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EFFECT OF TOOL SHOULDER DIAMETER ON THE MECHANICAL PROPERTIES OF 1200 ALUMINUM FRICTION STIR SPOT WELDING

Dr.Ayad M. Takhakh, samer J. AL-Jodi, Mohamed A. Al-khateeb.

Nahrain University, Iraq Baghdad.

ABSTRACT

A friction stir spot welding (FSSW) process is an emerging solid state joining process in which the material that is being welded does not melt. In this investigation an attempt has been made to understand the effect of tool shoulder diameter on the mechanical properties of the joint. For this purpose four welding tools diameter (10, 13, 16 and 19) mm at constant preheating time and plunging time were used to carry out welding process.

Effect of tool diameter on mechanical properties of welded joints was investigated using shear stress test and Microhardness of joint which welded was studied.

Based on the stir welding experiments conducted in this study the results show that aluminum alloy (1200) can be welded using (FSSW) process with maximum welding efficiency (80%) shear strength using tool diameter(19mm) with rotation speed (900rpm).

الخلاصة.

اللحام النقطي بالخلط والاحتكاك من طرق الحالة الصلبة والتي تكون فيها حالة المعدن الملحوم ليست منصهرة. في هذا البحث محاولة لفهم تاثير قطر العدة على الوصلات. لهذا الغرض استخدمت اربع عدد لحام باقطار (١٠،١٣، ١٦،١٩) ملم لاجراء عملية اللحام في وقت تسخين وغرس ثابتين.

تاثير قطر العدة وقت اللحام على الخصائص الميكانيكية لوصلات اللحام تم بحثها باستخدام فحوصات الشد والصلادة المجهرية لوصلات اللحام . بناء على التجارب المختلفة في هذة الدراسة اتضح بان سبيكة الالمنيوم (١٢٠٠) قابلة للحام النقطي بالخلط والاحتكاك مع الحصول على اقصى كفاءة لحام وصلت الى (٨٠%) اعتمادا على مقاومة القص باستخدم قطر اداة (١٩) ملم مع سرعة دورانية (٩٠٠ دورة بالدقيقة).

Keywords: friction stirs welding; aluminum; spot welding.

1-Introduction.

Friction stir welding (FSW), a solid-state welding process invented out at TWI (Cambridge, United Kingdom) in 1991 [Moustafa,2004]. The basic concept of FSW is remarkably simple. A non consumable-consumable rotating tool with specially designed pin and shoulder is inserted into the butting edges of sheets or plates to be joined and transverse along the line of joint. After which the tool is extracted from the workpiece. Heat produced at the tool/workpiece interface from friction and interfacial shear is sufficient to locally soften the workpieces. The rotation of the tool aids in 'stirring' the workpieces together to form a potentially defect-free bond. [Joshua,2005]. FSSW is a variant of FSW where the traverse part of the FSW process is eliminated, i.e. the tool is only plunged into the material and retracted **(Figure 1).** The resulting weld is a point or spot weld. FSSW can typically be used in applications where less strength is required, material is thin, and parts are highly contoured. Thus, it is very similar to resistance spot welding (RSW). It is also similar to RSW and other spot joining processes (e.g. riveting) in that FSSW requires significant forces.

FSSW has some distinct potential advantages on aluminum over other welding processes such as RSW, MIG-Spot and Laser - spot as well as performing better than mechanical joining techniques such as Toggle-loc. FSSW tends to have much lower operating costs due to improved energy efficiency and a virtual lack of a consumable. Additionally, FSSW equipment requires significantly less surrounding infrastructure. That is, FSSW requires no water, no compressed air, nor complex electrical transforming equipment [J.F.Hinrichs,2007].

In a previous report [Yasunari,2007], the authors indicated the effect of tool geometry on microstructure and static strength in friction stir spot welds of 6061 aluminum alloy sheets. The tool geometry such as probe length, probe shape and shoulder size is also a key parameter because it would effect the heat generation and the plastic material flow.

In this study, FSSW was performed to join 1200 aluminum alloy sheets to understand the effect of tool shoulder diameter on the mechanical properties of the joint. The aluminum alloy like 1200 commercially pure aluminum, highly resistant to chemical attack and weathering. They are easily worked, but the lowest strength aluminum. They are also excellent for chemical processing equipment and other uses where product purity is important and for metal pressings of all types where ductility is critical.

2- Experimental details

Friction spot stir welding in Aluminum 1200 plate of thickness,(1.5mm). The chemical composition of base material used in this study is given in **(Tables: 1).**

The nominal dimensions of weld samples are 130*25*1.5 mm as shown in **(Figure 2)** according to standards [ASTM,1988].

The stirrer tools were made by special tool steel X38 Cr Mo V 5 1 (DIN 1.2343) as shown in **(Figure 3).**

The welds were made on the Milling machine (Bridgeport CNC series 1 boss 5) with different shoulder diameters 10, 13, 16 and 19 mm. At constant preheating time, plunging time and depth as shown in **(Table 2),** to carry out FSSW process two aluminum plates were placed overlap on a flat steel plate. These two plates then clamped with special clamps so that they would not separate during welding process, (**Figure 4).**

By using the determined welding parameters three different samples (successfully samples), were used for tensile shear by using uniaxial tensile testing device(INSTRON 1159) and Hardness measurements as mechanical tests(MICROMET, ADOLPH 1. BUEHLER INC).
All samples produced with constant preheating time 20 sec, plunging time 60 sec, and plunging depth 2.7 mm. The influence of shoulder diameter was investigated; shoulder 10, 13, 16 and 19 mm.

3- Results and Discussion.

When rotating pin touches surface of metal, friction had been occur. Friction generates heat which rise temperature of metal, if shoulder diameter less than appointed value the joining area will be not enough to let the two pieces still connected. [k.Elangovan,2008]
As shoulder diameters increase from 10 to 19 mm for a given preheating and plunging time causing increase in shear force (weld force). The highest shear weld failure force 2200 N was obtained at tool shoulder diameter 19 mm **(Figure5).**

The increase in shoulder diameter improves welding force, because with the increasing shoulder diameter stirring area increases and metal mixing increases therefore joining area will increase and the welding become stronger. The results of welding process shown in **(Table 3).** The hardness decreases gradually from the base material through heat affected zone (HAZ) to thermo affected zone (TMAZ) then increase slightly at nugget zone because of metallurgical and amount of plastic deformation. In the stir zone, the hardness is the highest, dropping down in the TMAZ and then rising up to the hardness level of the base material [T.Rosendo,2009], **(Figure 6).**

4- Conclusion.

In this study the effect of shoulder diameter on welding strength of FSSW of aluminum alloy 1200 using simple experimental technique. The result derived from these experiments lead to the following conclusion:

1- Aluminum alloy 1200 is wieldable by using different (FSSW) tool shoulder diameter, it gave different welding efficiencies.

2- The weld joint fabricate with tool of 19 mm diameter showed better mechanical properties than the others.

3- The hardness decreases gradually from the base material through heat affected zone (HAZ) to thermo affected zone (TMAZ) then increase slightly at nugget zone because of friction heat and amount of plastic deformation.

4- Increasing tool shoulder diameter from (10mm to 19mm) step 3mm for a fixed other welding parameter caused increasing mechanical properties of the welds joint.

5- When the tool shoulder diameter had increase more than 19mm diameter it did not probably for the mechanical properties to be increased.

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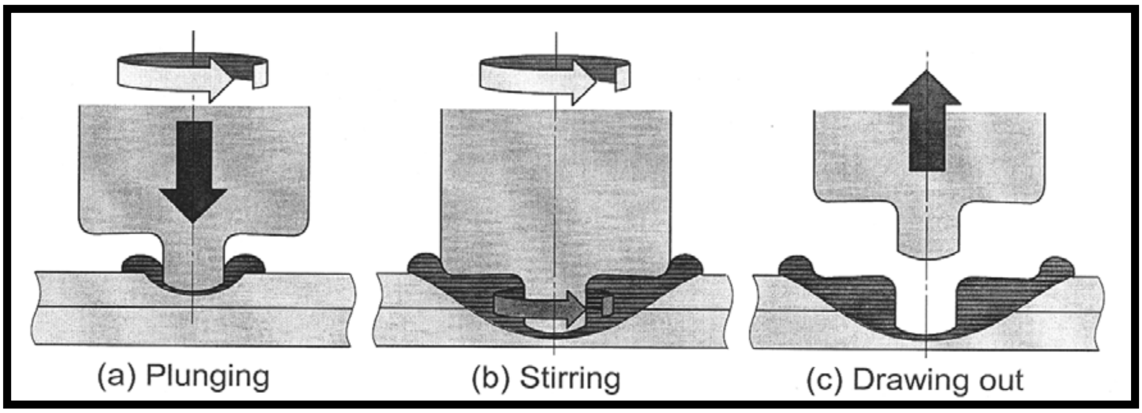

Figure (1) Frictions Stir Spot Welding Process [M.Awang,2005].

Table 1: Chemical Composition of Aluminum 1200 [ASM].

Zn%	Cu%	Fe%	Pb%	Mn%	Si%	Al%
0.0237	0.0986	0-9537	0.0253	0.0324	0.489	Bal.

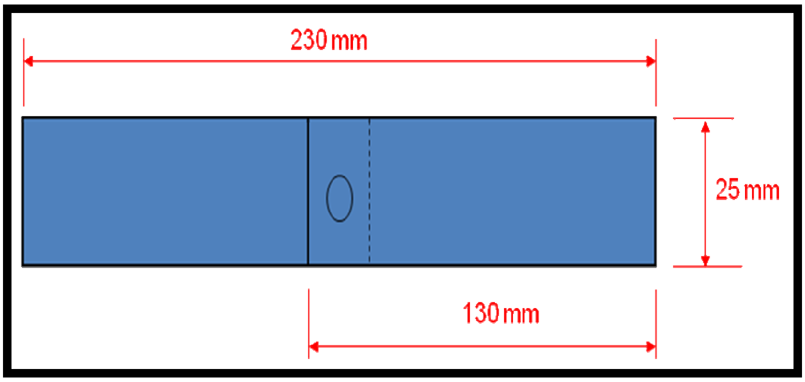

Figure (2) Nominal dimensions of weld sample.

Fig (3) the stirrer tools were made by special tool steel X38.

Figure (4) Clamping and Welding.

Table 2: Friction Spot Stir Welding Parameters.

Shoulder diameter D (mm)	Preheat dwell time (sec)	Plunging time (sec)
10	20	60
13	20	60
16	20	60
19	20	60

Table 3: The Results of Welding Process.

Shoulder diameter (mm)	Preheat dwell time (sec)	Plunging time (sec)	Shear force (N)
10	20	60	Failed
13	20	60	800
16	20	60	1800
19	20	60	2200

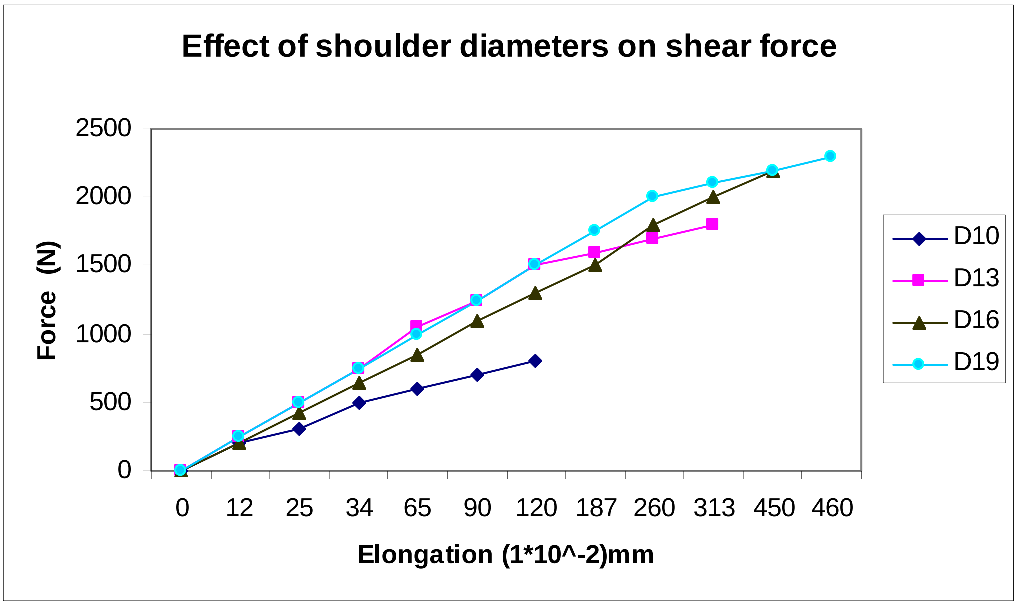

Figure (5) shear force change with shoulder diameter.

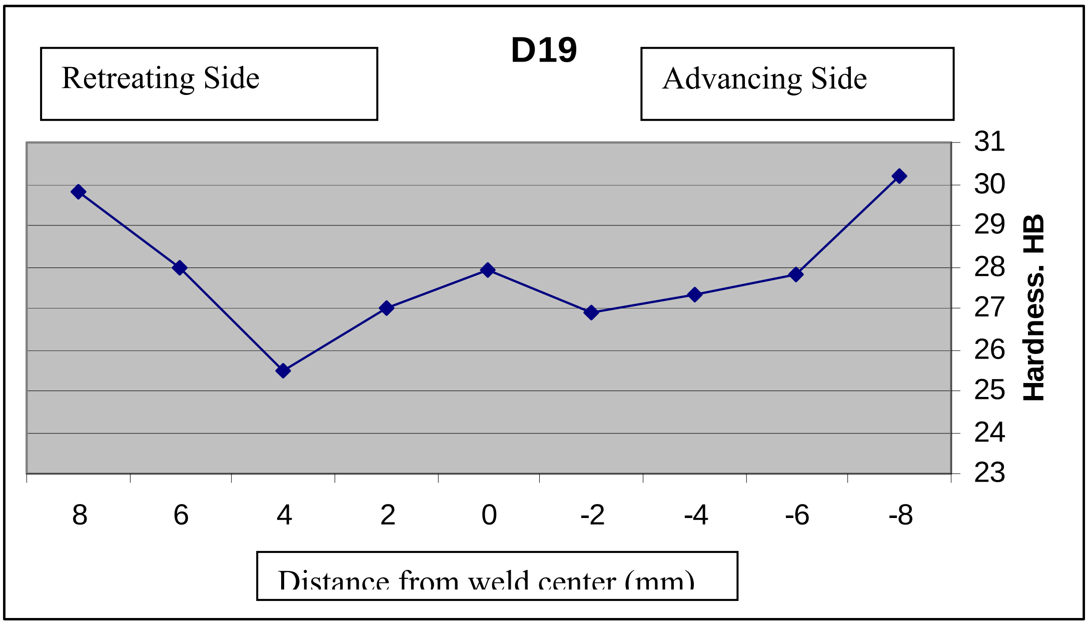

Figure (6) Microhardness at shoulder diameter 19 mm result.