Development of Eco-Friendly Insulating Refractories for Coke Oven Applications

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The iron and steel industry is widely recognized as a hard-to-abate sector due to its intensive energy consumption and high-temperature processes. Several strategies have been proposed to reduce its environmental impact, including the development of low-carbon steel through greener coke production, such as by partially replacing coal with biomass, and the use of more sustainable refractory materials. This research project focuses on the latter, aiming to create sustainable insulating refractories specifically designed for application in coke ovens.

In collaboration with Paul Wurth Italia S.p.A. (SMS group), the project investigates the development of silica-alumina insulating bricks using locally available raw materials and biomass-derived additives, including sawdust, rice husk, fly ash, and biochar. These materials serve not only as pore-forming agents but also as secondary sources of silica and alumina, enabling both lightweight structure formation and potential reductions in environmental impact.

The objective is to produce refractory bricks with properties comparable to conventional insulating products. Depending on the specific formulation, particularly the SiO_2/Al_2O_3 ratio, different types of bricks are developed, each tailored to meet specific performance requirements. Accordingly, the expected thermal conductivity at 800 °C must be in the range of 0.2–0.3 W/m·K, cold crushing strength around 1.5 MPa, and bulk density between 0.45 and 0.8 g/cm³. These variations reflect the diversity of formulations designed to suit different industrial applications and thermal stresses.

The environmental sustainability of the developed materials will be evaluated through a Life Cycle Assessment (LCA) and Life Cycle Sustainability Assessment (LCSA), with the aim of quantifying the benefits in terms of reduced emissions, lower energy consumption, and decreased dependency on critical or imported raw materials.

By integrating material innovation with sustainability metrics, this project aims to deliver reliable, eco-friendly refractory solutions that maintain industrial performance while supporting the steel industry's transition toward greener, more circular production models.

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