THE EFFECT OF WELDING TIME AND WELDING CURRENTS ON

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THE EFFECT OF WELDING TIME AND WELDING CURRENTS ON WELD NUGGET AND TENSILE PROPERTIES OF THIN ALUMINUM A1100 BY MICRO RESISTANCE SPOT WELDING

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ABSTRACT

In this paper, the electric resistance spot welding process was applied to thin Aluminum A1100 used for investigating the micro joining process. Resistance spot welding parameter such as, electrode form, electrode material, voltage and electrode force were stayed constant. This experiment uses different welding time and welding current to identify the optimum welding parameters for maximum joint strength. This paper studies the characteristic of resistance spot welded of an A1100 aluminum thin sheet with 0.4 mm in thickness. Material was cut by ANSI/AWS standard dimension. The performance is measured by tensile shear test and microstructure test. The tensile test was measured in the polymer technology center of BPPT (the research center of Indonesia). The thickness of specimen is 0.4 mm. It has Thermal Conductivity 222W/m-K, Melting Point 643-657.2°C, Solidus 643°C and Liquidus 657.2°C. The effect of welding current and welding time will give better performance, such as nugget weld and tensile properties. The welding time and welding current yield the square of nugget zone size or a hole of the specimen. From the results, the maximum load of specimen of 272N can be achieved with the welding parameters of holding time 10 second, cycle time 1, and welding current 2 kA. This welding result has the 292.1 mm^2 nugget size, and 107.85 mm^2 fracture size. This experiment shows the optimum welding parameters that can be used in micro joining application (thin plate).

Keywords: effect of welding time and welding currents, molten zone, micro resistance spot welding, Aluminum A1100.

INTRODUCTION

Welding is an important technology of material joining which has been used in the large manufacture industries [1, 2]. The product trend of more complex and sophisticated microsystems require miniaturized, high precision, and high-quality [3]. To joint thin plate less than 1mm is micro welding [4]. This last issue is the major concern in resistance spot welding [5], reported that resistance spot welding is today's industrial standard and it is leading joining process in automobile assembles. Ario. S. B. *et al*. [6] had studied the jig and joining techniques, the optimum parameters and their impact on the quality of welds, surface quality and stability of the welding results. The effect of current welding on micro-properties was very slight while nugget size was highly dependent on welding current [7]. The magnitudes of radial residual stresses in the inner and outer areas of the welding nugget are going to grow with increasing the welding time and current while the decrease slightly in the edge regions of the welding nugget [9]. Base material (BM), fusion zone (FZ) and heat affected zone (HAZ) of the resistance spot welded joint were used to analyze the residual stresses. The molten zone (welding nugget) and the effected heat transform area are HAZ of the resistance spot welding.

HAZ of resistance spot welding was studied by authors, the effect of the weld current on the nugget diameter and load-carrying capacity was evaluated by observing the nugget diameter and performing a tensile-shear test. A Gal annealed 780 MPa Dual Phase and an Al-Coated boron steel sheet (22MnB5) were used by Hong-Seok Choi *et al* [10] as an object material. Daniel, K. *et al* [2] studied the effect of welding currents on weld nuggets diameter size, load bearing capacity and failure energy of welded materials, in this research is used AISI 316L austenitic stainless steel as object material. M. H. Razmpoosh *et al* [11] studied the microstructure evolution and mechanical properties, which was observed on the Fusion zone, the HAZ, shrinkage cavities. Fe-31Mn-3Al-3Si TWIP steel is used in their research. A. S. Baskoro *et al* [12] studied welding time and welding current to the weld nugget size and tensile shear test, the material in this research is a cold rolled steel sheet.

The resistance spot welding studies had been done by researchers precisely about the effect welding time and welding current on weld nugget and mechanicals properties with the different materials and dimensions. The trend of product leads to more complex and sophisticated microsystem, the joining for micro construction of the products is need at industries. To joint thin plate less than 1mm is micro welding [4]. The problem in this case is the effect of welding time and current on weld nugget (molten zone) and tensile properties of the thin aluminum A1100 by micro resistance spot welding. Heat input is important factor in the welding process, and some parameter effect the heat input in the resistance spot welding method, the some parameters are Welding Current (I), Resistance (R), and Welding Time (t) [12] the equation shown at equation.1. The resistance spot welding was effected by welding

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current and welding time to get tensile properties or welding quality but welding time and current also led to hole (cavity) on thin aluminum, The compare weld nugget size by micro resistance spot welding before and after tensile shear test to know the effect of tensile properties, the work is not yet discussed by researches before.

$$Q=I^2 .R. t \quad (1)$$

MATERIAL AND EXPERIMENT METHODS

Materials

Ario S.B. *et al.* 2013 [6] researched the effects of high speed tool rotation in Micro Friction Stir Spot Welding of Aluminum A1100. This paper also uses aluminum A1100 which the chemical composition is listed in Table-1.

Table-1. Material composition [13].

Al	Be	Cu	Mn	Si+Fe	Zn
>= 99.0%	<= 0.0008 %	0.050-0.20%	<= 0.050 %	<= 0.95 %	<= 0.10 %

The weld ability of resistance spot welding affected by different thermal, physical, and metallurgical properties is extensively investigated by realistically computing transient mass, momentum, energy, species, and magnetic field intensity transport in the alloy sample and electrodes.

Table-2 shows the material properties of Al 1100 [13]. The Al 1100 sheet is cut by ANSI and AWS dimension standard [2, 8, 11], for the thin of material is less than 0.8mm so 19 mm of the wide, 76 mm of the length and 19 mm of the overlap. The material of this research is 0.4 mm of the thin material. The specimen was welded which is shown Figure-1.

Table-2. Material properties of A1100 [13].

Hardness, Brinell	HB	23
Ultimate Tensile Strength	MPa	89.6
Tensile Yield Strength	MPa	34.5
Electrical Resistivity	ohm-cm	0.00000299
Specific Heat Capacity	J/g-°C	0.904
Thermal Conductivity	W/m-K	222
Melting Point	°C	643-657.2
Solidus	°C	643
Liquidus	°C	657.2

Figure-1. The welded specimen.

The specification of welder machine is important device to get high quality joining process and accurate experiment. A single-phase resistance spot welder (PH4-1078), electrodes with Cr-Cu alloy flat-tip ends of 6.0mm diameter, coolant flowing water rate of 10 liter per minute [12]. Resistance spot welder, ARO with servo-gun and weld control, was used to quantify residual stresses in resistance spot welding of 6061-T6 aluminum alloy [1]. A Sciaky pedestal welding machine following ISO 18278-2 was used to study fracture toughness of the molten zone of resistance spot weld by Florent K. *et al*, [5].

Welding Experiment Process

The machine which used in this research is resistance spot welding machine PMC 25 type, the specification of this machine was presented in the Table-3. This machine can be used at medium and heavy industry.

Table-3. Specification of PMC 25 type welding machine.

Input voltage		220/380V(1or2-phase) 50/60Hz
Rated Capacity	KVA	25
Output Current (max)	A	12000
No Load Voltage	Vac	3
Duty Cycle	%	50
Dimension of Troath	mm	Depth 300, Length 150
Tip holder	mm	Diameter 22, Length 25
Tip	mm	Diameter 16, Taper 1/5
Maximum Electrode Force	Kg	150
Quantity of Cooling Water	L/min	6
Max. Material Thickness	mm	2.5 + 2.5
Weight	Kg	166
Dimension (LxWxH)	mm	830 x 375 x 1190
Electrode Control		Pneumatic Control

Each parameter of welding process there are five specimens to be welded, consisting of three specimens are used for tensile shear test, and two specimens were used to

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test the macro. The resistance spot welding machine is prepared before the machine is used:

- The first step is to determine welding current.
- The second step is to determine the cycle time by adjusting the cycle time indicator on the pole in accordance with the required amount.
- The third step is to connect the two electrodes on the welding machine where the machine uses pneumatic system to attach the two electrodes. And then hold time is measured when the two electrodes are connected.

The welding parameters are presented in Table-4. In this study, the force on the electrodes was kept constant.

Table-4. Welding parameter.

Specimen Number	Welding current (kA)	Holding time (S)	Cycle time
1	1	10	0.5
2	1	10	1
3	1	10	1.5
4	2	10	0.5
5	2	10	1
6	2	10	1.5

The Measuring of the Tensile Properties

The tensile shear properties were measured in the polymer technology center of BPPT (Agency for Assessment and Application of Technology) which has received a standard and license of Indonesian National Standard (SNI). The measuring parameter is shown in the Table-5.

Table-5. Tensile test parameter.

No	Parameter	Magnitude
1	Machine	Shimadzu AGS-10kNG
2	Tensile speed	10 mm/minute
3	Grip distance	65 mm
4	Unit result	Tensile Force (N)

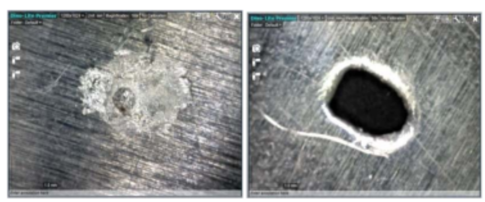
The Measuring Nugget Size

The nugget size was measured by digital microscope of Dino Lite and the software Dino Capture 2.0. The specification of the device is shown in Table-6.

Table-6. Digital microscope specification.

Special feature	No
ESD Safe	**Yes**
Measurement functionality	Yes
Calibration Function	Yes
Housing	Regular
Cap Changeable	Yes(AD / EDGE series)
Polarizer	Yes
Number of LEDs	8
Light / LED type	White
Working distance	Standard
Magnification	200x
Resolution	1.3 MP (1280 x 1024)
Connection	USB 2.0
Operating System Supported	Windows 8, 7, Vista, XP MAC OS 10.4 or later
Unit Weight	100 (g)
Unit Dimension	10.3cm (H) x 3.2cm (D)
Package Dimensions	16cm (L) x 16cm (W) x 6cm (H)

The object or specimen was measured before tensile shear test to know the nugget size. And after the tensile shear test, fracture area is measured, which is called fracture size. Two specimens to be measured are shown in Figure-2a and Figure-2b.



a. Welding nugget b. Fracture size

Figure-2. Welding result.

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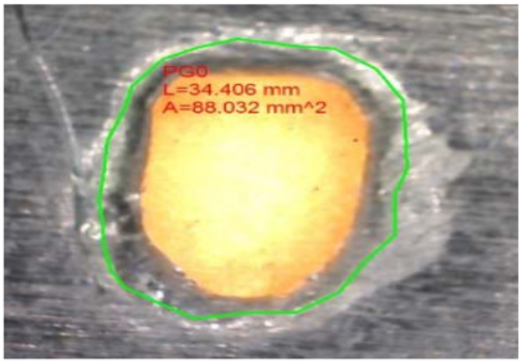

Figure-3. A result of the size measurement.

Fracture size was measured by using a digital microscope and the results are displayed on a computer screen, the measurement results shown in Figure-3. The green line was manually adjusted and measured results with the application

RESULT AND DISCUSSIONS

The specimens were tested and the results are presented in tensile load and strain graphs shown by the computer system. Graphic of tension load test on the specimen is shown in Figure-4. There are three lines of color in the chart shows that three materials were tested with the same parameters.

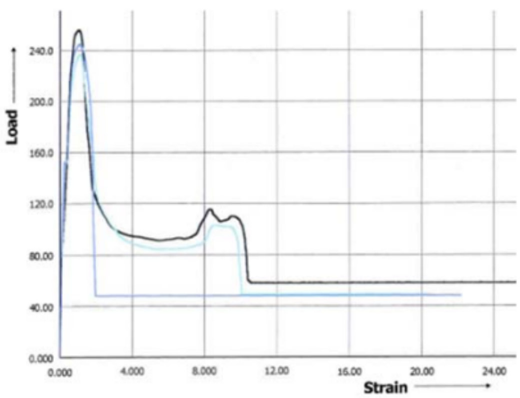

Figure-4. Load vs strain.

The average of maximum load is calculated for three specimens tested for each of the welding parameters as shown in Table-7.

Table-7. Results of the tensile shear test.

Specimen Number	Welding Current (kA)	Cycle Time	Max Load (N)	Stand. Dev (N)
1	1	0.5	189	32
2	1	1.0	210	8.4
3	1	1.5	246	9.6
4	2	0.5	271	5
5	2	1.0	272	4
6	2	1.5	264	16.8

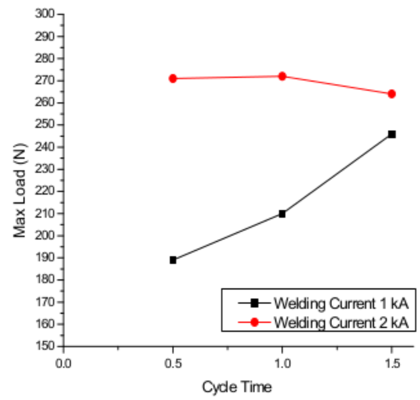

Figure-5. Maximum load vs cycle time.

Figure-5 shows the maximum load vs cycle time. With the increase of welding current, the maximum load will increase. At welding current 1 kA, when the cycle time increases, the maximum load will increase. However, for the welding current 2 kA, the increase of cycle time has no significant influence to the maximum load. The maximum load 272 N is reached at welding current 2 kA and cycle time 1.

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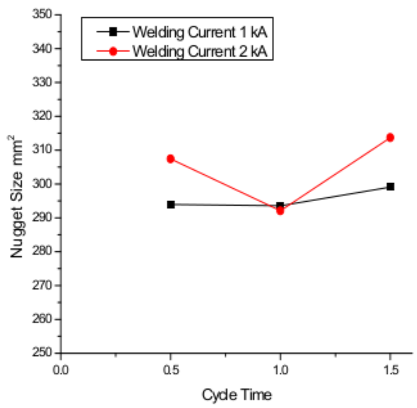

Figure-6. Nugget size vs cycle time.

Figure-6 shows the nugget size vs cycle time. It is shown that welding current and the cycle time has slight influence to the increase of nugget size at molten zone. Although on some point, with the increase of welding current, the nugget size will increase. The maximum nugget size is 313.69 mm^2 with the welding current 2 kA and cycle time 1.5.

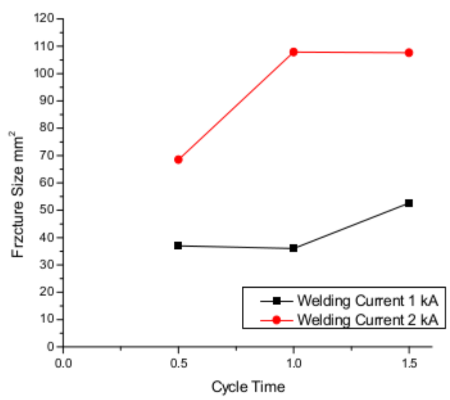

Figure-7. Fracture size vs cycle time.

Figure-7 shows the fracture size vs cycle time. With the increase of the welding current, the fracture size at molten zone will increase. With the increase of the cycle time, the fracture size tends to increase. The highest fracture size is 107.86 mm^2 at welding current 2 kA and cycle time 1.

CONCLUSIONS

This research studies the electric resistance spot welding process application to thin Aluminum A1100 used for the micro joining process. The effect of welding current and welding time influence the performance, such as tensile properties, nugget size, and fracture size. From the results, the maximum load of specimen of 272N can be achieved with the welding parameters of holding time 10 second, cycle time 1, and welding current 2 kA. This welding result has the 292.1 mm^2 nugget size and 107.85 mm^2 fracture size at molten zone. This experiment shows the optimum welding parameters that can be used in micro joining application.

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REFERENCES

[1] R.S Florea, D.J Bammann, A. Yeldell, K.N. Solankic, Y. Hammi. 2013. Welding parameters influence on fatigue life and microstructure in resistance spot welding of 6061-T6 aluminum alloy. Materials and Design. 45: 456-465.

[2] D. Kianersi, A. Mostafaei, A.A. Amadeh. 2014. Resistance spot welding joints of AISI 316L austenitic stainless steel sheets: Phase transformations, mechanical properties and microstructure characterizations. Materials and Design. 6: 251-263.

[3] D. A. Wang, C.W. Chao, P.C. Lin, and J.Y. Uan. 2010. Mechanical characterization of friction stir spot micro welds. Journal of Materials Processing Technology. 210: 1942–1948.

[4] A.S. Baskoro, Suwarsono, G. Kiswanto, Winarto. 2014. Effects of High Speed Tool Rotation in Micro Friction Stir Spot Welding of Aluminum A1100. Applied Mechanics and Materials. 493: 739-742.

[5] F. Krajcarz, A.F. Gourgues-Lorenzon, E. Lucas, A. Pineau. 2013. Fracture toughness of the molten zone of resistance spot welds. Int J Fract. 181: 209–226.

[6] A.S. Baskoro, A.A.D. Nugroho, D. Rahayu, Suwarsono, G. Kiswanto, Winarto. 2013. Effects of Welding Parameters in Micro Friction Stir Lap Welding of Aluminum A1100. Advanced Materials Research. 789: 356-359.

[7] W. Xiaodong, W. Yuanxun, and Z. Peng. 2014. Modeling the Effect of Welding Current on Resistance Spot Welding of DP600 Steel. Journal of Materials Processing Technology. 214: 2723–2729.

[8] M. Hessamoddin and S.F. Iradj. 2014. Resistance Spot Welding and the Effects of Welding Time and Current on Residual Stresses. Journal of Materials Processing Technology. 214: 2545–2552.

[9] D. Mitchell, and G. Fang, 2014. Detection of fillet weld joints using an adaptive line growing algorithm for mesin automatisic arc welding. Mesin automatisics and Computer-Integrated Manufacturing. 30: 229-243.

[10] H.S. Choi, G.H. Park, and B.M. Kim. 2011. Evaluation of Weld ability for Resistance Spot Welded single-lap Joint between GA780DP and hot-Stamped 22MnB5 steel sheets. Internasional of Mechanical Science and Technology. 25(6): 1543-1550.

[11] M.H. Razmpoosh, M. Shamanian, and M. Esmailzadeh. 2015. The microstructural evolution and mechanical properties of resistance spot welded Fe-31Mn-3Al-3Si TWIP steel. Materials and Design. 67: 571-576.

[12] A.S. Baskoro, M.R. Trianda, J. Istiyanto, S. Supriyadi, D.A. Sumarsono, G. Kiswanto. 2014. Effects of Welding Time and Weld Nugget and Shear Load on Electrical Rresistance Spot Welding of Cold Rolled Sheet for Body Construction. International Conference on Electrical Engineering and Computer Science 24-25 November 2014: 289-293.

[13] http://www.hmwire.com/aluminum_alloys.html (downloaded at August 1st, 2015).

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