Journal of Advanced Engineering Research
ISSN: 2393-8447
Volume 4, Issue 1, 2017, pp.5-9

Effect of Variation in Tool Rotational Speed on Tensile Strength and Hardness of Dissimilar Friction Stir Spot Welded Al/Cu Joints

S. Siddharth*, T. Senthilkumar

Department of Mechanical Engineering, University College of Engineering (BIT Campus), Tiruchirappalli, India

*Corresponding author email: sksmsiddharth1@yahoo.in

ABSTRACT

Dissimilar material joining possess much difficulty due to the differences in mechanical and metallurgical properties such as density, melting point and thermal conductivity. However solid state material joining techniques such as friction stir spot welding can be used to spot join dissimilar materials without much difficulty. In this investigation, dissimilar joints using aluminum Al 5083 alloy and commercial copper C10100 were made using friction stir spot welding. The important friction stir spot welding process parameters were varied and the effects of changes in tool rotational speed at constant plunge depth and dwell time were observed. The effect of the changes in tool rotational speed on the tensile properties and interface micro hardness of the joints were evaluated.

Keywords - Friction stir spot welding, dissimilar materials, aluminum, copper.

1. INTRODUCTION

Friction stir spot welding is a linear variant of friction stir welding developed by The Welding Institute at 1991 UK London [1]. Since friction stir spot welding is a solid state material joining process it is being used in industrial applications for successfully joining similar and dissimilar materials [2]. It is a better suited method than resistance spot welding for joining dissimilar materials as it is consumable free and causes very less environmental pollution. It is a three step process involving plunging where a high speed rotating non consumable tool is plunged into the workpieces to frictionally stir. Second is dwell period which is the duration till which the tool is retained at the plunged position to increase the frictional heat and soften the weld zone. Final is the drawing out when the tool is withdrawn from the weld region thereby allowing the weld region to cool and thereby form a spot joint [3]. It is shown in Fig 1.

Many researchers have used friction stir spot welding (FSSW) process for joining metallic alloys, with similar and dissimilar combinations. Joaquin M. Piccini et al conducted FSSW experiments on dissimilar combinations of AA6063 and galvanized low carbon steel and evaluated the effect of pin length on the tensile properties of the joints [4]. S. Joy-A-Kaa et al evaluated the fatigue fracture cracking mechanism of FSSW joints of low carbon steels. Under variable force amplitude the cumulative fatigue damage was also calculated for the joints [5]. Muna K. Abbass eta al optimized the friction stir spot welding process parameters on dissimilar FSSW joints of AA2024 T3 with pure copper sheets using Taguchi technique [6,7].

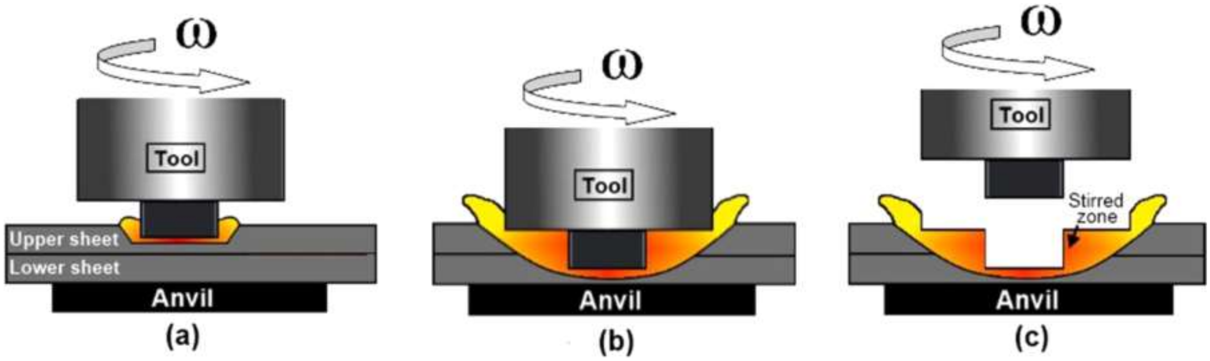
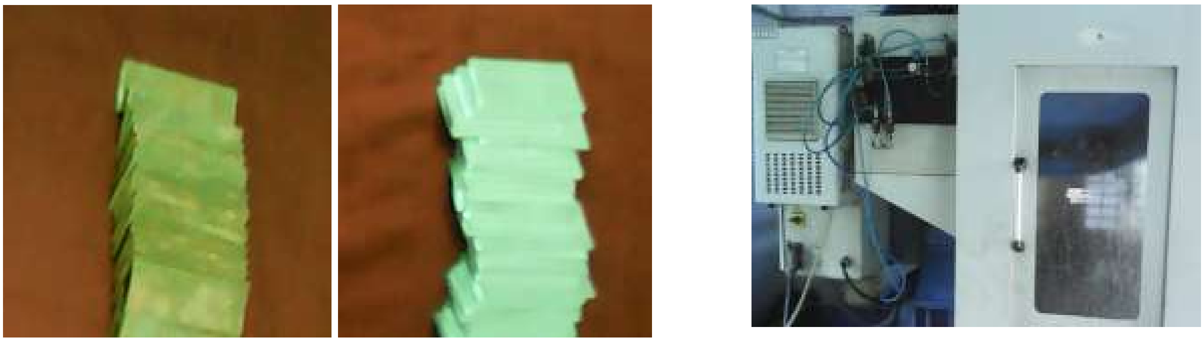


Fig. 1 Three step friction stir spot welding process

In this investigation an attempt has been made to analyze the variations in the speed of rotation of the non-consumable tool on dissimilar Al/Cu FSSW joint properties.

2. MATERIALS AND METHODS

For this investigations the base materials selected were Al 5083 aluminum alloy of 1.5 mm thickness and commercial copper sheet of 1.5 mm thickness. The surfaces were thoroughly cleaned and the joining sides were wiped with phenol to remove contaminants. The work pieces were sized to 100 mm length and 30 mm breadth. The sized materials are shown in Fig 2(a). For the purpose of fabrication of FSSW joints a heavy type vertical computer numerically controlled milling machine was used. It is shown in Fig 2(b).



(a) (b)

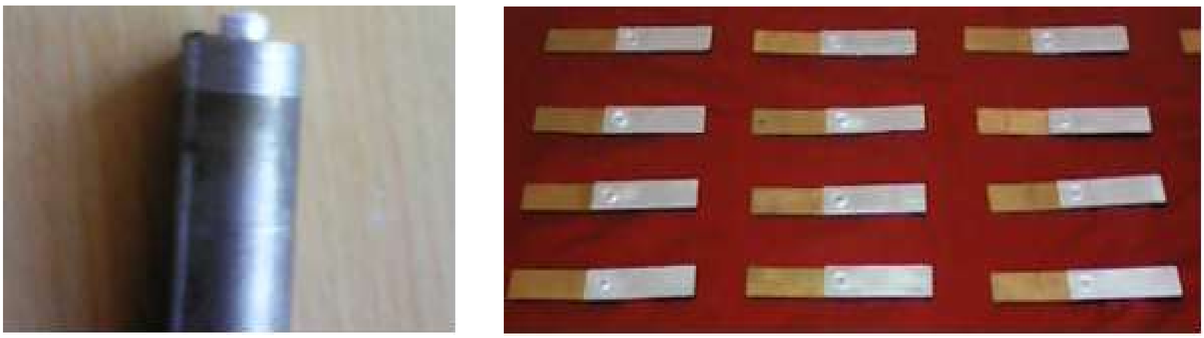
Fig. 2 (a) Base materials, (b) FSSW equipment

*Table **1** Nominal chemical composition of the base materials (wt. %).*

Al 5083	Si	Mg	Mn	Fe	Cr	Cu	Zn	Ti	Al
	0.4	4.0-4.9	0.4-1.0	0.4	0.25	0.1	0.15	0.19	balance
C10100	Pb	Sn	S	Fe	Zn	O	P	As	Cu
	0.003	0.002	0.004	0.004	0.003	0.002	0.002	0.002	balance

Table 2 Important mechanical properties of the base materials

Material	Yield Strength (MPa)	Tensile strength (MPa)	Elongation (%)	Hardness (HV)
Al 5083	156	286	21.5	95
C10100	288	321	19.5	87



(a) (b)

Fig. 3 Fabricated materials

Table 3 – FSSW process parameter values and observations.

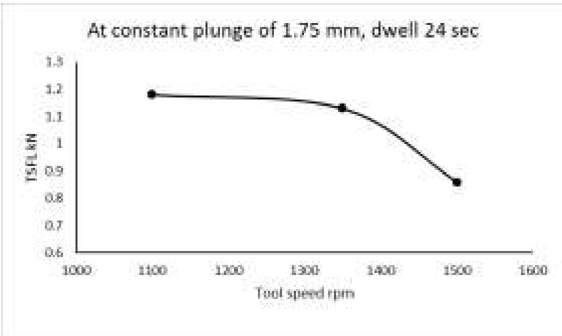
S No	Plunge depth (mm)	Dwell time (sec)	Tool rotational speed (rpm)	Tensile shear failure load (kN)	Interface hardness (HV)
1	1.75	24	1500	0.86	107
2	1.75	24	1350	1.13	105
3	1.75	24	1100	1.18	103
4	2.00	24	1500	1.22	106
5	2.00	24	1350	1.41	97
6	2.00	24	1100	1.12	103
7	2.25	20	1500	1.83	104
8	2.25	20	1350	1.62	101
9	2.25	20	1100	1.8	99
10	2.5	20	1500	1.43	102
11	2.5	20	1350	1.29	104
12	2.5	20	1100	1.07	105

The chemical composition of the base materials is given in Table 1 and the important mechanical properties are given in Table 2.

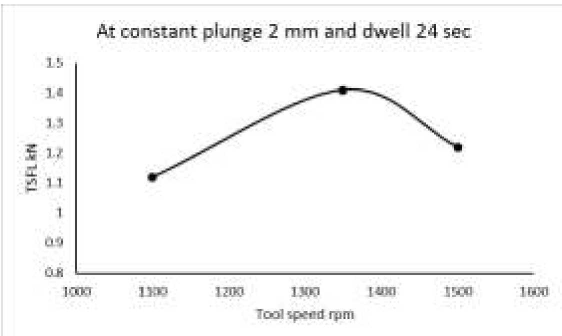
3. RESULTS AND DISCUSSION

The joints which were fabricated were subjected to tensile tests. The tensile shear failure load values of the joints were analysed using a 40-ton capacity electro mechanically controlled universal testing machine. As per ASTM standards the specimens were loaded at a uniform rate of 1.5 kN/min till fracture. The tensile shear failure load (TSFL) values of the joints are recorded in Table 3. The interface micro hardness (IH) was observed using Vickers micro hardness testing machine. For each specimen the micro hardness was calculated at three different regions and the average of the three were recorded and shown in Table 3.

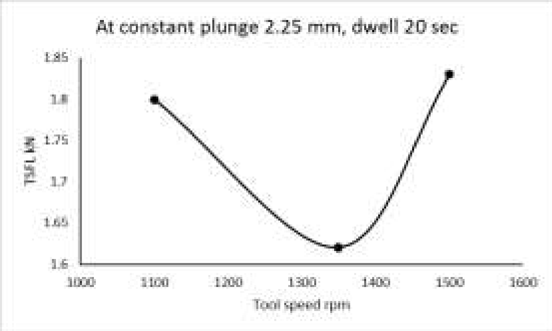
Effect of increase in tool speed is shown in Fig 4. At 1.75 mm plunge and 24 sec dwell decrease in TSFL is observed on increasing the tool speed (Fig 4(a)). At 2 mm plunge the tensile strength increases for certain rise in tool speed and then it decreases (Fig 4(b)). At 2.25 mm plunge and 20 sec dwell, TSFL fluctuates to a lower value and then increases (Fig 4(c)). At 2.5 mm plunge and 20 sec dwell, TSFL is found to increase from 1100 to 1500 rpm. The variations in interface hardness were studied and are shown in Fig 5. At 1.75 mm plunge and 24 sec dwell, gradual rise in IH is observed in Fig 5(a). At 2 m plunge, 24 sec dwell IH initially decreases and then increases on increase in tool speed (Fig 5(b)). This is attributed to the annealing effect of the heat generated by the tool. At 2.25 mm plunge and 20 sec dwell, gradual increase in IH on increase in tool speed (Fig 5(c)). At 2.5 mm plunge and 20 sec dwell, decrease in IH was observed on increasing tool speed due to increased stir.



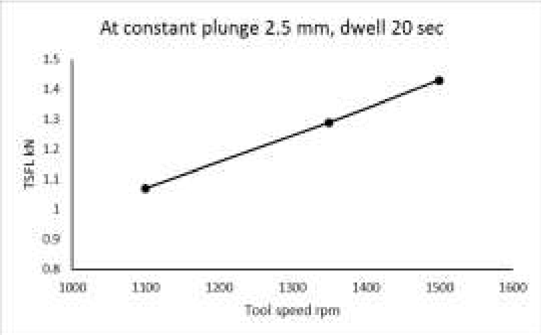
(a)



(b)

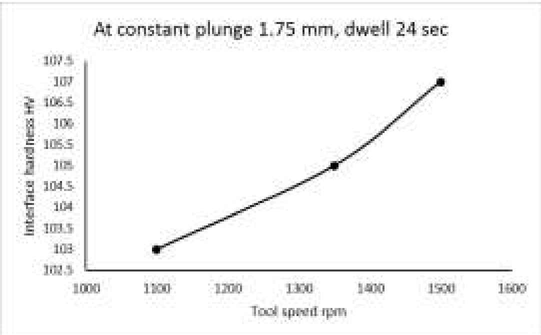


(c)

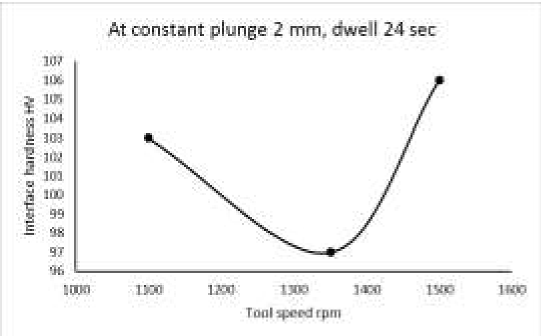


(d)

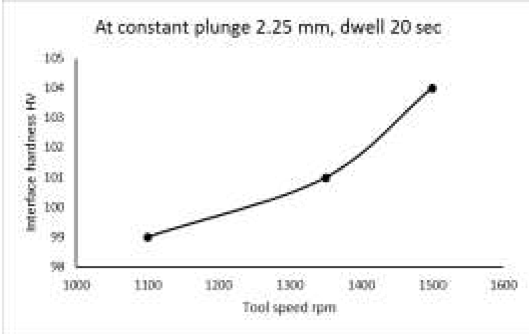
Fig 4. Variation of TSFL with changes in tool speed



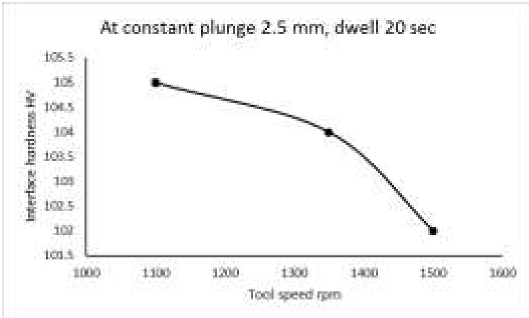
(a)



(b)



(c)



(d)

Fig 5. Variation of Interface hardness with changes in tool rotational speed

4. CONCLUSION

Thus dissimilar Al/Cu FSSW joints were made and the effect of changes in tool rotational speed on the tensile shear failure load values and interface hardness were evaluated. At 2.25 mm plunge depth, 20 sec dwell and 1500 rpm tool speed highest TSFL of 1.83 kN was observed. At 2 mm plunge depth, 24 sec dwell and 1350 rpm tool speed minimum interface hardness of 97 HV was obtained.

REFERENCES

[1] W.M. Thomas, E.D. Nicholas, J.C. Needham, M.G. Murch, P. Temple-Smith, C.J. Dawes, Friction stir butt welding, *International Patent Application* No. PCT/GB92/02203; 1991.

[2] S.W. Baek, D.H. Choi, C.Y. Lee, B.W. Ahn, Y.M. Yeon, K. Song, Structure–properties relations in friction stir spot welded low carbon steel sheets for light weight automobile body, *Mater Trans* 51(2), 2010, 399–403.

[3] M.K. Kulekci, U. Esme, Onur Er, Experimental comparison of resistance spot welding and friction-stir spot welding processes for the EN AW 5005 aluminum alloy, *Materials and Technology,* 45, 2011, 395–399.

[4] J.M. Piccini, H.G. Svoboda, Effect of pin length on Friction Stir Spot Welding (FSSW) of dissimilar Aluminum-Steel joints, International Congress of Science and Technology of Metallurgy and Materials, SAM – CONAMET 2014, *Procedia Materials Science,* 9, 2015, 504 – 513.

[5] S. Joy-A-Ka, Y. Ogawa, A. Sugeta, Y. F. Sun, H. Fujii, Fatigue Fracture Mechanism on Friction Stir Spot Welded Joints Using 300 MPa-Class Automobile Steel Sheets under Constant and Variable Force Amplitude, 20th European Conference on Fracture (ECF20), *Procedia Materials Science,* 3, 2014, 537–543.

[6] A. Bhojan, N. Senthilkumar, B. Deepanraj, Parametric Influence of Friction Stir Welding on Cast Al6061/20% SiC/2% MoS2 MMC Mechanical Properties, *Applied Mechanics and Materials*, 852, 2016, 297-303.

[7] M.K. Abbass, Sabah Kh, Hussein, Ahmed Adnan Kudair, Optimization of friction stir spot welding parameters of dissimilar welded joints of aluminum alloy (AA2024T3) with pure copper sheets, *International Journal of Engineering Sciences & Research Technology,* 4(12), 2015, 514-526.