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DIFFICULTIES ENCOUNTERED IN PERFORMING DISSIMILAR JOINTS ON SHEETS

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Abstract: *When performing dissimilar joints on sheets many problems appear, having implications on their quality and the possibility to appear stresses and strains. After presenting shortly the problems specific to dissimilar joints and the possible joining techniques, with direct applicability on different base materials, the paper insists on the case study related to the CMT (Cold Metal Transfer) joining. Advantages when applying CMT are also evidenced, insisting on the technological side, but also on the environment protection. The experimental program consisting of destructive testing is also presented, together with the microscopic aspect of the joints obtained by the CMT process.*
Key words: *dissimilar joints, sheets, cold metal transfer (CMT), stress, strain*

1. INTRODUCTION

Thin sheets can be joined by different joining processes, which must take into account their particularities. The joints to be obtained must be continuous, with good mechanical properties, without any stresses and strains. On the other hand, manufacturing of dissimilar joints from thin sheets raises supplementary problems. If spot welding or brazing were considered among the most commonly used, nowadays applicability tip the balance to processes such as TIG welding, laser beam welding respectively special variants such as MIG/MAG Tandem (developed by Cloos), CMT (developed by Fronius), Pulse-mix (a combination of CMT process and pulsed arc welding process, laser-CMT), TOPTIG and more.

Outstanding issues raised in these situations required specialized software applications, including finite element methods, with spectacular results and approaches in terms of economic efficiency.

2. MAKING OF DISSIMILAR JOINTS

Numerous applications of heterogeneous joints (copper-aluminium, aluminium -steel, aluminium-magnesium) required by the automotive industry, the field of agriculture mechanization, imposed the development of studies with direct applicability results, as follows:

- galvanized steel-galvanized steel joints;
- steel-aluminium alloys joints;
- galvanized steel-aluminium alloys joints;
- aluminium alloys-magnesium alloys joints;
- nickel alloys-steel.

3. CMT CASE STUDIES

3.1 General aspects

The CMT joining variant uses especially the technology of assisted detachment of the droplet, the result can be called “joining drop by drop”. Table 1 presents some of the technical characteristics of the Trans Puls Synergic 2700 CMT (Fronius) equipment. The weld-brazing CMR process is based on a completely new technologic principle, associated with specific equipment.

The inferior limit of applying the CMT joining process, with low heat input, is lower compared to conventional solutions with short arc and short-circuits transfer, which ensures a significant extension of the joining domain. Thermal power, respective the linear energy at CMT is lower compared to previously mentioned processes, with implications for joining similar or dissimilar thin sheets. In the case of conventional processes, using short arc or short-circuit transfer, the electrode wire has an advance motion until the short circuit is produced. The process is accompanied by abundant and uncontrollable spattering. In case of CMT joining, those situations can be avoided, since the wire performs an advance and retreat movement towards the part to be joined, with high frequency. High frequency oscillations of the wire contribute directly to the control of the process. Oscillation frequency of the wire varies in time, depending on the formation of short circuits, but the average is around 70 Hz. The CMT process is extremely flexible, uses the process controller to monitor the working parameters and provides information on the principal technological steps.

Technical characteristics	TPS 2700 CMT
Power supply	3 x 400 V, +/- 15%
Power consumption at 100%	4,5 kVA
Current domain (MIG/MAG)	3 - 270A
Current domain (electrode)	10 - 270A
Maximum current at 40% (10 min./40°C)	270 A
Maximum current at 60% (10 min./40°C)	210 A
Maximum current at 100% (10 min./40°C)	170 A
Working voltage (MIG/MAG)	14,2-27,5 V
Protection class	IP 23
Insulation class	F
Size (mm)	625x290x480
Weight	28 kg

Tab. 1. Technical characteristics of the Trans Puls Synergic 2700 CMT equipment

3.2 CMT dissimilar joining of galvanized sheets – aluminium alloy sheets (GS-AS)

The experiments have been directed towards making dissimilar joints, galvanized sheets – aluminium alloy sheets (GS-AS), using the equipment presented in table 1 and the parameters presented in table 2.

With the purpose of obtaining optimal joining parameters, it was imperative to establish the exact chemical composition of the base materials. That was conducted on an emission spectrometer. After grinding and polishing, the samples were etched as follows: for aluminium alloys the etchant was H_2O and HF, and for the steel the etchant was Nital 2% (98% ethanol and HNO_3).

Sample	Is [A]	Ua [V]	s [mm]	ds [mm]	Wire	Shielding gas	Gas flow, l/min
1	40	10.7	1.5 AS, 1.25 GS	1.2	AlMg3	Ar 100%	10
2	56	11.5	1.5 AS, 1 GS	1.2			11
3	50	11.4	1.5 AS, 1.25 GS	1.2			10
4	51	11.4	1.5 AS, 1.25 GS	1.2			10
5	62	11.8	3 AS, 1.25 GS	1.2			12

Tab. 2. Joining parameters for the CMT process

After sample preparation, the joints were ready for macroscopic and microscopic analysis. The macroscopic image of these joints reveal the formation of heat affected zones in the base materials, extended in the case of CMT joint samples number 1 and 4, compared to the other samples. At microscopic level, one can see that the zinc layer from the surface of galvanized sheet degrades in the heat affected zone, without any obvious modification of the structure. Remarkable is the fact that none of the samples (figure 1) show any alteration of the structure due to heating during the CMT process.

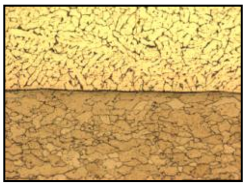


Fig. 1. Microstructure of the joint, OM 200x

Al-Mg wire was use as filler metal, since one of the components is an AlMg3 alloy, containing 3-6% Mg, with good corrosion resistance and high mechanical properties.

The Al-Mg system presents a eutectic reaction at 35% Mg and 450^{o} C, leading to the formation of a eutectic mechanical mixture, composed of an α solid solution of magnesium dissolved in aluminium, and the intermetallic compound Al_3Mg_2. As a consequence, at room temperature, for the alloys that have up to 17,4% Mg, Al_3Mg_2 will precipitate as an intermetallic and secondary phase at the limit of α grains. Microscopic analysis of the joint emphasizes a structure composed of the α phase dendrites, and coarse Al_3Mg_2 particles, disposed at grain limits (figure 2, 3). Notable is that precipitation of the Al_3Mg_2 phase at grain limits, increases the brittleness of the Al-Mg alloy.

Results of mechanical test conducted on the samples are presented in table 3. They show that the CMT joints have an adequate quality.

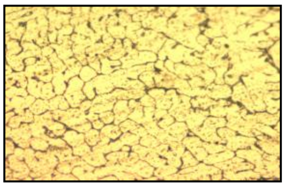
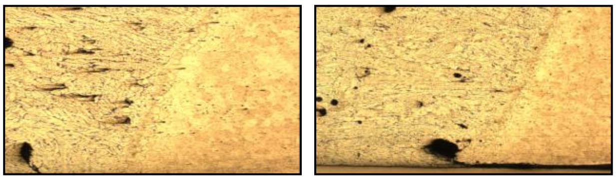


Fig. 2. Microstructure of the joint, OM 500x



sample 1 sample 3

Fig. 3. Microstructure of the joint, OM 500x

Sample no.	Joints size		F_{max} [KN]	$F_{max,med}$ [KN]	R_m [Mpa]	$R_{m,med}$ [Mpa]
	l [mm]	H [mm]				
1	20	2	3,08	3,16	77	91,90
2	20	2	4,24		106	
3	20	2	2,79		69,75	
4	20	2	3,28		82	
5	20	2	4,99		124,75	

Tab. 3. Mechanical properties of the samples

4. CONCLUSION

Thin sheets raise problems when joining, requiring special precautions to avoid the apparition of internal tensions and deformations, and ensure continuity and quality of the joint. Thin sheets dissimilar joints raise supplementary problems, due to the heterogeneity of the base materials.

CMT is a joining process, recommended when joining thin sheets. Unwanted aspects (deformations, excessive penetration) at welding of thin sheets are avoided, since CMT is a process situated at the border between welding and brazing. Supplementary alloying of the filler metal with 1…1.5% Si leads to the apparition of a ternary eutectic, improving the fluidity and wetability. Microscopic analysis of the joint emphasized a structure composed of the α phase dendrites, and coarse Al_3Mg_2 particles, disposed at grain limits. Precipitation of the Al_3Mg_2 phase at grain limits, increases the brittleness of the Al-Mg alloy.

CMT process eliminates one technological step, the removal of the zinc layer is not necessary prior to joining, as the classic welding processes require. New possible applications (components from agriculture equipments, air condition case) of the CMT are identified. Future research will concentrate on finding other thin base materials that can be joined with the CMT process.

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