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Optimizing the Process of Resistance Spot Welding For 2014 – O Aluminum Alloy Sheet

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ABSTRACT - There is a strong interest in the use of aluminum alloy sheet for vehicle applications, particularly the body, where resistance spot welding is the principle joining method. The resistance spot welding (R.S.W) quality has a great effected by the process variable such as, welding current, welding time, and electrode pressure beside other variable such as material thickness and type and electrode diameter. In this work the effect of process variable on welding quality was investigated. Trials were conducted on 1.2 mm thick 2014 – O aluminum alloy sheet. The tensile shear strength was used as primary index of welds quality. Experimental investigation show that the best current is 45 KA, best time is 10 cycle, and electrode pressure of 3 KN.

Keywords: Spot Weld, Aluminum Alloy Sheet, Shear Strength, Resistance spot Welding

1- THE AIM OF THIS WORK

Improving welds quality by optimizing process variable of spot welds in aluminum alloy sheet.

2- INTRODUCTION

The need to reduce vehicle weight, improve fuel economy and reduce exhaust emissions has led to increased materials such as aluminum alloys [(1)]. While the space frame concept has been claimed as being a cost – effective way of achieving a high – performance vehicle structure, it remains suited to low – volume manufacture. Aluminum alloys have found applications in the more classical design of high-volume vehicles [(2)]. Resistance spot – welding (RSW) has been heavily adopted by the automotive industry due to its relatively low capital and operating costs and the capacity to support high production rates [3]. Fewer studies have been made on the quality of the spot welds themselves [4, 5]. Improving the quality of welds has remained one of the major issues in R.S.W [6, 7].

3- THEORETICAL CONSIDERATION

3-1 The Time Factor

Resistance spot welding depends on the resistance of the base metal and the amount of current flowing to produce the heat necessary to make the spot weld. Another important factor is time. Fig. (1) shows the resistance spot welding time cycle [8]. The formula for heat generation was used with the addition of the time element [9].

$H=I^2RTK$ ……………….. (1)

Where

H=Heat, I^2 =Current squared, R =Resistance, T =Time, K =Heat losses

3.2 Electrode Force

The electrode force is an important process parameter. The force functions to ensure electrical contact and retain weld nuggets from weld expulsion. A simplified force profile in a welding schedule is shown in Fig. (2)[10]. The resistance of the sheet metal, R, can be further decomposed and analysed. The resistance consists of three components. If two piece of sheet metal of equal thickness are welded, as shown in Fig. (3) [10], then:

$R= 2R_b + 2R_c + 2R_f$ ………….. (2)

where,

R_b = Bulk resistance of the sheet metal, R_c = The interface resistance between the electrodes and the sheet metal, R_f = Contact resistance on the faying surface.

4 - EXPERIMENTAL STUDY

4.1 Materials

The materials studied was the heat treatable aluminum alloy (2014 – O) in a thickness of 1.2 mm in the mill – finished as – received condition and was not cleaned prior to welding. The specified chemical composition. And mechanical properties are shown in Table (1).

Table (1). Chemical Composition and mechanical properties.

Chemical composition wt %						
Cu	Mg	Mn	Si	Zn	Fe	Al
3.9-5	0.2-0.8	0.4 -1.2	0.5-1.2	<=0.25	<=0.7	90.4 -95

Mechanical properties				
Hardness brinell	Ultimate tensile strength (Mpa)	Tensile yield strength (Mpa)	Elongation at break	Modulus of elasticity
45	186	96.5	18 %	72.4 Gpa

4.2 Equipment

The welds were made on PSW – 2020 model with 25 KV/A Rating having an 80 KA current capacity. The electrodes were Cu / Cr / Zr with an 8- mm tip diameter and flat tip. Static tensile test was conducted on instron machine. The tensile shear test samples were made according to the French standards A87 and NFA 89-206 as shown in Fig. (4).

4.3 Experimental Procedure

Two (overlap) specimens are single spot welds as shown in Fig. (4). Each two specimen are spot welds with different parameter as the following:

A- First group: Experiments were designed and conducted under different current while another variable was kept constant. Electrode pressure of 3 KN and number of cycles of 12 was selected. The results of tensile shear tests are shown in Fig. (5).

B- Second group: Experiments were designed and conducted under different number of cycle while another variable was kept constant. Electrode pressure of 3KN and current of 45 KA was selected. The results of tensile shear tests are shown in Fig. (6).

C- Third group: Experiments were designed and conducted under different electrode pressure while another variable was kept constant. Current were seted at 45 KA, and time at 10cycle. The results of tensile shear tests are shown in Fig. (7).

4.4 Tensile Test

Weld quality was assessed by tensile-shear strength tests. The tensile-shear strength is one of the most important indices for weld quality and is commonly used in both research and industrial practice. In order to ensure the reliability of the strength data, five welds were made for each condition and the average of the strength measurements of the welds summarized.

5 .RESULTS AND DISCUSSION

The result of strength test show that the spot welds with stand much better shearing forces by increase current up to 45 KA. Then the shearing force began to decrease after 45 KA, as shown in Fig. (5). As stated in equation 1 we can recognize that the amount of heat generated in the nugget is directly proportional to the square of current. If the current density becomes too high, there is the possibility of expelling molten metal from interface of the joint there by weakening the weld. Fig. (5) shows that maximum shear strength occurred at 45 KA beyond which the value of strength began to degrease due to the function of porosity and crack which result from overheating.

Welding time is another important variable. If the time increased, the amount of current flow is also increase results in a large amount of heat generation in the heat effected zone. An increase in nuggets diameter (welds diameter) may be expected with increase of time [(4)]. The experimental results show that the shear strength rises with increase of time and reach its max. value at time of 10 cycles as shown in Fig. (6). After time of 10 cycles the strength began to decrease. This is because expulsion may be occurred with increase of time and nuggets growth as stated in [(6)]. The effect of pressure on the resistance spot weld quality should be carefully considered. As stated in equation 2, it can be recognized that the dynamic resistance of spot welds is depend to some extent on pressure, because the force function to ensure electrical contact between surfaces the force also must be set to be sufficient to compress a weld nugget to an extent where the nugget would be free of internal porosity or cracking, therefore the pressure plays the critical role in weld formation because an increase in the amount of heat in the heat effected zone may be expected with increase of pressure. Figure (7) explore the effect of increase electrode force on shear strength of the weldment. From this figure we can find that maximum strength occurred at pressure of 3 KN.

6 . CONCLUSIONS

The static shear strength properties of resistance spot welds in 1.2 mm 2014–O aluminum alloy have been studied to establish the effect of process variable on weld quality. The following conclusions are drawn.

1- Improving welds quality can be obtain by controlling process variable such as welding current, welding time, and electrode pressure.
2- The electrical current together with other welding parameters determines the heat input rate, which in turn influences the formation of the nugget and quality of the weldment.

3- Optimum quality of the weld is obtaining at current of 45 KA, time of 10 cycle, and electrode force of 3 KN.

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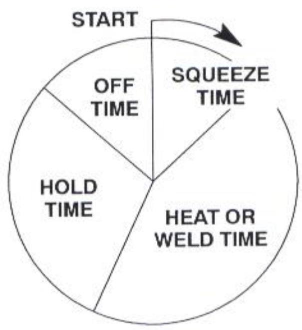


Fig.1 Spot welding time cycle

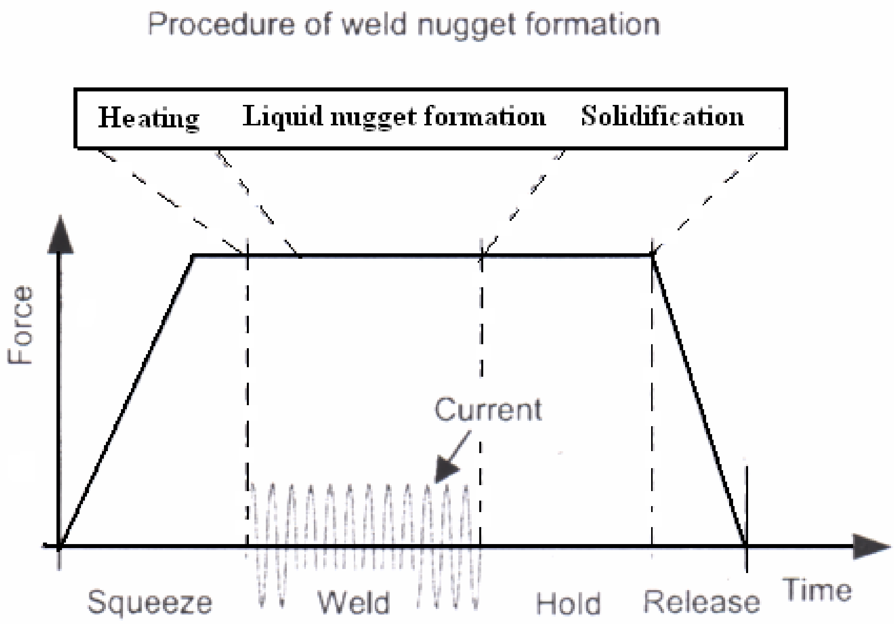


Fig.(2) Welding parameters and weld nugget formation [10]

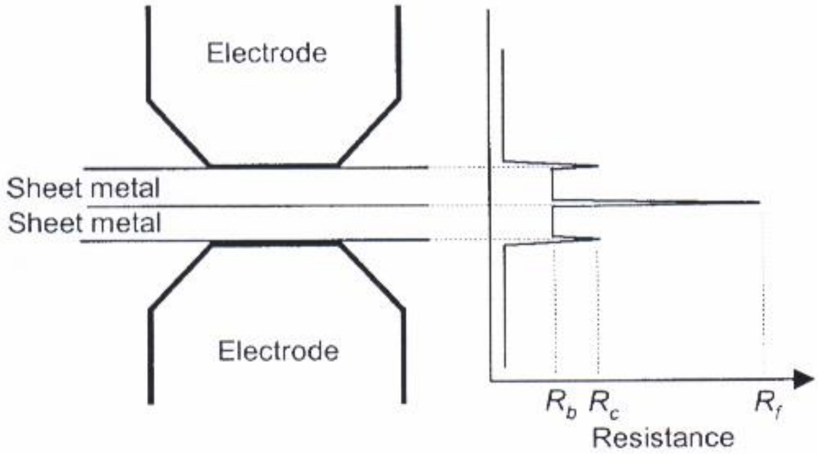
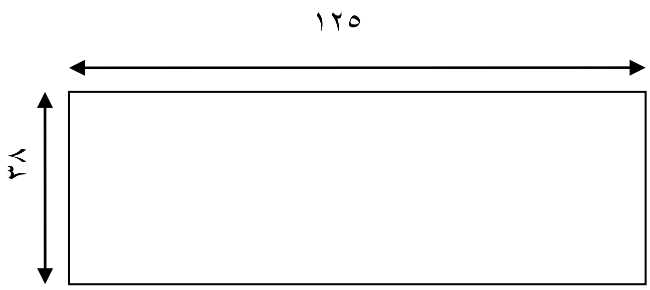
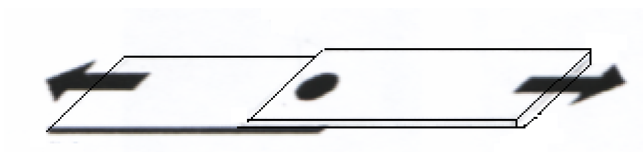


Fig.(3) Schematic representation of the resistance distribution on sheets[10]



(a)



(b)

Fig.(4) a-Specimen after preparation (dimension in mm)
b- Two overlap specimens under tensile shear

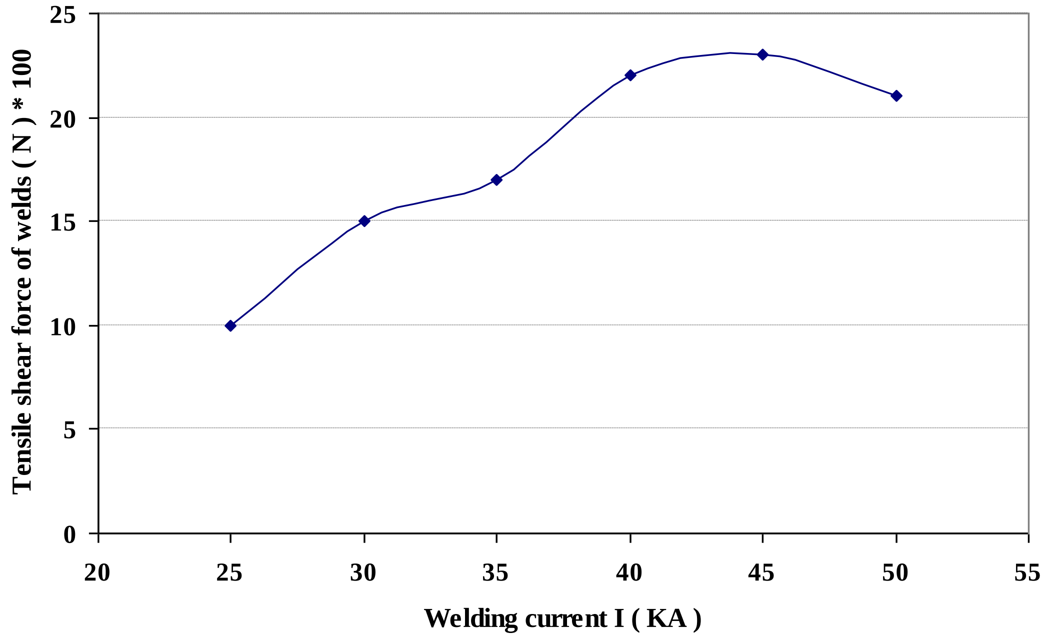


Fig.(5) Effect of increase current on weld quality at constant pressure and time (P = 3K , N = 12 Cycle)

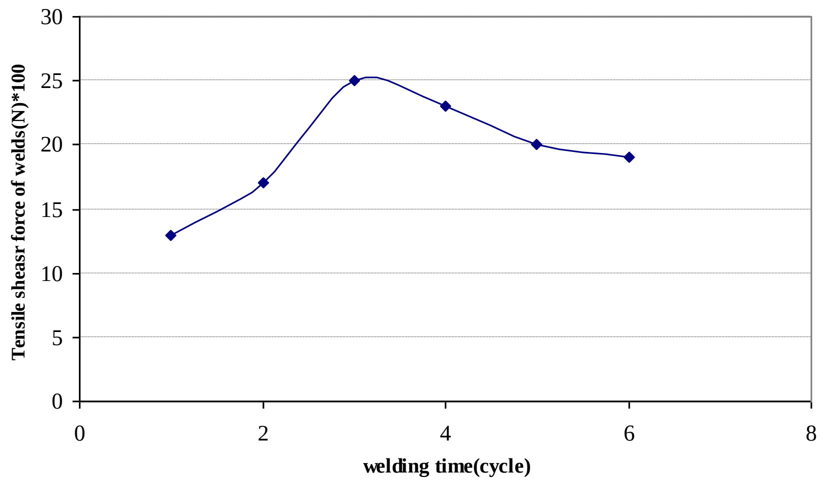


Fig.(6) Effect of increase time (cycle)on weld quality at constant pressure and current(P=3,I=45KA)

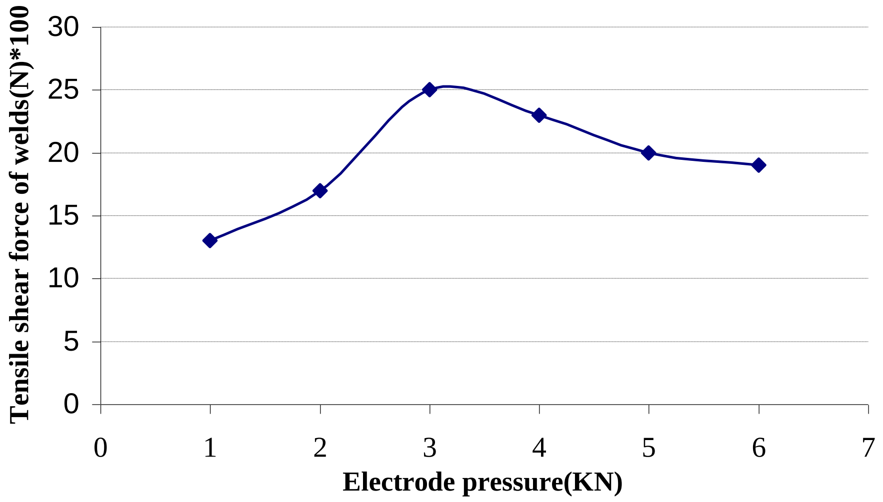


Fig.(7) Effect of increase electrode pressure on weld quality at constant time and current (N=10 cycle,I=45KA)

الاختيار الأفضل لمتغيرات لحام المقاومة النقطي لالواح سبيكة الالمنيوم 2014-O

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الخلاصة

هناك رغبة قوية في استخدام صفائح سبائك الالمنيوم في تطبيقات السيارات وخصوصا البدن حيث ان طريقة الربط الرئيسية هي طريقة اللحام النقطي .إن لحام المقاومة النقطي يتاثر بشكل كبير بمتغيرات عملية اللحام مثل التيار , زمن اللحام وضغط القطب بالاضافة الى متغيرات اخرى مثل سمك المعدن ونوعه وقطر القطب .في هذا العمل تم دراسة تاثير متغيرات اللحام النقطي على جودة اللحام .تم استخدام سبيكة الالمنيوم 2014-O وبسمك ١.٢ ملم .استخدمت مقاومة القص كمؤشر على جودة اللحام . نتائج الدراسة العملية اظهرت ان افضل تيار لحام هو (٤٥) كيلو امبير , وزمن لحام (١٠) دورة وضغط قطب (٣) كيلو نيوتن .