

Innovative Approaches in Steel Slag Utilization: Towards Sustainability in Industrial Waste Management

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Abstract : Steel production is a cornerstone of modern industry, yet it generates significant by-products, including steel slag, a material often regarded as waste. In recent years, the growing emphasis on sustainability and circular economy has spurred innovations in the utilization of steel slag, transforming it from an environmental burden into a valuable resource across various sectors. This article explores the latest advancements in steel slag applications and their potential for sustainable development. One of the most promising applications of steel slag lies in the construction industry. Recent innovations includes, Road Construction: Steel slag is being used as an aggregate in asphalt and concrete, offering enhanced durability and reduced maintenance costs. Studies show its superior resistance to weathering compared to traditional materials. Cement Production: Ground steel slag is incorporated as a supplementary cementitious material, reducing the carbon footprint of concrete production while improving its mechanical properties. Steel slag's chemical properties make it an effective material for environmental applications, including Water Treatment. The high alkalinity and calcium content of steel slag make it suitable for neutralizing acidic water and removing heavy metals. Advanced filtration systems utilizing steel slag are gaining traction in industrial wastewater treatment. Soil Stabilization: Steel slag is used to stabilize and improve soil quality in areas affected by erosion or contamination, aiding in land reclamation projects. Innovative methods are transforming steel slag into a resource for energy production and the recovery of valuable materials. Thermal Energy Storage: Steel slag's high heat capacity makes it ideal for use in thermal energy storage systems, particularly in renewable energy projects. Metal Recovery: Advanced techniques such as flotation and magnetic separation are being employed to extract residual iron and other valuable metals from steel slag, turning waste into an economic asset. Steel slag is emerging as a key material in carbon capture and utilization (CCU) technologies. Researchers have developed processes where steel slag reacts with CO₂ to form stable carbonates, effectively sequestering carbon and mitigating greenhouse gas emissions. While the potential of steel slag is immense, certain challenges remain, including variability in its chemical composition and logistical issues related to large-scale utilization. Future research is focusing on: Standardization: Developing consistent quality standards for steel slag to facilitate its widespread adoption. Innovative Processing: Exploring cutting-edge technologies like plasma arc treatment to enhance the usability of steel slag. Integration into Circular Economy: Designing holistic systems that integrate steel slag recycling with other industrial processes to maximize resource efficiency. The innovative utilization of steel slag represents a significant step towards sustainable industrial practices. By converting this by-product into a versatile material for construction, environmental remediation, energy storage, and carbon capture, industries can reduce waste and contribute to environmental conservation. As research and technological advancements continue, steel slag is set to play a pivotal role in shaping a greener future for the steel industry and beyond.

Keywords : steel slag, sustainability, circular economy, carbon capture, construction materials

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