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Influence of the Introduction of Carbon-Fluorine Additive to the Slag of the Production of Silicomanganese on the Weld Joint Quality[1]

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Abstract. In the paper a possibility in principle is outlined to use a silicomanganese by-product ladle slag and a gas purification dust of aluminum production for manufacturing welding fluxes. The appropriate component concentration in welding fluxes is determined. The results of metallographic research are provided. The use of carbon-fluorine additive makes it possible to reduce the level of non-metallic impurities in the weld joint.

1. Introduction

Various factors, such as types and methods of arc and weldpool shielding [1, 2]; systems and methods of impulse supply of the welding arc [3, 4]; methods and means of weld metal modification [5, 6]; chemical composition of welding materials and fluxes [7, 8] etc. influence on the quality of weld joints.

At present researchers focus on the issue of developing new fluxes and additives. The use of metallurgical production wastes as components of welding fluxes allows both considerable reducing the cost price of manufactured fluxes and efficient using the production wastes [6-14]. The authors of the paper outline the results of using the non-utilizable silicomanganese by-product ladle slag and gas purification dust of aluminum production as a welding flux, they also consider the effect of these fluxes on the weld joint quality.

2. Results and Discussion

The experiments are carried out using the flux made of the silicomanganese by-product ladle slag smelted in the ore-melting furnaces via the continuous carbothermic process and gas purification dust of aluminum production (Table 1).

The gas purification dust is mixed with the liquid glass and used for manufacturing carbon-fluorine additive FD-UFS on the base of technology covered by a patent of the Russian Federation [15, 16]. The procedure of flux production includes grinding, sieving, sifting the 0.45-2.5 mm faction of silicomanganese by-product slag and mixing with the carbon-fluorine additive taken in various percentage concentration (sample 1 – without the additive FD-UFS, samples 2 to 5 contain 2, 4, 6, 8 %

[1] – The work is performed in Siberian State Industrial University as a project part of the State Order by the Ministry of Science and Education of the Russian Federation № 11.1531.2014/к. The equipment of the Collective Use Center «Materials science» of Siberian State Industrial University and scientific and production center «Welding processes and technologies» is used when testing, examining and measuring

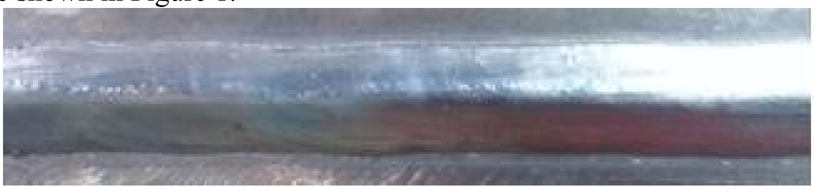
FD-UFS, respectively). The welding modes are tested by the welding tractor ASAW-1250 using welding electrodes Sv-08GA with the diameter of 4 mm. The process of welding 500×75 mm plates with the thickness of 16 mm is butt two-side welding, beveling under the flux layer is not necessary. The samples are welded in the following conditions: Iw=700 A; Ua=30 V; Vw=35 m/h.

The metallographic analysis is performed with the microscope OLYMPUS GX-51 in the bright field and zoom ranging ×100 to ×1000 after etching in 4 % nitric acid solution. The grain size is determined according to GOST 5639-82 when zooming in ×100. The samples are tested to detect non-metallic impurities in terms of GOST 1778-70. The polished surface is examined when zooming in ×100 with the microscope OLYMPUS GX-51.

Table 1 – Chemical composition of the components

Component	MnO	SiO_2	CaO	MgO	Al_2O_3	FeO	Na_2O	K_2O	F	S	P	C
Silicomanganese by-product slag	8.01	46.46	22.85	6.48	9.62	0.38	0.36	0.62	0.76	0.17	0.01	
Gas purifying dust of aluminum production	0.6	2.33	2.1	0.8	43.27	2.1	10.6	0.8	23.6	0.38	0.10	12.5

The welds are shown in Figure 1.



a

b

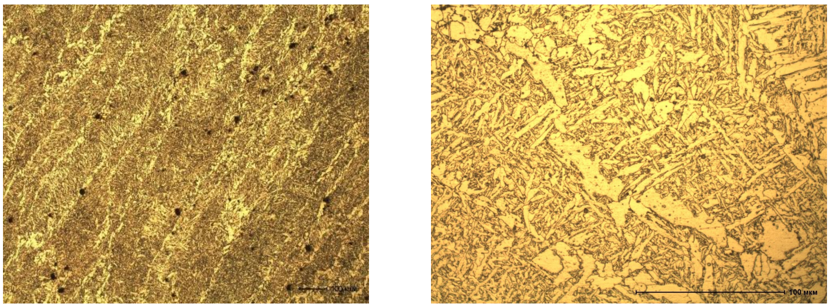
c

d

e

Figure 1 – Weld bead of the samples: a – sample 1, b – sample 2, c – sample 3, d – sample 4, e - sample 5

The welds of the samples under consideration have a Widmanstatten ferritic pearlite structure, which is distinguished by some needle-like ferritic zones, as the experiments have revealed. In some areas ferritic pearlite structure has a lamellar character (Figure 2).



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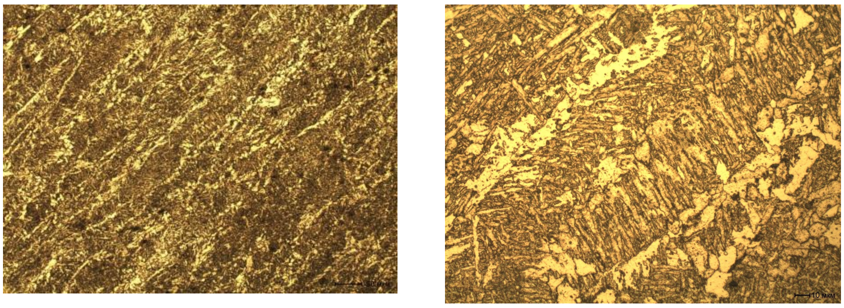

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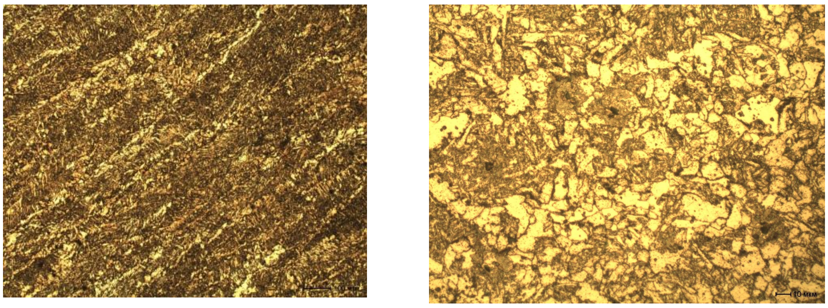

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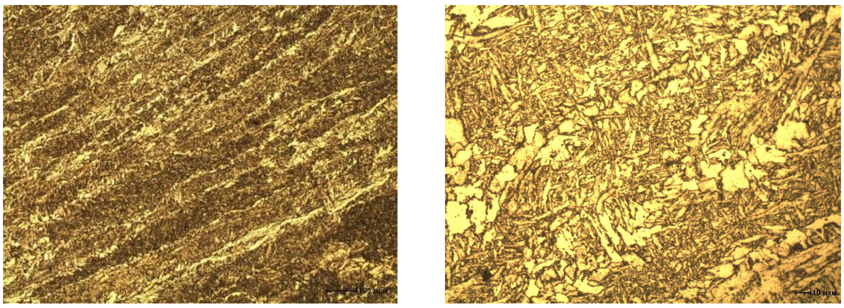

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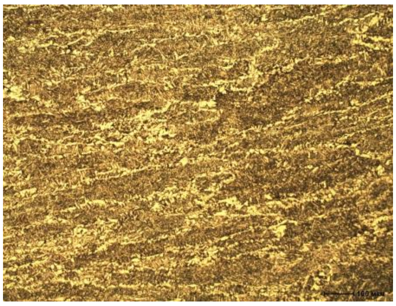
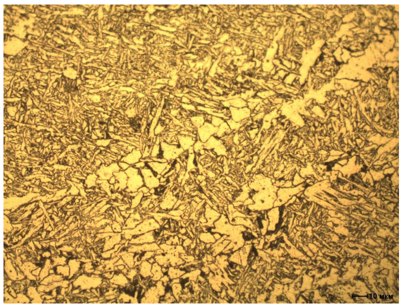



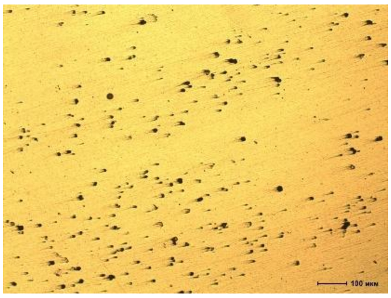
e

× 100 × 500

Figure 2 – Weld microstructure of the samples under consideration: a – sample 1, b – sample 2, c – sample 3, d – sample 4, e – sample 5

The grain size in the weld structure of sample 1 meets № 4, 5 according to the graininess scale. The grain size in the weld structure of samples №2 and №3 corresponds to №5, 6 and 7. The grain size of samples №4 and №5 answers № 5, 6, 7. Therefore, it has been revealed that increasing the FD-UFS concentration in the fluxes under consideration furthers the weld grain refinement.

The research into the character of non-metallic impurities has revealed non-deforming, brittle silicates, spot and stitched oxides in the weld area of the samples under consideration (Figure 3).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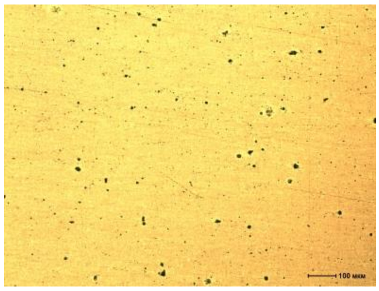
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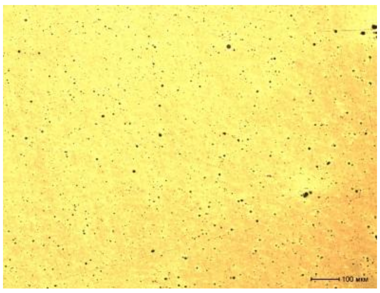
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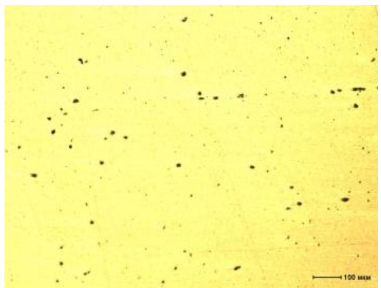
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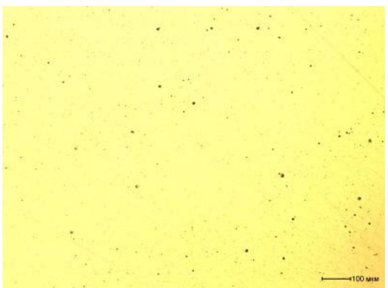
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Figure 3 – Non-metallic impurities in the weld area of the samples under consideration

In the weld area of sample 1 spot oxides of grade 1 (a) are detected, non-deforming silicates, generally, grades 4 (b) and 3 (b), less frequently grade 4 (a), brittle silicates of grade 3 (b) are rare. In the weld area of samples 2 and 3 there are non-deforming silicates of grades 2 (b), 4 (b) and spot oxides of grade 1 (a). In the weld area of sample 4 non-deforming silicates of grades 2 (b) and 1 (a) and spot oxides of grade 1 (a) are detected. In the weld area of sample 5 there are non-deforming silicates of grade 2 (b) and spot oxides of grade 1 (a). Using the carbon-fluorine additive (FD-UFS) in the flux effects positively on the weld, reducing the level of non-metallic impurities, their number and sizes (Figure 3).

The research described above is a foundation of welding fluxes manufacturing based on silicomanganese by-product slag and carbon-fluorine additive FD-UFS [17, 18].

3. Conclusions

1. The conducted experiments make it possible to demonstrate a possibility in principle to use a silicomanganese by-product slag for manufacturing welding fluxes.
2. The use of carbon-fluorine additive FD-UFS together with a silicomanganese by-product slag results in grain refinement.
3. The use of carbon and fluorine containing additive makes it possible to reduce the level of non-metallic impurities in the weld, their sizes and number.

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