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Gas mixtures used for welding of supports of mobile platforms

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ABSTRACT:

The demand for welding of difficult to weld, high-strength steels used in civil engineering and transportation is increasing. An example application for these steels can be the mobile platform supports. An important material for the fabrication of the supports for mobile platforms are fine-grained steels due to their high tensile strength of 1000 MPa. The purpose of the studies described in this article was to select the shielding gases for welding of thin-walled structures of the mobile platform supports made of hard-to-weld S960 MC steel.

Mieszanki gazowe stosowane do spawania podpór podestów ruchomych

Słowa kluczowe: inżynieria lądowa, transport, podpory, podesty ruchome

STRESZCZENIE:

Wzrasta zapotrzebowanie na spajanie trudnospawalnych stali wysokowytrzymałych stosowanych w inżynierii lądowej i w transporcie. Przykładem tego typu konstrukcji mogą być podpory podestu ruchomego. Ważnym materiałem w produkcji podpór podestów ruchomych są stale drobnoziarniste z uwagi na ich dużą wytrzymałość na rozciąganie na poziomie 1000 MPa. Celem prac opisanych w niniejszym artykule było dobranie gazów osłonowych do spawania cienkościennych konstrukcji podpór podestu ruchomego z trudnospawalnej stali S960 MC.

1. INTRODUCTION

In civil engineering and transport, construction equipment and means of transport are being constantly retrofitted [1-4]. In order to increase the performance of these structures, it is intended to increase their temporary strength. An important example of a modern means of transport used for the construction works are mobile platforms. The operating arms of the platforms are made of high-strength AHSS (DOCOL 1200M and DOCOL 1400M) steels, and the supports of the platforms are made of S700 MC and S960 MC steels [6].
This article focuses on welding of the thin-walled structure of the mobile platform supports. The purpose of the studies described in this article is to select the process parameters and to verify the properties of the thin-walled joint made of a fine-grained S960 MC steel.

2. MATERIALS AND METHODS

High-strength S960 MC steel (used for crane components) is increasingly used in civil engineering and transportation due to its high tensile strength, which allows the empty weight of the thin-walled structure of the platform support to be reduced [5-6]. At welding steels, their mechanical properties in the HAZ may deteriorate. It is therefore recommended to reduce the linear energy during welding to 5 kJ/cm [7-12]. Table 1 presents the mechanical properties of S960 MC steel use for the mobile platform supports.

Table 1 Mechanical properties of S960 MC steel [6]

Yield stress YS	Ultimate tensile strength UTS	Elongation A_5
MPa	MPa	%
950	1250	8

A high yield stress of 900 MPa should be noted. This is related to higher carbon and titanium content as compared to carbon and manganese steels. Table 2 shows the chemical composition of S960 MC steel. In C-Mn steels, the Ti content is introduced at the maximum level of 0.003%, and in high-strength steels the titanium content is at the level of 0.7% (Tab. 2).

Table 2 Chemical composition of S960 MC steel [6]

C%	Si%	Mn%	P%	S%	Al%	Nb%	V%	Ti%
0.12	0.25	1.3	0.02	0.01	0.015	0.05	0.05	0.07

2 mm thick metal plates were used to construct the mobile platform supports. It was decided to make the joints using the MAG (Metal Active Gas) method with three different mixtures: Ar + 5% CO_2, Ar + 10% CO_2 and Ar + 20% CO_2 as the shielding gas. UNION X90 welding electrode was selected (EN ISO 216834-A G 89 6 M21 Mn4Ni2CrMo) with the following chemical composition (Tab. 3).

Table 3 UNION X90 welding electrode – chemical composition [10]

UNION	C%	Si%	Mn%	P%	Cr%	Mo%	Ni%	Ti%
X90	0.10	0.8	1.8	0.010	0.35	0.6	2.3	0.005

The chemical composition of the electrode is different from the chemical composition of the welded steel. An addition of chromium in the welding electrode (which is not an alloy element of S960 MC steel) should be noted. The welding parameters of the S960 MC steel with the use of both welding electrodes were similar. Welding parameters were as follows: welding electrode diameter – 1.0 mm, arc voltage – 18 V, welding current intensity – 120 A. Welding velocity was 350 mm/min. Three different mixtures were tested. The DC source is connected from (+) on the electrode, while the thin-walled weld (2 mm) was a single-pass joint.

3. METHODS, SCOPE OF TESTS

The scope of the tests included non-destructive testing (NDT):
• Visual testing (VT);
• Magnetic particle inspection (MT).
The destructive tests included:
• bending test,
• tensile strength test,
• hardness measurement.

4. RESULTS AND DISCUSSION

Butt weld (BW) was made of 2 mm thick S960 MC steel. The MAG welding method was applied in flat position (PA) using 3 different casing gas mixtures. After welding, the following non-destructive tests (NDT) were carried out. The results of the joints of the mobile platform are presented in Table 4.

Table 4 Evaluation of NDT of the mobile platform joint

Shielding mixture Ar + 5% CO_2	Shielding mixture Ar + 10% CO_2	Shielding mixture Ar + 20% CO_2
No cracks	No cracks	Cracks in the HAZ

The table indicates that the type of gas mixture affects the correctness of the joint made of S960 MC steel. Cracks were observed only if when the content of CO_2 in the mixture was 20% – this mixture was too oxidizing.

4.1 Results of destructive tests

For further tests, only the proper joints made using Ar + 5% CO_2 and Ar + 10% CO_2 were taken into account. A static tensile test of a 2 mm thick butt joint at 20°C was performed on the ZD 100 strength testing machine. Test results for a sample with a cross-section of 2 mm × 12 mm (length of 25 mm) are presented in Table 5. Three tensile tests were performed each time.

Table 5 Mechanical properties of joints

Shielding gas	R_m	R_e	A_5
Ar + 10% CO_2	976	665	7.2
Ar + 5% CO_2	981	672	7.1

When analysing the data from Table 5, it can be noticed that the joints were made correctly. The rupture occurred mainly in the parent material near the heat affected zone. The cross-section of the broken samples was mainly plastic and brittle. Tensile strength and yield stress are at the required high level (R_e above the required value of 600 MPa, R_m above the required value of 900 MPa). A slightly higher strength of the joint was obtained using a more oxidising mixture (Ar + 10% CO_2). On the basis of strength tests, it can be concluded that the CO_2 content in the shielding gas mixture should be in the range from 5% to 10%.

Then a bending test was performed. For samples with a thickness of 2 mm, the parameters were as follows: sample width b = 20 mm, mandrel d = 14 mm, spacing of supports d + 3a = 31 mm, and the required bending angle – 180°. As part of the bending test, 5 measurements were performed for each tested joint thickness from the root side and from the face side. No cracks were observed in the weld and HAZ both from the root and face sides. The bending test was performed correctly and test evaluation is positive since no cracks and other imperfections were detected in the tested S960 MC steel joints.

Then microsections were taken and the structure of the welds made with all three tested mixtures was checked. The structure was very similar in all cases. It was dominated by martensite. Observations of the microsections etched in the Adler's reagent were conducted using a light microscope. Typical joint structure is shown in Figure 1.

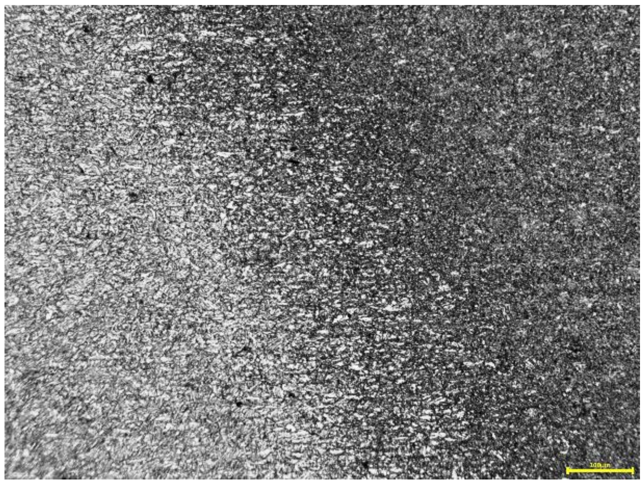

Figure 1 Structure of the weld made using Union X90 welding electrode and a shielding gas mixture Ar + 10% CO_2

The results of the structural tests indicate that martensitic and bainitic structures prevail in the tested joints. The results of all the tests presented in this article were positive, which confirms that the selected shielding gas mixtures are correct.

Then hardness in sections of the joint made using two gas mixtures (Ar + 5% CO_2 and Ar + 10% CO_2) was tested. The tests were performed in accordance with PN-EN ISO 15614-1. The results of hardness measurements are presented in Table 6.

When analysing the table data, it can be noted that the hardness of the weld, HAZ and parent material is comparable in both cases, which is very beneficial. In this case it can be concluded that the type of gas mixture does not have a significant impact on hardness of the tested welds. On the basis of hardness tests, it can be concluded that the CO_2 content in the gas mixture should be in the range from 5% to 10%.

Table 6 Hardness test results

Shielding gas mixture	Parent material			HAZ			Weld		
Ar + 5% CO_2	331	336	335	352	356	352	342	337	343
Ar + 10% CO_2	332	334	337	354	359	353	351	352	353

5. CONCLUSIONS

In order to make a proper joint of the support of the mobile platform, it is important to select the welding parameters. This study aimed at examining the impact of the shielding gas mixtures on the weldability of S960 MC steel used for the mobile platform supports. The possibility of making a proper joint was confirmed by non-destructive and destructive testing. It was concluded that the CO_2 content in the gas mixture should be in the range from 5% to 10%. An increase of CO_2 to 20% in the mixture causes cracks.

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