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STUDY OF THE POSSIBILITY OF APPLYING ALLOYED FLUX-CORED WIRE FOR PRODUCTION OF CORES FOR COATED ELECTRODES

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Abstract: The main objective of the paper is to explore the technological possibilities of making improved quality coated electrodes with alloyed flux-cored wire cores. Using experimental equipment at the Research Center IHIS alloyed flux-cored wire was produced with optimal thickness of the metal sheath, internal label IHIS E 35 R-3 Ø 3.25mm in diameter from which the core of the new rutile coated electrode was made. The paper presents the test results of the chemical composition and microstructure of the weld metal made with the new electrode. The test results of the chemical composition and structure of weld metal made with the produced electrode indicate the justifiability of further research towards the development of new coated electrodes with a core of alloyed flux-cored wire.
Keywords: coated electrode, alloyed flux-cored wire, weld metal structure

INTRODUCTION

Development and mastering of rutile electrodes with a core of alloyed flux-cored wire for manual metal arc welding and surfacing is a complex research process, which involves defining the chemical composition of the coating and the flux-cored wires [1-3]. The rutile electrode coating (internal marking IHIS E 35 R-3) is mainly composed of rutile TiO_2 containing more than 50% and the rest of the components are: marble, granite, kaolin, FeMn, mica, feldspar, talc, CaF_2, magnesite and Lucel. Introduced into the composition of the coating are ingredients which protect the weld pool and weld metal from the influence of atmospheric gases, create slag, eliminate or restrict the content of oxygen and nitrogen, increase meltability and stabilize the arc [4-7]. When making a coated electrode the coating is applied continuously to the cores using a suitable technological process. The cores are made of alloyed flux-cored wire, 350 mm in length and Ø3.25mm in diameter with a medium thick coating.

Produced rutile electrodes are intended for manual metal arc welding (MMAW) and surfacing with a coated electrode for low alloyed steels, alloyed structural steels, heat resistant steels and high alloyed steels with special properties. At the stage of development and mastering technology for production of coated rutile electrodes of improved quality with cores of alloyed flux-cored wire, and to economize, for experimental welding and testing of weld metal microstructure, steel plates of low carbon alloyed steel thickness of 10 mm were selected.

The microstructure of weld metal made with a rutile electrode depends on many factors such as: composition of the coating and core of the electrode, cooling rate, heat input during welding, etc. [8,9].

This paper presents the results of examination of chemical composition and microstructure of weld metal, which should contribute to defining a new quality of special rutile electrodes with a core of flux-cored wire in terms of operational and welding properties.

The results showed that a rutile electrode with a core of alloyed flux- cored wire, produced with domestic raw materials, improves the formation of a homogeneous structure of weld metal in welded joints.

MATERIALS AND EXPERIMENTAL DETAILS

Production of rutile electrodes with a core of alloyed flux-cored wire with local raw materials was carried out on experimental equipment in the Research Center IHIS. For the core of the rutile electrodes selected and produced were alloyed flux-cored wires of designed quality for welding and surfacing low alloyed steel, alloyed structural steel and high alloyed steels with special properties.

The experimental part includes welding a sample of low-carbon non-alloyed steel, 10 mm thick using a produced medium coated rutile electrode (in-house marking IHIS E 35 R-3). Determining the quality of the rutile electrode was done based on the results of testing the chemical composition of pure weld metal using spectrochemical analysis and the OES method on the ARL 2460 and the results of microstructure tests. Examination of the microstructure of the base metal and analysis of micro-constituents present in the weld metal was done on a scanning electron microscope (SEM).

RESULTS AND DISCUSSION

Table 1 shows the chemical composition of pure weld metal of a sample welded using a rutile electrode with a core of alloyed flux-cored wire. Examination of the composition of the weld metal was conducted to link the influence of Ni and Mo, from the core of the flux-cored wire with rutile coating, on the microstructure of the weld metal of the welded joint. Metallographic tests of the weld metal of welded joints showed that the chemical analysis of the weld metal (WM) is directly related to the microstructure.

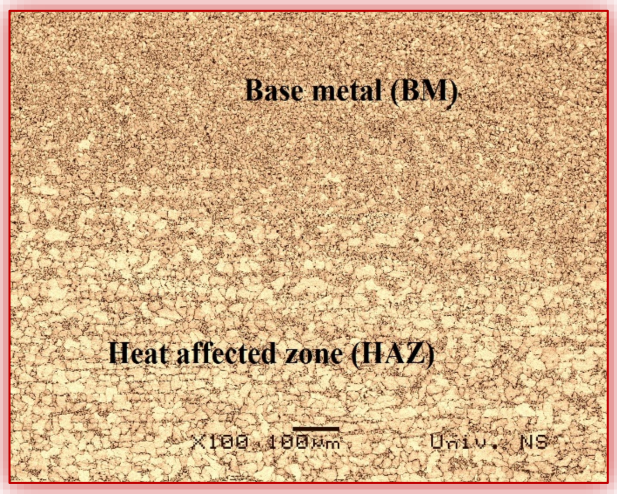
Table 1. Chemical composition of the pure weld metal

Chemical composition, wt.%				
C	Si	Mn	Cu	Al
0.023	0.539	0.97	0.092	< 0.003
Cr	Mo	Ni	Ti	Nb
0.025	0.32	3.284	0.012	<0.003

Nickel and molybdenum from the core of the electrode made of alloyed flux-cored wire favored forming of a large share of acicular ferrite (AF) in the weld metal, they lowered the share of proeutectoid ferrite (PF) and completely removed upper bainite [10] and this was confirmed by metallographic analysis of the weld metal.

Figure 1a shows the microstructure of the base metal (BM) of 10 mm thick low carbon non-alloyed steel tested on the SEM. The microstructure of the non-alloyed steel is homogeneous and ferritic with a small portion of pearlite. Figure 1b shows the microstructure of the transition zone between the base metal (BM) and the heat affected zone (HAZ). On the SEM micrographs in the heat affected zone (HAZ) an increase in ferrite grains is visible.

a)

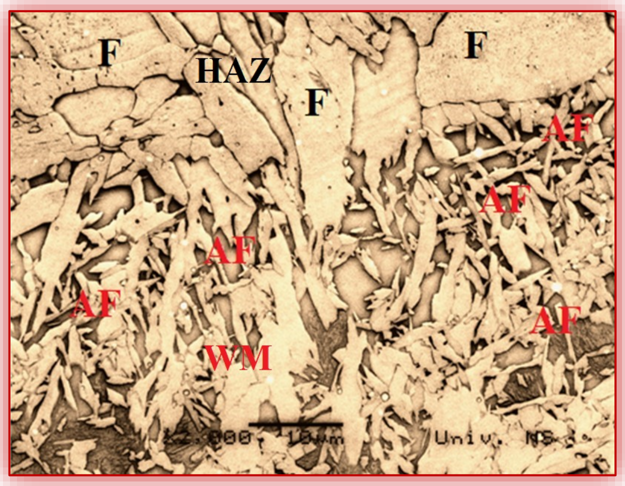


b)

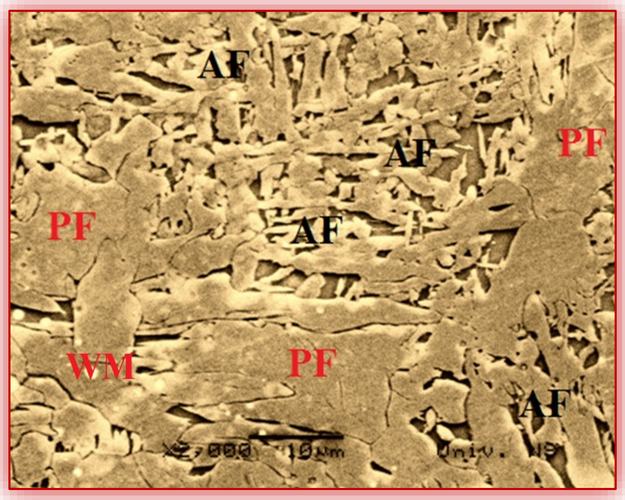
Figure 1. SEM microstructure: a) base metal (BM), 500x; b) transition zone (BM) and (HAZ), 100x.

Figure 2a shows scanning electron micrographs (SEM) of the fusion line between the heat affected zone (HAZ) and weld metal (WM). The fusion line separates the coarse grain ferrite structure of the heat affected zone (HAZ) and the fine-grained structure of the weld metal (WM). The structure of the weld metal consists of austenite grains with formed acicular ferrite (AF) within the austenite grains.

Acicular ferrite is a type of ferrite characterized by a three-dimensional lenticular shape. At certain points along the boundaries of the acicular ferrite (AF) non-metallic spherical inclusions, from the rutile coating, can be seen. These inclusions serve as nucleation centers for acicular ferrite (AF) crystallization [11]. This microstructure has an advantage over other microstructures, because it increases the toughness of the weld metal of welded joints.



a)



b)

Figure 2. SEM microstructure: a) transition zone between (HAZ) and weld metal (WM), 2000x; b) weld metal (WM), 2000x

Figure 2b shows scanning electron micrographs (SEM) of the microstructure of pure weld metal. Austenite grains are present in the weld metal; along their boundaries proeutectoid and polygonal ferrite (PF) are present. These types of ferrite are formed as primary phases along grain boundaries during cooling of austenite. Ni and Mo from the core of the alloyed flux-cored wire during cooling of the weld metal reduced the share proeutectoid and polygonal ferrite (PF) and thus increased the share of acicular ferrite (AF). In the austenitic crystal grains there were no observed secondary phases such as routed secondary phase ferrite (FS) and Widmanstatten ferrite which reduce the toughness of the weld metal (WM) of the welded joint. The microstructure of the weld metal of the welded joint is in full compliance with the chemical analysis of the weld metal.

CONCLUSIONS

Based on the chemical and microstructural analysis of the weld metal of welded joints made with a medium coated rutile electrode with a core of alloyed flux-cored wire marked IHIS E 35 R-3 Ø 3.25mm in diameter, the following conclusions can be made:

- Welding properties of mastered rutile electrodes relating to arc stability, uniformity of slag coverage of metal, splatter of molten material and porosity of the surface of the weld metal showed satisfactory quality.
- Micro-alloying elements Ni and Mo from the core of the alloyed flux-cored wire and non-metallic inclusions from the rutile coating influenced forming of a large share of acicular ferrite (AF) in the weld metal (WM) of welded joints, which indicates high weld metal toughness and uniform distribution of Ni and Mo in the rutile electrode.
- The rutile type electrodes, produced using domestic raw materials with a core of flux-cored wire, created a homogeneous structure of the weld metal and the planned chemical composition.

The results of examination of the weld metal justified further development and application of alloyed flux-cored wire for production of the core of coated rutile electrodes based on local raw materials.

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Note

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