Experimental Study on Effect of Changing Welding Current on Mechanical and Metallurgical Properties of Seam Welding Joint for Low Carbon Steel AISI 1005 (0.8 mm)

Ammar Azeez Mahdi AL-Yasari

Welding Department - Technical College Baghdad

Abstract

The aim of this work is to study the effect of changing welding current on the mechanical and metallurgical properties and choose the best welding current depend on result of study. The present work is an experimental study on effect of changing welding current on properties of seam welding joint for low carbon steel AISI 1005. Experiments results shows with increase welding current, hardness number will increase, also differentness in hardness number between weld nugget and HAZ (Heat Affected Zone) will increase and border of HAZ become bigger. Best mechanical results was achieved when welding current increased this doesn't mean that the highest current will become the suitable one, because the higher current will cause burin through in metal sheets and will cause leakage in products (liquid or gas storage tank), also will effect on grain size and microstructure due to changes in cooling rate, also the final shape of joints its important because most application of this type of weld is weight-goods industries (for civil using), so when use high welding current the final shape of joint will deform. Depended on above the best welding current rang is between $17 \leq I < 19$ K Amp.

Keywords: Mechanical and Metallurgical Properties of weldment, Seam welding.

الخلاصة

يهدف البحث الى دراسة تاثير تغير تيار اللحام على الخواص الميكانيكية والميتالورجية لوصلات اللحام النقطي المستمر للحديد واطىء الكاربون، واختيار افضل تيار معتمداً على النتائج، حيث اظهرت النتائج العملية انه كلما زاد تيار اللحام زاد رقم الصلادة للملحومة وزادة مقاومة الشد اي تحسنت الخواص الميكانيكية ولاكن هذا لايعني ان افضل تيار يستخدم هو الأعلى قيمة لانه قد يؤدي الى انصهار بعض مناطق اللحام مما يؤدي العيب في المنتج لأن اغلب استخدامات هذا النوع من اللحام يكون في الخزانات، كما ان تطبيقات هذا اللحام تكون ظاهرة للعيان في اغلب التطبيقات المدنية لذلك يكون الشكل النهائي للمنتج ضروري وبناءاً على معطيات الخواص المجهرية والميكانيكية كما اوصت الجمعية الأمريكية للحام كانت افضل نتائج هي باستخدام تيار لحام يتراوح بين١٧ و ١٩ كيلو امبير.

Introduction

Seam welding involves the joining of two or more pieces of sheet metal in localized areas where melting and coalescence of a small volume of material occurs from heating caused by resistance to the passage of an electric current. A common example is the gastight or liquid tight [1]. This study tries to choose the best welding current that improve joint mechanical and metallurgical properties, without deflect its final shape because some of these joint will be clear to show in the final products.

1- Theoretical parts

Resistance Seam Welding (RSEW) is a process in which heat caused by resistance to the flow of electric current in the work metal is combined with pressure to produce a welded seam. This seam consisting of a series of overlapping spot welds is normally gastight or liquid tight .Two rotating circular electrodes (electrode wheels) or one circular and one bar-type electrode are used for transmitting the current to the work metal . When two electrode wheels are used, one or both wheels are driven either by means of a gear driven shaft or friction drive that contacts the peripheral surface of the electrode wheel.

The series of spot welds is made without retracting the electrode wheels or releasing the electrode force between spots although the electrode wheels may advance either continuously or intermittently. The magnitude of the current, the duration of current flow, the electrode force, and the speed of work piece or electrode travel are all related and must be properly chosen and controlled to produce a satisfactory resistance seam welded joint. The principles described in the article “Resistance Spot Welding” (RSW) in this volume are applicable also to RSEW. [1]

1-2 Seam Welding Cycle

The process sequences of seam welding are explaining bellow there are five definite stages with time:

1- Squeeze time: - The time elapsed between the initial application of the electrode force on the work piece and first application of current in making seam weld.

2- Weld time (weld interval):- the time period in which welding current is applied to the work during making a single-impulse.

3- Heat time:- The time that the current flows during any one impulse .

4- Cool time: - The time interval between successive heat times.

5- Hold time: - The time period during which force is applied to the work after current ceases to flow.[2]

2- Experimental works:

According AWS (American Welding Society) resistance welding hand book there are three tests should be done to mead sure that the suitable settings are be used there are[1-3] :

1. Tensile-shear test
2. Micro hardness test
3. Microstructure test

The main steps of the experimental works conducted in this study are;

1- Measuring the mechanical properties and failure mechanism for base metal and resistance seam weld. This includes:

(a) Measuring the ultimate tensile strength and breaking load for base metal and resistance seam weld specimens.

(b) Measuring the micro hardness number to determine the limits of HAZ, and the deference in the hardness number between the base metal and welding zone.

2- Studying the microstructure of all welding zones (base metal, welding nugget and heat affected zone) to describe nugget size, grain size and arrangement.

The nominal chemical composition and nominal mechanical properties of cold rolled AISI 1005 low carbon steel sheet (0.8mm) is shown in Table 1 and Table 2, respectively.

Table (1) Nominal chemical composition of low carbon steel AISI 1005

Material type	C %	Mn %	Si %	P %	S %
Plain carbon steel	0.09	0.20-0.4	0.017	0.04	0.05

Table (2) Nominal mechanical properties of low carbon steel AISI 1005

Mechanical properties / Material type	Tensile strength (MPa)	Yield Strength (MPa)	Modulus of elasticity (GPa)	Strain mm / mm	HV
low carbon steel AISI 1006	325	177	200	0.25	119

2-1 The Tension-Shear Test

This test consists of pulling in tension, a test specimen obtained by lapping to strips of metal and joining them by a single weld.

The ultimate strength of the specimen and the manner of failure whether by shear of the weld metal, or by tear of the parent metal, and whether a ductile or brittle fracture is obtained, should be recorded. Specimens in same thickness and dimension selected were from the same Carbon steel sheet at the same roll direction, for lap- Tension shear test. The specimen dimensions are (25.4 mm) in width and (101.6 mm) in length according AWS Resistance Welding Hand Book [1] [4]. It is recommended that the grips of the testing machine be offset to avoid bending at the grips. As show in fig (2).

Fig (2) seam welding joints

2-2 Micro Hardness Test

According ISO standard metallic materials hardness test HV1 (1) Kg force load was applied to surface of specimen to achieve accurate result. Fig (3) shows a sketch explaining micro hardness locations, results have been taken along straight line starting at center of seam-weld through HAZ until reaching to unaffected base metal (results become same), these results have been taken at each 0.5 mm.[3]

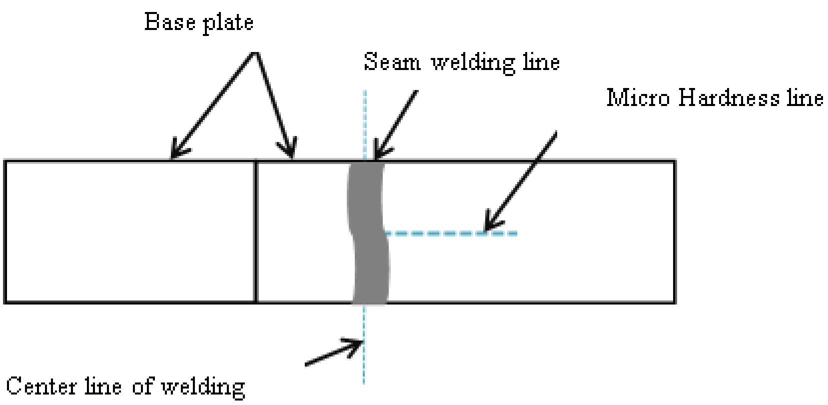


Fig (3) sketch show micro hardness line

2-3 Microstructure Testing

To show the microstructure changes and grains arrangement, and also to describe welding zone after welding process was completed, also to find the formed phases in the weld nugget and heat affected zone, the microstructure test was carried out.

3- Result and discussions

3-1 The Tension-Shear Test results

Figures (4) through (7) show the load displacement curves as a result of tensile shear test for different seam welding currents.

Fig, (4) shows load displacement curve for 13 Kamp welded joint, maximum load was 1830 N with 0.42 mm the fracture take place at welding metal, weld was clean, full smooth (without any concave or convex), the weldment was free from burn through and electrodes end dose not effected by welding.

Fig.(5) represented load displacement curve for 15 K Amp, 6000 N was the maximum load with 23 mm displacement and the tearing by 45◦ happen at the base metal, the joint was clean less smoothly than the previous one (low concave or convex), the weldment was free from burn through and electrodes end dose not effected by welding

Fig (6), shows load displacement curve for 17 K Amp maximum load was 6350 N at 23 mm also the tearing by 45◦ is happen at the base metal, the weld still clean has low concave and convex, more homogenous and electrodes dose not effect, the weldment was free from burn through

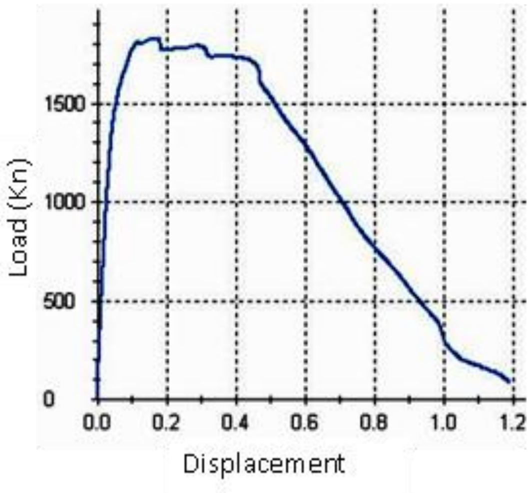


Fig (4) load displacement curve for 13 Kamp welded joint

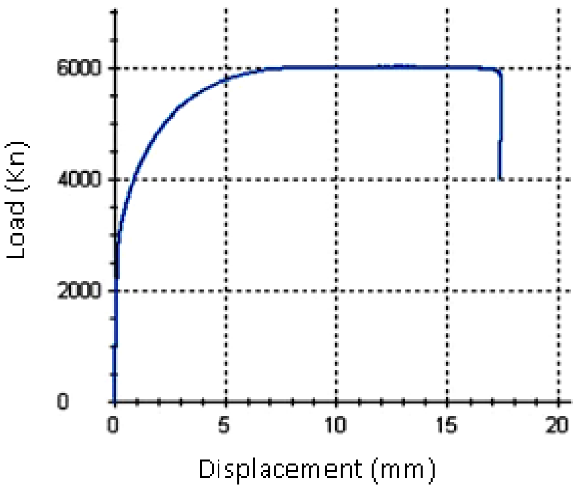
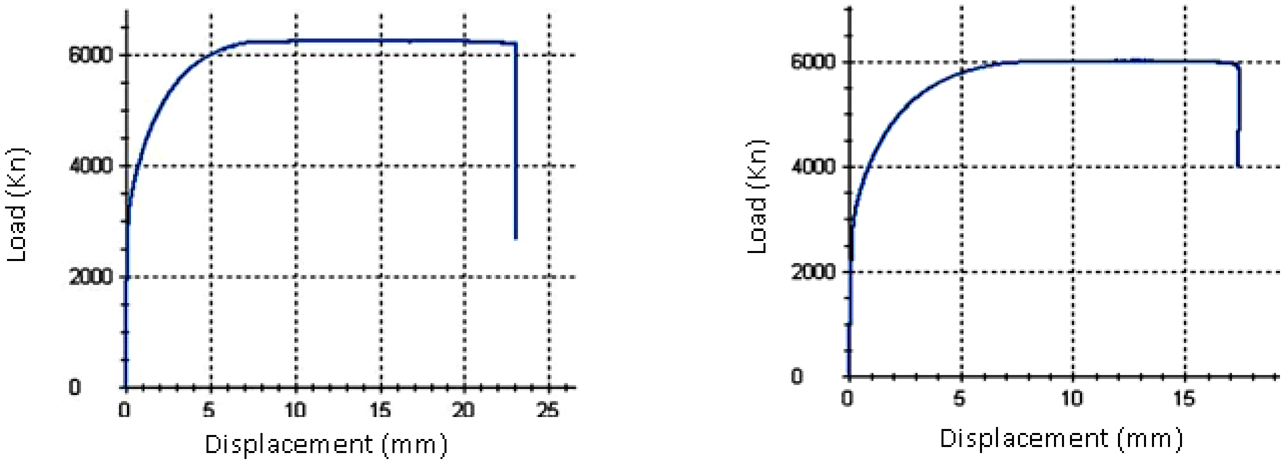


Fig (5) load displacement curve for 15 Kamp welded joint

At (19 Kamp) load reached to(6000 N) with displacement (18mm) and the tearing by 45◦ is happen at the base metal fig.(7).



3-2 Micro Hardness Test results

As explained in a previous chapter on the procedure of test, the measuring starts from center and along straight line outside nugget. It is obvious that the lowest hardness number (for welding zone) registered is in nugget center, the number of hardness gradually increases until it reaches its highest value in HAZ these differentness in hardness number due to the difference in cooling rate between nugget and HAZ which mainly affected in grain size. Fig(8), shows all hardness curves of all welded specimens, by careful look to this curve it's found: first HAZ width have direct relation with current increase, second the difference in hardness number between weld nugget and HAZ increase with increase of welding current this is normal because the cooling rate will be different in each time, and third all carve meat at 0.5 mm from center.[4-5]

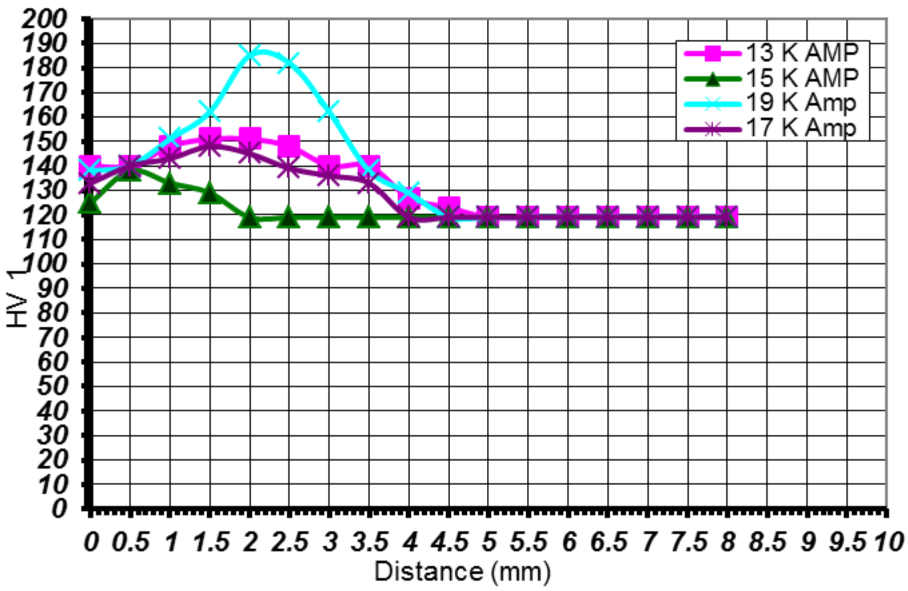


Fig (8), micro hardness test result

3-3 Microstructure Test Results

Figures (9) through (12) show the microstructure for different welding currents joints, this figure aim to show changes in grain size and arrangement with welding current. [6]

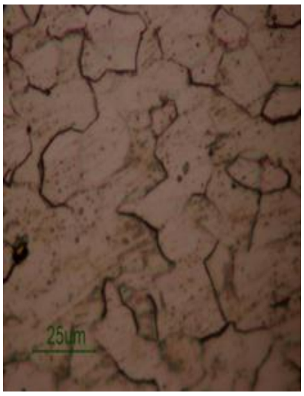


Fig (9) microstructure for 13 K Amp welded joint

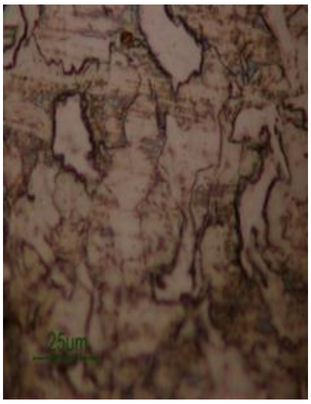


Fig (10) microstructure for 15 K Amp welded joint

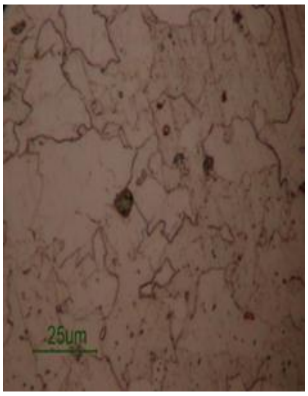


Fig (11) microstructure for 17 K Amp welded joint

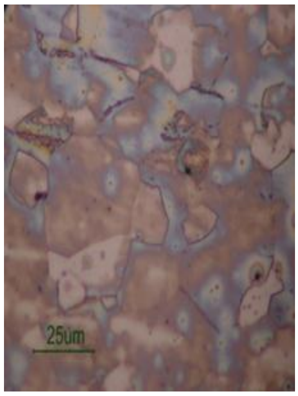


Fig (12) microstructure for 19 K Amp welded joint

First look for four microstructure photos its difficult make a distinction among grain size because there is direct water cooling during welding this made process is like quenching, but still some differentness, grain size appear somewhat bigger when welding current raised and became more homogenous specially for 17 K Amp.

4- Conclusions

1. The best welding current for AISI 1005 (0.8 mm) was 17 Kamp.
2. When welding current increase strength of welded joint increase to, until reach to 19 Kamp the metal become burn through.
3. The width of HAZ is between 3 to 3.5 mm and the difference between in the hardness number of weld nugget and HAZ become large when welding current increase.

No large difference in grains size when using different welding current but still there is relationships between them grain size appear somewhat bigger when welding current raised.

5- References

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