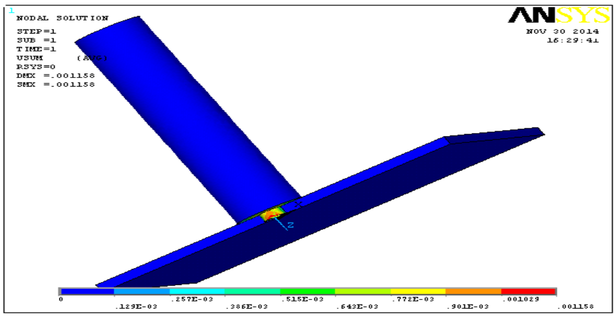

Fig. 7. Displacement at 7030C: for round tool.

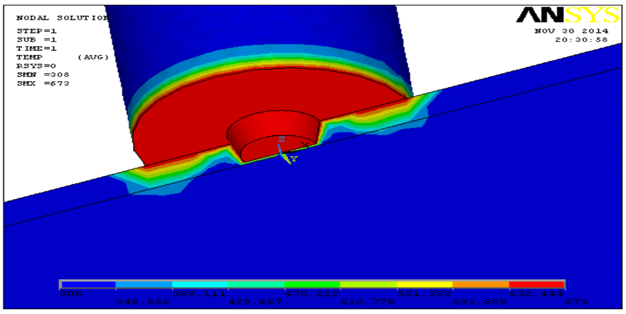

Fig. 8. Temperature distribution at 6730C: taper tool.

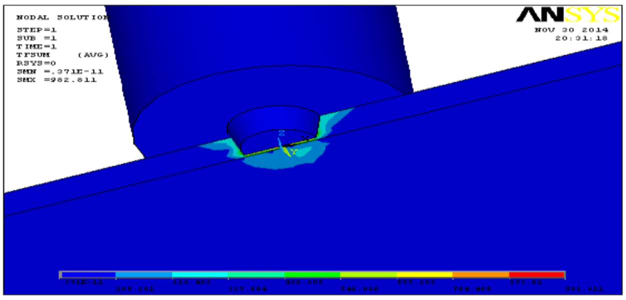

Fig. 9. Thermal flux at 6730C: taper tool.

IV. Results and Conclusion

TABLE III. THERMAL RESULTS: (T.G – TEMPERATURE GRADIENT, T.F- THERMAL FLUX)

	RPM	AA-6061 (WORK MATERIAL)		
		Temperature	***T.G***	***T F***
Round Tool	1000	673^{0}C	5398	971.667
	1200	703^{0}C	6232	1122
Round Taper Tool	1000	673^{0}C	5460	982.811
	1200	703^{0}C	5909	1064
	1200	703^{0}C	6406	1153
	1200	703^{0}C	1327	86.098
	1200	703^{0}C	5457	982.322

In this work, thermal analysis has been done for the welding process at variable speeds and temperatures. A comparative study has been done and tabulated as shown above.

The selected two types of tools viz., round tool, round taper tool shows properties as below:

- For the given material, as the RPM increases, working temperature, temperature gradient, thermal flux increases.
- For a given speed, temperature gradient and thermal flux for round taper tool is more when compared to round tool.

It can be observed from the above analysis and experiment that round tool shows better welding characteristics and is more suitable for welding.

References

[1] Thomas WM, Nicholas ED, Needham JC, Murch MG, Templesmith P, Dawes CJ.Friction Stir Butt Welding, GB Patent No. 9125978.8; 1991.

[2] Dawes CJ, Thomas WM. Friction Stir Welding of Aluminium Alloys. TWI Bulletin;1995; 6 : 124-127.

[3] Hwang YM, Kang ZH., Chiou YC, Hsu HH. Experimental Study on Temperature Distributions within the Workpiece during Friction Stir Welding of Aluminium Alloy, International J of Mach Tools Manu 2008; 48: 778-787.

[4] Kim D, Badarinarayan H, Kim JH, Kim C, Okamoto K, Wagoner RH, Chung K Numerical Simulation of Friction Stir Butt Welding Process for AA5083-H18 Sheets. Eurj Mechanics A-Solid; 2010; 29 (2): 204 – 215.

[5] Jauhari TK. Development of Multi-Component Device for Load Measurement and Temperature Profile for Friction Stir Welding Process [M.Sc Thesis]. Penang: University Saints Malaysia; Unpublished. 2012.

[6] American Welding Society, Welding Handbook, 9th Edition, Volume 3, Welding Process; AWS, 2007.

[7] Popov VL, Mechanics and Frictions, Physical Principal and Application, London: Springer 2010.

[8] Sherwood BA, Bernard WH. Work and Heat Transfer in the Presence of Sliding Friction. Am J Phys. November 1984; 52 (11): 1001-1007.

[9] Ravichandran G, Rosakis AJ, Hodowany J, Rosakis P. On the Conversion of Plastic Work Into Heat During High-Strain-Rate Deformation. Shock Compression of Condensed Matter Meeting. American Physical Society; June 24-29, 2001. p 557 – 562.

[10] Schmidt H, Hattel J, Wert J. An Analytical Model for the Heat Generation in Friction Stir Welding, Model Simul Mater Sc. 2004; 12 (1): 143-157.

[11] Nandan R, Roy GG, DebRoy T. Numerical Simulation of Three-Dimensional Heat Transfer and Plastic Flow during Friction Stir Welding, Metal Mater Trans A. April 2006, 34A: 1247 – 1259.

[12] Schmidt HB, Hattel JH. Thermal Modelling of Friction Stir Welding Scripta Mater 2008; 58: 332 – 337.