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Original Article

Mechanical characterization of welded overlapped stainless steel by MAG process

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ABSTRACT

MIG/MAG welding is an assembly process very commonly used in different industries. It has the advantage of being faster, especially on thicker materials, economical and suitable for welding steels. Stainless steels are very well suited for metal assembly applications with an attractive compromise between strength and density, reasonable manufacturing cost and good MIG/MAG weldability. In this paper, the present work is oriented the use of the MAG welding process for the mechanical characterization of a welded lap joint for an assembly of 304L stainless steel sheets. The tensile shear tests show that the load/displacement curves (i.e. mechanical characteristics) are affected by the variation in currents of welding. The tensile strength increases with increasing in current of welding. The fracture strength is reduced from 200 A of the current of welding.

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INTRODUCTION

MIG/MAG welding process is an assembly process very commonly used in different industries: automotive, mechanically welded structures, metal assemblies. It has the advantage of being faster, especially on thicker materials, economical and suitable for welding steels. Stainless steels Type 304L are very well suited for metal assembly applications with an attractive compromise between strength and density, reasonable manufacturing cost and good MIG/MAG (or GMAW) weldability. The GMAW welding process depends on a number of factors: the welding voltage (arc length), the unwinding speed (control of the Is current), the value of the self, the length of wire pulled out and the sense of advance of the torch. Stainless steels are very interesting, both for their resistance to corrosion and for their mechanical properties, as well as for a reasonable production cost. The welding GMAW process is summarized by Figure 1.

Valensi et al. [1] have conducted experimental study of a MIG-MAG welding arc where applied shielding gas have investigated. Solodskiy et al. [2] have developed a new technology of MIG-MAG welding process. A power AC and pulse feed of welding wire in the arc zone are introduced, that downsizes the heat affected zone, stabilizes formation of electrode metal droplets, as external magnetic field's ef-

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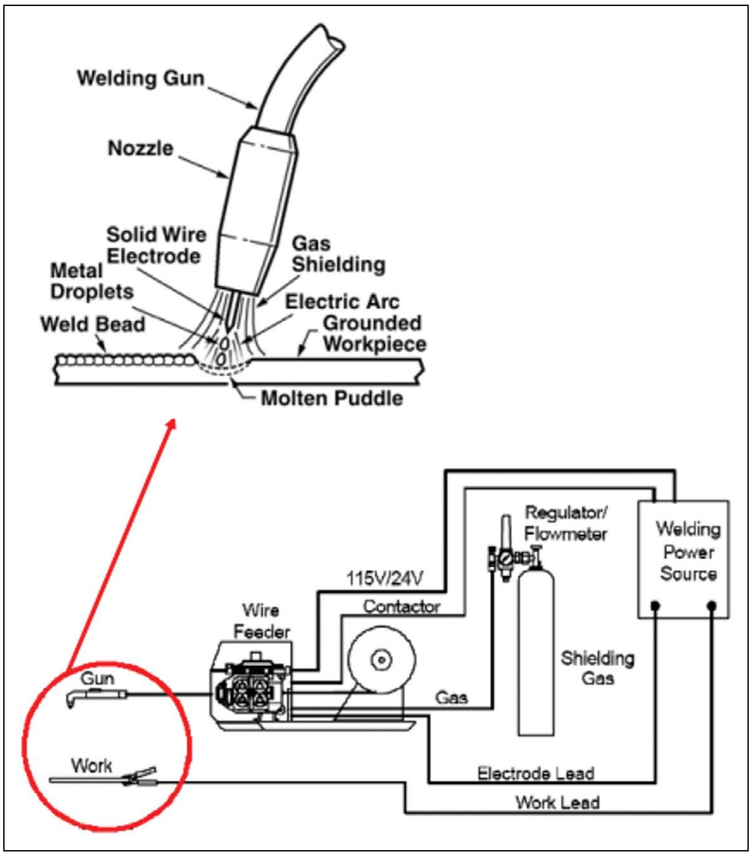

Figure 1. Typical GMAW process connections [3].

fect on the arc is reduced. Generally in overlapped welded sheets, resistance spot welding process is applied.

Welding time effect was studied by Akkaş et al. [4]. It is demonstrated that tensile shear strength increases with increasing in the welding time and the optimal value of the time depends on welding current. Also Pouranvari has investigated the effect of welding parameters of RSW (electrode pressure, holding time, welding current and welding time) on low-carbon steel resistance spot welds performance. It is concluded that increasing in welding time and current to some extent increases both peak load and maximum energy. However, excessive welding time and welding current not only do not increase weld nugget size and peak load, but also decrease maximum energy [5].

In Bouyousfi et al. [6] investigation, the effect of process parameters (welding current, welding time and applied load) on the mechanical characteristics of the weld joint of austenitic 304L stainless steel are studied. The results showed that the applied load seems to be the control factor of the mechanical characteristics of weld joint compared to the welding time and the current intensity. Lopez et al. [7] have analyzed the effect of GMAW weld process on mechanical properties of lap joints of Trip 780 stainless steel 2.8 mm thickness.

Purwaningrum et al. [8] have investigated the effect of DE-GMAW (Double electrode gas metal arc welding) on mechanical properties in joining of 5000 Al-alloy. The result show that the tensile strength of weld metals with resistance 30 Ω has highest value. In order to improve the weld ultimate tensile strength (UTS) Achebo [9] proposed to optimize the GMAW parameters by using Taguchi method. Ekaputra et al. [10] have studied the influence of welding speed parameter of GMAW process for 316L stainless steel. The ultimate tensile strength and yield strength of GMAW joints were found to decrease systematically with an increase in welding speed. Mezrag et al. [11] have applied CMT welding process derived from MIG-MAG process to joining dissimilar lap joints where the transfer of metal filler is controlled by welding current. In this paper, we investigate the effect of GMAW welding parameters on mechanical properties.

Experimental Procedures

Good functioning of MAG process is based on equilibrium of wire feed speed and melt speed. For a given wire and gas, this equilibrium depends on:

- The arc voltage U;
- The intensity of the welding current «I» or the wire speed «Vf»;
- The value of the self;
- The length of wire pulled out;
- The sense of advance

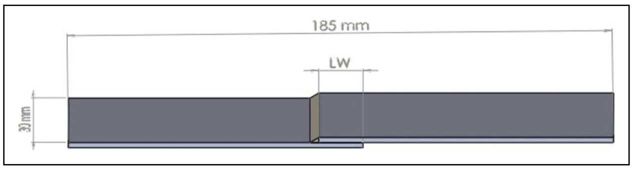

Figure 2. Welded specimen par GMAW process.

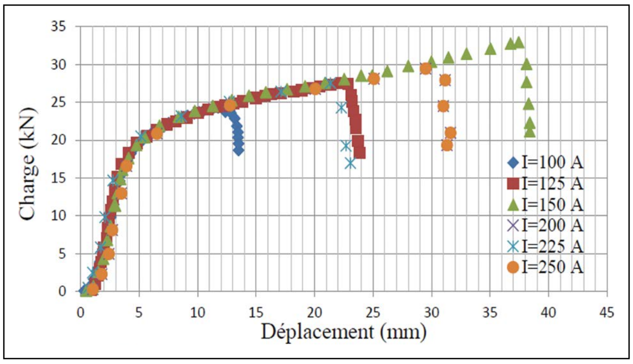

Figure 3. Welding current effect on evolution of load/displacement curves for 2 mm thickness of welded specimens.

Table 1. Welding parameter for 2 mm welding sheets

N°	Vd (min/mm)	I (A)	U (V)	Time (min)	Length (cm)	Vs (min/cm)
1	2.20	100	17	0.13	0.30	2.30
2	2.80	125	17	0.11	0.30	2.70
3	3.80	150	17	0.08	0.30	3.75
4	6.00	200	20.6	0.04	0.30	6.00
5	7.20	225	23.4	0.05	0.30	7.50
6	7.90	250	25.1	0.03	0.30	10.00

Table 2. Welding parameters for 3 mm welding sheets

N°	Vd (min/mm)	I (A)	U (V)	Time (min)	Length (cm)	Vs (min/cm)
1	2.20	100	17	0.14	0.30	2.10
2	2.80	125	17	0.20	0.30	1.50
3	3.80	150	17	0.13	0.30	2.30
4	6.00	200	20.6	0.11	0.30	2.72
5	7.20	225	23.4	0.08	0.30	3.75
6	7.90	250	25.1	0.06	0.30	5.00

The joining made by the MAG process between two 304L steel sheets is shown by (Fig. 2). The different tests made for welding by MAG process for two thicknesses are shown in Table 1 and 2. The gas protection CO_2 and filler with diameter 1.2 mm is in 308 L Si.

RESULTS AND DISCUSSION

The welds of a lap joint are subjected to shear forces where the failure mechanism depends mainly on defects

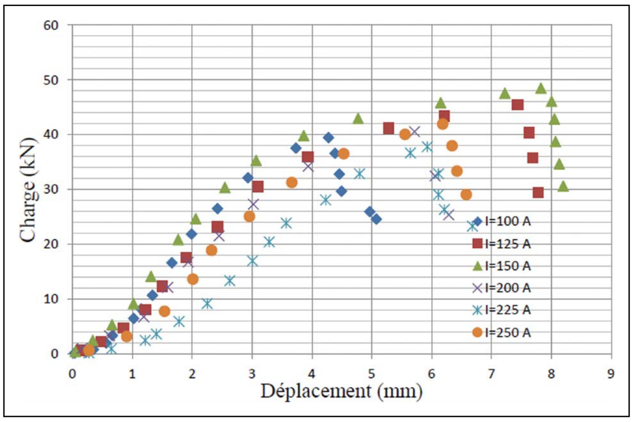

Figure 4. Welding current effect on evolution of load/displacement curves for 3 mm thickness of welded specimens.

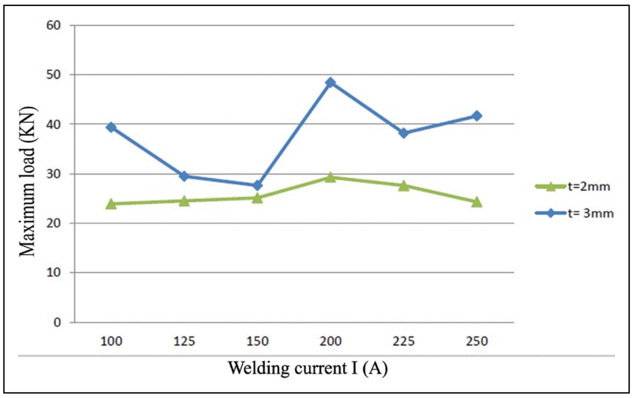

Figure 5. Effect of welding current on maximum resistance load for 4 mm thickness of welded specimens.

in the bead and the size of the melted area. These affect the mechanical strength of the assembly and the mode of fracture.

The tensile curves of welded specimens with different welding currents (see Fig. 3, 4) illustrate the mechanical behavior of welded assemblies with 2 mm and 3 mm thickness under tensile shear tests represented by the evolution of the load as a function of displacement respectively for different welding currents (100, 125, 150, 200, 225 and 250 (A)). Presented results show that an increasing in the intensity of welding current increases the plastic deformation with an unstable deformation. One always notices that the zone of the plastic deformation is more extended for 150 (A). The plastic deformation zone has decreased for welding currents 225 and 250 (A).

The effect of the welding current on the maximum breaking load for the two thicknesses is shown in Figure 5. The general appearance shows an increase in breaking load with increasing in welding current up to 150 (A). In order to better understand certain interactions of welding parameters and their random phenomena, statistical tests are necessary and accompanied by analyzes of fracture surfaces at the interfaces.

Figures 3 and 4 show also the effects of thickness on the load/displacement behavior. Note that 2 mm thick assemblies have a large plastic deformation zone compared to 3 mm thick assemblies. On the other hand, the breaking loads are important in the case of an assembly of 3 mm sheets compared to the assemblies of 2 mm sheets (Fig. 5).

CONCLUSION

In this study we investigate the effect of welding currents of GMAW process. From experimental study the results show that:

- Beyond the welding curent 150 (A) the extent of plastic deformation is reduced;
- Tensile strength incérasses with increasing welding current;
- The tensile strength is reduced apart from the welding current 200 (A);
- The break is done along the weld bead;

Nomenclature

I Welding current, (A)
F Load, (KN)
t Thickness (mm).

Data Availability Statement

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

Author's Contributions

Mustapha Benachour: Drafted the manuscript, performed the tensile tests experiments and result analysis.

Fethi Sebaa: Performed welding experiments and assisted in progress of manuscript preparation.

Nadjia Benachour: Assisted the state of art of mechanical behavior of welded structures and helped in manuscript preparation.

Conflict of Interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics

There are no ethical issues with the publication of this manuscript.

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