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The Innovation Breakthrough in Digital and Disruptive Era

Development Of Dissimilar Micro Friction Stir Welding Copper With Aluminium Plate

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Abstract. Friction welding as joining method has a good joining condition. The results of FSW welding have the advantage that the surface is smoother and flatter than the results of arc welding. Friction rotary welding includes several stages, namely material welding and microstructural analysis. In this study the material welding was used copper and aluminum alloy 1100 with sizes 60mm, 50mm, 0.5mm and macro structural analysis using a digital microscope. Experiments were carried out using lap joints with dimensions of 100mm, 50mm, 0.5mm with variations in loading parameters of 30kgf, 40kgf, 50kgf and variations in shoulder diameters of 4mm, 6mm, 8mm. In the experiment, the larger the diameter of the shoulder, the greater the loading required to connect the two materials, but if the loading is too large, it can cause defects in the welding results. The welding results at the welding pressure parameter of 40kgf with a shoulder diameter of 8mm show that welding with these parameters is capable of performing welding because the areas of the welding results are evenly connected and there are no holes (hooks) in the welding results. The results of welding at a welding pressure parameter of 50kgf with a shoulder diameter of 8mm show that the results of joining the copper and aluminum are mixed evenly but damage the surface of the copper. The macro structural results show that the welding pressure affects the shoulder diameter, if the welding pressure is too large and the shoulder diameter is too small it will only damage the copper and aluminum material because it only has a thickness of 0.5 mm, and vice versa if the welding pressure is too small and the shoulder diameter is too large, the two materials cannot be connected. In this study, the best results were obtained with a shoulder diameter of 4mm and a pressure of 40kgf because there were no defects or holes in the welding results.

Key word : Dissimilar Welding; Micro welding; Micro friction stir welding

1 Introduction

Friction welding as joining method has a good joining condition (Kumar, et al. 2023). Seerangan Ragu Nathan et al studied Friction welding used to joint light weight ship building structures (Nathan, et al. 2023). Friction Stir Process was also up date process of Friction Welding (Bella, et al. 2023). Four differences microstructures were formed at weld joint for friction alloy at dissimilar welding process of metallic alloy (Djili, et al. 2023). Friction stir welding has been studied by some researchers.

C. Mukundhan et al studied Friction pressure microstructure and tensile properties of linear friction welded of Ti-6Al-4V alloy joints, they presented microstructure and tensile properties (Mukundhan, et al. 2023). Ahmed Samir A. Alemdar et al studied AA2024-T3 and AA2198-T8 welded by Friction Stir Welding, they discussed corrosion in the nugget weld (Alemdar, Jalal and Mulapeer 2023). Danang Priyasudana et al developed double Friction Stir Welding which was used joint the aluminium alloy, they analysed the corrosion rate and microstructure

properties (Priyasudana, et al. 2023). Mahshad Javidikia studied evolution of temperature and grain size of Ni-base super alloy Waspaloy welded by Linear Friction Stir welding (Javidikia, Champlaud and Jahazi 2023). Each materials has advantages which can be used in one construction (H. M. Ario Sunar Baskoro, Effect of interlayer in dissimilar metal of stainless steel SS 301 and aluminum alloy AA 1100 using micro resistance spot welding 2018).

Micro Friction Stir Spot welding used to joint copper and aluminium (Hakam Muzakki and Bale 2023). Differences in melting point, thermal coefficient and thermal

2 Materials and Methods

2.1 Properties of Copper and Aluminum

The copper material used in this study is pure copper with a characteristic warm red color.

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The content contained in copper is $99.19\% \pm 0.09$; Ca : $0.21\% \pm 0.02$; Fe : $0.17\% \pm 0.005$; Ni : $0.11\% \pm 0.003$. Copper has important properties including being an excellent conductor of heat and electricity, ductility, its readiness to form mixtures and resistance to corrosion from air through the formation of an oxide layer. Copper has a melting point of 1084.62°C , has a Brinell hardness of 874 Mpa, an electrical resistance of 20°C , and a heat conductivity of 300°C .

The aluminum used in this study is aluminum 1100. The electrical conductivity of aluminum is 60% greater than copper, aluminum is shiny white, is a metal that has a melting point of 600°C and is corrosion resistant. Aluminum composition owned: Al : 99.1% ; Fe : 0.508 % ; Si : 0.132% ; Mn : 0.0879 % ; Cu : 0.0852 % ; Mg : 0.0189 % ; Ti : 0.0172 % ; Zn : 0.0072 % ; Cr : 0.0012 % ; others : 0.0424 %.

2.2 Welding

The experimental parameters in this welding are the rotational speed of the machine used 3068 RPM in the form of a shoulder with a diameter of (4mm, 6mm, 8mm) with a given pressure of 30kgf, 40kgf and 50kgf. With a shoulder diameter of 8mm, it only uses 40kgf and 50kg pressure because 30kgf cannot connect copper and aluminum materials.

2.3 Dissimilar Metal Welding

The use of different materials in a different system in a particular engineering system is an expected standard. Metal welding is different between aluminum alloys with magnesium or aluminum alloys with iron alloys, and so on, including different basic materials. Friction rotary welding has been extensively investigated not only for joining the same metals or alloys but also for dissimilar alloys. Fusion and non-fusion welding have been widely used for different metals.

This welding uses three variations of the shoulder with a pin. The variations of the three shoulder shapes used can be seen in Fig. 1.

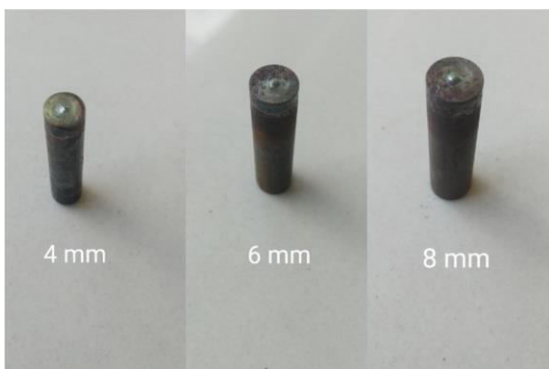


Figure 1. Shoulder with pin

Retrieval of welding data by adjusting the machine and cutting copper and aluminum specimens with a size variation of 60mm. 50mm. 0.5mm. The friction stir welding (FSW) process uses a lap joint type connection which is then combined 20mm long. The parameters used are the rotational speed of 3068 RPM in the form of a shoulder (4mm, 6mm, 8mm) with a given welding pressure of 30kgf, 40kgf and 50kgf using a weighing scale within 1 second. With a shoulder diameter of 8mm, it only uses 40kgf and 50kg pressure because 30kgf cannot connect copper and aluminum materials. The data collection process was carried out eight times with variations in pressure parameters and variations in shoulder diameter.



Figure 2. The best welding results with a shoulder diameter of 4mm with a welding pressure of 40kgf

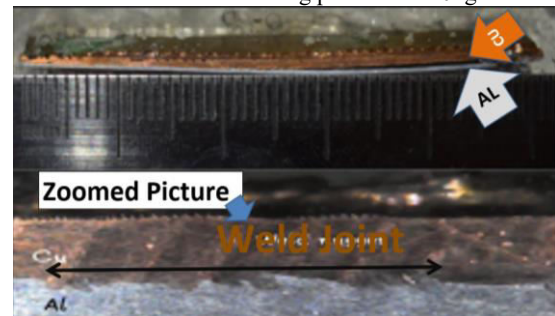


Figure 3. Results of the macrostructure with a shoulder diameter of 4mm and a welding pressure of 40kgf

The results of welding at a welding pressure parameter of 40 kgf with a shoulder diameter of 4mm can be observed that the results of joining copper and aluminum have no defects or holes (hooks). This can be interpreted that the results of welding with a welding pressure parameter of 30 kgf with a shoulder diameter of 4 mm are able to connect copper with aluminum, because there are no defects and the results of the welding are all connected.

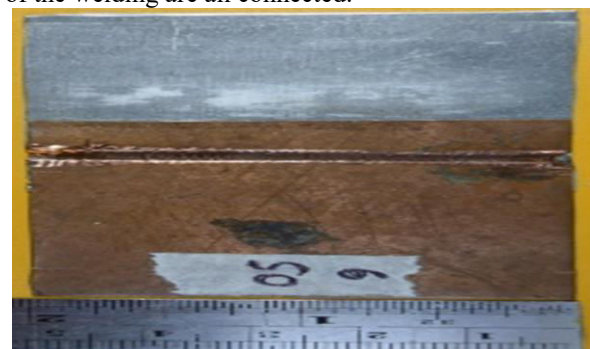


Figure 4. The best welding results with a shoulder diameter of 6mm with a welding pressure of 50kgf

3 Result and discussion

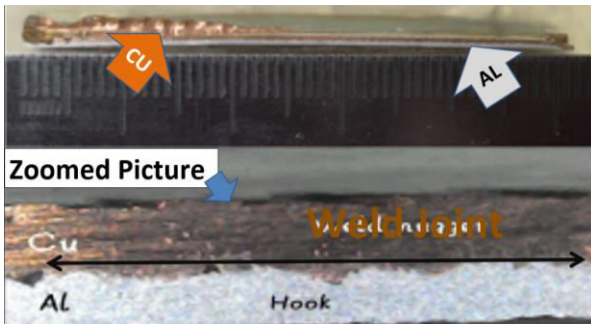


Figure 5. Results of the macrostructure with a shoulder diameter of 6mm and a welding pressure of 50kgf

The results of welding at the welding pressure parameter of 50 kgf with a shoulder diameter of 6 mm showed damage to the copper surface, and there was a hole (hook) in the welding area. This shows that the results of welding with a welding pressure parameter of 50 kgf with a shoulder diameter of 6 mm resulted in connecting copper with aluminum but there were holes in the welding area and the connection damaged the copper surface.

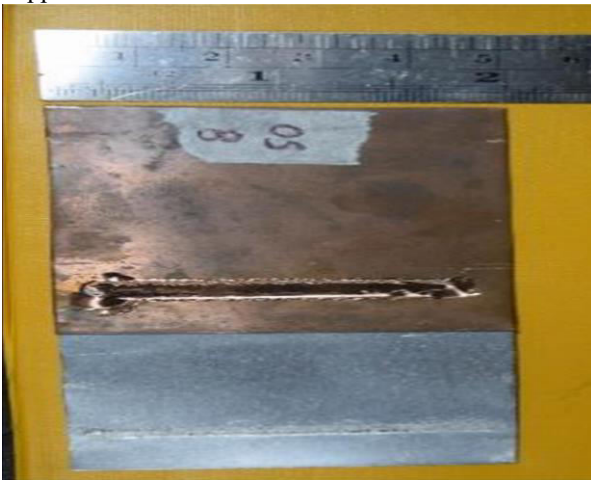


Figure 6. The best welding results with a shoulder diameter of 8mm and a welding pressure of 50kgf

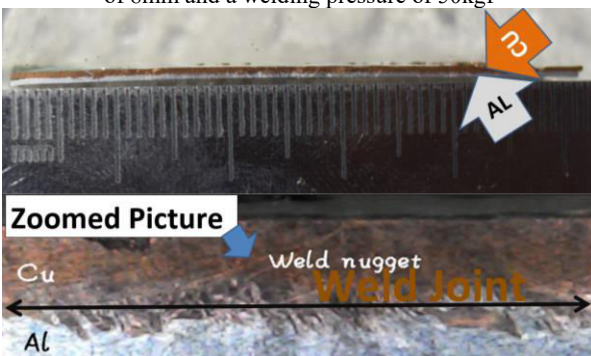


Figure 7. Results of the macrostructure with a shoulder diameter of 8mm and a welding pressure of 50kgf

The results of welding at a welding pressure parameter of 50 kgf with a shoulder diameter of 8 mm indicate that the results of joining copper and aluminum are connected evenly but damage the surface of the copper. This can be interpreted that the results of welding with a welding pressure parameter of 50 kgf with a shoulder diameter of 8 mm are able to connect copper with aluminum, but there are defects on the copper surface.

In this study there were also specimens that could be said to have failed because the parameters did not match between the shoulder diameter and the welding pressure. The following is an example with an explanation.

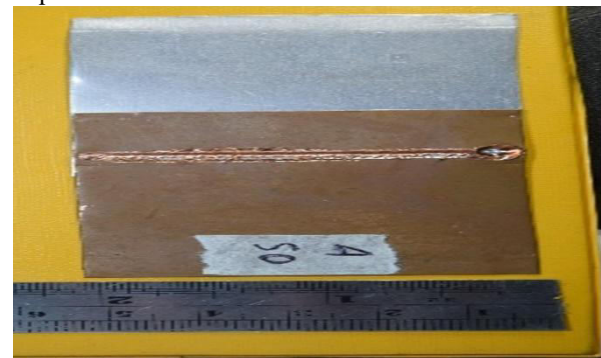


Figure 8. Results of welding with a shoulder diameter of 4mm and a welding pressure of 50kgf

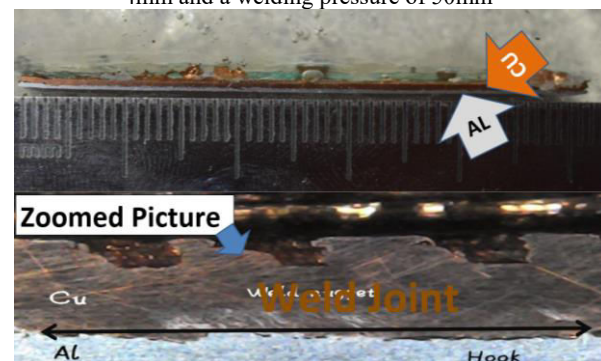


Figure 9. Results of the macrostructure with a shoulder diameter of 4mm and a welding pressure of 50kgf

The results of the welding at the welding pressure parameter of 50 kgf with a shoulder diameter of 4mm showed damage to the copper surface, the results of the copper and aluminum welding were not all connected and there was a hole (hook) in the welding area. It can be concluded that the results of welding with a welding pressure parameter of 30 kgf with a shoulder diameter of 4 mm are damaging.



Figure 10. Results of welding with a shoulder diameter of 6mm and a welding pressure of 40kgf

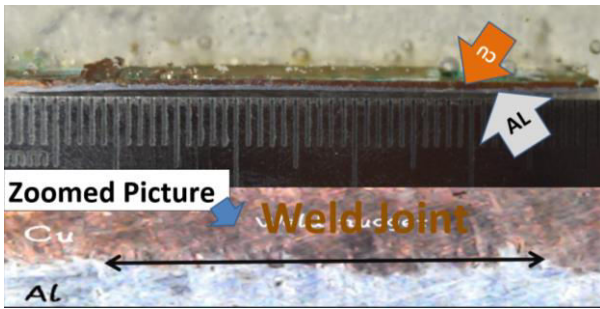


Figure 11. Results of the macrostructure with a shoulder diameter of 6mm and a welding pressure of 40kgf

The results of welding at a welding pressure parameter of 40 kgf with a shoulder diameter of 6 mm indicate that the copper and aluminum joints are perfectly connected because they are mixed evenly and there are no defects or holes (hooks). This can be interpreted that the results of welding with a welding pressure parameter of 40 kgf with a shoulder diameter of 6 mm are able to connect properly between copper and aluminum, because there are no defects and the results of the welding are connected evenly.



Figure 12. Results of welding with a shoulder diameter of 8mm and a welding pressure of 40mm

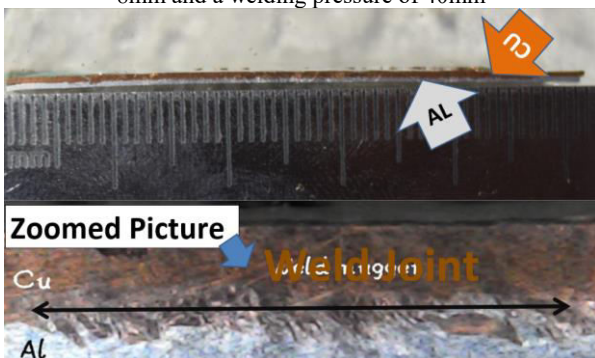


Figure 13. Results of the macrostructure with a shoulder diameter of 8mm and a welding pressure of 40kgf
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The results of welding at a welding pressure parameter of 40 kgf with a shoulder diameter of 8 mm indicate that welding with these parameters is capable of performing welding because the areas of the welding results are evenly connected and there are no holes (hooks) in the welding results. It can be concluded that the results of the welding pressure parameters of 40 kgf and a shoulder diameter of 8 mm can connect well between copper and aluminum.

Shoulder diameter and welding pressure affect the

welding results. This is because the friction between the shoulder and the work piece produces up to 80% of the melting point of the work material and the pin is pressed towards the area of the work piece to be connected and pulled. Insufficient rotational speed can cause the material to be mixed evenly and insufficient tool pressure will cause the material flow to not move properly to fill the empty cavities during rotational, translational motion and cause defects in the specimen. Based on the description above, it can be concluded that the best welding results with welding parameters at a shoulder diameter of 4 mm, welding pressure of 40kgf. This is because the results of welding with a pressure of 40 kgf and a shoulder diameter of 4 mm found no defects.

4 Conclusion

The conclusion in this study the results of welding with a welding pressure of 30 kgf, 40 kgf, 50 kgf and a shoulder diameter of 4 mm obtained the best welding results at a welding pressure of 40 kgf, the two materials were connected without damage. Whereas the welding pressure parameters of 30 kgf, 40 kgf, 50 kgf and a shoulder diameter of 6 mm succeeded in connecting the two materials but the best welding was with a pressure of 50 kgf. The welding pressure parameters of 30 kgf, 40 kgf, 50 kgf and a shoulder diameter of 8 mm can connect the two materials but the best results are at the welding pressure parameter of 50 kgf. The results of the macro structural analysis show that the welding pressure affects the shoulder diameter, if the welding pressure is too large and the shoulder diameter is too small it will damage the copper and aluminum material because it only has a thickness of 0.5 mm, and vice versa if the welding pressure is too small and the shoulder diameter is too large then the two materials can not be connected. In this study, the best results were obtained with a shoulder diameter of 4 mm and a pressure of 40 kgf because there were no defects or hooks in the welding results.

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