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## Development of Digital Tools at HYBRIT's Pilot Plant for H2 Direct Reduction

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The HYBRIT initiative was launched in 2016 by SSAB, LKAB and Vattenfall with the aim of creating a completely fossil-free value chain from mine to steel, using fossil-free electricity and hydrogen. The focus of technical development has been to build up expertise and to set the technical prerequisites for implementing HYBRIT's fossil-free value chain in full-scale production. Large parts of the development work have been carried out in facilities that correspond to full-scale industrial production environments in terms of both equipment and process control, but with lower production capacity.

HYBRIT's pilot plant for direct reduction (DR pilot) has capacity of approximately 1 tonne DRI/hour and has produced more than 5000 tonnes of fossil-free sponge iron since 2021. Data collected from pilot trials include process data, for instance detailing conditions for input and output streams, as well as measurements and material sampling from inside the DR pilot shaft (labelled reactor excavations). This data has provided a unique and solid foundation for developing accurate physics-based models of the H2 direct reduction process. Simulations have in turn supported process understanding and process development.

To leverage the investments in digital tools and extend their utility, efforts have been made to overcome the typically long execution times of detailed models of strongly coupled processes. Fast and accurate models have been developed by training deep neural network (DNN) models on data sets from high-fidelity physics-based models. In addition, the tools' graphical user interfaces have been tailored based on needs and feedback from engineers and technical staff working at the DR pilot plant. So far, digital applications have been developed for on-line process monitoring and for evaluating process responses in "what-if" scenarios. The applications have been tested during pilot trials running continuously for 6-8 weeks.

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