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EFFECT OF ADDING COPPER FOILS ON SEAM WELDING JOINTS OF 304 AUSTENITIC STAINLESS STEEL

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ABSTRACT: - The aim of this work is to study the effect of adding copper (C10200 AISI) foils on the welding joint of the austenitic stainless steel type (AISI 304).The austenitic stainless steel has low weldability by resistance welding where the concentrated current causing a high thermal expansion. Due to heat stored, non-complete fusion, burn throw, warp edge and distortion of weldments even when change machine settings. So to solve this problems a copper strips used as a filler metals between the stainless steel sheets, these problem disappears, because of that strip will be act as a heat sink and no burn through; but complete fusion, uniform weld.

Keywords: Seam Welding, Electrical Resistance Welding, Weldability of Stainless Steel.

1- INTRODUCTION

Electrical resistance spot welding processes have high speed and adaptability for automation in high-rate production and are used for the fabrication of sheet metal assemblies. Resistance spot welding processes are extensively used for joining low carbon steel components. Nevertheless, the high-strength low-alloy steel, stainless steel, nickel, aluminum, titanium and copper alloys are also spot welded commercially [1].

Stainless steel sheets are increasingly used for several applications because of their high corrosion resistance, beautiful appearance and good weldability. Stainless steel plays an important role in the modern world. Austenitic stainless steels represent more than 2/3 of the total stainless steel production. These stainless steels are preferred more than other stainless steel types due to their good weldability [2].

In seam welding weld is made between or upon overlapping members wherein coalescence may start and occur on the faying surfaces by heat obtained from resistance to the flow of welding current through the work pieces from electrodes that sever to concentrate the welding current and pressure at weld area, seam welding is a series of spot welds which is used in gastight or liquid-tight.

2. RESISTANCE SEAM WELDING PROCESS (RSEW):

Resistance seam welding process is one of resistance welding processes, in which heat caused by resistance to flow of electric current in the work metal, two rotating circular electrodes are used for transmitting the current to the joint, as shown in Figure (1), [3, 4].

3. WELDABILITY OF AUSTENITIC STAINLESS STEEL:

During welding austenitic stainless steel is susceptible to carbide precipitation if heated for any appreciable time in a temperature range of (427-537) °C. If serious carbide precipitation occurs, this steel is subject to inter-granular corrosion and somewhat less ductile. It can be resistance welded without producing harmful carbide precipitation, providing the time of current flow is suitably short [5]. Less current is required than for low-carbon steel, since its electrical resistance is approximately seven times greater. Higher electrode forces are used because of its higher hardness and strength at elevated temperatures and minimize the effect of faying surface contact resistance.

Austenitic stainless steels have much higher coefficient of thermal expansion than mild steel and as a result its subject to more severe warp edge. Because of this high degree of expansion, it has been found advantageous to use short times of current flow in resistance welding [6].

During the welding; thousands of Amperes will pass through sheets in a part of second, this will produce a large amount of heat locally, in stainless steel this amount of heat will greater than carbon steel and aluminum this is due to high electrical resistivity, as shown in Figure (2). This amount of heat will remain for longer time in welding zone than carbon steel and aluminum before sinks because of low thermal conductivity of stainless steel, as shown in Figure (3). This will produce unacceptable welding shape some time burn through will accrue, even when reduce welding current [7.8]. So to solve this problem heat should sink away, this will done by using copper filler metal between stainless steel sheets, as shown in Figure (4), copper have high thermal conductivity.

4. EXPERIMENTAL WORK:

4.1 Base Metals:

Stainless steel type AISI (304) with (0.8 mm) thickness, and copper type (C10200 AISI) filler metal with (0.05mm) thickness.

4.2 Materials and Procedures:

Stainless steel sheets type 304, (10×8)inches is prepared to be welded by seam welding with and without copper filler metal under constant welding variables according to AWS(American Welding Society)standard (electrode force 300 Ib, welding speed 60"/min, max over lapping0.25") except standard welding current, four different values of weld current (6700, 7300, 7900, 9200)Ampere, all of them welded with copper filler metal except (7300 Ampere) (standard current),the specimens are welded, as shown in Figure (5).

AWS standards, resistance welding hand book used. The purpose of these standard is to present recommended tests which are in common use for determining the quality of resistance welds. There are many tests that should be done on welding joints.

- Test No.1-Tension-Shear Test.
- Test No.2-Macro etch Test.
- Test No.3-Hardness Test.

1) Tension-Shear Test

Three samples for each condition are prepared (130X25.4X0.8mm). Additional plates with thickness (0.8mm) were fixed at the end of each specimens, as shown in Figure (6).Universal Testing Machine Type 142510, No.8-652, are used for this tests.

2) Macroetching Test

According to AWS resistance handbook macroetching should be carried out; the purpose of this test is to ensure that coalescence occurs with suitable penetration; it includes the following steps:

1- Cut welded specimen through the weld zone.

2- Cold mounting used to support the specimen.

3- Grind the mounted specimens with 320,400, 600, 800, 1000, 1200, 2000 grades of silicon carbide paper, with rotating speed of (2000 rpm), by using universal polishing and grinding machine for metallographic specimen preparation. The specimen rotated 90˚ after each change of grinding paper; during the grinding process water applied as a lubricant liquid [9].

4- Polishing the specimens with cloth (for hard material), alumina as a polishing materials with grain size (0.5, 0.2) µm respectively, the rotating speed (500 rpm).

5- Etching the specimen using concentrated HCl then rinse in warm water and dry.

3) Hardness Test

After macroetch test is carried out hardness number can measured on it and Knoop hardness Test ZHV1-M, UK are used for this tests. It should be care taken to select a hardness test point so that the impression doses not distort the edge of specimen.

5. RESULTS AND DISCUSSIONS:

5.1 Tension-Shear Test Results:

From the figure (7) it can be found that specimen with 7900A and copper foil gives the highest shear force 7.4KN in addition to that the nugget shows complete fusion and uniform welding line no burn through; but the standard current without copper foil gives a shear force less than that. So the foil improve the max shear force with about 6%; figure (8).

The decrease of the welding current to 6700A reduced the shear force to 5KN and the nugget shows incomplete fusion and non-uniform welding line; figure (9) , but in the other hand the increasing of current to 9200A lead to burn the plats and decreasing the shear force to 6.8KN; figure (10).

5.2 Macroetching Test Results:

The etching of the welding joint show that the decreasing of the welding current lead to the melting and segregation of copper; but without melting or joining of stainless steel ; figure (11).

Figure (12 A) shows the macroetching for (7300 Ampere) weld specimen without filler metals no uniform welding and in some place there is burn through, (B) with using filler metals, there is no weld occur.

Figure (13), the etching of weld specimen with current (7900 Ampere), shows that no burn through and in another hand there are complete fusion, uniform weld and no segregation for copper filler metals.

Figure (14), shows macroetching structure for (9200 Ampere) weld specimen, with 5X magnifications non- uniform weld, some places have cracking, also there is a burn through and welding cavity.

5.3 Micro Hardness Test Results:

Figure (15), shows the micro hardness test results for all welding currents test specimens, the hardness number for base metals (before welding) for stainless steel 180 HV0.5and for the copper foil is 72 HV 0.5. The most specimens have a large different in hardness number between the nugget and HAZ (heat effected zone), this will lead to sensitivity for cracking in HAZ , but for specimen with 7900 Ampere and copper foil the homogenous hardness found .

6. CONCLUSIONS:

1) The using of copper filler metals between stainless steel sheets, will act as a heat sink and complete fusion, uniform weld, but no segregation or burn through found. So the copper filler metals lead to improve welding joints.

2) The best welding current is about (7900 Ampere) which shows complete fusion and uniform welding line and no burn through.

3) The addition of foil improve the tensile shear force about 6%.

4) The copper foils reduce the difference in micro hardness of the welding zone and HAZ which will reduce the possibility of cracking in HAZ.

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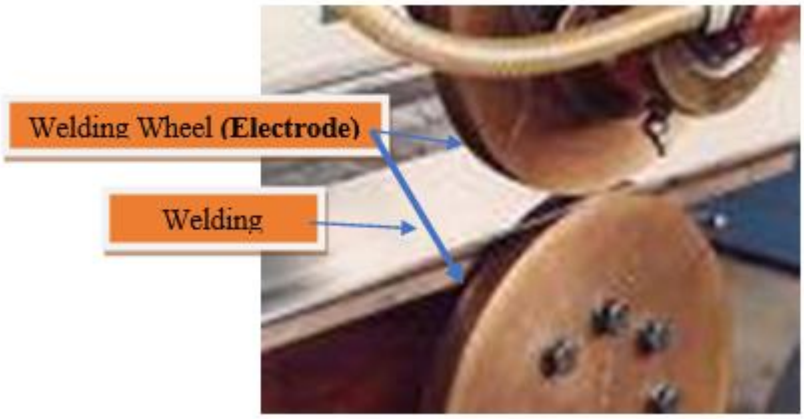

Figure (1): Resistance Seam Welding Process.

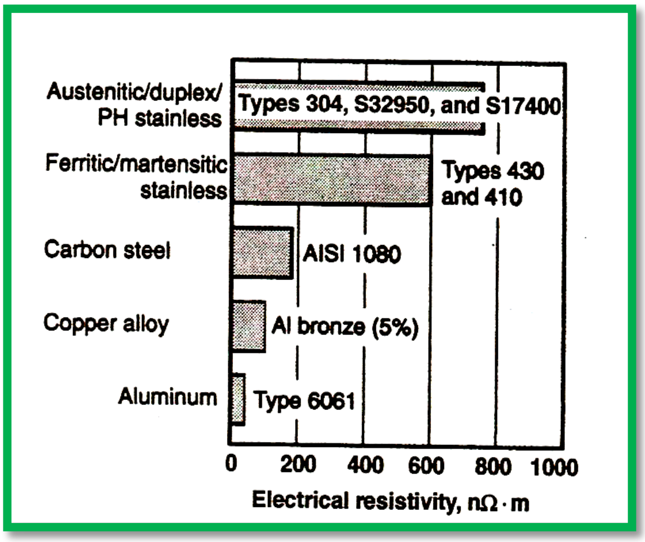

Figure (2): Comparison of electrical resistivity for copper alloy and stainless steel.

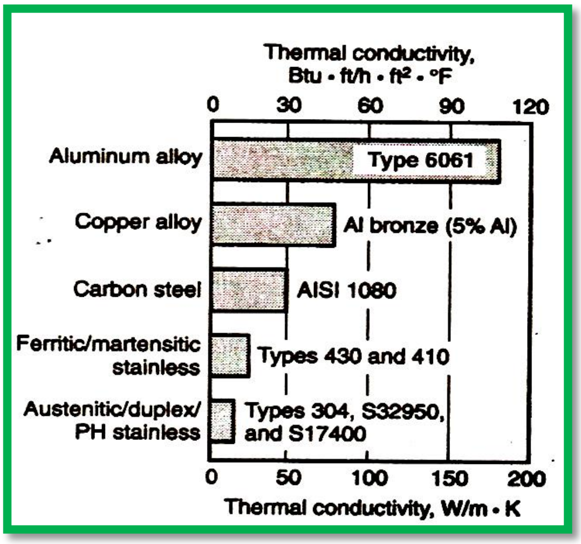

Figure (3): Comparison of thermal conductivity for copper alloy and stainless steel.

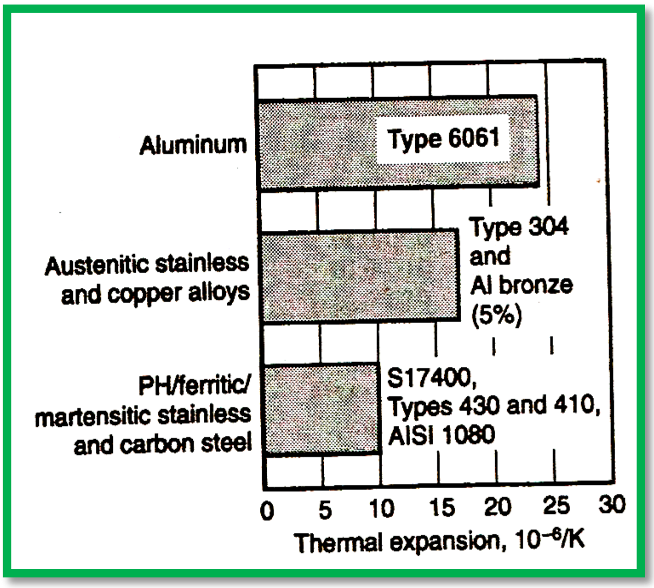

Figure (4): Comparison of thermal expansion for copper alloy and stainless steel.

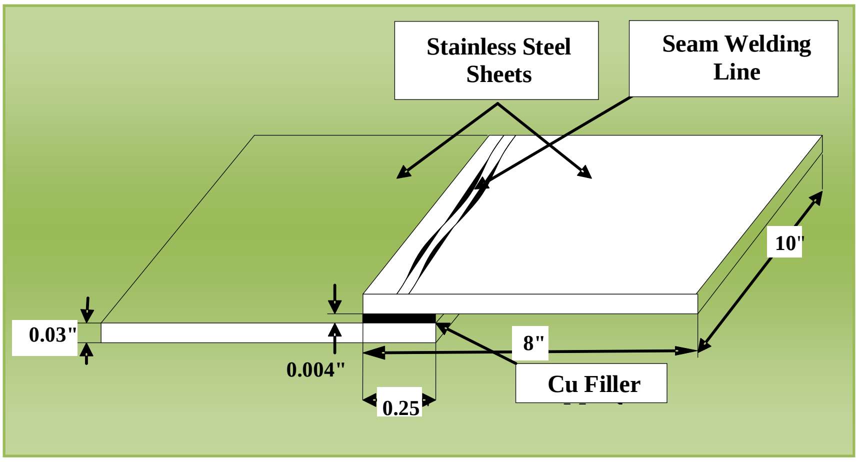

Figure (5): Standard Seam Welding Joints with Copper Filler Metal.

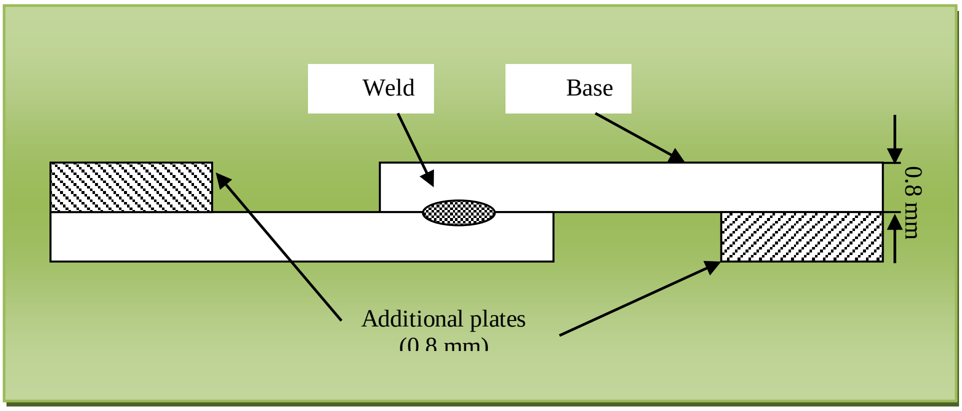

Figure (6): Standard Tension Test Specimen for Seam Welded Joints.

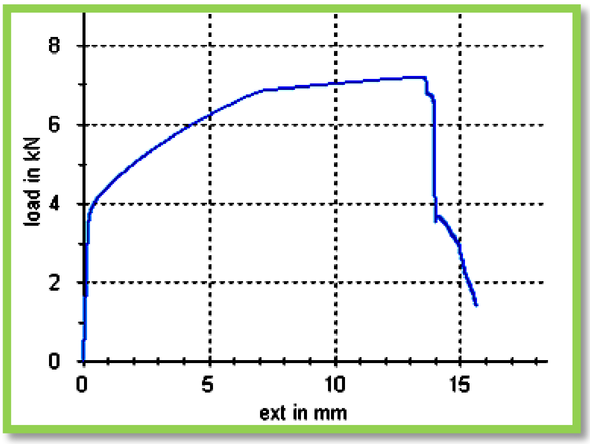

Figure (7): Tension test result of (7900 Amp) test specimen.

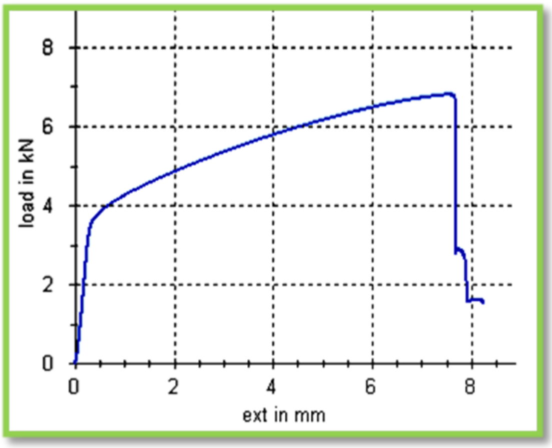

Figure (8): Tension test result of (7300 Amp) without copper foil.

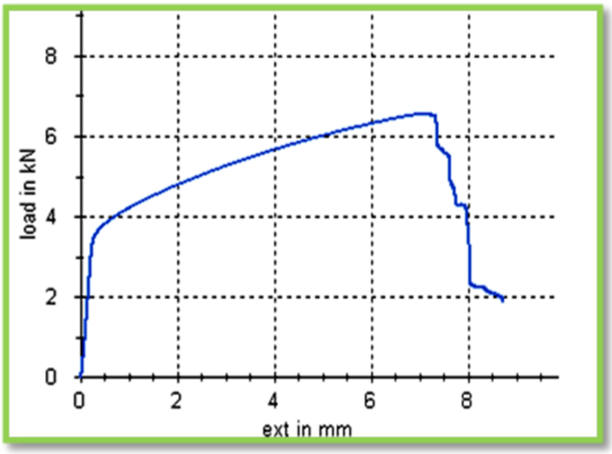

Figure (9): Tension test result of (6700 Amp) test specimen.

Figure (10): Tension test result of (9200 Amp) test specimen.

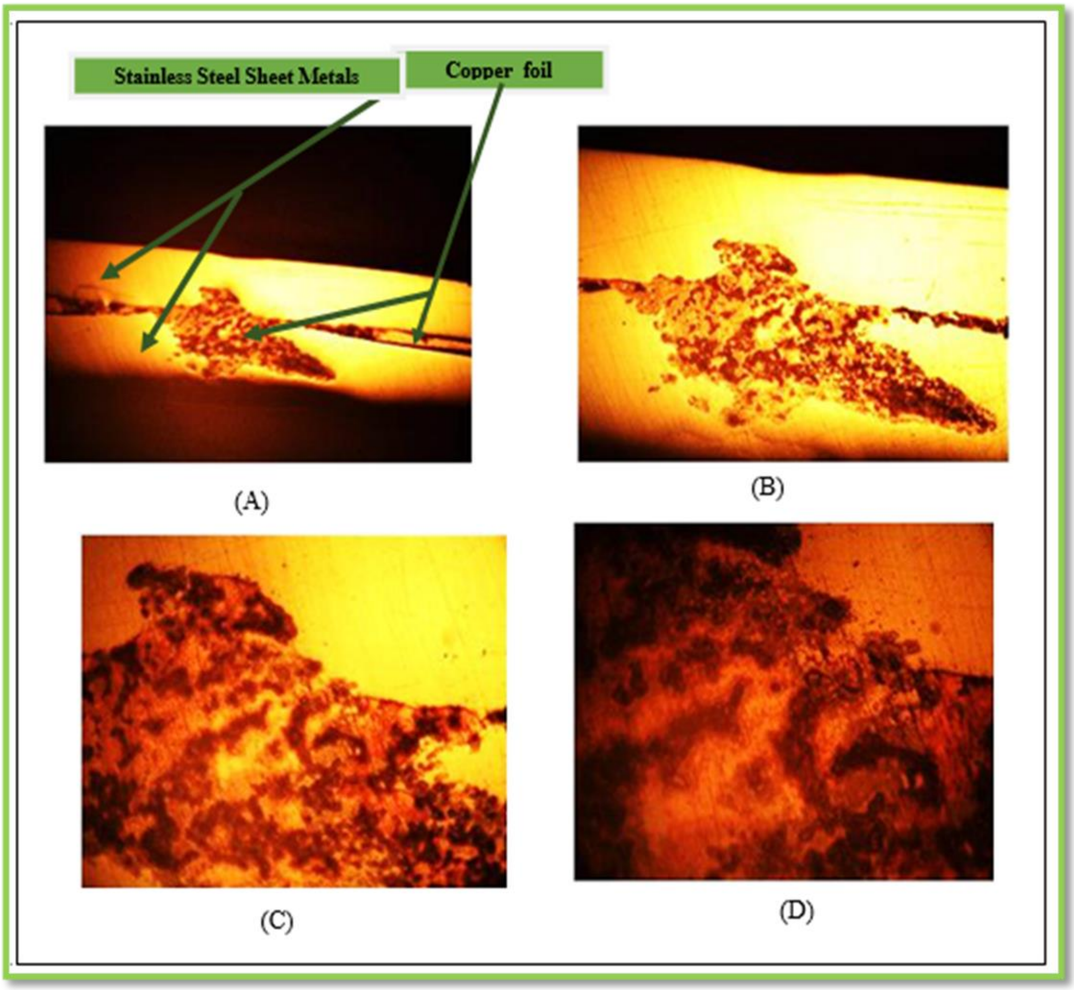

Figure (11): Macroetching structure for (6700 Ampere) weld specimen, with different magnifications (A) 5X, (B) 10X, (C) 20X, (D) 40X.

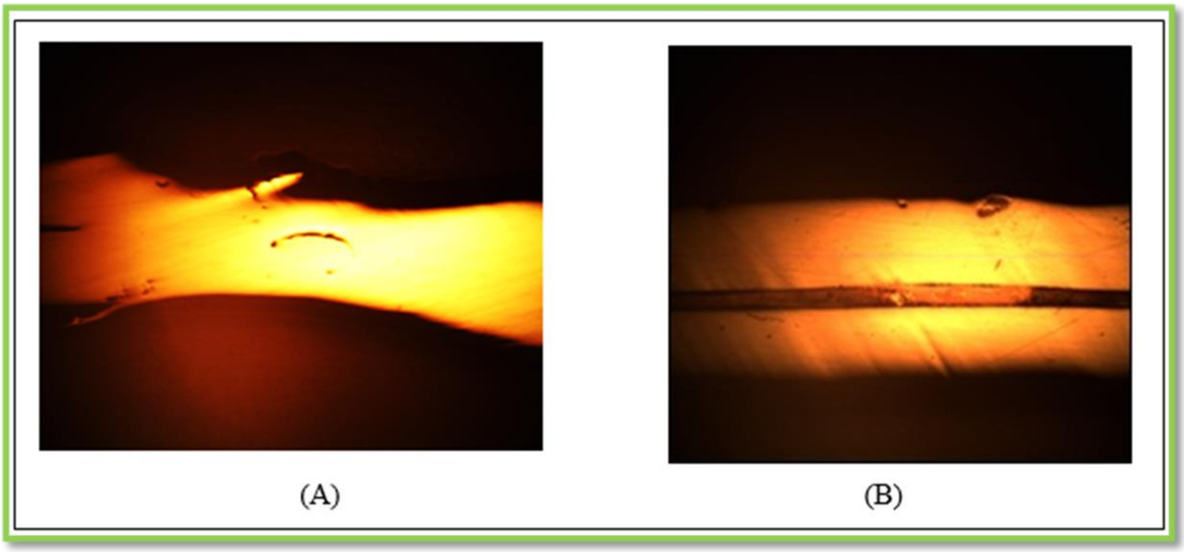

Figure (12): (A) 5X welding current 7300 Ampere without copper foil (B) 5X welding current 7300 Ampere with copper foil.

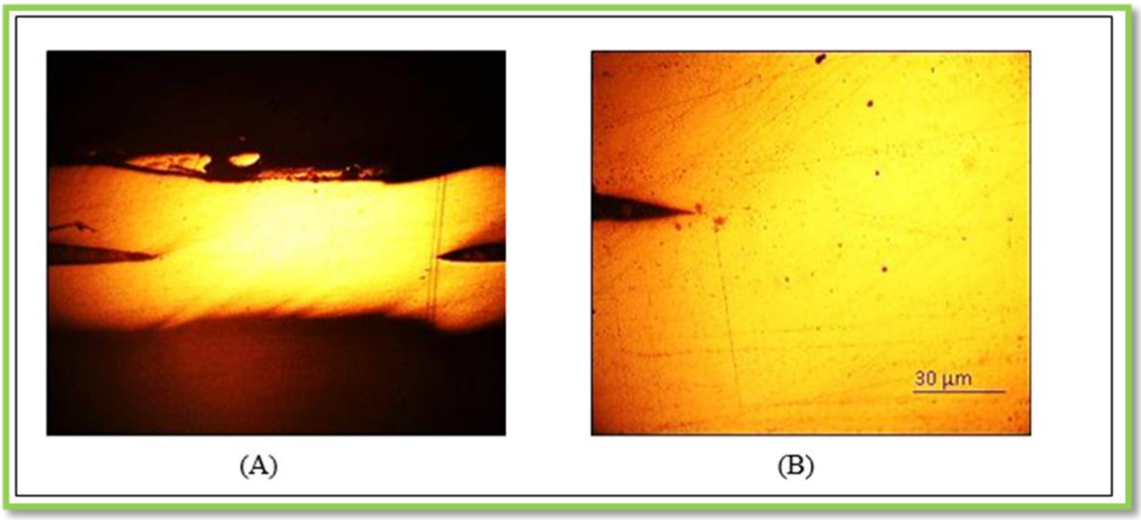

Figure (13): Macroetching structure for (7900 Ampere) weld specimen with different magnifications (A) 5X and (B) 10X.

Figure (14): Macroetching structure for (9200 Ampere) weld specimen, with 5X magnifications.

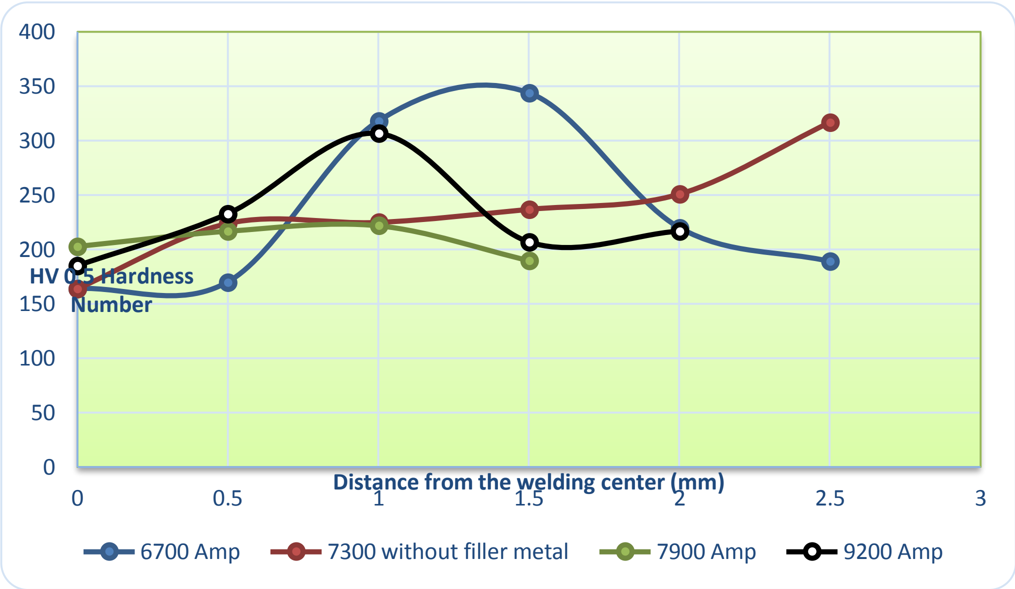

Figure (15): Micro Hardness Test Results.

تأثيـر أضافـة رقائـق النحـاس على وصـلات اللـحام الخطـي للصـلب المقـاوم للصـدأ الأوسـتنـايتي نوع 304

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الكلية التقنية / بغداد

الخلاصة :

يهدف البحث الى دراسة تأثير إضافة رقائق من النحاس الى وصلة اللحام الخطي للصلب المقاوم للصدأ الأوستنايتي نوع (304). أن الصلب المقاوم للصدأ الأوستنايتي يمتلك قابلية لحام واطئة عند استخدام طرق اللحام بالمقاومة الكهربائية لان التيار المتركز في منطقة اللحام يؤدي الى تمدد حراري عالي. وبسبب الحرارة المتولدة من ذلك فأن رقائق الصلب المقاوم للصدأ تعاني من اللحام غير المنتظم الذي يؤدي الى عدم اكتمال الانصهار في بعض المواضع أوالأحتراق في مواضع أخرى وتشوه الشكل الخارجي للملحومة. وهذه المشاكل لا تختفي حتى أذا تم تقليل تيار اللحام الى أقل قيمة له. ولحل هذه المشكلة تم أستخدام شرائط رقيقة من النحاس بين رقائق الصلب المقاوم للصدأ الأوستنايتي لتسهيل عملية تسريب الحرارة خلال المعدن وحصول انصهار كامل ولحام منتظم لوصلة اللحام التي تحسنت بواسطة هذه الإضافة.