DOI 10.31891/2307-5732-2024-331-60
UDC 669

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TECHNOLOGICAL PROCESS OF ALUMINUM RECYCLING METHODS

The aim of the article is to study the specific features of these methods, studying the technological process of production methods of aluminum, the level of recycling of which is increasing every year. Aluminum is present in about 8 percent of the Earth's surface. For the first time, the use of aluminum in industry began in 1886 using the electrolysis method. The production of aluminum by processing the ore containing aluminum is called primary processing, and the production of recycled amulinium by using the aluminum obtained as a result of this processing is called recycling. While the process of primary production of aluminum is a process that requires a lot of investment and pollutes the environment more, recycling is a process that requires less costs and has a relatively low environmental damage, which increases the scale of aluminum recycling every year.

As the theoretical and methodological basis of the research, aluminum remanufacturing methods and scientific-research works reflecting the technological process of these methods and concrete facts were analyzed. During this study, the topic was thoroughly investigated, using mathematical analysis methods, pictures, tables, and graphs.

The main scientific innovation put forward is that the development of technology is of paramount importance in improving the specific methods of the aluminum recycling process, and the impact of the recycling process carried out with the help of these methods on environmental pollution occurs at a lower level. The drop in costs, in turn, has an impact on the price of aluminum products.

The result of the study:

- In large consumer countries, effective measures are being taken against global warming and CO2 emissions, as a result of which recycling, sustainability and industrial emission reduction have become increasingly one of the priorities in the commodity market;

- Under such conditions, aluminum will continue to stand out as a much superior material than all alternative materials, and its consumption will increase;

- As the aluminum sector prepares for this new era, the certification of recycling processes must increase its competitiveness by developing its capacity and technology, as well as yield for a clean environment.

Key words. Aluminum, aluminum processing, recycling, processing methods, processing technologies

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ТЕХНОЛОГІЧНИЙ ПРОЦЕС МЕТОДІВ ПЕРЕРОБКИ АЛЮМІНІЮ

Метою статті є вивчення особливостей цих методів, вивчення технологічного процесу прийомів виробництва алюмінію, рівень переробки якого з кожним роком зростає. Алюміній присутній приблизно на 8 відсотках поверхні Землі. Вперше застосування алюмінію в промисловості почалося в 1886 році методом електролізу. Виробництво алюмінію шляхом переробки руди, що містить алюміній, називається первинною переробкою, а виробництво переробленого амулінію з використанням алюмінію, отриманого в результаті цієї переробки, називається переробкою. У той час як процес первинного виробництва алюмінію є процесом, який вимагає великих інвестицій і більше забруднює навколишнє середовище, переробка є процесом, який потребує менших витрат і завдає відносно низької шкоди навколишньому середовищу, що збільшує масштаби переробки алюмінію з кожним роком.

Теоретико-методологічною основою дослідження були проаналізовані способи переробки алюмінію та науково-дослідні роботи, що відображають технологічний процес цих методів і конкретні факти. Під час цього дослідження тема була ретельно досліджена з використанням методів математичного аналізу, малюнків, таблиць та графіків.

Головна висунута наукова інновація полягає в тому, що розвиток технології має першочергове значення для вдосконалення конкретних методів процесу переробки алюмінію, а вплив процесу переробки, який здійснюється за допомогою цих методів, на забруднення навколишнього середовища відбувається на нижчому рівні. . Падіння собівартості, у свою чергу, позначається на ціні виробів з алюмінію.

Результат дослідження:

- У великих країнах-споживачах вживаються ефективні заходи проти глобального потепління та викидів CO2, в результаті чого вторинна переробка, стійкість і скорочення промислових викидів все більше стають одними з пріоритетів на ринку товарів;

- За таких умов алюміній буде продовжувати виділятися як набагато кращий матеріал, ніж усі альтернативні матеріали, і його споживання зростатиме;

- Оскільки алюмінієвий сектор готується до цієї нової ери, сертифікація процесів переробки повинна підвищити його конкурентоспроможність шляхом розвитку його потужностей і технологій, а також сприяти чистому навколишньому середовищу.

Ключові слова: Алюміній, переробка алюмінію, переробка, методи переробки, технології переробки

Introduction (problem statement)

Aluminum was obtained by separating it from its oxide compound for the first time in 1807 by Sir Humprey Davy. Aluminum is present in approximately 8 percent of the Earth's surface. The use of aluminum in industry began in 1886, when the electrolysis method was used for the first time. Thus, since the discovery of electrolysis production, aluminum production has increased from 13 tons to over 21 million tons annually in the world, and it has become the second most used metal after iron and steel. With the increase in production quantities, the unit price of aluminum, although it was included in the class of precious metals such as gold and silver in the years when it was first released, has now fallen to a level comparable to copper.

The production of aluminum by processing the ore containing aluminum is called primary processing, and the production of recycled amulinium by using the aluminum obtained as a result of this processing is called recycling. While the process of primary production of aluminum is a process that requires a lot of investment and pollutes the environment more, recycling is a process that requires less costs and has a relatively low environmental damage, which increases the scale of aluminum recycling every year. If it is necessary to give an example, the share of secondary production in the total world aluminum production has reached 30%, while it was 15% in the 1950s. Especially in South American and European countries with limited energy resources, collection networks with the ability to collect scrap at very high rates have been established and the awareness of "re-evaluation" has spread to all levels of society. The European aluminum industry plans to meet 50% of its total aluminum demand through recycling over the next 30 years. While the recycling of aluminum in the European Union was 3.6 million tons in 2018, it is aimed to increase this amount to 8.6 million tons by 2050.

Here Japan is a very interesting example. After the oil crisis in the 1970s, with the increase in energy prices, it stopped primary aluminum production and focused on secondary production.

Based on the results analyzed below, it can be concluded that aluminum recycling is easier and more efficient than other metals.

In recent years, a number of scientific studies on the subject have been conducted and published.

When we look at the literature about the aluminum recycling process, it is possible to make the recycling process at lower temperatures [7] and the application of different methods that provide high pressure in the recycling process, we see more studies aimed at making improvements by changing the parameters in the process. Another study is the production of aluminum alloy without using flux, salt [12] is related to the design of special equipment for. The use of thermodynamic reactions during the melting of aluminum to purify aluminum recycling materials from some elements contained in them [1] is an old method used in the industry. Changing the process parameters by using statistical interests and reaching an optimal value between quality and economic value [9], the application of the Taguchi Method is also among the studies found in the literature. In this thesis, the aim is to analyze how the different groups of materials used in aluminum recycling affect the components in the aluminum alloy produced using statistical methods and to create a model that shows how much they can reach the alloy components required by the customer by using which groups of materials.

Presentation of the main material

The aluminum production industry where the revaluation process is applied is defined as the "secondary aluminum industry".

Aluminum is a "renewable" material. Aluminum products fulfill their functions throughout their lifetime. Expiry of their useful life means that their properties such as high strength, corrosion resistance, high elasticity, electrical and thermal conductivity are lost. However, scrapped aluminum material is reprocessed under appropriate conditions and re-enters the system as secondary aluminum, regaining all its lost properties. By putting 1 ton of aluminum scrap into the remanufacturing process, approximately 0.9 tons of new aluminum material can be produced (due to scrap preparation and melting losses). The aluminum economy is a circular economy. Aluminum products are only used, not lost. When their useful life is over, they re-enter the system as raw materials for the secondary aluminum industry. As long as they are processed under appropriate conditions. Therefore, every gram of aluminum that is not reused is "lost" and allowing it to happen is a "mistake" [4, p. 2692].

At the same time, aluminum is an energy bank; the energy required during its production is not consumed, but is preserved or stored due to secondary production. When aluminum is reused, it provides economic, environmental and social benefits, which constitute the three pillars of the concept of sustainable development: Recycling is a process that includes collection, recovery (upgrading) and remelting. However, since the term recycling does not include the processes in the recycling process and only describes the result without taking the process into consideration, the term re-evaluation will be used in this article. Due to the difference in processing, recycling is sometimes described as 'surface mining'.

Primary raw materials: Unprocessed metallurgical quality alumina (Al2O3) obtained from bauxite ores by the Bayer process and metallic aluminum production process from alumina by the molten salt electrolysis method, with a metal purity between 99.0% and 99.8%. It is raw aluminum [8].

Secondary raw materials: It is the metallic aluminum obtained from secondary sources, that is, aluminum materials (old scrap) that have expired and the process residues formed in various aluminum processing processes, and the slag formed during the melting of primary or secondary aluminum.

Secondary materials are generally not identifiable materials and are found together with many other materials and impurities. Therefore, they need to be processed after collection. That is, they are collected, grouped, separated, subjected to various preparation processes and melted.

Secondary aluminum raw materials can be examined in 3 classes [6, p. 8-9]:

1. Old scrap is aluminum materials that have exceeded their useful life.
2. New scrap is the process residues generated in aluminum production processes.
3. Slag is metallic aluminum and oxide mixtures formed during aluminum melting, refining and transfer processes.

From a material flow perspective, the concept of re-evaluation can be examined in two groups [11, p.2-3]:

1. With closed loop re-evaluation, aluminum material that has completed its useful life is re-melted, made suitable for its original purpose and reused. For example, remelting aluminum soft drink cans and turning them into soft drink cans.

2. In the open-loop re-evaluation process, aluminum materials in different alloys that have expired are melted and alloyed. Thus, aluminum materials with new alloys and intended uses are produced. For example, production of piston caps from rim chips.

Aluminum scrap is very important not only because it can be re-evaluated, but also because it has economic value. By increasing the re-evaluation rate of aluminum materials and using secondary aluminum more, the re-evaluation cycle can be closed, resulting in the previously listed production of fewer greenhouse gases, thereby reducing the risk of global warming and saving energy.

High-quality process alloys are very largely included in the closed loop, while casting alloys are usually produced in the open loop. As the applicability of the closed loop increases, it will be possible to re-evaluate it with the ideal quality and quantity and cost. However, due to the different service life of aluminum products and the problem of regular availability, it usually works open loop.

When we look at the rates of reuse of materials globally, up to 95% of products used in transportation with widespread aluminum usage, up to 98% of products used in construction, and 65-70% of beverage cans can be returned to production [3, p. 66].

From an industrial perspective, secondary facility investments are investments that can start production much simpler and faster than primary facilities, in terms of investment infrastructure, planning and operation. The investment cost of a secondary aluminum plant with roughly the same capacity is approximately 10-25% of the primary aluminum plant investment cost. The time it takes for a secondary facility to start production is 70% shorter than that of a primary facility.

While the most critical issue in primary aluminum production is energy, in secondary aluminum production it is "scrap quality and availability". The secondary aluminum production process is a 7-stage process [2, p. 48]:

- Scrap collection;
- Scrap separation, preparation and pre-treatments;
- Melting;
- Alloying;
- Metal refining;
- Casting;
- Slag cleaning and slag evaluation.

Approximately 30% of world aluminum consumption comes from secondary sources. Although secondary aluminum has such a high share in general consumption, the secondary aluminum production rate and therefore the consumption rate of secondary materials is quite low.

From here, technically there are 6 basic and potential work areas for secondary aluminum engineers [6, p.16]:

a) Development of scrap preparation and scrap separation (especially separation of casting and process alloys, that is, separation on an alloy basis) technologies (LIBS: laser induced breakdown spectroscopy, XRF: development and dissemination of neutron avtivation analysis technologies);

b) Development of cleaning technologies for non-aluminum metals and non-metal contaminants (lacquer, paint, oil, etc.) on aluminum scrap;

c) Depending on the developments in scrap preparation - separation and scrap cleaning, creating the opportunity to use low quality scraps efficiently;

d) Minimizing energy consumption during melting and reusing waste heat;

e) Producing technologies that will reduce the production of slag and salt cake and allow these wastes to be reused in different sectors;

f) Development of molten metal refining processes that will bring molten aluminum closer to primary aluminum quality and thus increase its usage areas.

This technical development potential should also be supported by legal regulations and training studies, and by popularizing the concept of "scrap collection and evaluation" instead of consumption.

As a result of these [3, p. 64];

- Design of aluminum products at the design stage, taking into account that the re-production with the life cycle assessment system is part of aluminum products and/or production processes,
- Increasing the consumption of secondary aluminum by diversifying the products in which secondary aluminum is used;
- Within the total aluminum consumption, secondary products replace primary products more;
- The suitability of aluminum metal for the sustainable development process and the support of secondary production will have consequences.

The most important obstacle to the secondary aluminum industry here is that new products with different alloys and forms and therefore different chemical impurities (such as lacquer, paint, plastic) come into use every day. However, increasing sensitivities, especially due to the reality of "global warming", have made "the use of materials that can more easily participate in the secondary cycle" one of the basic criteria in designs where both aluminum and other "recyclable" materials are used.

There are several advantages to aluminum recycling. These benefits and efficiencies can be summarized under three main headings. These are: economic, environmental and social benefits

Economic benefits include [13, p. 12]:

- Aluminum metal is defined as an energy bank. Because in the time from bauxite mining to the casting process, approximately 194,000 MJ of energy is consumed for 1 ton of primary aluminum. But this energy does not disappear. When the material reaches the end of its life and is scrapped, it can be remanufactured by consuming 10,500 MJ of energy (approximately 5% of the energy spent in primary production) and without losing its original properties to a great extent.

- 20 beverage cans can be produced from scrap with the energy required to produce 1 beverage can, a primary aluminum product produced from ore. The amount of energy saved by producing 1 aluminum beverage can from scrap is equal to the amount of energy consumed by a television in 3 hours.

- With re-evaluation, rational use of raw materials and therefore protection of natural resources are possible.

- Aluminum scrap is a valuable commercial material and a profitable business. This economic value has also been a driving force for secondary aluminum production. Particularly, countries that gained their independence after the collapse of the Soviet Union are typical examples of this.

- By using fewer alloying elements with secondary production, similar advantages are created for these elements.

Environmental benefits include [2, p. 47]:

- Primary aluminum production alone produces 1% of the total human-caused greenhouse gas production. While approximately 40% of this 1% share are direct greenhouse gases produced during the aluminum production process, the remaining 60% are emissions generated during the energy production process required for aluminum production.

- During the production of 1 kg of primary aluminum, approximately 9.7 kg of CO_2 equivalent greenhouse gases are released into the atmosphere. 5.4 kg of this is generated during electricity production, and the remaining 4.3 kg is generated during bauxite mining and alumina production. This greenhouse gas emission increases significantly in electrolysis facilities with old technology and in facilities where electricity is obtained from coal. When coal-based electricity is produced, CO_2 equivalent greenhouse gas production per kg of aluminum can reach up to 20.8 kg.

- Today, approximately 80 000 000 tons of greenhouse gas emissions are reduced annually by reintroducing "old aluminum scrap" into production. This figure is equal to the amount of greenhouse gas produced by 15 million passenger cars.

- Nature destruction caused by waste material storage and the environmental problems it creates are reduced. For example, it takes 500 years for aluminum soft drink or aerosol cans to disappear in nature.

- During primary aluminum production, 650 kg of CO_2 equivalent to 0.1 kg of fluoride is produced for 1 ton of aluminum production, while the amount of greenhouse gases released as a result of secondary production is 250 kg of CO_2 equivalent.

- From the perspective of the concept of sustainable development, aluminum is the only metallic material that finds a place in this concept.

- Harmful wastes and high water usage generated in bauxite mining and alumina production processes do not occur in the secondary process.

- Thus, with re-evaluation, the use of both material resources and energy resources will decrease and a cleaner and wealthier world can be left to future generations.

Social benefits include [10, p. 94]:

- Secondary aluminum production is an industry and creates serious job opportunities for scrap collectors, smelters and other sub-industries that support them.

- Reduces waste storage and waste disposal costs.

- It eliminates the risk of contamination of groundwater that occurs during waste storage processes.

In light of all the economic, environmental and social benefits listed above, the main goal for aluminum producers is to increase the amount of secondary materials in the raw material combination they use, without sacrificing quality.

Conclusions

The result of the study:

- In large consumer countries, effective measures are being taken against global warming and CO_2 emissions, as a result of which recycling, sustainability and industrial emission reduction have become increasingly one of the priorities in the commodity market;

- Under such conditions, aluminum will continue to stand out as a much superior material than all alternative materials, and its consumption will increase;

- As the aluminum sector prepares for this new era, the certification of recycling processes must increase its competitiveness by developing its capacity and technology, as well as yield for a clean environment.

Looking at the main goal of the secondary aluminum industry or with reference to the total aluminum industry, the main function of the secondary aluminum industry is to introduce the largest amount of aluminum materials into the secondary cycle, to ensure that the secondary cycle proceeds on the basis of "closed loop reclamation", and in each cycle, scrap preparation, smelting and is to minimize metal loss in the refining stages. This is the ideal point that can be reached.

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