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The Effect of Micro Friction Stir Spot Welding Parameters to Cu-Al Dissimilar Joint

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***Abstract*—Dissimilar welding or joining dissimilar metals using welding process, Micro welding or welding process for joining metals less than 1 mm, have unique problem difference of thermal properties from metals lead to melting processes and thin of metal affected easy to filed (hole). Welding parameters affected to weld join performance, this study discussed effect of Micro Friction Stir Spot Welding (Micro-FSSW) parameters to performance of both thin plate of 0.5mm of Copper with 0.5 of aluminium which were joined by welding process. Tensile test was used as the mechanical performance analysis. Micro-FSSW succeeds to joint thin Cu and Al plate. Weld joint welded by shoulder diameters 6 mm, welding force 50 kgf, and 3000 rpm of rotation speed (constant), and welding time 60 sec could be achieved 401.7 N of maximum load.**

***Keywords*—micro friction stir spot welding, dissimilar metals, copper-aluminium, mechanical properties**

I. Introduction

Each materials has advantages mechanical properties which can be applied for a construction or a device, however difference thermal properties is a problem of welding process [1]. Micro Friction Stir Welding (Micro FSW) is a welding process for base metals which has thickness less than 1mm using Friction Stir Welding[2]. Micro Welding or welding process for plates with thickness less than 1mm can be applied to light construction for supporting low weight construction such as battery and fuel cell. Production high efficiency and low weight construction as highlight issues for researchers and engineer to improve a production of hybrid structures [2]. Many researchers studied dissimilar FSW to encourage hybrid construction structures.

Some researchers studied dissimilar welding such as Tianhao Wang et all studied mechanical properties and interfacial both metals a magnesium-steel joint welded by Friction-stir Assisted Scribe Technique [3]. Elnabi et all studied a nugget of dissimilar Fe-Al friction stir weld, they evaluated the intermetallic compound formation. Intermetallic compound developed tend to brittle [4]. Gagliardi et all joined metallic and Polymeric using Friction Stir Forming [5]. Differences materials lead to intermetallic compound and also thermal resistance effected to melting condition, these are problems in dissimilar welding. Thinness of base metals is as also big problem for welding process not only for friction but also another. Some studies about mechanical properties of weld joint have been studied by some researchers. Mechanical properties of Aluminum to Magnesium joint with Sn-coated steel as interlayer welded by Resistance spot welding were studied by M. Sun et al. [6]. Lacki and Niemiro studied the strength on beam made of titanium grade 2 and 5 welded by Resistance spot welding [7]. Xiao-yong WANG et al also studied mechanical properties of magnesium to steel used Metal Inert Gas (MIG) welding [8]. Mechanical and microstructure properties of a new alloy join of Al-Zn-Mg-Cu welded by TIG and Laser were compared by Liang Zhang et al [9]. I. Tomashchuk et al studied the evolution of mechanical and microstructure properties from the titanium alloy and stainless steel with copper as interlayer welded by an electron beam welding [10]. M.H. Razmpoosh et al also studied the mechanical properties and microstructural evolution from TWIP steel joint welded by Resistance spot welding [11].

Micro welding has been also studied by researchers such as Mehlmann et al developed laser micro welding for joining thin cupper of 300 μm, Ultrasonic welding was used to create aluminum with copper bonding [12]. Kondapalli Siva Prasad et al analyzed weld performance from Austenitic Stainless Steels joint of Micro plasma arch welding, the plate thickness of 0.25 mm. The compared welding quality of some type AISI 3xx, AISI 304 has highest hardness and tensile strength [13]. Hu Zhang et al analyzed of high frequency of radiation of micro plasma welding, SS 304 with thickness 0.1 mm as specimen [14]. Baskoro et all studied mechanical properties and microstructure from dissimilar welding of SS301-Al1100 micro RSW joints, the thickness of both base metals is 200 μm and 400 μm [15].

Manickam et all had been studied Friction Stir Spot Welding (FSSW) AA-Cu Alloy [16]. AA-Cu lap joint of Micro-FSSW with Cu on the AA sheet has been studied in this discussion. Few researchers discussed micro dissimilar welding, dissimilar welding has differences thermal properties, it is the problem for welding process and thinness of base metals is also problems in micro welding. In this study discussed performance of a Cu-Al micro-weld joint. This study discussed the performance of AA-Cu micro-FSSW joints.

II. Material and Methods

Cupper sheet was cut based on dimension standard of American Welding Society (AWS), 19 mm of wide, and 76 mm of length because of the thickness from plate 0.5 mm[17]. The thickness of Copper and Aluminum sheet are 0.5 mm. Each piece of both metals was washed by pure alcohol. Both base metal types were cut shown in Figure 1.

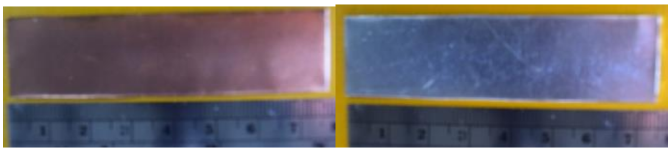

Fig. 1. A piece of copper and a piece of aluminum.

Both metals were welded by FSSW lap joint with copper sheet on aluminum sheet. Welding position from base metals was shown by Figure 2. Circle on the cupper represented that Up-side of copper sheet was plunged by shoulder.

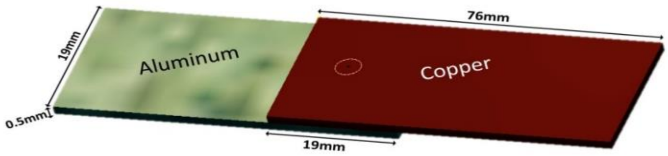

Fig. 2. Overlap of both based metals with a piece of copper above of an aluminium.

Dimension of shoulder in this study has pin inter center, the diameter of shoulders is 4mm, 6mm, and 8mm. Long and diameters of pin were same or constant. Electric motor was used to rotate the shoulders with rotation speed of shoulder constant 3000 rpm, and shoulder forces were 30 kgf, 40 kgf, and 50 kgf (Table 1).

TABLE I. WELDING PARAMETERS AND VALUE OF LEVELING

Solder Diameters (mm) S	Pressure / Force (kgf) F	Rotations Speed (rpm)	Welding Time (Sec)	Specimen Code
4	30	3000	60	SD4F30Sx
6	40	3000	60	SD6F40Sx
8	50	3000	60	SD8F60Sx

Each combination of welding parameters was used to joint 5 specimens, 3 specimens used to tensile tested, and 1 specimen used macrostructure analysis. A welded specimen was shown in Figure 3.

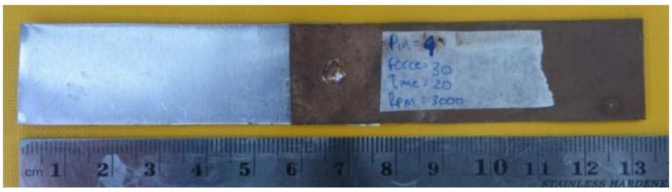

Fig. 3. Both pieces of metals welded.

27 specimens were measured load maximum represented the mechanical properties from weld nugget performance.

Tensile test process for three specimen of each combination welding parameters, each tested specimen was given such as SD4F30S1, SD4F30S2, SD4F30S3. Hydraulic Universal Testing Machine of UH-500kNI Series from SHIMADZU was used for tensile test. The tensile test machine was shown by Figure 4.

Fig. 4. A specimen installed and tensile test machine.

Base metal loss each other because of resistance from weld nugget lower than load force. Speed load was 0.5 mm/min used 10 N of sensitivity.

III. Results and Analysis

Specimens welded by each combination welding parameter, third of repetition have difference maximum load value. Welding parameters with 4mm of Shoulder Dimension, 30 kgf of Welding Force, 60 Sec of Welding Time (constant), and 300 rpm of Rotation Speed (constant) succeed to joint Cu-Al however each repetition achieved maximum load was difference, 401.6 N of SD6F50S3 that represent Shoulder Diameter is 6mm, Welding Force is 50 kgf, and Second of repetition 2, 272.6 N of SD6F40S1, and 292 N of SD6F40S3. The highest of maximum load achieved by weld joint from leveling of shoulder diameter were shown in Figure 5.

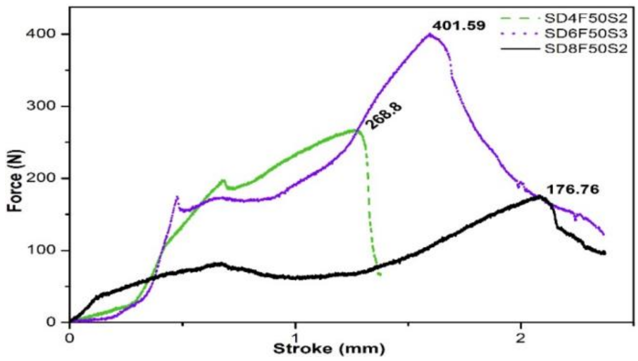

Fig. 5. The highest of maximum load from each shoulder diameter leveling.

IV. Conclusion

A weld joint joined by shoulder diameters 6 mm, welding force 50 kgf, and S2 or second repetition could be achieved 401.7 N of maximum loading from tensile test. Shoulder used by diameter 8 mm could only achieve 176.8 N as the highest of the diameter 8 mm. A joint welded by shoulder diameter 4 mm with welding force 50 kgf can be resistance 268.8 N of load.

Acknowledgments

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