TECHNICAL SCIENCES

SLAG WASTE FROM THERMAL POWER PLANTS AS A PROMISING SOURCE OF ALUMINA

Oleksii Khlopytskyi[1]
Yuriy Gorbachov[2]

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The combustion of coal at thermal power plants (TPPs) is one of the main sources of energy; however, this process results in the generation of significant volumes of ash and slag waste (ASW). Up to 7 million metric tons of such waste are generated annually in Ukraine, and the total volume of accumulated ash and slag waste exceeded 370 million metric tons as of 2021. By the most conservative estimates, this figure could rise to over 415 million metric tons by 2035. This problem is particularly acute because the ASW recycling rate in Ukraine stands at only 8.3%, which stands in stark contrast to figures in European Union countries, where this rate reaches 43% and, in some cases, even 100%. Such a low recycling rate highlights significant untapped potential and an urgent need for effective solutions.

The recovery of alumina (Al_2O_3) from ash and slag waste is an extremely relevant area of research with dual benefits [1, p. 25]. First, ash and slag waste is a valuable secondary source of alumina and silicon dioxide. The alumina content in some types of ash can be comparable to that of bauxite, which is the traditional raw material for aluminum production. Given the finite nature of natural bauxite reserves and the ever-increasing global demand for alumina, the use of secondary sources is becoming strategically important. Second, the processing of fly ash to extract valuable components helps address large-scale environmental problems. The accumulation of ash and slag leads to the contamination of soil, water resources, and air with heavy metals and other toxic substances. This results in reduced soil fertility, negatively impacts biodiversity, and occupies significant areas of agricultural land.

Fuel pellets, which are the primary source of alumina recovery, consist of fine spherical particles ranging in size from a few microns to 50–60 μm. The chemical and mineralogical composition of fly ash is highly variable and depends on the type of solid fuel being burned and the combustion technology.

[1] Ukrainian State University of Science and Technologies, Ukraine
[2] Ukrainian State University of Science and Technologies, Ukraine

The main oxides in fly ash are SiO_2 (10% to 68%), Al_2O_3 (10% to 40%), Fe_2O_3 (2% to 30%), CaO (2% to 70%), MgO (0% to 10%), as well as Na_2O and K_2O (0% to 10%). [2, p. 110].

When selecting technologies for extracting alumina from high-ash coal, a preliminary characterization of the raw material is of decisive importance. Coal ash is classified into Class F (primarily from bituminous and anthracite coal, with a low CaO content and a high Al_2O_3 content) and Class C (from subbituminous coal, with a high CaO content). Class F, which contains aluminosilicate glass and mullite, is a more direct and promising source of alumina. The extraction of alumina from ash and slag waste is a complex process that requires the transformation of the stable mullite phase – which primarily contains aluminum – into less stable forms. Pyrometallurgical, hydrometallurgical, and combined methods are used for this purpose.

Thus, the recovery of alumina not only provides access to a valuable resource but also transforms environmental responsibility into an economic opportunity, contributing to the principles of the circular economy.

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