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EFFECT OF RESISTANCE SPOT WELDING PARAMETERS FOR STEEL SHEETS ON THE WELDING STRENGTH

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ABSTRACT: - The resistance spot welding processes are widely used in the automobile, appliance and industries that use steel sheets, because of its low cost, high productivity, simple mechanism and applicability for automation. In this welding operation, two or more metal parts were joined together in a localized area by resistive heating and pressing force.

In this research, the effect of some welding parameters (voltage-current, and welding cycle time) on the resistance spot welding strength was investigated. Specimens made of mild steel sheet were spot welded and examined by using tensile test. The objective is to find out the optimum values of these parameters that give the best weldment strength which minimizes the frailer of the welded joint due to unsuitable welding parameters, and also to reduce the time and energy in using this process.

The results show that the welding parameters significantly affect the joint strength of the resistance spot welding. It shows that at low welding voltage-current, the welding joint strength increased by increasing welding cycle time, however at higher voltage-current, it increased by increasing welding cycle time to a specific values then started to decrease. It is obvious that voltage-current is more influential on welding joint strength than the welding cycle time. At (5 KVA) and (0.6 s) welding cycle time gave the best improvement in weldment strength for three sheet thicknesses (1, 1.5, and 2) mm of mild steel sheets.

1-INTRODUCTION:

Resistance welding operations are the mostly used process in joining steel sheets(1).In order to find spot welding conditions in production operations, many experiment investigations have to be performed, because the resistance spot welding process is a combination of three physical fields which are the mechanical field, the electric field, and the thermal field(2).In the spot welding operation, overlapped sheets are welded together by local fusion due to heat generated as a result of the flowing current between two pressing electrodes through a specific location as shown in Fig(1).

Spot welding electrodes are made of materials which have high electrical, thermal resistivity, and the strength to withstand high pressure at high temperatures, and it is important to make the electrodes with proper shape, and the current density is depending on the contact area between the welding electrodes and the welded parts (3).

In this process, thin sheet materials can be used up to 3 mm. The voltage is in a range of (1-30 V). The current is often in a range (1,000-100,000 A). The thermal energy input is efficiently used because of the combination of the high current with a rapid heating time, where K. S. Yeung and P. H. Thornton (4) concluded that in the spot welding operation the radiant heat and convective losses were not important. Filler materials are not required in this process; therefore spot welding has many advantages such as: small deformation of the welded sheet parts, because the thermal energy is restricted to the immediate accomplishing of the welding operation. Thermal energy (Q) is produced as the current (I) passes the electrical contact resistance between the two sheets (R) during a period of time (T)), as given by[5]:

$$\boldsymbol{Q = I^2 \cdot R \cdot T} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

The contact resistance between the welded pieces is higher than the resistance of the contact between the work-piece and the electrodes and also than the resistance in the metal itself. In the spot welding the current is concentrated to a few contact points because there are some non-even nesses on the metal surface where the heating is greatest at these points. Changing the pressing force could modify the actual contact area which results in changing resistance of the contact and thus changing the heating.

As welding starts, the temperature rises due to the resistance to the current passing through the welding zone until the melting temperature of the metal is reached, while the surfaces continue to be pressed together by the clamping force, so that a weld nugget forms in the contact area.

The resistance spot welding includes variables that can be modified in order to achieve optimum welding performance so it is necessary to optimize the process by trial and error [5]. Welding variables are; welding current, clamping force, welding cycle time, holding time.

The size of the area through which the current passes is determined by the electrode area. The electrode diameter (d) is determined in relation to the thickness of the metal (t)from the following formula[6]:

$$\mathbf{d} = 5 \cdot \sqrt{\mathbf{t}} \ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

The factor of (5) in the formula can suitably be increased to about 6-8 when welding high-strength steels

2- EXPERIMENTAL METHOD & MATERIALS

In this study, sheets samples of three groups made of mild steel(ISO 630 1995 E235 B) of chemical composition shown in table (1), was welded as lap joints of similar thickness by using resistance spot welding as shown in fig (2).Each group of is(75)sheet samples for each thickness of(1, 1.5, and 2) mm. The pressing force remained unchanged of (2.5, 3.5 and 4.5) KN for each thickness respectively. Surfaces of the samples were cleaned, free of from grease, dirt, paint, oxides and smooth surfaces. Samples were been cut by using shear cutting machine.

According to eq. (2), the welding diameter of the electrodes was (5, 6.1, and 7) mm been used for the sheet thicknesses of (1, 1.5, and 2) mm respectively.

The welding cycle time was changed to (.4, 0.6, 0.8, 1 and 1.2) s, and the welding current were changed by changing the voltage to (1, 2, 3, 4, 5 and 6) KVA.

The specimens' weldment strength of the spot welded joints was tested by using tensile test for each welding sample till failure of the welding joint. The test results were in (KN).WE-100A universal testing machine were been used to determine the tensile strength.

3- RESULTS AND DISCUTION

In this study, welding strength is an indicator on the resistance spot welding quality. Welding parameters changed by changing one factor and fixing the other factors. Tensile test was done on each of the welded samples.

The results of the weldment strength are shown in figures; (3, 4 and 5) respectively, where figure (3) represents the welding strength for the sheet samples of (1 mm) thickness. It shows that the welding joint strength increased by increasing welding cycle time at(1 and 2) KVA. This because increasing welding times caused high heat input to the welding zone and expanding weld area[7, 8]. Welding strength gave better results by increasing welding voltage-current from (1 to 2) KVA. However, at (3, 4 and 5) KVA the welding joint strength increased by increasing welding cycle time but it started to decrease after (1, 0.8, and 0.6) sof welding cycle time respectively. This because of extra heat were generated at the welding zone and gives more time for welding defects to be formed which is according to Mohd Zaim Bin Din [7] who concluded that excessive heat energy input causes cavity and cracks, and so, the strength of joint decreases. The maximum welding joint strength was (4.8 KN) at (5 KVA) and (0.6 s) welding time.

Figure (4) shows that at (2 KVA), the welding strength gave better results than at(1 KVA) for the sheets of (1.5 mm) thickness, which is less than that at(1 mm) thickness, however at higher voltage-current it gave better result than at (1 mm) thickness. This means for thicker sheets it required more heat to be welded. At (3 KVA), welding joint strength increased by increasing welding cycle time till (1 s) then it started to decrease. At (4 and 5) KVA the welding joint strength started to decrease after (0.8and 0.6)s respectively. The maximum welding joint strength for the (1.5 mm) thickness was (10.7 KN) at(5 KVA) and (0.6 s) welding time.

Figure (5) shows that for sheets of (2 mm) thickness, there were no welding at (1 KVA) for the (0.4 and 0.6) s of welding cycle time, and at (2 KVA) for the (0.4 s) welding cycle time. The welding operation failed in these particular cases. It is because the heat generated was less than that required to perform the welding operation. At (1 KVA) case, the welding joint strength increased by increasing welding time for more than (0.8 s), while it increased by increasing welding time to more than (0.6 s). That was because at (2 KVA) case the heat generated was more than that at (1 KVA)for same welding time(0.6 s). At (3, 4 and 5) KVA the welding joint strength started to decrease after (1, 0.8 and 0.6) s respectively. The maximum welding joint strength was (17.4KN) at (5 KVA) and (0.6 s) welding time.

4- CONCLUTION

In this study, the strength of resistance spot welded joints has been assessed with a tensile test for samples of mild steel sheets. The samples were of three groups of (1, 1.5, and 2) mm thickness. At each thickness, the voltage-current and welding cycle time was changed while the other welding parameters remained constants.

The result showed the following:

1. Spot welding strength increased by increasing each of the voltage-current and welding time, till specific values which gave the best weldment strength, then it started to decrease with increasing welding time. The peak value of each depended on the sheet thickness. So that, the proper selection of spot welding parameters is essential to get better weldment strength and preventing weld joint frailer.
2. The voltage-current is more influential on welding joint strength than the welding cycle time.
3. The maximum welding joint strength was at (5 KVA) and (0.6 s) of welding time for each thickness of (1, 1.5, and 2) mm.

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Table (1) Grade and Chemical composition of the used mild steel sheet metal

Designation	Grade	Chemical Composition				
		C	Mn	Si	P	S
ISO 630 1995	E 235 B	0.17	1.4	0.40	0.045	0.045

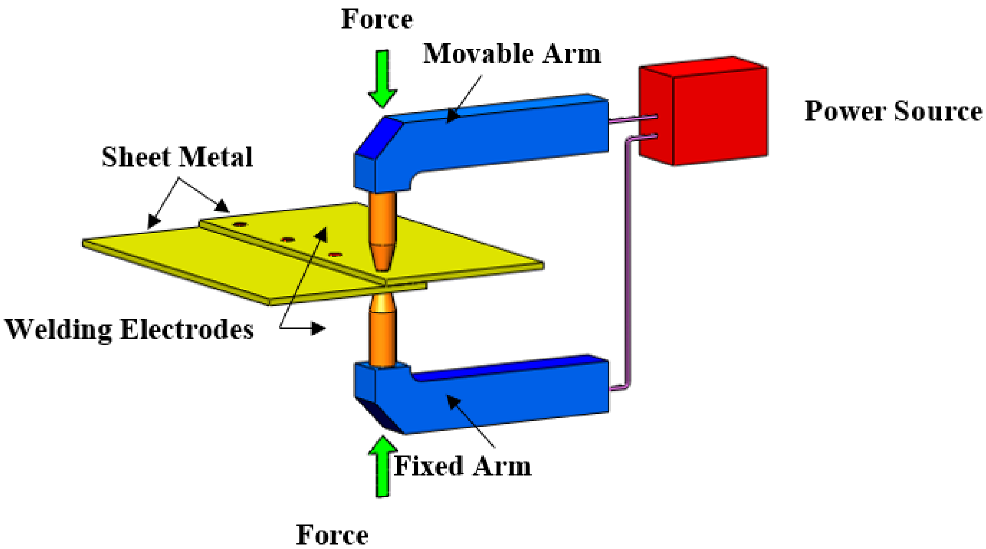

Fig. (1) Resistance Spot Welding

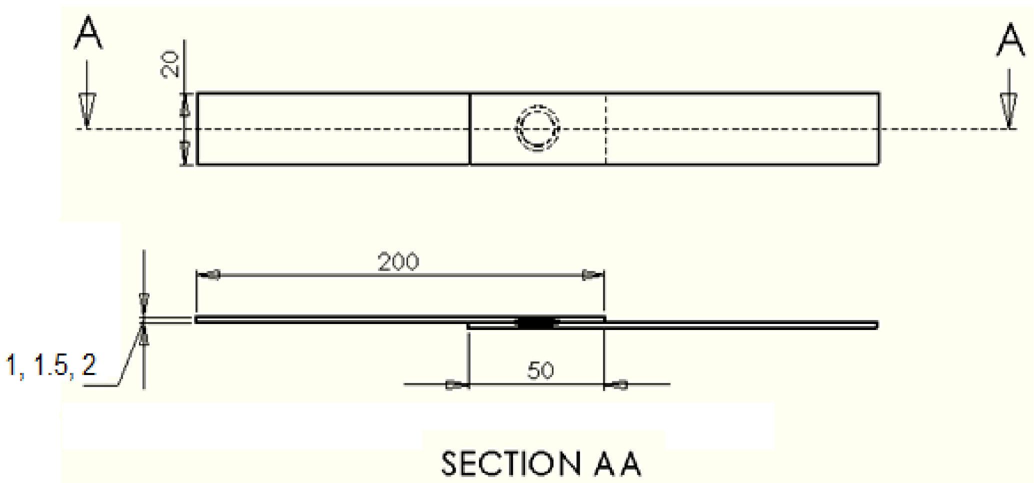

Fig. (2) Dimensions of the steel Sheet specimens

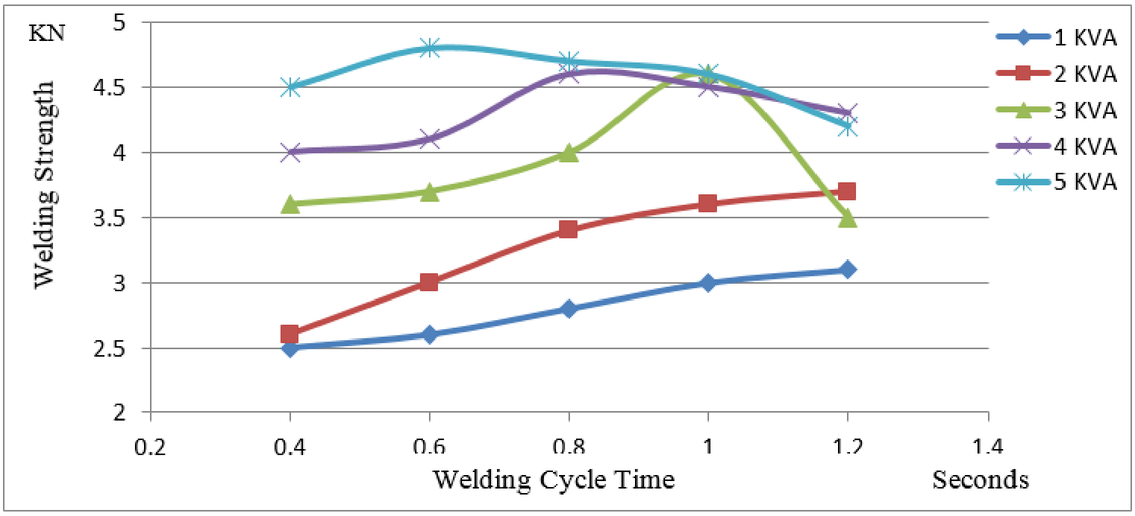

Fig. (3) Relation between welding time and welding strength for sheet thickness (1 mm)

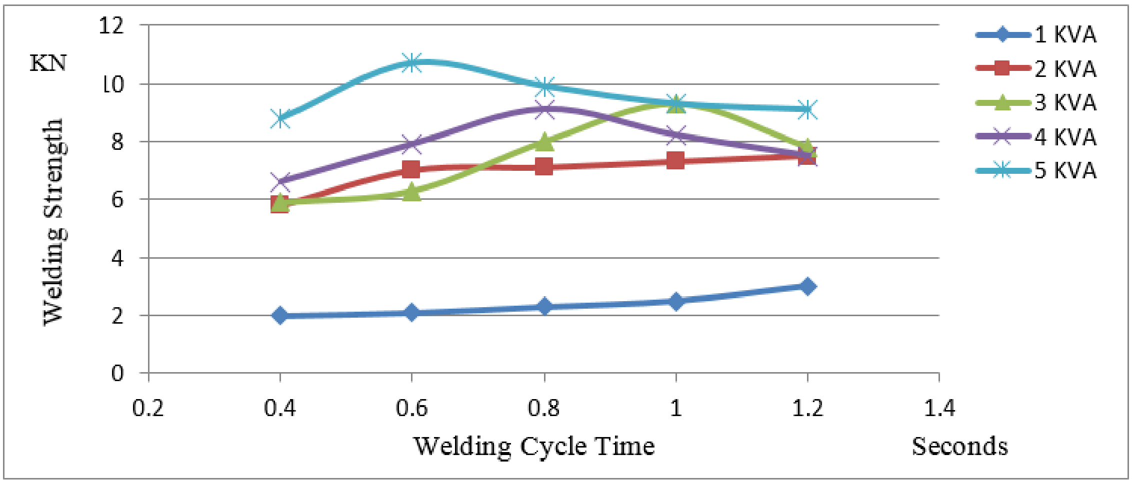

Fig. (4) Relation between welding time and welding strength for sheet thickness (1.5 mm)

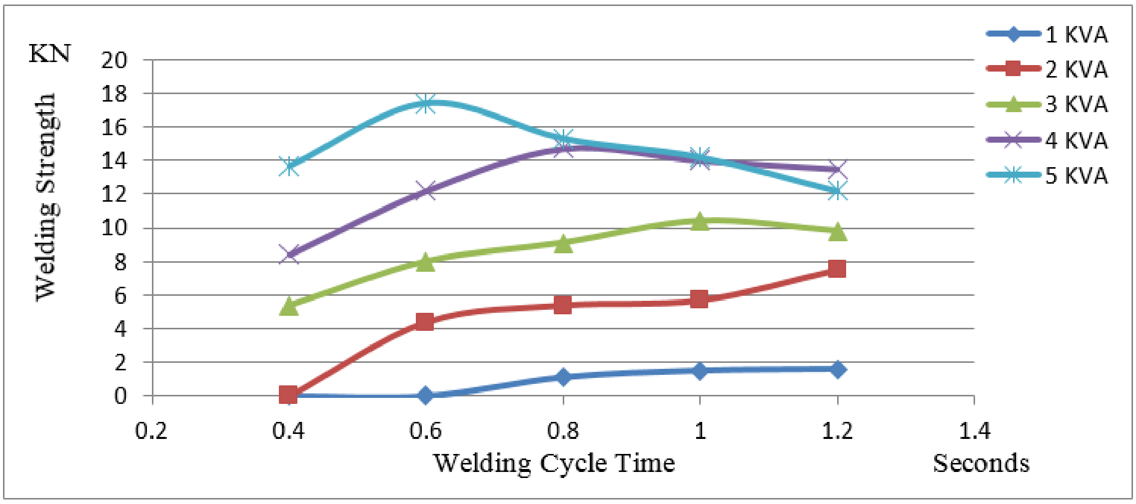

Fig. (5) Relation between welding time and welding strength for sheet thickness (2 mm)

تأثير ظروف لحام المقاومة النقطي لصفائح الفولاذ على متانة الوصلة الملحومة

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الخلاصة:

ان عملية اللحام النقطي باتت شائعة الانتشار وخصوصا في مصانع المركبات الالية و المبردات والافران وغيرها من الصناعات التي تدخل صفائح الفولاذ في صناعتها, وذلك كون هذه العملية منخفضة التكاليف, انتاجية عالية, الية بسيطة مع امكانية جعل هذه العملية اوتوماتيكية. في عملية اللحام هذه يتم ربط صفيحتين او اكثر مع بعض بواسطة التسخين الناتج عن مقاومة التيار المار خلال موقع اللحام مع استخدام قوة ضاغطة.

لقد تم في هذا البحث دراسة تأثير بعض المتغيرات لعملية لحام المقاومة الكهربائية النقطي (فرق الجهد – تيار و زمن مرور تيار اللحام) على متانة الوصلة الملحومة لصفائح الحديد الصلب, وذلك بفحص العينات الملحومة بجهاز شد وذلك للتوصل الى افضل قيم لظروف اللحام هذه والتي تعطي افضل متانة لحام والذي يقلل حدوث الفشل في الصفائح الملحومة نتيجة ظروف لحام غير ملائمة, وكذلك لتقليل الوقت والطاقة المصروفين في عملية اللحام هذه.

يتبين بوضوح من النتائج العملية بان ظروف عملية اللحام النقطي تؤثر بشكل ملحوظ على متانة الوصلة الملحومة بطريقة لحام المقاومة النقطي. لقد بينت النتائج بانه عند استخدام فولتية–تيار قليل نسبيا فان متانة الوصلة الملحومة تزداد بزيادة زمن مرور تيار اللحام, وعند استخدام فولتية–تيار اعلى نسبيا فان متانة الوصلة الملحومة تزداد بزيادة زمن مرور تيار اللحام الى قيم معينة ثم تبدا بالتناقص. وبينت النتائج ان فولتية–تيار اللحام هو اكثر تأثيرا على متانة الوصلة الملحومة من زمن مرور التيار, وكانت افضل مقاومة شد بالنسبة للظروف التي تم اعتمادها في البحث كانت عند استخدام (5 KVA)و (0.6) ثانية في لحام صفائح الصلب بسمك (1, 1.5 , 2) مم.