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THE STUDY OF INCREASED HEIGHTATMIG-CMTCONTINUOUS ORPULSECOMBINED BRAZE-WELDING OF THETHINSHEETSOFGALVANIZEDSTEEL AND ALUMINUM

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ABSTRACT: This work presents a comparative study of continuous CMT braze-welding and pulse CMTP braze- welding joint’s increased height on galvanized steel sheet with aluminum, the influencing factors being the braze-welding current, the speed of the braze-welding head and the dynamic correction factor of the source. Finally revealed that the increased height is significantly influenced by the process type and source dynamic correction factor (+5/-5) at the same linear energy.

KEY WORDS: braze-welding of galvanized steel with aluminium, factorial experiment, intermetallic layer

1. INTRODUCTION

To solve corrosion problems and simultaneously obtain alight construction, in practice it is necessary to achieved is similar joints between elements of galvanized steel and aluminum, [1].

Joining by welding the combination of steel and aluminium base material sis difficult, due to metallurgical incompatibility issues and physical characteristics of the two materials. In metallurgical terms, aluminium with iron are forming solid solutions, intermediate phase sand eutectic inter metallic compounds. The solubility of iron in aluminium is insignificant. At low content of iron in aluminium an intermediate compound Fe3Al appears, containing approximately34% Fe. At higher levels of aluminium FeAl2 (66% Fe), Fe2Al5 (70.2% Fe), FeAl3 (74.5% Fe), intermediary compounds appears [2].

The presence of these intermetallic compounds makes difficult to do a welded joint.

A second difficulty in combining steel and aluminum by welding is due to the large difference between the melting temperature of steel (1536^0C) and melting temperature of aluminum (660^0C). By using of a fusion welding process is difficult to melt the two basic materials in a single welding bath.

The reasons described above makes it extremely difficult to use welding procedures to achieve this type of dissimilar joints. Joining methods that do not produce the melting of the materials (pressure welding processes or ultrasound), [3] or processes that brought the welding energy to be minimized are preferred. For this reason, using a braze-welding process may be a favourable alternative against using a conventional fusion welding process [4].During the jointing just the material with the lower melting temperature is melted, in this case the aluminum. The filler material is chosen according to the characteristics of aluminum.

In fact, during the braze-welding of galvanized steel with aluminum the filler material and base material are melted and deposited on the surface of galvanized steel. The link between aluminium and steel sheet is mainly mechanical, due to sudden contraction by cooling of the aluminum in contact with the surface of not melted steel [5].

It should be noted that this combination of heterogeneous zinc present in the material behaves as an etching agent in the joint, supporting the joint. Another positive factor introduced by zinc is the increased surface roughness in the base material where the joint is done. The presence of zinc has a negative effect by favouring pore production in the joint.

2. EQUIPMENTUSED INEXPERIMENTS

Weld brazing experimental program by CMT process was accomplished using a welding station consists of the following elements, (figure 1):

- Power MIG /MAG welding torch and CMTFronius with buffer device for wire feed speed variation with maximum rated current of 270A;

-Welding tractor equipped with running path (mechanized welding);

-Table positioning and welding device;

- Device for monitoring parameters;

-Electron Microscope.

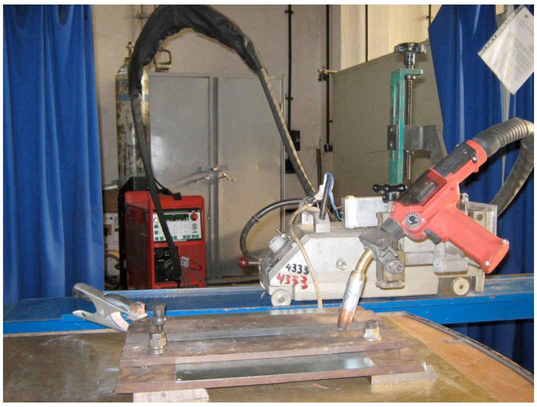

Figure 1. Equipment used in experiments

3. THE EXPERIMENTAL

Performing the experiment program were used the following materials: galvanized steel sheet DX51D+Z150-N-A-C (SR EN 10327:2004) and aluminium alloy sheet EN AW 1200 (SR EN 1706: 2000), both having a thickness of1mm.

Basic material	$R_{p0,2}[N/mm^2]$	$R_m[N/mm^2]$
Galvanized steel sheet (DX51D+Z150-N-A-C)	348-395	min 405
Aluminum alloy sheet (EN AW 1200)	150-165	min 205

Table 1. Main mechanical properties of base materials

As filler material for weld brazing was used AlSi5 alloy electrode wire diameter 1.2 mm [6], the chemical composition of the material deposited with the wire according to DIN1732 are shown in table 2 and mechanical characteristics of the material AlSi5 wire are shown in the table 3.

Filler material	Chemical composition, %			
	Si	Mn	Fe	Al
AlSi5	4,5-5,0	<0,5	<0,5	rest

Table 2. Chemical composition of deposited metal wire electrodeAlSi5

Yield Rp0,2 N/mm2	Hardness HB	Tensile Rm N/mm2	Elongation at break A10[%]
70-90	48-60	110-160	min. 15

Table 3. Mechanical characteristics of the materialAlSi5wire

Technical Argon (Ar100%), as shielding gas was used this being the recommended gas for welding aluminum alloys, [7]. The braze-welding was done mechanized.

The experimental program included a factorial experiment type 23 having the following parameters: the speed of welding, dynamic correction factor welding methods – CMT (continuous) or CMTP (pulse)-,each factor was regulated on two levels. The implementation plan of this experiment is shown in table 4, experiments were performed on sheet size150x250x1mm.

Nr.	vs [mm/min]	I_{na}	Types of transfer	$I_s[A]$	$U_a[V]$	El [J/cm]	s [mm]
0	900	0	CMT	63,5	11,4	482,6	
1	800	+5	CMT	67	11,9	509,79	0,689
5	800	-5	CMT	60	11,3	439,42	0,362
4	1000	+5	CMT	67	11,9	410,26	0,589
8	1000	-5	CMT	60	11,3	360,76	0,337
2	800	+5	CMTP	67	12,2	533,53	0,350
6	800	-5	CMTP	60	11,3	441,58	0,267
3	1000	+5	CMTP	67	12,2	426,82	0,348
7	1000	-5	CMTP	60	11,5	352,48	0,201

Table 4. Parameter values used to make joints

Braze-welding samples were analyzed macro-and microscopically, and also breakings hear tests were made.

Increased heights and joint measurements were performed on macro structural samples, as shown in figure 2, the measured values are shown in table 4 (last column). It was also measured the zinc diffusion layer thickness, measured at the microscopic level.

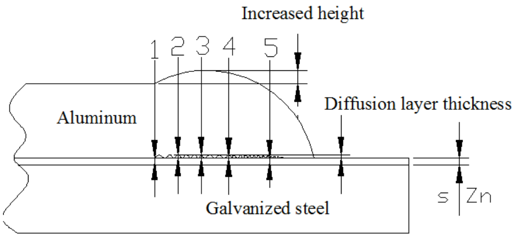

Figure 2. The measurement of increased high and zinc diffusion layer

Macrostructure samples taken are shown in figures 2 and 3, as indicated also the increased high value.

Macroscopic examinations of dissimilar joints made on analyzed variants showed no welding defects such cracks, but in all versions in welding have appeared fine pores with a maximum diameter of 0,3 mm (Figure 3 and Figure 4). The appearance of pores can be made by the presence of zinc, or high cooling rate due to low linear energy and high thermal conductivity of aluminum.

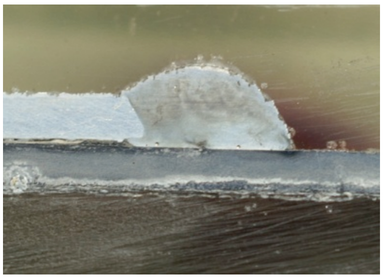

Figure 3. Macrostructure of braze-welded sample 0, t he central point

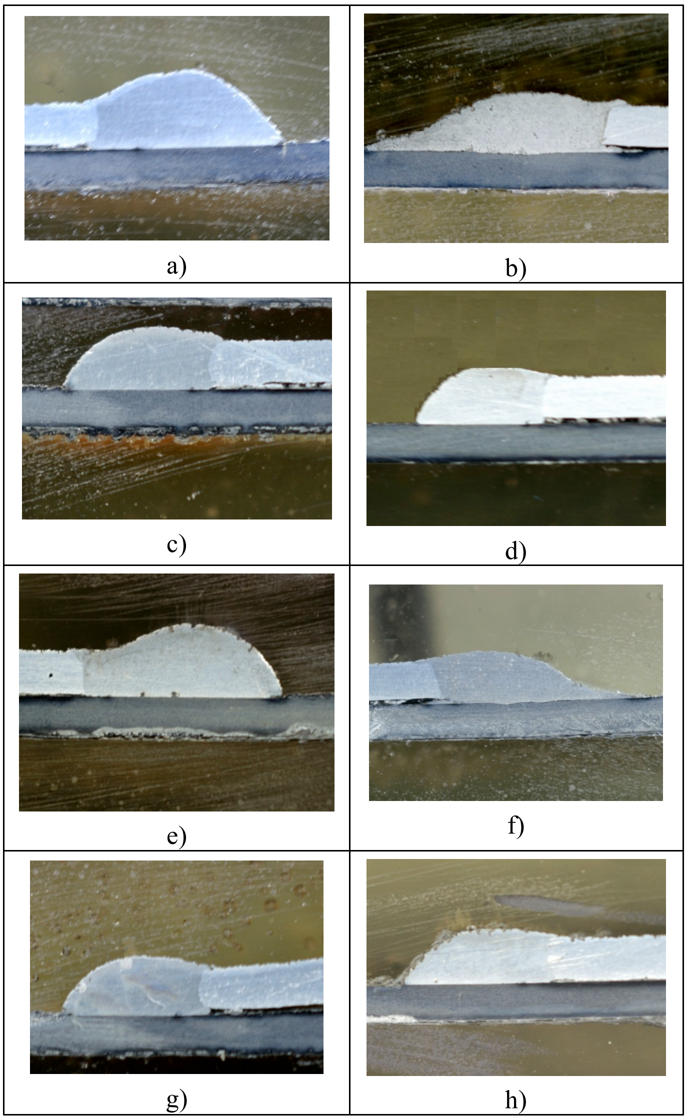
a) b) c) d) e) f) g) h)

Figure 4. Experimental macrostructure samples a) sample 1, s=0,689mm; b) sample 2 s=0,35mm; c) sample 5, s=0,362mm; d) sample 6, s=0,267mm; e) sample 4, s=0,589mm; f) sample 3, s=0,348mm; g) sample 8, s=0,337mm; h) sample7, s=0,2mm

The strength of the braze-welded joints were assessed by shear attempts performed on flat specimens according to SR EN 12797:2002 For each technology option two specimens were tested, the results are presented in figure 5.

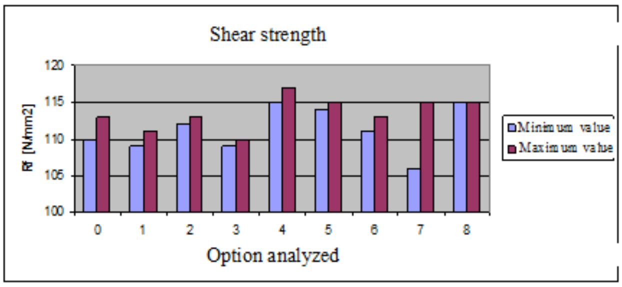

Figure 5. Variation of shear resistance (strength) based on variants of braze-welding

The split of the specimens occurred in the base metal with the exception of two samples, variants 7 and 8 which breakage occurred in welds (joints).

Shear strength do not depend significant of CMT or CMTP joint process. It was noted, however, values of about 10-15% higher in the CMT process than those of the characteristic CMTP process.

This difference can be explained by more pronounced burning of zinc in the impulse version and forming of zinc oxide.

Microscopic examinations were performed in specific areas of dissimilar braze-welded joints (SUD=jointing, MB=basic material, ZIT=heat affected zone) according to EN 1321:2000, disclosing the microstructures shown in figure 3 and figure 6, the sample attack was made with Nital 2% + NaOH 5%.

Figure 6. Varianta de sudobrazare 0, 100x

On the heat affected zones (HAZ) in the aluminum alloy, α(Al)structures with fine aluminum-silicon-zinc intermetallic compound particles, are observed (figure 7).

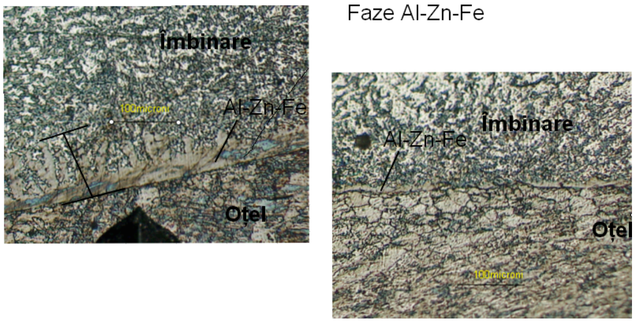

Figure 7. The diffusion layer of zinc measurement mode

On the microstructural probes the thickness of the zinc diffusion produced in the aluminum joining interface was measured. Figure 7 shows how these measurements were performed. For each kind of welded joints 5 measurements were performed, the averaged values were retained.

4. FINAL CONSIDERATIONS

Macroscopic examination of trials comparing the results with the two methods combined is showing that the increased height on joints made continuously (CMT) is higher by about 10-30% than the one made by pulse welding (CMTP). This can be explained by the additional current introduced by the CMTP process in the moment of the droplet detachment. This makes the drop to be further heated on the CMTP process comparing to CMT process. At the same time, we notice a significant influence on the dynamic correction factor profile (convexity) joint. Lowering the value of this factor the joint becomes more convex.

Pulse process is, therefore, preferable, if a lower increased height is desirable. Using a negative dynamic correction factor has an opposite effect leading to an increased height.

The analysis of the results leads to the conclusion that the diffusion layer thickness depends in fact linear by the linear energy used, the process variant significantly affecting the dependency.

At the same linear energy, the diffusion layer thickness of zinc is significantly higher for CMTP variant (pulses) compared with CMT version (continuous).

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