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Biochar as a substitute for fossil-based injection coals in EAF operation –definition of criteria for material suitability based on lab tests, particle conversion modelling and industrial injection trials

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In electric arc furnaces typically fossil coal in form of petrol coke or similar is used to create slag foaming in the refining phase. This is responsible for roughly 5-10 % of total CO2-emissions in electric steel production, which means potential savings of 30–60 kg CO2/t steel if carbon neutral sources are applied.
Therefore, a fundamental investigation of the reaction behaviour of different carbon sources in EAFs is studied in this paper. This includes lab tests, various simulations as well as industrial injection trails.
The primary objective is to enable the substitution of fossil-based injection coals with biochar in EAF operation by establishing robust criteria for material suitability, especially concerning the ability of the coal to produce foaming slag. The approach models the thermal and chemical conversion of individual coal particles, employing a layer-based model tailored to EAF conditions. The model parameters are calibrated using experimental data from laboratory-scale decomposition tests of biochar and petrol coke. The model is then applied to calculate the conversion of biochar and petrol coke under EAF conditions (gas atmosphere and temperatures) and assess the performance of biochar regarding slag foaming.
The enhanced layer model, validated by experimental decomposition tests, accurately predicts the conversion behaviour of both biogenic and fossil coals. Key findings include:
• Particle density and diameter are primary influencing factors on conversion time; lower density and smaller diameter accelerate conversion.
• Specific surface area and pore size exhibit compensatory effects; increased surface area can be offset by reduced pore diameter due to diffusion limitations.
• High volatile content in biochar is disadvantageous for EAF use, as volatiles are rapidly released and do not contribute to slag foaming.
• The model supports the definition of optimal particle size and density for each type of biochar, ensuring comparable performance to fossil coal in EAF operation regarding slag foaming.
These findings have also been verified within several injection trials in an electric arc furnace where almost no difference of reaction behaviour was noticeable between petrol coke and biochar. Within these investigations it could be shown that each carbon source needs to be prepared and produced in a different way to get the desired results. Following, it is technically possible to substitute fossil carbon sources as injection material for slag foaming by biochar if the correct type of biochar combined with the appropriate pre-treatment is chosen.

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