Contribution ID: **15** Type: **Oral Presentation - Presentation will be held without submitting a Full Paper**

Selection of carbon bio-sources based on inherent properties and reactivity for electric smelting furnace applications

Wednesday 21 May 2025 16:10 (20 minutes)

In electric smelting furnaces, a carbon source functions as both a reducing agent and a carburizer. Carbon bio-sources, namely biochar, offer an alternative to fossil carbon sources but differ in properties and reactivity. Reactivity is a complex characteristic and requires considering properties such as volatile matters (VM), ash and mineral matters, fixed carbon (FC), specific surface area (SSA), thermochemical properties, etc. The biochar selected is derived from wood chips (VM: 5.41 wt.%-daf; FC: 92.02 wt.%-db). For comparison, anthracite (VM: 2.27 wt.%-daf; FC: 92.88 wt.%-db) and coke (VM: 1.59 wt.%-daf; FC: 87.70 wt.%-db) were included. Determined SSA revealed the following increasing order: coke (2.54 m²g⁻¹) < anthracite (9.07 m²g⁻¹) < wood chips biochar (273.71 m²g⁻¹), indirectly indicating that the biochar reactivity can be significantly higher. Thermogravimetric combustion analysis under non-isothermal conditions showed increasing average reactivity and comprehensive combustion characteristic index in the order of coke < anthracite < wood chips biochar. To obtain key kinetic parameters, the Coats-Redfern integral method, combined with main reaction mechanism models for solid-state, was used. Anthracite and coke show higher activation energies than biochar, with anthracite ranging from 66.7 to 150.1 kJ mol⁻¹ and coke from 84.2 to 185.7 kJ mol⁻¹, indicating more difficult ignition and lower reactivity. In contrast, wood chips biochar has lower activation energies, ranging from 53.9 to 121.1 kJ mol⁻¹, suggesting easier ignition and combustion. Additionally, the pre-exponential Arrhenius factor values for wood chips biochar are lower than those for the coke. Ultimately, wood chips biochar can offer a more reactive and easier-to-ignite alternative to fossil carbon sources such as coke and anthracite, with the added benefit of significantly reduced nitrogen and sulphur inputs.

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Session Classification: Transformation towards electric steelmaking (EAF, SMELTER)

Track Classification: Transformation towards electrical steelmaking (EAF, SMELTER)