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Nano- and microparticles in welding aerosol: electronic and microscopic analysis

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Abstract

The paper presents the first results of the research of the morphological and material composition of the particles in welding aerosol. It is shown that in terms of morphology the particles are hollow and solid balls, sometimes covered with easily chipped off shell. There are also objects of other forms– ovals, polygons and needles. Fragments of the shell of hollow spheres have the size of up to 10 μm (PM10) and jagged edges, making them and nano-sized particles the most potentially dangerous to human health components of welding aerosol. It is found that the aerosol particles are mainly composed of Fe> Mn> Zn> Ti, but there are minor components of Si, Cl, Zr, Co, Cr, Br, Al, Ca, Mg, K, C, S.

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1. Introduction

It is known that in the process of electric welding one of the main safety hazards in the breathing zone of welders, as well as in the working area is the maximum permissible concentration of harmful substances in welding aerosols. In addition, finest particles of melted and crystallized electrode coating, spattered metal of welding rods and the weld pool are of certain danger.

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The purpose of this work is to assess the particles sizes in welding aerosols in the air of working area with the help of laser granulometry and author's methods.

2. Materials and methods

The samples were collected as follows: during the process of welding a 3 liter sterile plastic container with distilled water was placed under welding spatter. After that the samples were transported to the laboratory and dried up. The analysis of samples was carried out using a scanning microscope JEOL JXA 8100 (Japan). The samples were not covered.

During the experiments different types of welding rods and varying strength of current were applied for several days (Table. 1).

Table 1. Welding rods and welding components used in the experiment.

No.	Welding component	Welding rod	Strength of current
1	Steel pipeC245 Ø 630x12 mm	UONI-13/55. Ø3 mm. LEZ	80A
2	RebarAIII, Ø12 mm	JHJ422 Ø3 mm	80A
3	Steel pipeC245 Ø620x12 mm	UONI-13/55. Ø3 mm	90A
4	Double-T ironNo.24 C245	UONI-13/55. Ø3 mm	90A
5	RebarAIII, Ø12 mm	JHJ422 Ø3 mm	75A
6	Steel pipeC245 Ø108x5 mm	UONI-13/55. Ø3 mm	75A
7	RebarAIII, Ø12 mm	Lincoln Electric. Omnia 46. Ø3.2 mm	90A
8	RebarAIII, Ø12 mm	Hyundai S6013Ø3.2 mm	90A
9	Silumin	Welding rod AlMni Ø2 mm	90A
10	Cast iron pipe(high-strength cast iron with spherical graphite) Ø150 mm	Hyundai ESTØ3.2 mm	100A
11	PipeC245 Ø 25x4 mm	AWS E6013Ø3.2 mm	100A
12	RebarAIII, Ø12 mm	Lincoln Electric UONI 13/55 Ø4 mm	110A
13	RebarAIII, Ø12 mm	Lincoln Electric Omnia 46 Ø3.2 mm	80A
14	RebarAIII, Ø12 mm	Lincoln Electric MGM-50K Ø3.25mm	80A
15	RebarAIII, Ø12 mm	Lincoln Electric Conarc 52 7016. Ø4 mm	80A
16	Metal sheet t=12 mm. Steel gradeC245	Welding rods ESAB OK 46 E6013. Ø4 mm	80A
17	Pipe C245 Ø180x5 mm	UONI-13/55 Ø3.2 mm	80A
18	Angle barC245 50x5 mm	UONI-13/55 Ø3.2 mm	80A
19	Pipe08X18H12T Ø89x5 mm	Welding rodsCL-11 Ø3 mm	60A
20	Pipe 08X18H12T Ø89x5 mm	Welding rods S-309L.16 Ø3.2 mm	60A
21	Pipe 08X18H12T Ø89x5 mm	Welding rods KST-308L Ø4 mm	60A

The research was carried out using the equipment of Shared Use Center "Interdepartmental Center of analytical control of the environment" of FEFU.

3. Results

As described in (Kirichenko K.Yu. et. al. (2016)) nano- and micro-sized particles dominate in the welding aerosol. Studying these particles by microscopy is difficult because of their extremely small size and methodical difficulties arising from it.

Using a scanning electron microscope we examined the morphology of the largest microparticles in the welding aerosol (Figures 1-9).