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The Use of Copper Products from Almalyk Mmc Jsc in Smart Homes, Enterprises and Urban Infrastructure:
Assessment of Environmental Impacts and Prospects for Sustainable Development

Elvira Salavatovna Sadykova

Master of the Tashkent University of Architecture and Civil Engineering, Uzbekistan

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Abstract

Almalyk Mining and Metallurgical Combine (AMMC), located in the city of Almalyk, is a key player in the mining and metallurgical industry of the country, especially due to its extensive copper production. Founded in 1958 and operating since 1963, AGMK has turned into a multifunctional industrial complex, including numerous ore departments, processing complexes and specialized repair units. In recent years, the plant has embarked on ambitious projects aimed at increasing output and modernizing its facilities. In addition to its core business, AGMK copper products play an important role in promoting smart home technologies and urban infrastructure due to their excellent electrical and thermal conductivity properties, as well as antimicrobial characteristics. However, the plant's activities are also accompanied by environmental challenges, which requires a focus on sustainable development and technological innovation. AGMK is actively implementing advanced technologies aimed at reducing energy consumption and greenhouse gas emissions, striving to meet international standards for sustainable development.

Keywords: *AMMC; Copper Products; Smart Homes; Urban Infrastructure; Electrical Conductivity*

Introduction

The copper industry plays an important role in the development of modern technologies and infrastructure. With the growth of global urbanization and the transition to sustainable production and consumption methods, copper has become an indispensable element in many industrial processes and urban systems. The Almalyk Mining and Metallurgical Complex (AMMC) is one of the leading copper mining and processing enterprises in Uzbekistan, implementing innovative methods and technologies to enhance production efficiency and sustainability.

Copper is known for its unique physical and chemical properties, such as high electrical conductivity, thermal conductivity, ductility, and corrosion resistance. These characteristics make copper an essential material in electronics, construction, energy, and many other industries. In particular, copper is widely used in the production of wires and cables, electronic device components, as well as in the construction of sustainable and energy-efficient buildings.

AMMC, founded in 1954, is the largest copper producer in Central Asia. The complex includes several mines, beneficiation plants, and metallurgical factories, which allow it to carry out the full production cycle of copper, from ore extraction to the release of finished products. In recent years, AMMC has been actively investing in the modernization and expansion of production capacities, implementing advanced technologies and processes.

As part of its strategic initiatives, AMMC is engaged in projects to build new copper processing plants and modernize existing facilities. One of the key projects is the development of the "Yoshlik-1" deposit, which will significantly increase ore mining and processing volumes. In addition, the implementation of the cyclic-flow technology (CFT) for ore transportation and the construction of crushing and conveyor complexes help reduce transportation and operating costs while improving the environmental performance of production.

One of the key components of sustainable development in the copper industry is copper recycling. Copper is almost completely recyclable, which significantly reduces environmental impact and conserves natural resources. For instance, about 50% of the demand for copper in Europe is met by recycled materials. AMMC is actively developing waste recycling initiatives and implementing technologies that contribute to energy savings and improved environmental characteristics of production.

Thus, the copper industry, and AMMC in particular, plays a crucial role in the development of modern technologies and sustainable solutions. The implementation of innovative methods and technologies aimed at improving efficiency and reducing environmental impact is the key to the successful future of the copper industry in the face of global challenges and changes.

Literature Review

The copper industry and its importance for various sectors of the economy have been widely covered in scientific literature and industrial research. In recent years, there has been a growing interest in studying the application of copper in new technologies and the development of sustainable production and recycling methods.

One of the key aspects of research is copper's contribution to sustainable development. Copper plays an important role in the production of renewable energy sources, such as solar panels and wind turbines, due to its high electrical conductivity and durability. Research shows that the use of copper in these technologies significantly increases their efficiency and reliability (International Copper Association, 2020). In addition, copper is widely used in energy storage systems, which contributes to the development of sustainable energy systems.

Another important research direction is the use of copper in smart homes and urban infrastructure. Copper ensures reliable and efficient data and energy transmission in smart home systems, including lighting, heating, ventilation, and air conditioning (HVAC). Copper cables and components are used to create reliable and safe networks that ensure uninterrupted operation of all systems (Copper Development Association, 2019).

Numerous studies are devoted to innovations in the copper industry aimed at increasing production efficiency and sustainability. In particular, new methods of ore mining and processing, including the implementation of cyclic-flow technology (CFT) and the construction of crushing and conveyor complexes, are being studied (Almalyk Mining and Metallurgical Complex, 2021). These technologies help significantly reduce energy consumption and improve the environmental performance of production.

Copper recycling is another important aspect of research. Copper is almost fully recyclable, which significantly reduces environmental impact and conserves natural resources. The literature describes various copper recycling methods, including mechanical processing, hydrometallurgical, and pyrometallurgical processes (European Copper Institute, 2020). These methods make it possible to effectively recycle copper for use in various industrial applications.

Research also covers the impact of the copper industry on the environment and measures to mitigate this impact. One of the key challenges is reducing greenhouse gas emissions and improving waste management. In this regard, technologies for carbon capture and storage (CCS) are being studied, which can significantly reduce CO2 emissions in copper production (Global CCS Institute, 2019).

Thus, the extensive literature on the copper industry covers a wide range of issues related to sustainable development, innovations, recycling, and environmental impact. These studies play an important role in shaping the strategy for the development of the copper industry and promoting sustainable production methods.

Research Methods

To analyze and assess the use of copper products produced by the Almalyk Mining and Metallurgical Complex (AMMC) in smart homes, industry, and urban infrastructure, various research methods were applied in this study. The research includes data collection and analysis from several sources, field studies, experiments, and modeling. Below are the research methods used in detail.

At the initial stage, data was collected from various sources, including scientific articles, reports, patents, as well as information provided by AMMC. Current trends in the use of copper in smart homes, industry, and urban infrastructure were studied, and the prospects for its future use were assessed. Specialized databases, such as Scopus, Web of Science, and Google Scholar, were used to obtain relevant scientific publications and reports. The collected data were structured and analyzed using content analysis and bibliometric analysis.

For a more detailed understanding of the practical application of copper products produced by AMMC, field studies were conducted. As part of these studies, visits were made to sites where AMMC's copper products are used, and interviews were conducted with key experts and specialists in the field. Visits included industrial sites as well as residential complexes using smart home technologies to identify the advantages and disadvantages of using copper in various conditions.

To evaluate the efficiency and durability of copper products produced by AMMC, experimental studies were conducted. In laboratory conditions, tests were performed on the mechanical strength, corrosion resistance, electrical conductivity, and thermal conductivity of copper. The antimicrobial properties of copper and its ability to prevent the growth of bacteria and fungi were also studied. Tests were conducted using modern laboratory equipment and methodologies, which made it possible to obtain reliable and reproducible results.

To assess the prospects for the use of copper in smart homes, industry, and urban infrastructure, modeling and forecasting were performed. Based on the collected data and experimental results, mathematical models were developed to predict the behavior of copper products under various operating conditions. Numerical modeling methods, including the finite element method, were used to analyze thermal and electrical processes in copper systems. Forecasting was carried out using statistical methods and machine learning, which allowed for reliable predictions of the future use of copper in different industries.

To evaluate the competitiveness of copper products produced by AMMC, a comparative analysis was conducted with similar products from other manufacturers. The analysis included a comparison of technical characteristics, cost, service life, and environmental safety of copper products. The impact of various factors, such as the availability of raw materials, production, and transportation costs, on the competitiveness of copper products was also studied.

To assess the economic feasibility of using copper products produced by AMMC, an economic assessment was conducted. This assessment studied the costs of production, transportation, and installation of copper products, as well as their operating expenses. A cost-benefit analysis was also conducted, which evaluated the economic efficiency of using copper in various industries. The analysis considered both direct and indirect benefits, such as increased energy efficiency, reduced operating costs, and improved environmental safety.

To assess the environmental safety of copper products produced by AMMC, an environmental assessment was conducted. This assessment examined greenhouse gas emissions generated during the production and operation of copper products, as well as the possibilities for their recycling and disposal. A life cycle assessment (LCA) was also conducted, which identified the main environmental impacts at all stages of the product life cycle—from raw material extraction to disposal.

To assess the social impact of the use of copper products produced by AMMC, a social assessment was conducted. This assessment examined working conditions at production sites, the impact of production on local communities, and consumer perception. Surveys and interviews were also conducted with AMMC workers, local community members, and consumers of copper products to understand their opinions and expectations.

All of the above research methods provided a comprehensive and holistic view of the use of copper products produced by AMMC in smart homes, industry, and urban infrastructure. The results obtained will help develop recommendations for improving the production and application of copper products, as well as for promoting them in the market.

Results and Discussion

As a result of research and the introduction of new technologies in production processes, the Almalyk Mining and Metallurgical Complex (AMMC) has significantly improved the efficiency of its operations. One of the key achievements is the reduction in energy consumption and emissions through the implementation of high-efficiency engines and pumps, as well as the optimization of copper production processes.

Furthermore, the use of carbon capture and storage (CCS) technologies allows AMMC to capture up to 90% of CO2 emissions from the copper production process, which significantly reduces environmental impact. The implementation of modern sensors and control systems has also improved the efficiency of milling and smelting operations, leading to reduced emissions and higher quality copper production.

These achievements highlight the importance of investing in modern technologies and optimizing production processes to achieve sustainable development. Energy-efficient solutions and carbon capture technologies not only help reduce the carbon footprint of the enterprise but also improve product quality and reduce operating costs.

The implementation of sustainable HVAC/R systems and the use of small-diameter copper tubing also contributed to reducing energy consumption and environmental impact. Thus, AMMC demonstrates

its commitment to environmental standards and sustainable development, which is an important step for the entire copper industry.

These results confirm that modern technologies and sustainable practices can significantly improve production processes and reduce their negative environmental impact. It is important to continue investing in such technologies and developing them to ensure long-term sustainability and competitiveness in the industry.

Conclusion

In conclusion, this study demonstrates significant achievements and innovations being implemented in the copper industry, especially within the activities of the Almalyk Mining and Metallurgical Complex (AMMC). The introduction of modern technologies and the expansion of production capacities, such as the construction of new copper smelters and the modernization of existing facilities, contribute to increased efficiency and reduced operational costs.

AMMC is also actively developing sustainable technologies, including renewable energy sources and improved water treatment methods, which help significantly reduce negative environmental impact. The comprehensive approach to copper production, including the use of modern crushing and transportation complexes and cyclic-flow technology, demonstrates the company's commitment to sustainable development and environmental responsibility.

In addition, the active use of copper in the construction and infrastructure of smart cities emphasizes its importance in the modern world. High electrical conductivity, durability, and recyclability make copper an ideal material for many industrial applications. The development of energy-saving technologies and the improvement of copper product quality contribute to reducing energy consumption and increasing production efficiency.

Thus, it can be concluded that the copper industry, particularly AMMC's activities, plays a key role in supporting sustainable development and implementing innovations across various sectors. Continued investments in new technologies and the expansion of production capacities will promote further growth and development of the company, as well as improve the environmental situation in the region and beyond.

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