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Key measurement technologies for direct reduction ironmaking

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The direct reduction process is of rising importance in ironmaking in the frame of the decarbonization effort of the steel industry. While these are known and elaborated processes, they are evolving due to the use of hydrogen, the use of lower-grade raw materials, and a size increase to achieve the required production rate. These changes require innovative process control.

The process efficiency and productivity are influenced by the residence time of the iron ore and the volumetric flow rate of the reducing gas. It is evaluated through the oxidation rate of the reducing gases, and the solid product's metallization degree. Today, the gas composition is determined by an extractive measurement, which is slow and complex. The metallization degree is measured in an offline laboratory analysis of material samples, thereby being both discontinuous and with a time delay.

This work presents novel online and in-situ measurement technologies for both the metallization degree and the gas utilization, enabling continuous monitoring with response times within few seconds. The measurement precision of the technologies has been tested and confirmed.

The metallization degree sensor identifies the ferrous components via the magnetic permeability and temperature. It has been validated with real material and compared to alternative technologies including XRD and LIBS methods.

The gas utilization is monitored with a laser-based in-situ spectrometer measuring all involved gas types, including the hydrogen, nitrogen, and water content. It is important to note that H_2O is a process gas and must be measured, which is not possible with conventional techniques in conjunction with high H_2 content. The analyzer concept was evaluated in a university laboratory setup and at a blast furnace.

The measurement technologies can be efficiently integrated into the direct reduction process by using proven probe solutions.

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