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The Multipoint Relief Projection Study

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Abstract

Projection welding is a joining process based on the electrical resistance of metal components that have small protrusions on the areas where assembly is desired. In this case, the welding electrodes that ensure the transfer of the electric current have a flat geometry, which allows uniform pressing of the areas with protrusions, which have the role of ensuring the concentration of the current lines for the formation of welding points. Excessive deformation can cause the protrusions to collapse rapidly, causing greater dispersion of the current and limiting the effect of localized heating and melting, and welding no longer occurs. The process is widely used in the electrical, electronic, automotive, food and construction industries, etc. The paper analyzes the effect of regime parameter values during the resistance welding process on the joints made between 2 steel components with surfaces protected by aluminization. The surface of one of the components was imprinted with 5 equidistant protrusions created by plastic deformation to concentrate the electric current lines and achieve melting points with a limited surface area. The thin layer of aluminum deposited on the surfaces of the parts has the role of protection against corrosion, but it produces hard compounds located on the welding interface. The chemical micro-composition analyzes performed with the EDAX method highlighted the diffusion effects of chemical elements in the welding area and the formation of hard compounds Al-rich loccated on the fusion line of the welded points. The microstructure of the welded areas was analyzed and the fracture strength tests of some welded samples were performed to establish the most suitable values of the welding process for this application.

Keywords: projection welding; current; microstructure; tensile test; microhardness

Introduction

Nowadays, talking about production problems and challenges, it represents an important research topic in modern industry, due to the challenges it faces. Since we are in a continuous change, where the digitization and technology are constantly changing, it is a breath of fresh air to talk about discoveries and tests, which help the industry to significantly reduce costs, production time and increase efficiency and control. Due to the changes in modern characteristics, any assembly must adapt to the operating conditions, to be functional both mechanically and durability. From experience, I can say that the welding projection plays a major role in modern industry, and this made me want to study the entire welding process on different adjustment parameters depending on the thickness of the parts. Using relief welding, the shape, depth, and type of the punch used for imprinting on the parts to be welded must be studied. Penetration tests of the welding process at different parameters and material thickness will be presented to find the optimal work option. To obtain the most uniform and high-quality welding inside and outside, in order to ensure quality, it should not affect the design part of the product, which in the final form is to be painted or covered with different coating liquids according to their functionality.

The projection welding process is based on the resistive effect of electric current that generates in the material the amount of heat required for localized melting and the welded spots formation [1-3]. Different from the classic process of electric resistance welding is the method of locating the joining areas. For this, some small grouped protrusions (3 or 5 simultaneous protrusions) are printed on the surfaces of one of the components by mechanical pressing, which will be the effective electrical contact points. The dimensions of the projection (0.5 to 1.5 mm) are determined according to the thickness and characteristics of the materials to be welded [4-5]. When the current passes through the protrusions, they heat up quickly until they melt, and the subsequent pressing causes their flattening and the simultaneous formation of several welded points. This process is often used for quickly joining thin sheets and plates with thicknesses below 3 mm.

In projection welding, the projection height is very important, the optimal value being considered to be 0.2 mm [4]. During the rapid heating under the resistive effect of the electric current, the flow limit of the material drops suddenly, leading to its flattening and the expansion of the heated area. Therefore, a progressive adjustment of the projection dimensions and the welding regime parameters values is necessary to obtain a correct joint [5-7]. At the same time, it is necessary to remove contaminating elements from the surfaces to be welded (grease and oxide films) that can significantly reduce the quality of welds, especially in the case of multi-point joints [7-8].

An important advantage of this joining process is a lower rate of tip electrodes wear, because in this case flat electrode surfaces are used, with dimensions of 25x25 mm or larger. Regarding the establishment of the values of the parameters of the welding regime, it was found that by increasing the current value from 4 to 11 kA and to the welding time from 50 to 300 ms, an increase in the diameter of the welded spot occurs which determines the grains growth and cracks formation in the joint [9-10].

The paper presents the effect of the parameters of the welding regime on the quality of some joints made by projection welding between two steel plates having 1.2 mm thickness.

On the surface of one aluminized steel component, 5 protrusions were made by mechanical pressing, which allow a higher value of the shear resistance of the joint to be achieved. The values of the electrodes pressing forces, the current and the welding time on the geometry of the welded area and their influence on the shear resistance of the welded joint are studied.

Research Methods

A TECNA 8005D Series Spot and Projection Welder machine (maximum welding power of 200 kVA, maximum welding current for steel of 28kVA) was used for projection welding (Figure 1).

The 2 copper electrodes with the flat surface of the machine transmit the electric current and also press the steel plates during welding.

Although the welding time is very short, chosen so that the protrusions on the surface of the plates do not flatten too much, it is enough to form solid melting points between the two overlapping components.

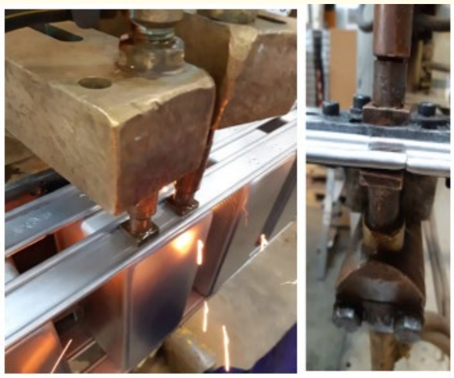

Figure 1: Sequences from the projection welding.

The parameters of the welding regime were controlled with dedicated devices, namely hydraulic manometers for measuring the welding force (Figure 2a) or the hydraulic dynamometer for measuring the pressure force at the electrodes.

The electrical parameters can be measured using AMADA WELD TECH MM-315B apparatus shown in Figure 2b. The device can measures welding current (kA), welding welding time/cycles (sec), electrical conductivity level (deg), power (%).

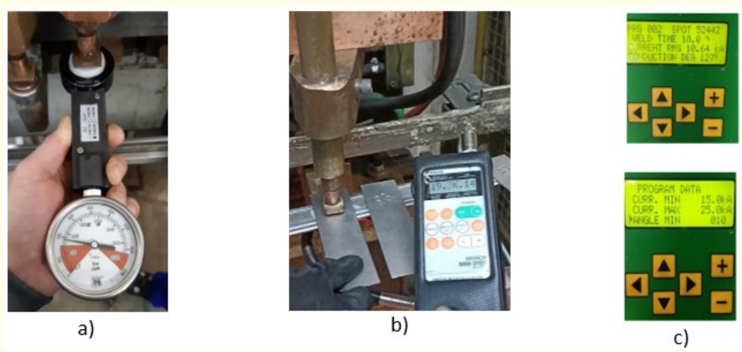

Figure 2: Apparatus for measuring welding parameters.

After the welding process, the welding points were visually analyzed, highlighting the dimensions and degree of oxidation of the adjacent surfaces.

They were then subjected to destructive tensile shear tests in order to record and analyze the stress diagrams, the fracture resistance values and the fractured areas.

The “W+b” Walter + bai ag tensile/compression machine was used to perform the shear tests (Figure 3).

Figure 3: The tensile/compression machine and sample during test.

The microstructure of the welded areas was evaluated by optical method with the Olympus GX51 and by scanning electron microscopy using the Inspect S microscope equipped with the Z2e EDAX AMETEC sensor. Microhardness measurements were performed on the cross-section of the welded samples, applying the indentation load of 0.2 N and the indentation time of 10s, with the Shimadzu HMV 2T apparatus.

Experimental procedure

The paper analyzed the projection welding behavior of 0.9 mm thick aluminized steel sheets. Aluminization is a process of covering surfaces with thin layers of aluminum, with the aim of ensuring better corrosion behavior and wear during operation. However, the aluminum layer can be a source of problems during welding, as there is the possibility of hard compounds forming at the welded interface.

A mold with 5 pins was used to create, by plastic deformation, the projections necessary to concentrate the current in discrete points (Figure 4).

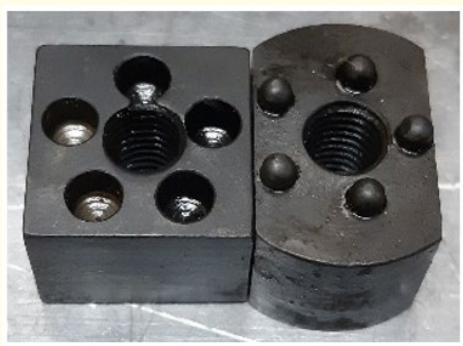

Figure 4: Mold used for projections making.

Projections are obtained by stamping using dedicated dies and devices. For printing, pressure is applied to the punches which locally deform the sheets, creating pairs of protrusions (5) of a certain shape, size and spacing.

For the study of the welding regime parameters effects on the shear strength of the projection joints, several sets of welded samples were made. (Figure 5).

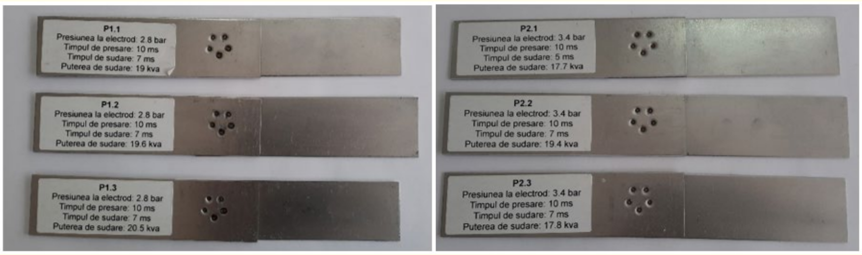

Figure 5: Batches of welded parts.

In the first set of tests, the values for welding time, electrode pressure and pressing time were kept constant, while the power had 3 different values. In the next batch, the welding time and electrode pressure were increased while the power value was slightly decreased. The values of all welding parameters are presented in Table 1.

Sample	***Electrode pressure, bar***	***Pressure time, ms***	***Welding time, ms***	***Welding power, kVA***
P1.1	2.8	10	7	19
P1.2	2.8	10	7	19.6
P1.3	2.8	10	7	20.5
P2.1	3.4	10	5	17.7
P2.2	3.4	10	7	19.4
P2.3	3.4	10	7	17.8

Table 1: Values of the welding regime parameters.

The stages of the welding process were:

- Adjusting the values of the welding parameters at the control panel of the machine.
- Introducing and positioning the assembly of the 2 overlapping components between the welding electrodes.
- Pressing the electrodes and passing the electric current through the assembly formed by the electrodes and overlapping plates.
- Formation of welded points.
- Extraction of the welded assembly and control of the welded points.

Results and Discussion

During the destructive testing procedure, the shear resistance values were precisely determined by continuous stress (tensile test). The following parameters have been determined: rigidity, determined by regression on the linear portion of the curve, between 1.5 - 5kN, with adjusting of the curve shape by” nose” removing; the maximum force value (Fmax) during the test; failure, by the coordinates of first weld failed point; energy, by the area under the curve measured from the coordinates (0,0) to first failure. The values of the tensile test parameters are presented in Table 2 and the stress versus strain diagram in Figure 6.

Sample	Rigidity [kN/mm]	Fmax [kN]	Failure		Energy [kN*mm]
			F[kN]	d[mm]	
P1.1	32.076	16.246	16.081	3.8674	53.39
P1.2	33.446	16.282	16.243	5.042	72.71
P1.3	31.401	16.342	16.068	4.4323	62.67
P2.1	31.257	14.946	14.90	1.8215	21.73
P2.2	32.561	16.075	16.005	4.163	57.89
P2.3	30.812	14.448	13.557	2.1532	25.34

Table 2: The tensile test parameters.

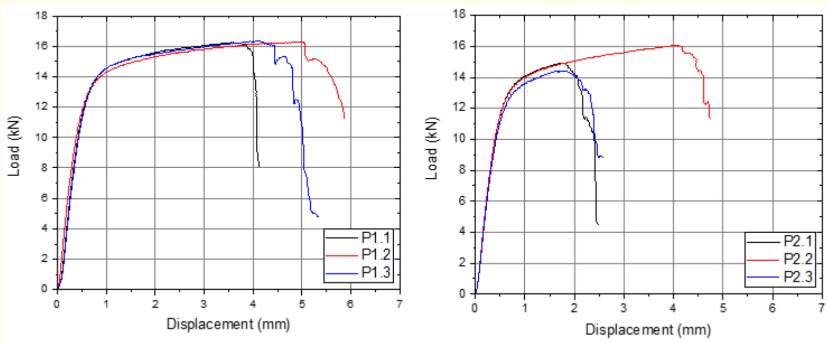

Figure 6: Stress/strain diagrams.

As results from the data presented in Table 2, the maximum values for Fmax were obtained for the samples of the first batch, namely P1.3 (16,342 kN), P1.1 (16,282 kN) and P1.2 (16,246 kN). From the second batch, only sample P2.2 has an acceptable value (16.075 kN). This evolution is graphically reflected by the stress/strain diagrams in Figure 6. Regarding the energy consumed for failure, the best results were obtained in the case of sample P1.2 (72.71 kN*mm) and the lowest energy value was recorded by samples P2.1 (21.73 kN* mm) and P2.3 (25.34 kN*mm).

Conclusion

In the paper, deferent welding regimes were analyzed for the joining of thin aluminized steel sheets by the projection welding process with 5 points welded simultaneously.

This research contains destructive methods instead of non-destructive methods because the first ones are used for welds that cannot have a very good clear relationship with non-destructive ones. These relief welds go through thousands of cycles through various high and low temperatures. Many mechanical forces appear on the welds along the stress and resistance process. Through various acid solutions for cleaning and over time these welds fail due to the work system.

In order to choose the optimal welding regime, several sets of samples were subjected to the tensile test, and the values of the maximum forces at which the first welding point broke were determined.

The parameters of the welding regime that were analyzed were: electrode pressure (2.8 - 5 bar), welding time (5-7 sec), and welding power (17.7 - 20.5 kVA). The microhardness has been measured on base material, fusion line and heat affected zone (HAZ). Very high hardness values were measured above the welded point (about 850 HV0.2), due to the formation of hard Al-Fe compounds.

Recording a comparative analysis of all the tests carried out on several samples, listed in the study, the conclusion is that the best results were obtained for the electrode pressure value of 2.8 bar, welding time of 7 ms and pressing time of 10 ms, associated with the electric power values between 19 and 20.5 kVA. By reducing the welding time to 5 ms and increasing the electrode pressure to 3.4 bar combined with reducing the electric power to 17.7 and 17.8 kVA, there was a reduction in the fracture strength of the welded spots.

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