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ISSN 0543-5846
METABK 63(2) 287-289 (2024)
UDC – UDK 669.15.26.295.293:66.04:621.791.057.002.61=11

EFFECT OF TITANIUM POWDER ADDITION AND HEAT TREATMENT ON THE GRAIN SIZE IN THE WELD OF FERRITIC STAINLESS STEEL OF THE X2CrTiNb18 GRADE

Received – Primljeno: 2023-07-31
Accepted – Prihvaćeno: 2023-10-20
Preliminary Note – Prethodno priopćenje

Improving the strength properties of ferritic stainless steel welds is associated with reducing excessive grain growth. The article presents the research results on the effect of the titanium additive introduced to the weld material during the welding process of X2CrTiNb18 steel and using different temperature ranges of the heat treatment process for the welds obtained. Significant importance of the influence of titanium addition during welding and heat treatment operations on the change of weld morphology, including the reduction of ferrite grain growth and the change of selected mechanical properties of welds (strength, hardness, plasticity), was demonstrated.

Keywords: ferritic stainless steels, welding, heat treatment of ferritic stainless steels, growth of ferrite grains, ferrite

INTRODUCTION

Ferritic stainless steels with low strength properties such as impact strength and thus notch sensitivity [1], low hardness and tensile strength are used primarily for structural elements that do not carry high loads [1-4]. These limitations are primarily the result of the phenomenon of ferrite grain growth, which is formed in an uncontrolled manner due to the heat introduced during the welding process, causing brittleness of the weld area [1].

Ferritic stainless steels, despite low mechanical properties, due to the high content of chromium, which is also the main alloying component, are characterized by high corrosion resistance, primarily resistance to oxygen and sulphur at high temperatures [2]. To improve the strength properties of ferritic stainless steels, a post-weld heat treatment process is introduced to temper the martensite or alloying elements are added such as titanium or niobium, causing the formation of durable carbides at the grain boundaries, effectively inhibiting the growth of ferrite grains [2,3,6].

RESEARCH MATERIAL

To carry out the test, a material in the form of a plate of ferritic stainless steel of the X2CrTiNb18 grade with dimensions of 2,0 x 350,0 x 150,0 mm was used. The mechanical properties and chemical composition of the material used in the test are presented in Tables 1 and 2. The samples can be grouped into two groups: the samples from P1 to P2 made without titanium, and the second group of samples from P4 to P6 made with the addition of about 1g of titanium.

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Table 1 **Chemical composition of X2CrTiNb18 steel/wt. % [7]**

C	Si	Mn	P	N	Cr	Nb	Ni	Ti
0,017	0,570	0,410	0,024	0,014	17,630	0,371	0,220	0,137

Table 2 **Strength properties of X2CrTiNb18 steel [7]**

Tensile strength R_m /MPa	Yield limit $R_{p\,0.2}$/MPa	Elongation A %	Hardness HV
473	317	29	154

WELDING METHOD

The welding samples were made using the inert gas-shielded welding method with the non-consumable TIG 141 electrode (according to PN-EN ISO 4063). The samples were welded in the PA position and in accordance with the welding process parameters given in Table 3. Argon, with the designation “I1”, was used as the shielding gas according to PN-EN ISO 14175-I1-Ar in the amount of 14 l/min. The forming gas was also Argon of the “I1” grade but in the amount of 12 l/min. Strips with dimensions of 2,0 x 5,0 x 150,0 mm cut from the basic material were used as the additional material. Therefore, the chemical composition of the additional and the basic materials was the same.

RESEARCH RESULTS

The grain size was measured using the line method according to EN ISO 643 [6]. Comparing the weld area of the P1 sample made without the addition of titanium and without post-weld heat treatment with the area of the weld of the P4 sample welded with the addition of titanium and without heat treatment, we can see that the

Table 3 **Welding parameters for individual samples (own elaboration)**

No. samples	Current type	Current A	Arc voltage V	Welding speed mm/s	Heat input kJ/mm	Heat treatment parameters
P1	DC=(-)	65	10,7 ÷ 12,4	0,83	0,50 ÷ 0,58	-
P2	DC=(-)	65	11,2 ÷ 12,5	0,97	0,53 ÷ 0,59	880 ^{0}C/30 min
P3	DC=(-)	65	10,3 ÷ 12,5	1,00	0,48 ÷ 0,59	920 ^{0}C/30 min
P4	DC=(-)	80	10,5 ÷ 12,1	0,94	0,61 ÷ 0,70	-
P5	DC=(-)	80	10,7 ÷ 12,3	1,09	0,62 ÷ 0,71	880 ^{0}C/30 min
P6	DC=(-)	80	10,8 ÷ 12,1	1,09	0,62 ÷ 0,70	920 ^{0}C/30 min

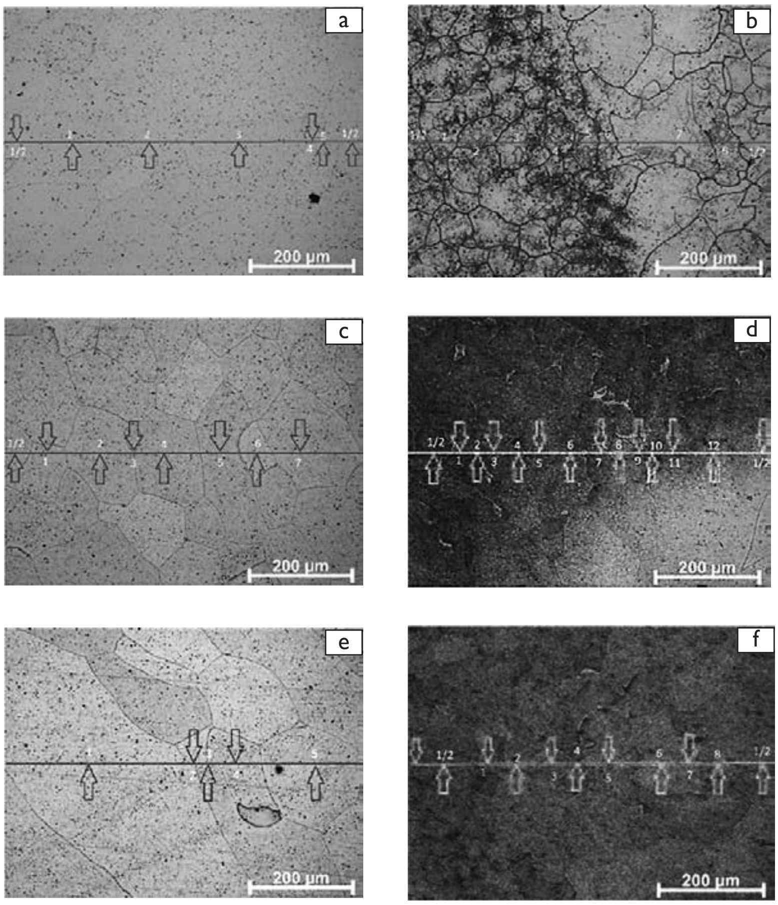

Figure 1 Measurement of the number of ferrite grains of sample: (a) - P1, (b) - P4, (c) - P2, (d) – P5, (e) - P3, (f) - P6.

number of grains increased slightly from 7 grains for the P1 sample to 9 grains for the P4 sample.

In the case of samples made with additional heat treatment after welding at the temperature of 880 °C, it is visible that the P5 sample made with the addition of titanium as a component intended to limit the growth of ferrite grains in the area of the weld material, is characterized by a larger number of ferrite grains (13 grains) compared to the P2 sample in the same measurement area (8 grains), which can be interpreted as a positive effect of titanium as an alloying component limiting the phenomenon of ferrite grain growth.

A large difference in the number of grains in the tested area of the weld material was also obtained in the case of samples heat treated after welding at 920 °C. Sample P3 made without the addition of titanium, showed the smallest number of visible ferrite grains compared to samples P1 and P2, which were also made without introducing titanium into the weld area. Sample P3 has 5 visible grains in the measured area compared to sample P2, where the number of grains is 7 and compared to sample P1 with 6 visible grains.

Sample P6, made with the addition of titanium and subjected to heat treatment at 920 °C, showed the same number of grains as sample P2. This result can be interpreted as follows: in the absence of a component inhibiting the growth of ferrite grains and as a result of additional heat after welding, the grain size based on the measurement of the number of grains present in the observed weld material begins to increase.

CONCLUSIONS

Based on the macroscopic observations of six samples, the following conclusions can be drawn:

1) Titanium, as an alloying additive used in welding ferritic stainless steel, can effectively reduce ferrite grain growth.

2) The heat treatment process introduced after the welding process of ferritic stainless steels without the addition of titanium does not reduce the size of ferrite grains, which can be observed by comparing the weld structure of samples P1, P2 and P3 where the number of ferrite grains is 5, 7 and 5 grains, respectively.

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[7] Material quality certificate X2CrTiNb18, APERAM Stainless Service&Solutions Poland Sp. Z o.o., Nr cert. 1106 80989.

Note: The responsible translator for English language is Weronika Zawierucha, Gliwice, Poland.