RESEARCHES ABOUT THE INFLUENCE OF SURFACES ROUGHNESS ON RESISTANCE SPOT WELDING (RSW) RESULTS

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Abstract

This work studies the influence sheet surface roughness on resistance spot welding (RSW) results. For the experimental research was used a S235JR (low carbon steel) sheet with 1 mm thickness. Were prepared 3 sets of different samples: a). Genuine steel sheet, b). steel sheet brushed c). sand blasted. The pieces were spot welded using the following parameters: the electrodes pressure constantly at 1.5kN, the welding time constantly at 6 cycles and the welding current was variable 5, 6 and 7 kA.

For pursuing the influence sheets surfaces conditions was measured roughness, electrical and mechanical resistance, for all three types of joints. Relationships were established between the three factors studied. It was observed that the higher roughness drives to the increasing of the contact resistance between pieces. Hence, the mechanical resistance was not raised simultaneous with the extension of roughness and contact resistance.

Keywords: resistance spot welding, surfaces conditions, roughness, contact resistance

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Introduction

RSW is a process of joining two or more pieces that uses the Joule's effect of electricity.

The pieces are tightened between two electrodes with good electrical conductivity; when an electrical current goes through them, a maximum contact resistance occurs in welded area, which allows a local melting of materials (Lenz Joule effect) and joint formation. RSW is one of the most applied processes in automotive industry. At a vehicle building are used about 5000 welding joints. This process is also used in home electronics industry, aerospace and at other different applications where joints of quasi-manufactured thin materials are needed. Different metallic materials can be welded, but not in the same welding conditions.

The surfaces condition of the components that are going to be welded is a very important agent for the weld ability. The same material, with different conditions of the surfaces obtained through diverse method, behave different at RSW because of the influence exercised on the electrical contact resistance. The contact resistance varies depending on the surface peculiarities (roughness, oxides, etc), applied pressure and applied current, managing to influence the final result. Previous studies were made regarding the influence played upon the contact resistance by the applied pressure and the temperature changes. It was proved that contact resistance increases with pressure but the highest the temperature, the lowest the contact resistance is [1].

Studies were also made for obtaining some lubricants for covering the parts before welding [2]. It was noticed that a preliminary welding with a low current followed by a welding with a stronger current is used for lubricants. Different studies were made for noticing the reaction layer at welding some pieces made of different materials [3,4]. Surfaces roughness, covering and its type and the oxides layer influence the welding joint quality[5]. In [6] it is said that the distance created between the pieces by the surfaces irregularities should not exceed 10% of the welded material thickness.

This paper accomplishes a comparative analyze of the contact resistance for RSW as a function of the surfaces preparation mode. Mechanical tests were made in order to notice the influence of the surfaces preparation mode on the tensile shear resistance.

Experimental work

A low carbon steel sheet, S235 JR grade, 1 mm thickness with the chemical composition listed in table 1 was used. The sample's dimensions before welding and for tensile test are given in figure 1.

Fe	C	Si	Mn	P	S	Cr	Mo,Ni , Sn	Al	Co	Cu	Nb, Ti	W	Pb
99,4	0,028	0,05	0,31	0,018	0,012	0,03	0,005	0,04	0,002	0,02	0,002	0,01	0,03

Table1. The chemical composition of low carbon steel, S235 JR grade

After cutting the whole needed batch, sets of specimens were prepared different for welding: a set was sand blasted, another brush polished and another was just degreased. The treatments were applied only on the surfaces to be in contact at welding. The roughness of the surfaces for all the conditions was measured. The following average roughness values were obtained: for as delivered sheet 1,34μm, for brushed samples 1,51μm and for blasted sheets 9,65μm.

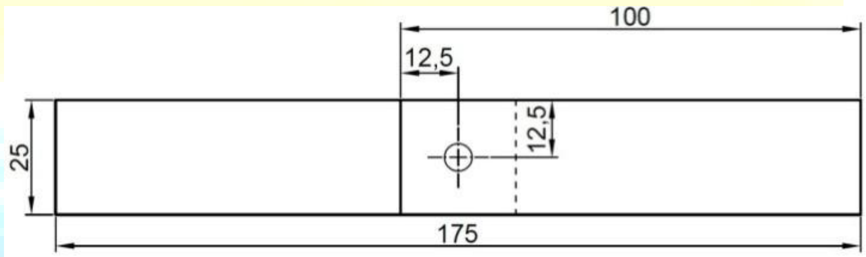

Fig.1.The specimen's dimensions and weld place

The pieces were welded using the Machine Digital Spotter 9000. This one disposes a maximum current of 7KA and a pneumatic clamping mechanism for the electrodes. The used working parameters were: pressure maintained constant at 1.5kN, the welding time maintained constant at 6 cycles and the welding electrical current varied at 5,6 and 7KA. There were used electrodes with conical shape and tip diameter of 4 mm.

Results

Influence of the sample surface roughness on the electrical resistance. As we know from the literature at the surfaces contact during welding an electrical contact resistance develops. The two components which define the contact resistance are:

Striction resistance given by the contact through a finite number of elementary joints;

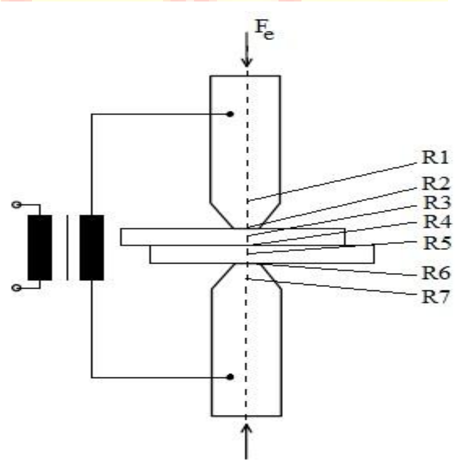

Fig.2. The occurrence of resistances in electrical resistance spot welding

Film resistance given by the oxides and impurities layers, with electrical resistance higher than that of the metal.

The quantity of heat released during the welding depends on this resistance magnitude, because:

$$Q=I^2Rt \qquad (1)$$

Where: Q= the heat quantity, I= electrical current intensity, t= the welding time.

At RSW, the work resistance is a sum of resistances: the resistances of the secondary circuit of the machine (R1,R7), including that of the electrodes; the electrical contact resistance between the electrodes and the parts to be welded (R2,R6); the resistances of the sheet (R3,R5) and the resistance of the contact between the semimanufactured materials (R4) (refer with: Fig. 2). The lowest values of the resistance are those of the secondary circuit of the machine and the highest resistances are registered at the contact between sheets. This depends on the conditions of the basic material surfaces and the applied pressure of the electrodes. In this paper are presented the influence of the total electrical contact resistance determination for the material S235 JR. For this purpose, the pressure of the electrodes was maintained constant, varying only the method of preparing the surfaces and the welding parameters.

Resistance Measurement methodology: The measurement technique consists in measuring the voltage drop between the electrodes. This method summarizes the voltage drop between sheets and electrodes - sheets. The samples are placed between the electrodes (refer with: Fig. 3) which are connected through electrical wires to the TCT-2 current and voltage kit. The variable resistor was added in order to protect the power supply from short circuit. The measurement of the current was made by using a *Metradigital ammeter* placed in a series connection with the power supply and the electrodes. The contact resistance was made using and LeCroy

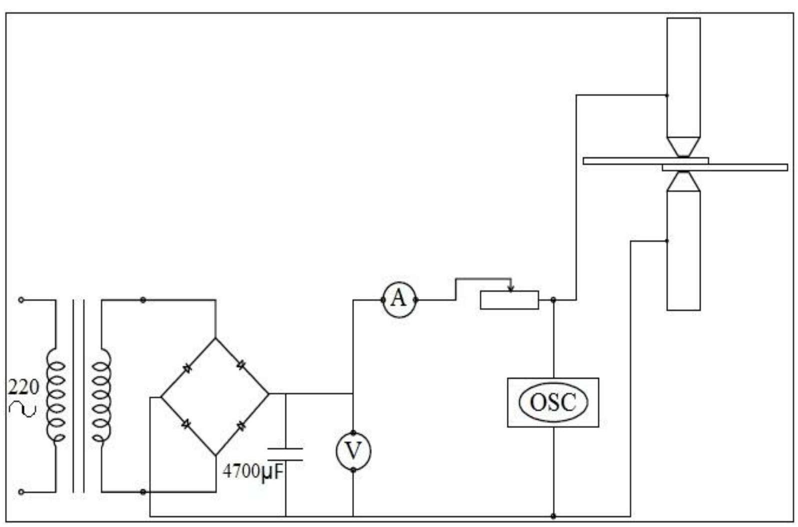

Fig.3. Schematic representation of the experimental device for

343 Wave Surfer Oscilloscope which was connected in parallel with both electrodes. The measurements of the contact resistances were achieved between electrodes at a constant temperature of 21 ^{o}C and a constant pressure of 1.5 kN.

Because of the curved profile of the new electrodes which are quickly flattened while the number of welding increases [7,8] the measure was made using a 6 KA current. For this current value the TCT-2 kit provide a voltage of 7 V.

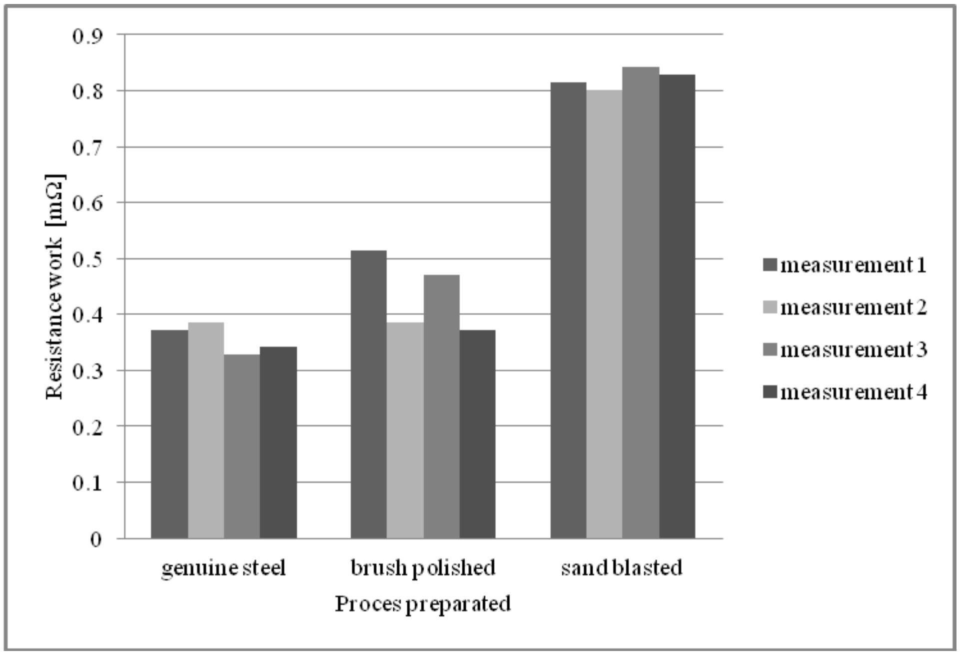

Fig.4. Resistance work measurements for those three types specimens

The results are summarized in the figure 4. One can notice that the measured resistance has different values for each preparing process of the surfaces. The lowest resistance was noticed between the sheets of genuine steel. The highest values of the resistance were measured on the sheets of blasted steel. Comparing these results with the values for the roughness measurement we notice that the work resistance increases with the increase of the contact surfaces roughness.

At the sheets with a highest roughness the genuine contact surface is lower. This involves an increase of the contact resistance and implicitly the increase of the total resistance.

Mechanical tests. After the welding process, all the samples were tensile shear tested on a machine for general attempts WDW 50. It was followed the registered failure resistance and some aspects regarding the place and the appearance of the failure.

After the tensile shear tests three types of failure were noticed (refer with: Fig. 5):

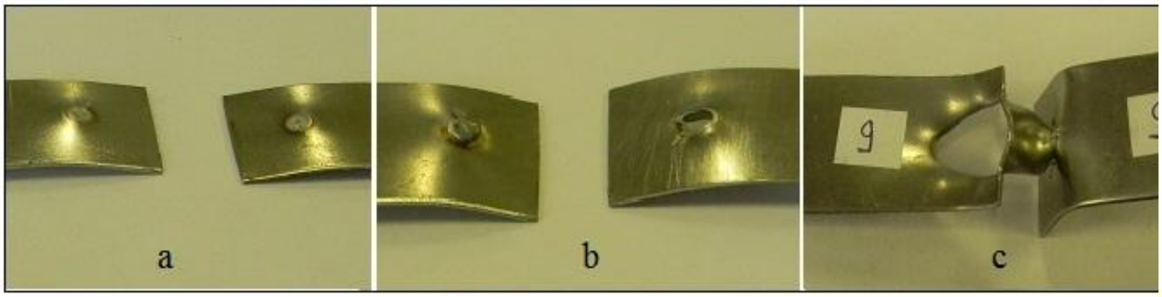

Fig. 5. Types failure of spot welding: (a) separation; (b) knotting; (c) tearing.

For all the steel sheets was noticed a pronounced increase of the tensile shear resistance of the samples welded with 6 KA as compared with those welded with 5 KA. The rising tendency of the shear stress values is preserved for the 7 KA welding current but with a lower intensity. (refer with: Fig. 6). The highest tensile shear stresses are registered in all the welding conditions for the brushed samples.

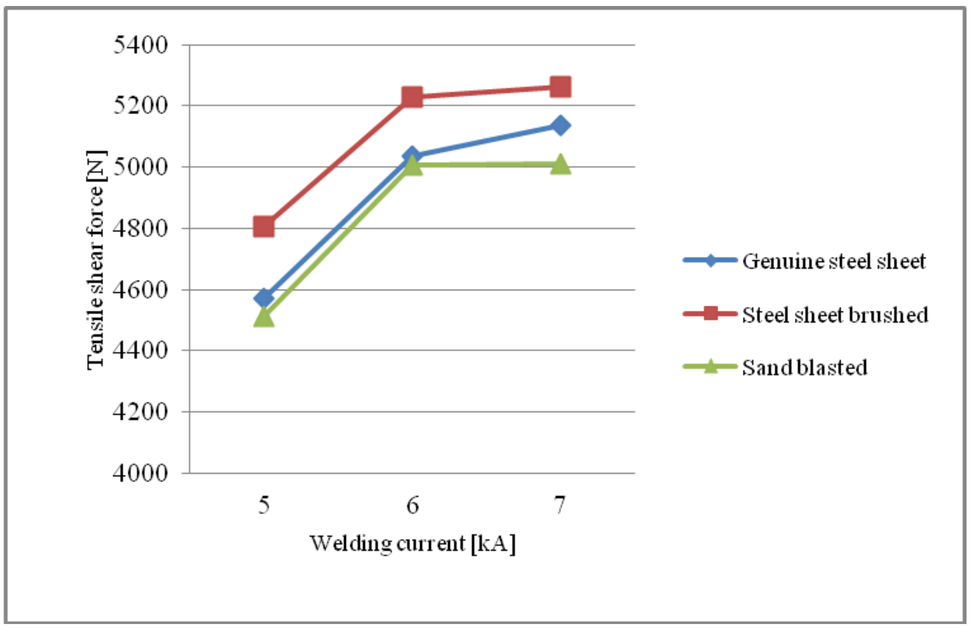

Fig.6. Strength of the three different prepared types specimens

The tensile sheer tests showed that the blasted steel sheets had the lowest resistance for all the three values used for electrical current.

Studying the results was noticed that for the brushed steel sheets the work resistance increase conducted to a higher homogenization of the nugget and to an increase of the tensile shear resistance against the genuine steel sheets. Even if for the blasted steel sheets the work resistance was the highest, these ones had the lowest tensile shear resistance. This effect could be the result of too much heat formed in the first moments of the welding cycle. The asperities are molten too fast without any strain and so the nuclei forms too fast. Another influence that can damage the quality of the blasted samples is the presence of the impurities in the superficial layer of the sheet. The blast impurities could not have been cleaned with solvents and the nugget has no its full surface.

Conclusions

Preparing the surfaces by brushing generated the highest tensile shear resistance for all the used values of the electrical current, 5, 6 and 7 KA. The highest tensile shear resistance was obtained using the welding current of 7 KA.

Even that the highest electrical resistance contact was obtained at the blasted sheets, these ones had the lowest tensile shear resistance.

It can be noticed that the best preparing method of the S235 JR surfaces for the RWS is the mechanic brushing, this generating a roughness and a work resistance higher than those for the genuine steel sheets.

Acknowledgement

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