Effect of Interlayer in Dissimilar Metal of Stainless Steel SS 301 and Aluminum Alloy AA 1100 Using Micro Resistance Spot Welding

Ario Sunar Baskoro¹, Hakam Muzakki¹, Gandjar Kiswanto¹, Winarto²
¹Mechanical Engineering Department, Faculty of Engineering Universitas Indonesia, Depok, Indonesia (16424)
² Metallurgical and Material Engineering Department, Faculty of Engineering Universitas Indonesia, Depok, Indonesia (16424)
E-Mail: ario@eng.ui.ac.id

ABSTRACT

Each material has advantages and disadvantages properties, and two different metals, which have advantages properties, were welded to apply its advantages in a construction. Different thermal and electrical properties will influence to a welded joining performance. Aluminum and steel joining by welding process lead to decreasing lap shear strength of welded joint, due to thermal properties. The objective of this study analyze peak load, elongation, and fracture area (fractographic) from a welded joint between SS301 and AA 1100 with ferro interlayer which was welded by Micro Resistance Spot Welding (RSW). Ferro sheet was inserted between stainless steel and aluminum sheet, RSW machine was used to weld three different plates. Tensile test machine used to measure load and elongation value, and teared plates effected by tensile tested were measured by digital microscope. The highest load value could be achieved by 8 kV of welding current. Elongation of the highest peak loads was shorter than the lowest peak load. Welding time more than 8 CT tend to produce the elongation become shorter. Welding time affected to decrease fracture area, however welding current has also significantly effect.

Keywords: interlayer; dissimilar metal; micro resistance spot welding

INTRODUCTION

Each material has advantages and disadvantages properties. And two different metals which have advantages properties were welded to be applied its advantages in a construction. Different thermal and electrical properties will influence to a welded joining performance. Welding process can make the welding performance decreased. This study analyzed the effect of interlayer to tensile strength and fractographics of weld joint which welding current and welding time were varied. Some researchers have studied dissimilar materials joining with interlayer. Cu was used as interlayer of AA-6063 to UNS S32304 joint using bonding process. Cu interlayer effected to extent of weldability [1]. Cu-W composites and CuCr alloy, Cu-Fe powder used interlayer were joined by bonding technology. The interlayer effected to increase tensile strength, however Fe composition also affected to decrease tensile strength [2]. When to join Copper with Copper, nickel was used as an interlayer, and the diffusion process used Ultrasonic or ultrasound. The result showed that interlayer can improve bonding joint quality [3]. Nickel titanium (NiTi) was welded with AISI 216L stainless steel wires used tantalum (Ta) as interlayer using laser welding. Ta content lead to increase the tensile stress and strain and also affected the microstructure of intermetallic compound [4, 5].

RSW can be applied to joint two or more different metals, however there still many problems or disadvantages occur. Many researchers have developed and studied dissimilar welding by Resistance spot welding. Development of RSW by thermo-compensated applied to joint Aluminum alloy (AA) and Magnesium alloy with zing interlayer was studied by Yu Zhang et al. Thermo-compensated lead to significantly improve mechanical properties of nugget [6]. M Sun et al studied about effect from Sn-coated steel as interlayer for AA 5052 to Magnesium alloy welded by RSW. The result of their study explained that the interlayer affected tensile shear improved to become 88% [7]. M.R. Arvaghani et al developed RSW to joint Aluminum and Steel with Zinc as interlayer. They stated that Zinc interlayer could to reduce intermetallic compound growth [8].

Joining aluminum and steel by welding process lead to decrease lap shear strength of welded joint, due to thermal properties. The problem is more complex when the process uses the thin based material, that less than 1 mm which is called micro welding [9]. Not so many researcher studied the thin plate of aluminum welded to stainless steel with ferro as an interlayer by micro RSW. Peak load, elongation, and fracture area (fractographic) from welded joint between SS301 and AA 1100 with ferro interlayer by Micro Resistance Spot Welding were analyzed in this study.

MATERIALS AND METHOD

Aluminum Alloy (AA) 1100 of 0.4 mm and Stainless Steel (SS) 301 of 0.2 mm were cut by AWS standard, which has size of 19 mm wide and 76 mm length [10]. The 0.2 mm of low carbon steel thin sheet as interlayer was cut circular. The base materials of SS 301 and AA 1100 where the ferro sheet was placed in between AA 1100 and SS 301. Welding position from materials is illustrated by Figure-1.

Figure-1. Materials position of weld processing
Table -1. Welding parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding Time (Cycle Time)</td>
<td>6 CT, 8 CT, 10 CT</td>
</tr>
<tr>
<td>Welding Current</td>
<td>5 KVA, 8 KVA</td>
</tr>
</tbody>
</table>

A resistance spot welding machine using AC current without cooling system was applied to weld. Welding current and welding time could be arranged and presented in Table 1. The welding force of 40 kg and holding time of 10 second were assumed constant. In this study welding time and welding current were varied to analyze the effect from welding current and welding time.

Tensile test was used to measure maximum load which represented the tensile strength. The figure of tensile test machine is shown in Figure-2. Peak load and elongation were presented in a curve, as a representation of tensile tested results. Length of elongation represents the ductility of the weld nugget, and load represents strength of weld nugget.

Fractography analysis was measurement from fracture on a weld nugget after the tensile test process [11]. Tensile test from specimens lead to produce a hole. Digital microscope was used to measure or to analyze a fracture on metal. The result of measurement is shown in Figure-3.

RESULT AND DISCUSSION

Equations can be formatted as follows, with equation Results of measurement and analysis are presented in an elongation and load curve and chart. The highest and the lowest of tensile test peak load shown in Figure-4 and Figure-5.

Figure-4 shows the highest peak load from each welding parameter result test. Welding current 5 kV, welding time 6 CT effected the elongation 0.7575 mm and the peak 196.76 N. 5 kV of the welding current and 8 CT of welding time yielded 0.89712 mm of elongation and 229.58 N of peak load. And welding current 5 kV and welding time 10 CT affected the length of elongation of 0.95696 mm and peak load of 222.4728 N. Welding current 8 kV effected to the peak load more than 240 N, however the elongation was shorter than 5 kV of welding current. Welding current 8 kV and welding time 6 CT effected the elongation 0.598 mm and the peak load 269.56 N. Welding current 8 kV and welding time 8 CT also lead to 0.29894 mm of elongation and 252.06 N of peak load. And welding current of 8 kV and welding time 10 CT produced the elongation of 0.398 mm, and peak load of 242.14 N.

Peak load rise up from 5 kV at welding time 6 CT to welding current 8 kV at welding time 10 CT, and it was 7 N lower than welding current 5 kV at 8 CT of welding time. Peak load from 8 kV of welding current was higher than 5 kV of welding current however peak load due to welding current decreases. Elongation was affected welding process where the welding current of 5 kV tend to increase. Welding current of 8 kV effected the elongation shorter than 5 kV. Peak load of 269.56 N was the highest and its elongation 0.598 mm, this condition could be achieved when the welding current of 8 kV and welding time 6 CT. The shortest elongation was 0.207129 mm when welding current and welding time were 8 kV and 8 CT.
Welding current of 5kV and welding time of 6 CT produced the elongation of 0.83748 mm and the peak load of 123.27 N. Welding current of 5 kV and welding time of 8 CT affected to the elongation 0.61816 mm and the peak load of 130.52 N. And welding current of 5 kV and welding time of 10 CT produced an elongation of 1.01692 mm and peak load of 93.30 N. Welding current of 8 kV and welding time of 6 CT cause an elongation of 1.05678 mm and peak load of 162.485 N. Welding current of 8 kV and welding time of 8 CT affected the elongation of 0.61816 mm and the peak load of 158.74 N. 8 kV welding current and welding time of 10 CT produced the elongation of 0.7179 mm, and peak load of 156.37 N.

The highest peak load could be achieved by 8 kV of welding current and 6 CT welding time, the highest of peak load from the lowest peak load was 162.49 N and 1.05678 mm elongation. 93.3 N of peak load was the lowest of each peak load which was resulted by welding current 5 kV and 8 kV. This peak load was welded by welding time 10 CT and welding current 5 kV. Figure-5 shows that the load increased at 5 kV of welding current and welding time 8 CT and decreased at 10 CT. Effect of welding current of 8 kV has significant effect to increase the peak load value, however the peak load of welding time 6 CT to welding time 10 tend to decrease.

A hole on specimens resulted from tensile tested was measured by digital microscope. The measurement values were counted the mean of each fracture value that represented fracture area of the tear due to tensile tested. Mean of fracture area value is shown in Figure-6.

A tear which was affected by welding current of 5kV and welding time of 6 CT, the fracture area was 0.6704 mm2. When the welding current of 5 kV and welding time of 8 CT, the fracture area was 0.5515 mm2. And the 0.5037 mm2 fracture area was achieved by welding current 5 kV and welding time 10 CT. Figure-6 represents the fracture area tend to decrease. Welding current 8 kV affected fracture area to increase, however it will decrease at welding time 8 CT where the fracture value of 0.8944 mm2 could be achieved. 8 kV welding current and 10 CT welding time yields the fracture area to become 1.9673 mm2. Welding current of 8 kV and welding time of 6 CT affected 1.1559 mm2 of fracture area.

SS301 sheet and AA1100 sheet could be welded by resistance spot welding, with the thickness of AA1100 and SS301 were 0.4 mm and 0.2 mm, respectively. A joining of SS301-AA1100 that was inserted ferro sheet could achieve the peak load 269.556 N of welding tested when welding current 8 kV and welding time 6 CT of welding process.

Elongation of the lowest peak load from each parameter shown Figure 6 represented that elongation value was more 0.6 mm, so that the average of elongation more than 0.6 because of two elongation values that less than 0.4 mm. Welding current of 8 kV and welding time 8 CT lead to 0.29894 mm of elongation and 252.06 N of peak load. And the elongation of 0.398 mm, and peak load of 242.14 N could be achieved by welding current of 8 kV and welding time 10 CT. Welding time more than 8 CT influence elongation to become shorter.

Fractures which were affected by welding current 5 kV were smaller than 8 kV and fracture area of 8 kV rise twice of 5 kV. Welding current of 8 kV and welding time 10 CT produced the largest fracture area. Welding time affected to decrease fracture area, however welding current has also significantly effect the fracture area.

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REFERENCES

CONCLUSIONS

Figure-6. Average value of fracture area


