WAYS OF REDUCING WELDING AEROSOLS GENERATED DURING THE WELDING PROCESS

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Abstract. This article presents measures to reduce the harmful effects of welding aerosols on the human body during the welding process. The reduction of the harmful effects of welding aerosols on the body is carried out through technological and sanitary-technical measures, as well as through the use of protective equipment. This article considers the problems of improving working conditions in welding.

Keywords: welding aerosol, welding, dust, electrode, metal.

Introduction. Welding processes are used in all spheres of human economic activity. At present, welding types using electric and gas energy have become the most widespread. A specific feature of welders' working conditions, compared with other professions, is the presence of a number of characteristic dangerous and harmful production factors that are an integral result of the welding process.

Among them, the greatest threat to welders' health is welding aerosol, against which modern protection is still very weak. Medical examination results confirm that bronchopulmonary diseases caused by exposure to welding aerosols account for 80 percent of occupational diseases among welders in Uzbekistan and other CIS countries. These include pneumoconiosis detected among welders who have worked in welding workshops for more than 15 years and chronic bronchitis occurring after 5 years of work in the welding profession. When welding work is performed in enclosed spaces where ventilation is impossible, the period of development of pneumoconiosis is reduced to 5 years. In addition, there is information indicating that the effect of welding aerosol on the respiratory organs may increase the risk of cancer development. It is obvious that today the profession of welder is one of the most dangerous jobs and is gradually losing its social prestige.

Many people may not know what aerosols in welding are. Vapors and gases form a mixture with air. Solid and liquid particles – dispersion systems – are called aerosols and they can be of three types:

- Dust (solid particles larger than 1 μm).
- Smoke (particles smaller than 1 μm).
- Mist (liquid particles smaller than 10 μm).

Harmful substances can enter the human body mainly through the respiratory tract, skin, and food. After harmful substances enter the body, they dissolve in the biological environment, react with it, and disrupt normal life processes. As a result, a disease condition – poisoning – occurs.

During the welding process, when metal and electrode melt, or when metal is welded without being properly cleaned, the elements released from it, such as chromium, manganese, silicon and others, cause harm to human health. If we take manganese alone, it causes disorders of hereditary activity, impairment of lung function, and cardiovascular diseases.

The air environment of industrial buildings is polluted with welding fumes. These fumes consist of fine particles of welding fumes freely floating in the air. The chemical composition of welding fumes is different and depends on welding technology, welding materials, and welding mode. Basically, welding fumes contain aerosols of metals and their oxides (iron, manganese, chromium, vanadium, tungsten, aluminum, titanium, zinc, copper, nickel and others), gaseous fluoride compounds, and many other elements. In addition to aerosols, the fumes may also contain harmful gases: carbon monoxide, nitrogen, and ozone.

As a result of welding only steel, the following pollutants (kg) are released into the atmosphere: welding aerosol – 27.3, iron oxide – 24.2, manganese compounds – 1.03, Cr+6 in terms of chromium trioxide – 1.08. Inorganic dust content from 20 to 70% – 0.75, titanium dioxide – 0.085, hydrogen fluoride – 2.69, nitrogen dioxide – 1.38, nitric oxide – 2.91. In general, more than 60 kg of pollutants are emitted into the atmosphere during welding. The average amount can be reduced to 0.09 g/kg and the gas content in the emitted air can be reduced to 0.006 g/kg.

Now let us consider the composition of welding wires:

1. Carbon wires intended for welding low-carbon and medium-carbon steels, as well as some low-alloy steels containing up to 0.12% carbon (these include Sv-08, Sv-08A, Sv-08GA, Sv-10A, Sv-10GA, Sv-10G2).
2. Wires alloyed with manganese, silicon, chromium, nickel, molybdenum and titanium, used in welding corresponding grades of low-alloy steels; these include Sv-08GS, Sv-08G2S, Sv-12GS, Sv-18KhMA, Sv-10Kh5M, Sv-20KhGS and others.
3. Highly alloyed wires intended for welding special steels; these include Sv-06Kh14, Sv-07Kh19N9, Sv-07Kh25N20 and others.

As a result of the melting of electrode wires, welding aerosols are formed. As a result, the probability of these substances entering the lungs becomes very high, and this leads to impairment of lung function. Over time, a person's breathing becomes faster, the heart rhythm changes, and loss of health is observed. We can also see from this that a very large number of elements are released as a result of welding.

Technological measures include the development and implementation of low-toxic welding materials that reduce the composition of the protective gas environment (when welding in shielding gases), the reduction of burning carbon dioxide gas, the selection of a welding mode that ensures minimal release of welding aerosols.

Sanitary and technical measures include: the organization of local and general exchange ventilation, as well as the use of suction devices installed on welding equipment (burners with built-in suction systems). Then, for the protection of the respiratory organs, respirators or special protective welding shields with a clean air supply mask should be used.

To clean ventilation emissions from welding aerosols, plate electrostatic precipitators providing a cleaning efficiency of up to 0.95 can be used. It is advisable to equip large ventilation systems with such filters, to which small local exhaust ventilation systems should be connected. These filters should be periodically cleaned from accumulated welding dust.

Together with emissions of nitrogen, sulfur and carbon oxides from technological transport enterprises, oil refineries and service bases, welding aerosols, sulfuric acid, lead vapors, toluene, acetone, paints, oils and other chemical products are released into the environment.

Research Theory. A great many scientists have conducted research on improving occupational safety in welding. In particular, Chudinova Ya.N. provided information about welding aerosols in her article, including the amount of aerosols released into the air depending on the level of metal evaporation and the composition of electrodes.

In the monograph "Welding Aerosols," Grishagin V.M. provided detailed information about welding aerosols, including welding technology, welding types, welding using shielding gases, flux welding, electric arc welding, and the levels of aerosol formation resulting from their use. Information was also provided about the correct placement of ventilation sections in welding workshops and about protective masks.

We have presented proposals for improving occupational safety during the welding process, including the organization of sanitary and technical measures and reducing the impact of welding aerosols on humans. We considered the amount of dust and fumes released as a result of electrode melting and their effect on humans.

Research Methodology. The welding process is accompanied by a number of factors that are dangerous both for the welder's health and for people located near this process. These include ultraviolet and infrared radiation, the dazzling brightness of visible light, sparks and molten metal, and welding aerosol. The degree of metal evaporation depends on the liquid and slag melt formed during the melting of the electrode and the base metal, on welding modes, technology and spatial position of welding, electrode coating compositions, and base metals.

Various welding methods are used for the repair of steel products: automatic welding, mechanized welding in carbon dioxide, and others. Due to its simplicity and flexibility, manual welding remains the most widespread method of thermal joining of metals. However, this method allows instability of the mode, which increases the concentration of welding aerosol in the working area. It is known that there are several directions for reducing the impact of factors harmful to health during welding.

• The first direction is technological: reducing the level of welding aerosol emissions into the air through improvement of the welding process, selection of the type and grade of welding material, shielding gas, and welding mode.

• The second direction is sanitary-technical: consisting of the localization and neutralization of welding aerosol through the application of modern effective local ventilation means.

• The third direction is the use of a new generation of personal respiratory protection, making it possible to protect the respiratory organs of welders under various production conditions [1].

The implementation of the first direction can be based on the study of the processes of welding aerosol formation. For the remaining two directions, this information is also the starting point for determining appropriate methods and developing means for the neutralization of welding aerosols.

Welding aerosols are a mixture of gases and the smallest solid particles – the solid component of welding aerosols. Medical studies show that welding aerosols are one of the main causes of the development of occupational diseases, such as welder's pneumoconiosis, as well as other dangerous factors that reduce the duration of human life [2,3]. From the point of view of industrial safety, the maximum permissible concentration in the air of the working area of harmful substances that make up the solid component of welding fumes is standardized for each element or its oxide [4].

To understand the danger arising from aerosol formation, it is important to know the specific gross emissions of dust and its toxic components, expressed in milligrams per kilogram of consumed materials. Analysis of the data [6] shows that when welding with electrodes coated with rutile, acidic and other elements, welding aerosols are formed that are close in chemical composition. The most harmful substances included in welding aerosols formed during the welding of carbon and low-alloy steels with basic-coated electrodes are fluoride compounds (especially gaseous ones), and when using rutile, acidic and cellulose-coated electrodes, manganese compounds.

According to data from the Institute of Occupational Hygiene and Occupational Diseases of the Academy of Medical Sciences, the specific amount of dust (the solid phase of the aerosol) formed during the burning of various electrodes has been determined. From a hygienic point of view, rutile-coated electrodes are the most favorable. However, cellulose-coated electrodes are characterized by the highest aerosol emissions. In this case, the high level of welding fumes is caused by the large amount of emitted gases: CO, CO_2, H_2. The high emission of welding aerosol when welding with basic-coated electrodes is associated with volatile fluoride compounds (CaF_2, Na_2SiF_6) and the high basicity of the slag phase, which contributes to the intensive transfer of alkali metal compounds into the welding aerosol.

Table 1

Specific Dust Emission During Electrode Burning

Electrode Coating Type	**Dust Content**
Ore-type coated electrodes	18.6 – 36.5 g/kg
Basic-type electrodes	11.3 – 13.5 g/kg
Rutile-coated electrodes	7.1 – 15.3 g/kg

The fumes generated during various types of welding have a negative effect on human health, resulting in the development of occupational diseases. To reduce this effect, it is necessary to improve the welder's working conditions and comply with all rules for performing repair and welding work.

Research Results. Welding fumes generated during various types of welding have a negative effect on human health, resulting in the development of occupational diseases. Medical studies have shown that welding aerosols are among the main causes of occupational diseases such as welder's pneumoconiosis and chronic respiratory disorders.

Analysis of welding materials showed that the amount of aerosol emissions depends on the type of electrode coating. According to the obtained data, rutile-coated electrodes are characterized by the lowest dust emission rates (7.1–15.3 g/kg), while ore-type coated electrodes generate the highest amount of dust (18.6–36.5 g/kg). Basic-type electrodes occupy an intermediate position with dust emissions ranging from 11.3 to 13.5 g/kg.

The conducted analysis also showed that welding aerosols contain harmful components such as iron oxides, manganese compounds, chromium compounds, fluorides, carbon monoxide, nitrogen oxides, and ozone. These substances can enter the human body through the respiratory system and negatively affect lung function, cardiovascular activity, and overall health.

The study determined that the most effective reduction of the harmful effects of welding aerosols can be achieved through the combined application of technological, sanitary-technical, and personal protective measures. The use of local exhaust ventilation systems, modern filtration devices, low-toxic welding materials, and respiratory protective equipment significantly reduces the concentration of harmful substances in the welder's breathing zone.

The obtained results indicate that improvement of working conditions in welding shops and the implementation of modern occupational safety measures contribute to the reduction of occupational diseases and improvement of workers' health conditions.

Conclusion and Recommendations. If we draw a conclusion regarding the improvement of working conditions in welding, we can reduce its negative effects.

To reduce the negative impact, it is necessary to carry out the following:

• correct lifting of loads;
• regular changing of positions;
• performing work under comfortable conditions;
• short breaks for rest and warming up;
• convenient placement of devices and materials in the workplace;
• reduction of vibrations.

The measures previously applied to improve the working conditions of welders did not show significant positive results. The problem of creating healthy and safe working conditions for welders remains relevant. A more radical approach is required for its solution, namely, world and domestic experience shows that a combination of technological and sanitary-technical measures for eliminating the harmful effects of welding aerosols, as well as the use of individual respiratory protective equipment, should be applied for welders.

• The first direction is technological: it consists of reducing the spread of welding aerosol into the air through improvement of the welding process, selection of welding technology, the type and grade of welding material, shielding gas, and welding mode.

• The second direction is sanitary-technical: it consists of localizing the neutralization of welding aerosol through the application of modern effective local ventilation systems.

• The third direction is the use of a new generation of protective equipment that makes it possible to protect the respiratory organs of welders under various production conditions.

Occupational safety is such a condition of working conditions in which the effect of dangerous or harmful production factors on workers is prevented. In one word, improving working conditions ensures the quality of production and significantly reduces costs.

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