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Experimental and model-based investigations on the influence of iron ore properties on hydrogen-based direct reduction kinetics.

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The considerable reduction of CO2 emissions is one of the main challenges the steel industry is facing and the transition towards sustainable production routes is imminent. Especially H2-based direct reduction, which allows for up to 98 % emission reduction, is seeing a lot of attention [1]. Besides the availability of green H2, the supply with DR-grade iron ore pellets is a major potential bottleneck and might inhibit the transition to low-carbon steelmaking in future [2]. One possible approach is a flexible utilization of varying iron ore feedstocks. In this context, knowledge on direct reduction kinetics is of major importance for an efficient process as key operational parameters of an industrial direct reduction plant, e.g. temperature and residence time, can be adjusted to the applied feedstock.
However, most available literature is focused on the influence of gas phase parameters on direct reduction kinetics, while less attention is paid to solid phase properties. In addition, experimental investigations often only provide a limited number of reduction tests resulting in high statistical uncertainty. In this work both issues will be addressed with an extensive investigation of different industrial as well as purpose-built iron ore pellets. For manufacturing of the purpose-built pellets, process parameters were altered in order to achieve a defined variation of porosity, grain size and gangue content. To evaluate the influence of those solid phase parameters on direct reduction kinetics, a high number of reduction experiments were conducted in a set-up designed for time-efficient testing. In fact, the presented results are based on over 300 single pellet reduction experiments. Accompanying, a detailed evaluation of the experimental results was performed including a particle-scale modelling allowing for the determination of kinetic parameters.

[1] Müller et al., 2021, DOI: 10.1016/j.clet.2021.100158

[2] Agora Industry and Wuppertal Institute, 2023, 15 insights on the global steel transformation

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