

RECYCLING AS A WAY TO SOLVE ECOLOGICAL PROBLEMS OF ALUMINUM PRODUCTION

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Abstract. Main ecological problems associated with the process of electrolytic aluminum production are described. Obtaining of primary aluminum is accompanied by depletion of natural sources, deterioration of health of population, development of occupational diseases of employees of aluminum enterprises, environmental degradation due to harmful ejections and accumulation of solid wastes. Recycling of metal wastes and scrap of aluminum alloys allows to eliminate and reduce the risks of aluminum industry with high efficiency. Thus the amount of emissions of harmful substances into the atmosphere are reduced significantly, compounds without class of danger or related to 3-4 classes are used, power consumption and expense of non-renewable raw sources are decreased.

Keywords. Recycling, aluminum, electrolysis, secondary alloy, danger, occupational disease.

Introduction. Relatively high level of structural and operating properties leads to extensive use of aluminum alloys in a plenty of industries - mechanical engineering, electrical engineering, shipbuilding, aerospace, food processing, construction, etc. Aluminum has light weight. For example, aluminum parts are three times lighter than the steel parts of the same size. In specific strength aluminum alloys are not inferior the number of carbon and alloy steels. Aluminum alloys have a high corrosion resistance in air and in a medium of many liquids and gases. They have a high resiliency and do not embrittle at low temperatures. Aluminum is a good conductor of electricity and heat. By volumes of use of aluminum takes the second place after steel today. Thus, replacement of one kilogram of steel on one kilogram of aluminum alloy in automobile construction decreases the overall consumption of 8.5 liters of gasoline and emission of carbon dioxide of 20 kg [1]. A capability of aluminum to compete with steel, cast iron, copper alloys, plastics and concrete is provided mainly by one important feature - the ability to be recycled. When appropriate technologies are used once obtained from the ore materials aluminum can be repeatedly melted and used to make new products.

Due to the constant increase of production of products made from aluminum alloys and the accumulation of scrap and waste, there is a world problem use of secondary raw materials. This question is particularly relevant for Ukraine, which has developed aluminum-consuming alloys (missilery, aeronautics, automotive, civil and industrial building), but lost its own production of aluminum. Main disadvantages of secondary aluminum alloys are lowered technological and mechanical properties due to contamination of harmful impurities of iron, oil, plastics and others.

Basic Material of the Research. Production of aluminum from ore raw materials has the negative impact on the environment, which is related to the release of harmful gases and the accumulation of solid waste. When alumina from bauxite is obtained "red sludge" (solid waste based on silicates and metal oxides) is formed.

During electrolysis of alumina the greatest amount of harmful gases is allocated.

Acutely toxic sludge contains 25...70 % of carbon, 6...16 % of fluorine, 4...10 % of aluminum, 6...19 % of sodium, up to 1% of cyanide and other components. Sludge processing is not exposed and stored in significant quantities in landfills. Production of one ton of aluminum oxide is accompanied by the release of 360... 800 kg of sludge. Today the world has accumulated tens of millions of tons of such waste. At the same time achievement a perfect waterproofing of sludge fields is almost impossible, which adversely affects on ecological situation.

In the preparation process of aluminum fluoride and cryolite environment is polluted with gaseous HF, which is converted to a corrosive hydrofluoric acid. The atmosphere is also contaminated with the connection CF_4 , related to greenhouse gases. Participation in the biochemical processes CF_4 does not accept; its lifetime in the atmosphere is 2600...5000 years. Warming potential for CF_4 is in 6500 times bigger than that for CO_2 , which results in a strong influence on the temperature of the planet. Solid fluorides and sulfur dioxide negatively affect on flora, in particular covering of needles. When interacting with oxygen, sulfur dioxide is oxidized to SO_3 , which contributes to acid rains. Over the last few decades, the acidity of rain water increased to 40 times.

According to [2] the level of occupational diseases of workers reaches 43.8 cases per 10,000 people, which is almost three times bigger than the level of occupational diseases in steel industry. The stuff of electrolysis sections is affected by fluoride compounds, coal tar products, magnetic fields, infrared light, unsatisfactory climate conditions, physical load, etc. The penetration of harmful substances into the human body predominantly occurs via the respiratory tract, at least - by skin and the gastrointestinal tract.

The solids in the electrolysis have the form of dust containing Al_2O_3 , Na_3AlF_6 , AlF_3 , NaF and so on. Prolonged contact with dust alumina (Al_2O_3) may cause chronic illness of respiratory tract, leading to changes in the lungs - pneumoconiosis, fibrosis, etc. The main components of the electrolyte are cryolite $3\text{NaF}\cdot\text{AlF}_3$, aluminum fluoride AlF_3 , sodium fluoride NaF , calcium difluoride CaF_2 , lithium fluoride LiF and magnesium difluoride MgF_2 . Cryolite worsens blood composition, leads to diseases of bones and teeth. Aluminum fluoride adversely affects the circulatory system. Sodium fluoride is poisonous, toxic, it affects the central nervous system. Calcium difluoride impairs the blood, affects the proteins in the human body. In acute poisoning CaF_2 affects the central nervous system and gastrointestinal tract. With long-term effects of lithium fluoride and magnesium fluoride fluorosis appears.

Such compounds as CO , CO_2 , HF , SO_2 , SiF_4 as gaseous substances during electrolysis are emitted. Carbon oxide (over 80% of the total emissions) may change blood composition and lead to asphyxia, consciousness loose, convulsions. Carbon dioxide increases blood pressure, causing dizzinesses and syncopes. Hydrogen fluoride affects the mucous membranes, causing bleedings, ulceration of the respiratory tract, nasal bleeding, pulmonary edema, purulent bronchitis, asthma, laryngeal spasm, convulsions, damage to the heart muscle, fluorosis, etc. Consumption of fluorine compounds with the production of 1 ton of aluminum

reaches 20 ... 45 kg [3]. Silicon tetrafluoride causes irritation of eyes, nose and respiratory tract. Sulphur dioxide irritates mucous membranes, causing a dry cough, burning and sore throat, and affects the lungs.

It should be noted that obtaining of 1ton of aluminum from ore materials about 3.0... 3.5 kg of CO, 11.0... 12.0 kg of NO₂, 6,5 ... 7,5 kg C_nH_{2n+2}, 2590 ... 2650 kg of (CO + CO₂), 2.0...2.5 kg of organic acids, 5.5...6.0 kg of carbon black [4]. Nitric oxide leads to decrease of blood pressure, headaches, dizziness and other ailments. When released into the atmosphere NO₂ contributes to the destruction of the ozone layer. Hydrocarbons C_nH_{2n+2} cause drowsiness, dizziness, breathing and circulation. When released to the atmosphere C_nH_{2n+2} forms photochemical fog or smog.

Working conditions at workplaces in electrolysis, anodic and casting sections are regarded to the 3rd class. As a result of exposure of harmful substances musculoskeletal system of employees of enterprises for production of primary aluminum is hit, chronic lung diseases, allergies and dermatitis occur. Numerous data indicate that emissions of aluminum production cause catastrophic damage to human health and its progeny. Growing tumors, endocrine system diseases and mental disorders are observed.

According to the research [5] the risk of chronic intoxication related to toxic substances pollution of air connected with aluminum production in the area of living and working areas air was 0.344 ... 0.408. The total cancer risk associated with air pollution of workspaces at aluminum plant and air of the city for one person was 2,89·10⁻⁵...3,25·10⁻⁵, which significantly exceeds the acceptable level of lifetime risk (1·10⁻⁵).

Remelting of aluminum helps to reduce the negative impact on the production staff and emissions of harmful substances into the environment significantly. It is accompanied by decrease of outlays of raw materials and energy. According to various sources for the production of secondary aluminum in 2,5 ... 6,0 times less raw materials should be used compared with the primary metal. Production of 1 ton of aluminum from ore requires the expense of 13,000 ... 16,000 kW/h of electricity, whereas the remelting of scrap and waste requires the expense of about 200 ... 550 kW/h only. Receive of 1 ton of recycled aluminum allows to save nearly 4 tons of bauxites, 700 kg of coke and reduce harmful emissions (including CO) on 35 kg [6]. Thus the cost price of aluminum alloys is reduced by 25 ... 50 %.

World leaders of use of recycled aluminum are the United States, Japan, Germany, France and Italy. To date, the EU produces about 5.1 million tons of primary and 5.2 million tones of secondary aluminum alloys per year. Motor vehicle contains on average more than 120 kg of aluminum, 60% of which refers to secondary. The terms "primary" and "secondary" increasingly characterize the source of the alloy, but not the quality of the metal itself.

Conclusions

Nowadays aluminum and its alloys are among the most claimed and promising structural materials. Light weight, high corrosion resistance, electrical and thermal conductivity, processability, strength and plasticity, and ergonomic characteristics of products from aluminum alloys cause their widespread use in mechanical engineering, food processing, electrical engineering, architecture, etc.

For production of aluminum alloys as mineral as secondary raw materials are used. Electrolytic method of producing of aluminum from alumina provides an output of high quality, but is associated with a number of disadvantages – exhaust of natural resources, occupational diseases of employees of aluminum industry, emissions, deterioration of health, accumulation of waste products, etc. Emissions of harmful substances into the atmosphere cause the greenhouse effect, destruction of the ozone layer, acid rains, photochemical fog, etc. Employees of aluminum plants suffer from chronic lesions of the respiratory tract, musculoskeletal system, poisonings, allergies and dermatitis. The population of industrial regions with electrolytic aluminum production lives at increased risk of cardio-vascular diseases and cancer.

Mainly to solve these problems allows the recycling of scrap and waste. There is an economy of energy resources near 80 %, decrease of emissions by 95 % and reduce of water pollution about 95 % [7] for production of secondary aluminum alloys. Besides scrap and waste products, which are used for recycling, otherwise, would be placed in landfills and special burials, which would lead to the degradation of natural ecosystems.

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