Smelter — Green Steelmaking Using Low-Grade DRI

Hydrogen-based direct reduction is expected to become one of the main levers to reduce CO_2 emissions in future iron- and steelmaking. For melting and refining of the direct reduced iron, an electric arc furnace (EAF) is the ideal method if iron ore grade is high and resulting slag amount in the EAF is reasonably low. But as most of the iron ore globally is of lower grade and beneficiation has its limits, a new type of furnace — the Smelter — is required. Details of the Smelter as well as the road map for development are presented.

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Introduction

The iron and steel industry together with the cement industry are the two largest industrial CO_2 emitters. Most of the emissions are generated during ironmaking, which is still dominated by the integrated blast furnace route using coal as the primary energy carrier. Steel recycling and pushing the scrap rate in steel production is the first and most effective measure to reduce CO_2 emissions.[1] But to meet future quantity demands, iron ore–based steelmaking will still be required to a wide extent. Therefore, direct reduction, today done mainly with natural gas, in the future with hydrogen, will become more prominent.

Fig. 1 shows a comparison of the integrated route, which is still the dominant route today, and a future green production route using H_2-based direct reduction (DR) followed by a two-step process employing a Smelter and a basic oxygen furnace (BOF). The comparison shows that the transition to a green steel production requires a complete change in the energies consumed; while the integrated route is using enormous amounts of carbon carriers (typically 400 kg to 700 kg of carbon carrier per ton hot metal), significant electrical energy is required for the green route. The biggest share of that electrical energy is required for hydrogen production. Depending on the electrolysis technology and the direct reduction processes (e.g., with or without electrical heating), 3,800–4,400 kWh per ton of direct reduced iron (DRI) need to be considered. Total CO_2 emissions of such green production route therefore heavily depend on the carbon intensity of the electrical grid (g of CO_2 per kWh).

While today mainly a pellet-feed shaft process is used for direct reduction, followed by an electric arc furnace for melting, a wider variety of options for direct reduction will be seen in the future, such as fluidized bed for sinter feed (HyREX) or ultra fines (HYFOR). For high-grade iron ores with low gangue content, the slag amount during melting is low, hence the EAF is the ideal method for processing. For lower-grade ores with high gangue content, a two-step process combining a Smelter with a BOF converter is required.[2,3] The Smelter is an electrical furnace with main power input via resistance heating and brush arcing. Due to its closed design, a reducing atmosphere is generated in the furnace. There the hot direct reduced material is melted, final reduction of the DRI is done, and metal and slag are separated. The slag tapped from this furnace is similar to blast furnace slag[4] and can be used after granulation in the cement industry. The metal is similar to hot metal from the blast furnace and is sent to the BOF for refining. The