EXPERIMENTAL STUDY OF FRICTION STIR SPOT WELDING FOR BRASS ALLOY(426/1CUZN10)

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ABSTRACT

Friction stir spot welding (FSSW) is a promising solid state joining process and is widely being considered for automotive industry. In this work mechanical properties of friction stir spot welded joints were investigated for ISO(426/1CuZn10) copper alloy. The effect of main welding parameters were studied including, welding tool rotational speed, preheat time (15, 30)s , plunging time (10,30)s , dwell time 10 s ,plunging depth (0.7,0.8) mm. Group of matrices of welding parameters were used to study the effect of each parameter on properties of welded joints. Series of (FSSW) experiments were conducted using manual drilling machine.

Effect of welding parameters on mechanical properties of welded joints were investigated using tensile shear test. Micro-hardness test used to indicate the changes in hardness across welding region. Based on the welding experiments conducted in this study, the results show that copper alloy (426/1CuZn10) was easy weldable using (FSSW) process with maximum failure load (420 N) at (2000 rpm) rotating speed and (70 s) total time for (0.5 mm) sheet thickness.

دراسة تجريبية لطريقة اللحام بالاحتكاك والخلط الموقعي لسبيكة براص (246/1CuZn10)

الخلاصة

اللحام بالاحتكاك والخلط الموقعي من طرق لحام الحالة الصلبة الواعدة التي تستخدم بشكل واسع في صناعة السيارات. في هذا العمل تم دراسة وتحري الخواص الميكانيكية للحام الاحتكاك والخلط الموقعي لسبيكة النحاس (**426/1CuZn10**). تم دراسة تأثير العوامل الرئيسية للحام المتضمنة سرعة الدوران وزمن التسخين الابتدائي (15 ،30) ثانية وزمن سرعة الاختراق (10 ،30) ثانية وزمن الانتظار 10 ثانية وعمق الاختراق (0.7 ،0.8) ملم.

تم دراسة مجموعات من المصفوفات المتضمنة عوامل اللحام ودراسة تأثير كل من هذه العوامل على خواص اللحام. تم تصنيع عدة خاصة باللحام وتم اجراء هذه التجارب بواسطة ماكنة تثقيب يدوي.

تأثير عوامل اللحام على الخواص الميكانيكية تمت دراستها بواسطة اختبار الشد القصي. اختبار الصلادة تم إجراءه لملاحظة التغير في الصلادة عبر منطقة اللحام. بناءا على تجارب اللحام في هذه الدراسة ظهر ان سبيكة النحاس (**426/1CuZn10**) قابلة اللحام باستعمال هذه الطريقة (اللحام بالخلط والاحتكاك الموقعي) مع اكبر حمل للفشل بلغ 420 نيوتن عند سرعة 2000 دورة\دقيقة وزمن كلي 70 ثانية لصفائح سمكها 0.5 ملم.

KEYWORDS: Friction, Stir, Spot, Welding, Brass, 426/1CuZn10, Qasim, Doos, Harith, FSSW.

INTRODUCTION

The FSSW process consists of three phases; plunging, stirring, and retraction. The process starts with spinning the tool and slowly plunging it into a weld spot until the shoulder contacts the top surface of work piece. Then, the stirring phase enable the materials of two work pieces mix together. Lastly, once a predetermined penetration is reached, the process stops and the tool retract from the work piece. The resulting weld has a characteristic hole in the middle of the joint [**Scheme et al 2005**]. Show **Fig.1**.

Tools consist of a shoulder and a probe which can be integral with the shoulder or as a separate insert possibly of a different material. The design of the shoulder and of the probe is very important for the quality of the weld. The probe of the tool generates the heat and stirs the material being welded but the shoulder also plays an important part by providing additional frictional treatment as well as preventing the plasticised material from escaping from the weld region. The plasticized material is extruded from the leading to the trailing side of the tool but is trapped by the shoulder which moves along the weld to produce a smooth surface finish [**Cemal, 2005**].

Welding of brass is usually difficult by conventional fusion welding processes because the brass has the high thermal diffusivity, which is about 10–100 times higher than in many steels and nickel alloys. Brass materials, as known, are copper (Cu) and zinc (Zn) alloys. The welding temperature, for example in the TIG welding, reaches almost 4200 °C in the electrode (cathode) and nearly 3200 °C in the work piece (anode) during welding. These temperatures exceed both the melting and boiling temperatures of both copper (1083 °C) and zinc (419 °C). In addition, the melting temperature of zinc oxide occurs as a result of zinc evaporation is 1907 °C. For this reason, during welding it is possible for zinc and copper to evaporate from the work piece [**Cemal, 2005**].

Weldability varies inversely with electrical and thermal conductivities. Welds of moderate quality can be obtained on very thin metal, but it is generally not practicable to attempt the spot welding of copper. The high conductivity of copper dissipates power input throughout the work, instead of concentrating it to produce useful heat [**L. Phillis, 1960**].

The main objective of present work is Study caplibility of friction stir spot welding process to weld poor weldability materials such as brass (by conventional welding process), obtain the best procedures for this process and study the effect of welding parameters (rotating speed rate, plunging rate, dwell time and plunging depth) in the weld strength.

EXPERIMENTAL WORK

The experimental work involves the procedures for friction stir spot welding of brass alloy. Drilling machine was used to get these joints by using steel tool with different welding parameters. Tensile shear tests are carried out to evaluate the maximum shear force (i.e. strength) of weld joints. The material used in this work was copper alloy (90% Cu 10% Zn), its chemical composition as shown in **Table (1)**. Properties of metal measured by tensile test and their as shown in **Table (2)**. This alloy is difficulty in welding by conventional spot welding processes. Sheets cut as rectangular shape; their long and width according to ASTM [**T.B. JEFFERSON, 1951**], standard dimensions of spot weld test specimens. 0.5 mm thickness sheet used and it was useful because the available machine has small power capacity which cannot use for high thickness. Single sheet have dimension 16 x 76 mm comparing with steel and aluminum alloy show Fig. 2. Machine used in this work was drill which has variable speed range (500 to 3000 rev/min). Tool was made from tool steel, tool dimension as shown in Fig. 3.

Many experiments had been done before set good procedure for welding a brass. Procedures involved the following step: Preheat Step :This step not recorded in literatures, but many experiments in this study showed preheat step is essential step. A tool dwells many seconds to heat sheets by friction. We can call this time "Preheat time". To carry out FSSW process, two brass plates, 0.5 mm in thickness, 76 mm length and 16 mm in width. These two brass plates were then placed one on another and clamped with a vice so that they would not separate during welding process. During the experiments it had been used a drill machine which has high rotation speed to rotate stirrer tip. The stirrer was made by special hot working steel. Length of stirrer tip had been chosen 0.8 % from total thickness of material to obtain better stirring effect. The welds were made on one side using three combinations of tools rotation speed; preheat time and plunging time where each test result was obtained from the average of three tests. Considering previous works the welding process was carried out by rotating the stirrer at rang from 1000 to 2000 rpm and by plunging the plates at various speeds under a constant friction force. Two values used for each parameter (only rotating speed 3 values taken) to experiments its effect on welding force due to values of tensile test for samples were very near and testing devices not have high accurate. By using the predetermined welding parameters, three different samples were welded for mechanical tests. Tension and hardness measurements were made as mechanical tests. Other specimens welded for study effect of plunging depth. Two various depths (0.7, 0.8 mm) are used. Tensile specimens were preparation according to ASTM. Tensile shear test was used to measure tensile shear force (or strength) which used for spot welding. Microhardness testing for spot welded joint was carried out across welding region. The type of microhardness tester was "Micromet" in mechanical department.

RESULT AND DISCUSSION

From experiments, welds joints failed when rotating speed was 600 rpm or less. When rotating speed less than appointed value, the generating heat will be not enough to stir and mix operation. Welding occur when temperature of metal reach 0.8 of melting temperature of welding metal. Results show direct relation between rotating speed rate with welds joint force, show Fig.4.

Use low rotating speed rate and more preheat time and plunging time allow to generating more heat, and metal mixing, results are shown in Fig. 5. Preheat time allow to rise temperature of brass where ductility increase too ,so recrystalian of grain occur at this state mixing operation became ready at stir step.

At plunging time equal to 30 second welding process passes as shown in Fig. 6 at three values of rotating speed. 420 N force occur at 30 second preheat while 340 N force at 15 second. Weld shear force increases with plunging time, show Fig. 7. Weld shear force increases from 160 N at 10 second to 340 N at 30 second. Long plunging time allows to efficient mixing of metal.

Decrease in shear force at rotating speed 2000 rpm with dwell time 20 s may be occur due to enlarge of grain size, force decreases with grain size. Plunging depth increases 0.1 mm from 0.7 to 0.8 as shown in Fig. 8.

That cause rise in welding force from 180 to 250 N. Increasing plunging depth improve weld force by increase volume of mixing metal in welding region ,show Fig. 9. Welding process failed at 15 s preheat time with 10 s plunging time while welding joint done at 15 s preheat and 15 s plunging time for same rotating speed. That is mean a last parameters represent critical point for welding operation. Microhardness test was done on top surface of spot weld joint according points 0,1,2,3 as shown in Fig. 10. Results of Microhardness test is shown in fig. 11.

CONCLUSION

According to results of the present study for FSSW process on selected copper alloy, several conclusions can be written regarding alloy weldability and mechanical properties.

- Poor weldability alloys by conventional spot welding process as copper alloy (426/1CuZn 10) can be welded using different (FSSW) parameters giving different welding results.
- Preheat dwell time is very effective parameter on the welding process for high thermal conductivity alloys and small thickness.
- Main welding parameters affected joints strength are tool rotating speed and plunging depth of tool.
- It was found that there is direct relation between above parameters and strength of joints. Total time for welding process is more effective parameter than other.

- The maximum weld force obtained was (420N) for sheet thickness (0.5 mm) with rotating speed 2000 rpm and total time 70 s.
- The microhardness in welding region was 97 HV higher than shoulder region 76 HV and base metal 67 HV.

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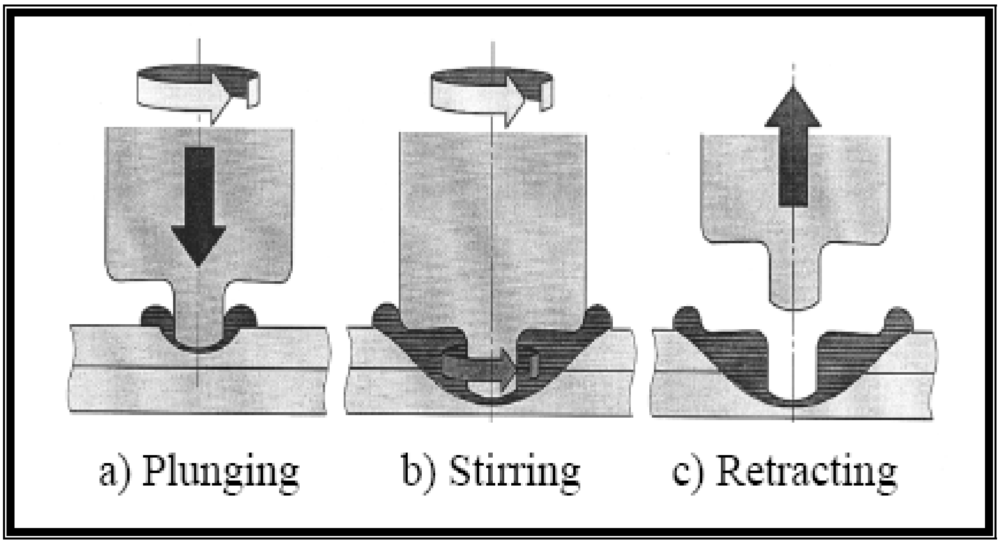


Fig. (1): Three stages of friction stir spot welding process [Cemal, 2005].

Table (1): Chemical Composition for Brass Alloy.

Material type	**426/1CuZn 10**
Chemical composition	**90% Cu 10% Zn**

Table (2): Mechanical Properties of Brass Alloy

Ultimate strength	**290 N/ mm^2**
Elongation	**46 %**
Hardness	**67 HV**

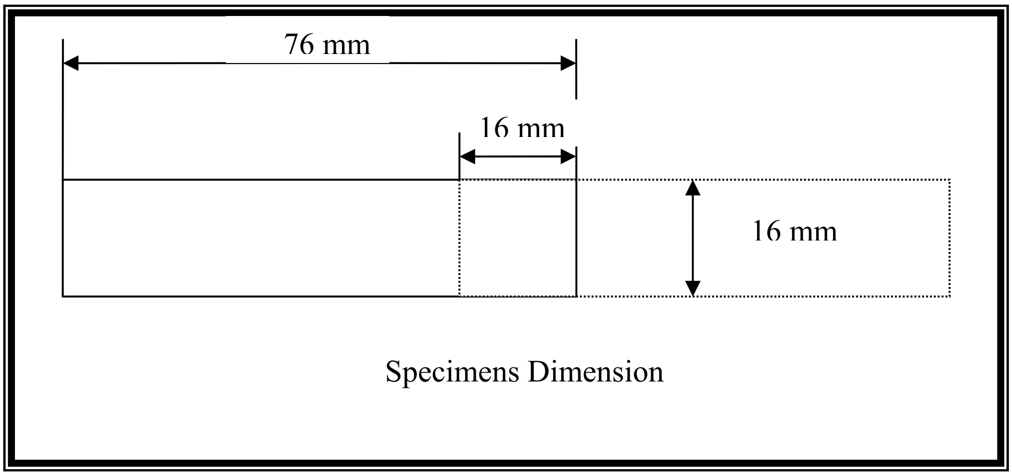


Fig.(2) : Specimen Dimensions

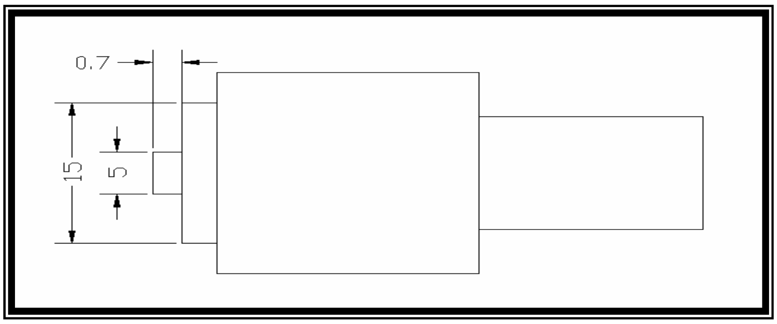


Fig.(3) : Tool Dimensions (mm).

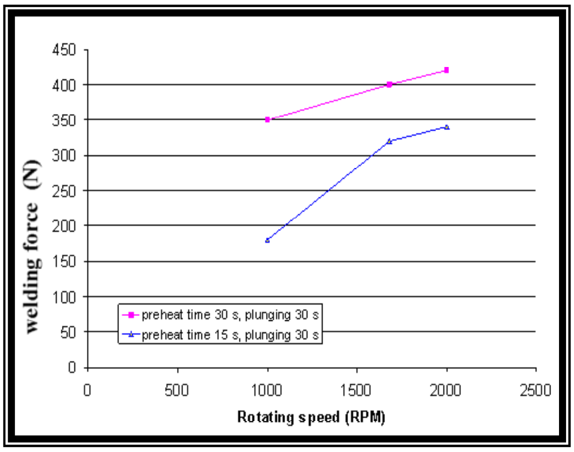


Fig. (4): Effect of Rotating Speed on Weld Shear Force at Constant Plunging

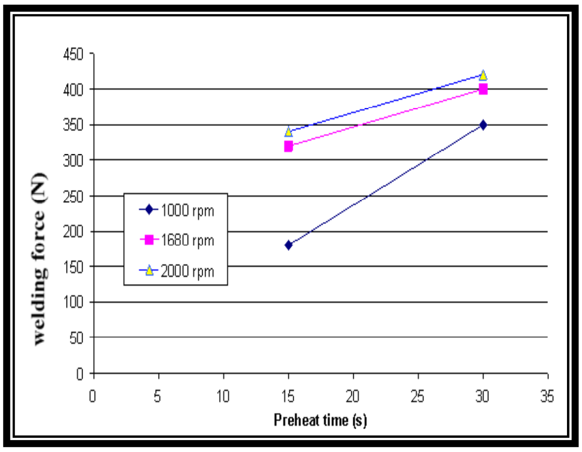


Fig. (5): Effect of Preheat Time on Welds Forces with Constant Plunging Time Equal to 30 Second.

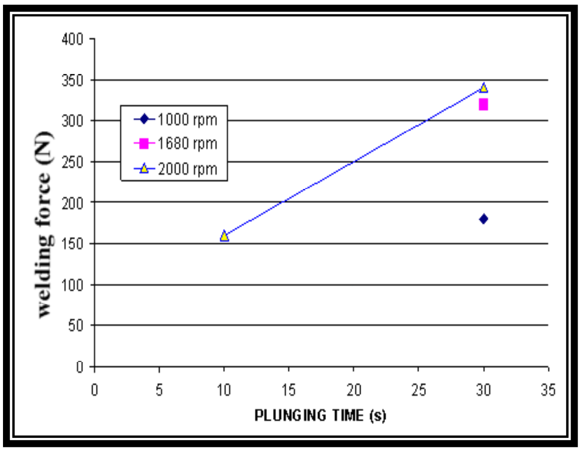


Fig. (6): Weld Force vs. Plunging Time at Constant Preheat Time 15 Second.

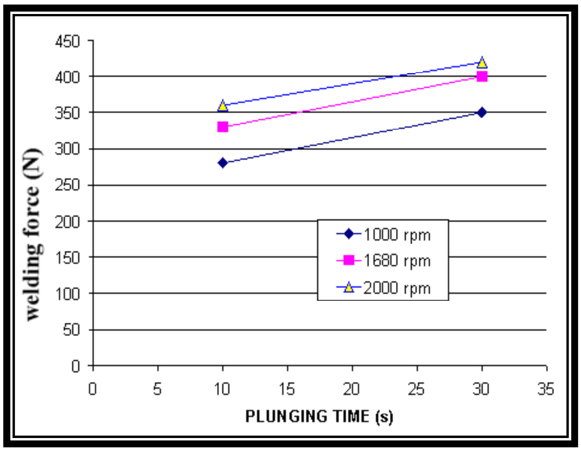
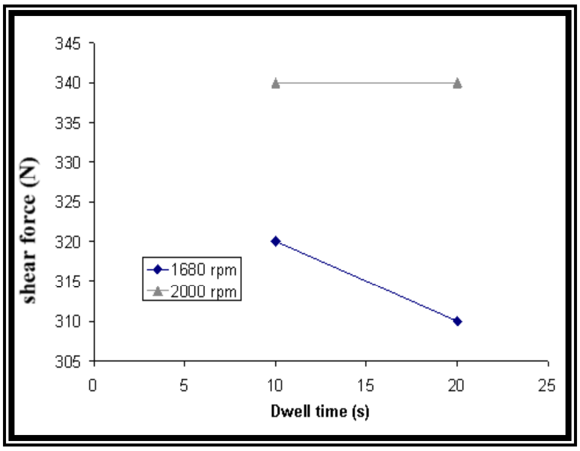


Fig. (7): Weld Forces vs. Plunging Time at Constant Preheat Time 30 Second.



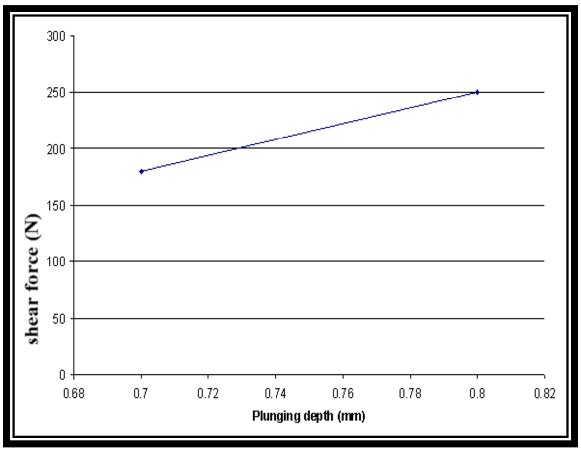


Fig. (8): Effect of Dwell Time on Shear Force of Welds.

Fig. (9): Effect of Plunging Depth on Shear Force of Welds.

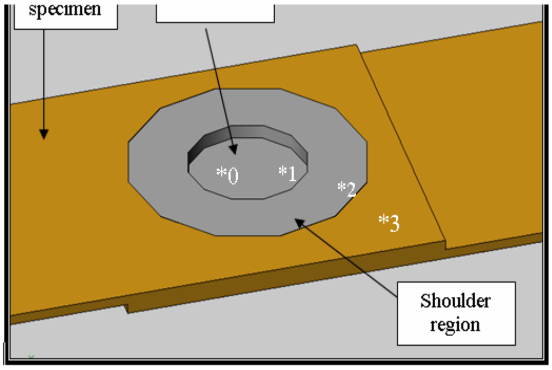


Fig. (10): Points measured by microhardness test

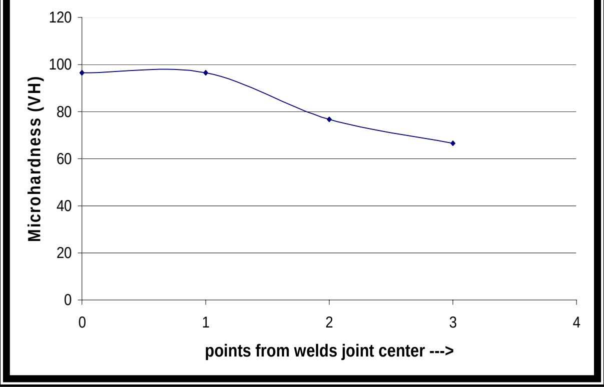


Fig. (11): Microhardness values across welds joint area.