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ADVANTAGE OF USE OF ACTIVATED FLUX-CORED WIRE INSTEAD OF SOLID WIRE WITH THE MAG WELDING PROCESS FROM THE MECHANICAL PROPERTIES ASPECT

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The objective of this paper is the analysis and evaluation of the quality of the new flux-cored wire designed for the MAG welding process that was developed and produced using special laboratory equipment. Experimental welding was performed with the new activated flux-cored wire and classic solid wire with changing of welding parameters and shielding gas composition (100 % CO_2 and gas mixtures of Ar + CO_2 + O_2).

Key words: welding, electrode, activated flux-cored wire, solid wire, heat affected zone

INTRODUCTION

The MAG – process is widely used for welding of constructions made of carbon and low alloyed steels, due to a number of advantages compared to similar processes [1-3]. Melting of the wire electrode and the transfer of droplets through the electric arc depend on the shielding environment, parameters of the welding process (current power, voltage, polarity), chemical composition and diameter of the wire [1-6].

Besides positive outlined features the MAG process has some technological limitations when welding with wire of more than 2,0 mm in diameter and drawbacks such as intense splatter and unsatisfactory shape of weld metal. Eliminating these deficiencies in the MAG welding process is possible in two ways. The first is to replace the shielding CO_2 gas with an optima two ways. The first is to replace the shielding CO_2 gas with an optimal composition of a gas mixture, and the second is the development of a new quality of filler, primarily, different qualities and forms of flux-cored wires.

Numerous investigations have indicated the possibility of replacing CO_2 with a gas mixture (Ar + CO_2 + O_2) which improves the quality of the welded joints and reliability of the welded constructions. Similar effects, can be achieved by using the new quality activated flux-cored wire which compared to the classical solid wire represents significant technological progress [1-5].

The main goal of this paper is to, based on mechanical properties of welded joints, determine the positive effects and advantages for justified use of activated flux-cored wire in relation to use of classical solid cross section wire [5, 7-12].

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EXPERIMENTAL WORK

For experimental welding boiler plate was chosen as the base metal, two fillers (standard solid and activated flux-cored wire) CO_2 shielding and several systems of gas mixtures (Ar + CO_2 + O_2) [5, 8, 12].

In the first part of the preliminary experiments defined were the optimal energy parameters of root welding and groove filling with solid or activated flux-cored wire in CO_2 shielding, provided that the heat input was in the interval from 1,0 to 1,1 KJ/mm. The share percentage of singular components in the mixture was changed on two levels.

Base metal and fillers

The base metal chosen for experimental welding was in the shape of a strip marked Č. 1204, 12 mm thick [4]. The chemical composition and mechanical properties of the chosen base metal according to the certificate of the producer, Iron Mill Skopje, are given in Table 1.

Table 1 **Chemical composition and mechanical properties of the base metal Č. 1204 / wt. %**

C	Mn	Si	P	S
0,19	0,55	0,21	0,013	0,025
Mechanical properties				
Tensile strength / MPa	Yield strength / MPa	Elongation / %	Toughness / KV (J)	
500	310	31	93 - 100	

The filler chosen for the experimental MAG welding process was in two metallurgical qualities of which the first is in the form of activated flux-cored wire a diameter of 1,2 mm marked **FW-10** (producer: “Paton” Institute, Kiev, Ukraine, internal marking AP-AN10), and the second quality is a standard solid wire marked **SW-60** (producer Zeljezara, Jesenice, marked VAC-60). The chemical composition and mechanical properties of the pure weld metal, according to producer's data are given in Table 2.

Cut base metal plates for experimental welding size: 300 x 150 x 12 mm were cut from a metal sheet so that the longer end is in the direction of rolling achieving that after welding the position of specimens, for mechanical testing of welded joints, have a transverse direction to the rolling direction of the steel strips [4-8]. After cutting the obtained plates, along one longer side are mechanically processed and brought to an angle of 60º (JUS C.T3.061).

Table 2 **Chemical composition and mechanical properties of pure weld metal / wt. %**

Filler	C	Mn	Si	Ti	P	S
FW-10	0,08	l,50	0,50	0,045	0,025	0,023
SW-60	0,1	1,45	0,90	-	-	-
Mechanical properties						
Filler	Tensile strength / MPa	Yield strength / MPa	Elongation / %	Toughness / KV (J)		
				+ 20 °C	- 40 °C	
FW-10	620	520	25	120	42	
SW-60	590	490	22	80	38	

Experimental welding

The experimental welding of prepared specimens was carried out using the MAG device LAH 320 –ESAB in CO_2 shielding and a gas mixture (Ar + CO_2 + O_2) formed using gas mixer type Wedmix. Table 3 shows the sequence of carrying out of experimental welding.

Table 3 **Experimental welding sequence, with solid SW-60 and flux cored FW-10 wire in various shielding gas mixtures**

Filler		Shielding gas composition		
FW-10	**SW-60**	/ %	/ %	/ %
Specimen marking	Specimen marking	Ar	CO_2	O_2
1FW	1SW	70	25	5
2FW	2SW	56	39	5
3FW	3SW	66	26	9
4FW	4SW	52	39	9
5FW	5SW	61	32	7
6FW	6SW	61	32	7
7FW	7SW	0	100	0

TESTING QUALITY OF WELDED JOINTS

Tensile strength and toughness testing

For tensile strength testing and the bending angle of the welded joint, flat shaped specimens were prepared according to standard JUS C.T3.051. For toughness testing according to set standard a standard specimen with a "V" notch was prepared which was placed vertically along the weld metal axis of the welded joint.

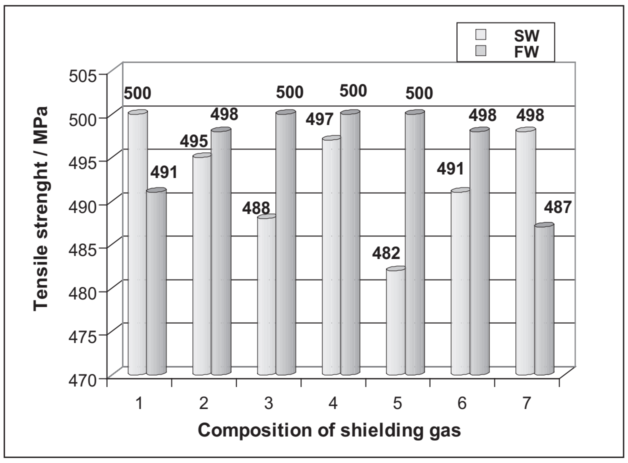

Figure 1 Changes in value of tensile strength of welded joints made using solid wire SW-60 and using flux-cored wire FW-10 in gas mixtures shielding

The tensile strength test results of welded joints (according to Table 3) that were done with solid wire quality **SW-60** and with flux-cored wire quality **FW-10** are sown in the diagram Figure 1.

Changes in value of toughness of welded joints at temperatures of + 20 °C and – 40 °C performed in gas mixtures shielding using activated flux-cored wire **FW-10** and using solid wire **SW-60** are shown in the diagram in Figure 2.

Hardness testing of welded joints

Hardness testing was performed according to Rockwell on samples for microscopic examination of welded joints as per JUS C.A4.003 standard. Locations where the test was performed are along the lines which go transversally (s) and vertically (v) on the welded joint, Figure 3.

Regarding the base metal, in all the welded joints, a decline of hardness appears in the HAZ, and then in the weld metal hardness increases up to the axis of the weld metal and then decreases again towards the HAZ on the

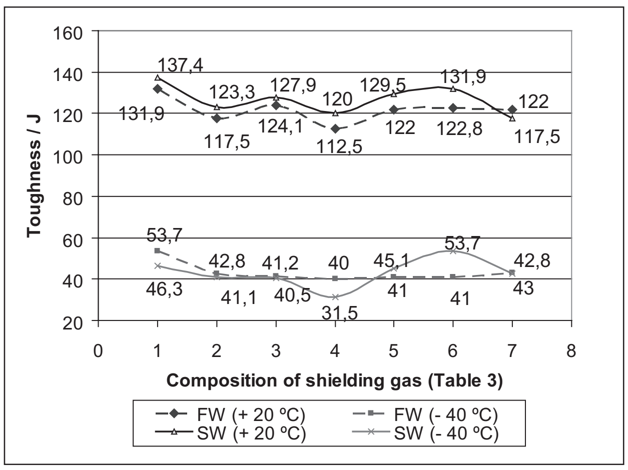

Figure 2 Changes of toughness depending on the test temperature of welded joints made using flux-cored wire FW-10 and using solid wire SW-60 in different gas mixtures shielding

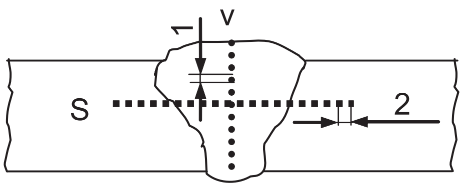

Figure 3 Layout of measuring points for hardness testing of welded joints

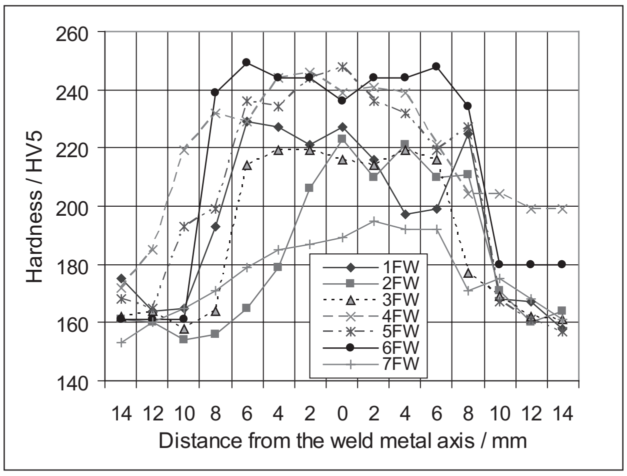

Figure 4 Changes of hardness of welded joints made with flux-cored wire FW-10 in different gas mixtures shielding

other side of the weld metal. There is a significant increase in hardness in the weld metal made with FW-10 in comparison to specimens made using SW-60.

Changes of hardness along the line that runs along the middle of the weld metal, for welds performed with flux-cored FW-10 are given in the diagram, Figure 4.

In the diagram, Figure 5, shown are changes in hardness of welded joints of steel Č. 1204, made with solid wire SW-60.

In the diagram, Figure 6, for welded joints made with solid wire SW-60 and flux-cored wire FW-10 in different gas mixtures, given are the changes of hardness values along the line which passes vertically in the middle of the weld metal from face to root.

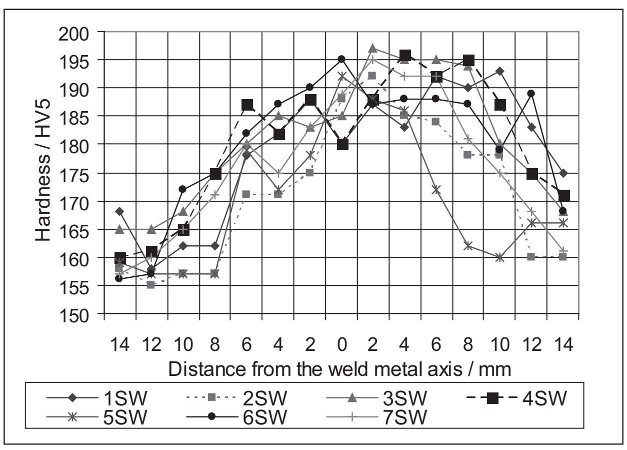

Figure 5 Changes of hardness of welded joints made with solid wire SW-60 in different gas mixtures shielding

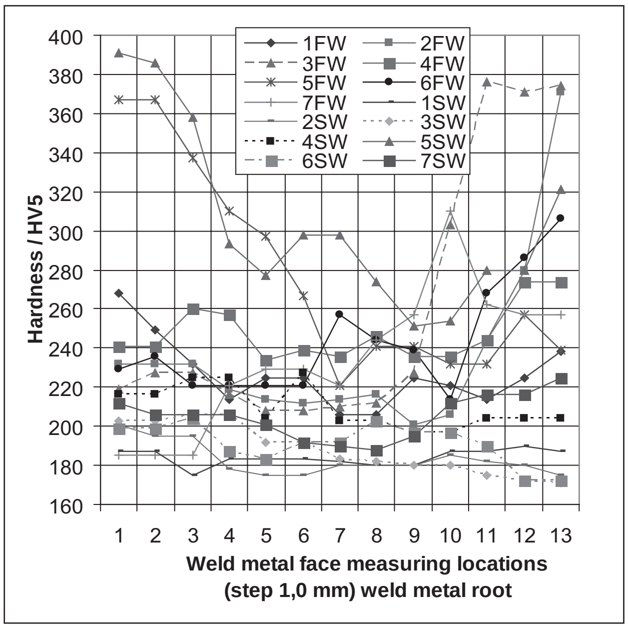

Figure 6 Changes of hardness of weld metal (along the vertical line from face to root) made with electrode wires FW-10 and SW-60 in CO_2 and gas mixtures shielding

RESULTS AND DISCUSSION

The fillers of selected quality have tensile features beyond the features of the base metal Č.1204.

The biggest difference between the hardness of base metal and weld metal was achieved in the weld metal made with flux-cored electrode wire (Ti alloy, which in the weld metal favors the formation of needle ferrite, particularly with increased Mn content in the weld metal in the amount of ~ 1,5 %).

Toughness results of the weld metal have shown that the greatest influence on toughness has the chemical composition of the base metal and then the burning of elements during welding.

The results show that the best toughness at + 20 °C is achieved when welding with solid wire in a gas mixture in which the content of CO_2 and O_2 is at the lower level. However, the toughness at – 40 °C was significantly higher when welding with activated flux-cored wire in a gas mixture in which CO_2 and O_2 content is also at the lower level.

CONCLUSIONS

On the basis of obtained experimental results of influence of the composition of gas mixtures on the quality of welded joints made with solid and activated flux-cored wire, the following conclusions can be made:

1. Using activated flux-cored wire instead of classical solid wire an increase tensile strength and toughness at low temperatures.
2. It has been established that activated flux-cored wire retains all positive properties of wire with a full cross section along with the following improvements of welding-technological properties: easy

formation and stable burning of the arc, minimal splatter, a flat and smooth weld metal surface, a gradual transition of the weld metal onto the base metal, secure penetration of the root, a satisfactory shape of weld metal in all spatial positions and easy separation of slag. By using activated flux-cored wire there is an increase in productivity up to 30 % compared to use of classical solid wire.

3. Replacing CO_2 with an optimal gas mixture 70 % Ar + 25 % CO_2 + 5 % O_2 uring welding with classical solid wire led to the improvement of the quality of the welded joint and the processability of the MAG process.
4. The performed research has confirmed that activated flux-cored wire has numerous advantages compared to solid wire and can be recommended for semi-automatic, automatic and robotized welding in CO_2 shielding.

Acknowledgement

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