

Metso:Outotec

Fine Ore Direct Reduction

Circored™

100% Hydrogen based
Fine Ore Reduction
as one route to CO₂
neutral steelmaking





Fine ore direct reduction

The Metso Outotec Circored™ process is a 100% hydrogen-based process for direct reduction of iron ore fines. The flexible process, which produces highly metalized direct reduced iron (DRI) or hot briquetted iron (HBI) that can be fed directly to an electric arc furnace, has proven its functionality and performance in an industrial-scale demonstration plant.

Benefits

- No fossil fuels required for reduction of fines
- Energy and costly pelletizing step eliminated
- HBI or DRI can be fed directly to an electric arc furnace, improving energy efficiency
- Proven performance in industrial-scale demonstration plant using established fluidized bed process

A proven, cost-effective alternative to traditional steelmaking routes

Hydrogen-based direct reduction using fine ore instead of pellets is an alternative to the traditional blast-furnace/basic oxygen furnace (BF/BOF) steelmaking route and to the DR route (CO/H₂ based reduction in shaft furnaces using DR-pellets). The Metso Outotec Circored process completely eliminates the need for expensive and energy intensive pelletizing.

The process is based on the extensive fluidized bed knowledge and experience developed and applied by Metso Outotec over decades in hundreds of plants for different applications, including alumina calcination, roasting of sulfidic ores, and other special processes.

Circored is the only 100% hydrogen-based process for iron ore reduction that has proven its functionality and performance in an industrial-scale demonstration plant. The plant, which commenced operations in 1999 in Trinidad, produced over 300,000 tons of high-quality HBI over several months of successful operation.

Besides merchant cold HBI, which can easily be shipped, hot and cold DRI can be produced and directly linked to EAFs and BOFs as a substitute for hot metal and/or other virgin iron units. This guarantees the production of the high-quality steel products that have traditionally been the strength of integrated steel plants.





The Circored™ process

Due to the reduction behavior of iron ore, Circored applies a two-stage reactor configuration with a circulating fluidized bed (CFB) followed by a bubbling fluidized bed (FB) downstream. In the flow sheet on the next page the core process area for ore reduction is indicated by the gray circle.

The normal plant capacity, considering the technical and economical optimum for an industrial scale plant, is 1.25 Mt/y per line. Two or more lines can be combined using joint facilities and utility areas.

Main process features:

- Iron ore fines (0.1 — 2.0 mm) are dried and preheated in a CFB preheater up to 900 °C before being introduced into the first-stage CFB reactor for the primary reduction stage.
- Fast prereduction to a reduction level of up to 80%.
- Final reduction in bubbling FB reactor achieves reduction degrees in excess of 95%.
- The use of hydrogen as the sole reductant enables low temperatures of < 700°C in the CFB and the FB; this lower temperature avoids particle sticking and means that the reaction is easy to control.
- Even lower CO₂ emissions can be achieved with the use of alternative source of energy as renewable electricity and/or non-fossil fuels.

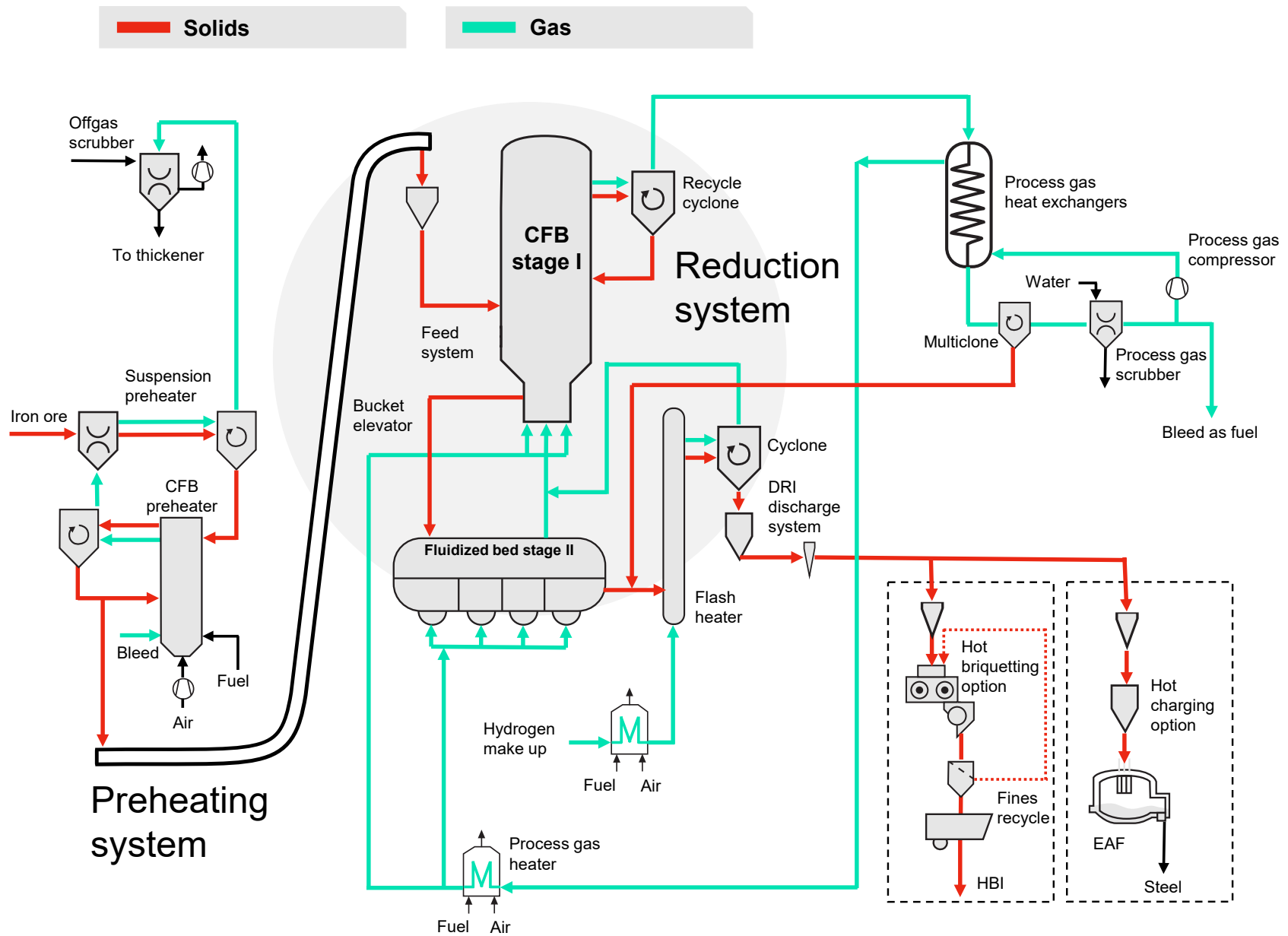
Possible modifications to the core process

In stand-alone Circored plants, the produced DRI is briquetted to HBI to enable further handling and safe transport. If a Circored plant is integrated into an existing steelmaking facility, the energy efficiency can be further increased by direct hot feeding of the DRI to an EAF.

As a general rule, the Circored process can handle feeds with a particle size of up to 2 mm, however, depending on the decrepitation behavior, particle sizes of up to 6 mm are possible. For processing ultrafine (< 50 µm) ores and scrubber dust, Metso Outotec has patented a simple microgranulation process. In this process, the ultrafine particles are agglomerated to microgranules to an average size of < 0.5 mm with the addition of a binder. The process does not require any additional heat-hardening equipment as the hardening of the granules takes place in the preheating section of the Circored plant.

For low-grade iron ores, a combination of a single reduction stage Circored process (metallization degree of up to 85%) with smelting reduction in an electric smelter for hot metal production is feasible. This combination provides the benefit to remove large volumes of impurities in the smelter via slag and further metal refining can be done in downstream steel facilities.

The Circored™ process





Mine to steel

The figure in the next page compares the Circored/EAF steelmaking route with other state-of-the-art routes in the context of the conversion of an iron ore concentrate to raw steel with all the required intermediate steps.

Both Circored and shaft furnace direct reduction technologies produce DRI or HBI that can be used directly in an EAF. The product from the blast furnace, pig iron, is fed to an oxygen converter (BOF). These downstream processes are taken into account in the CO₂ and cost figures.

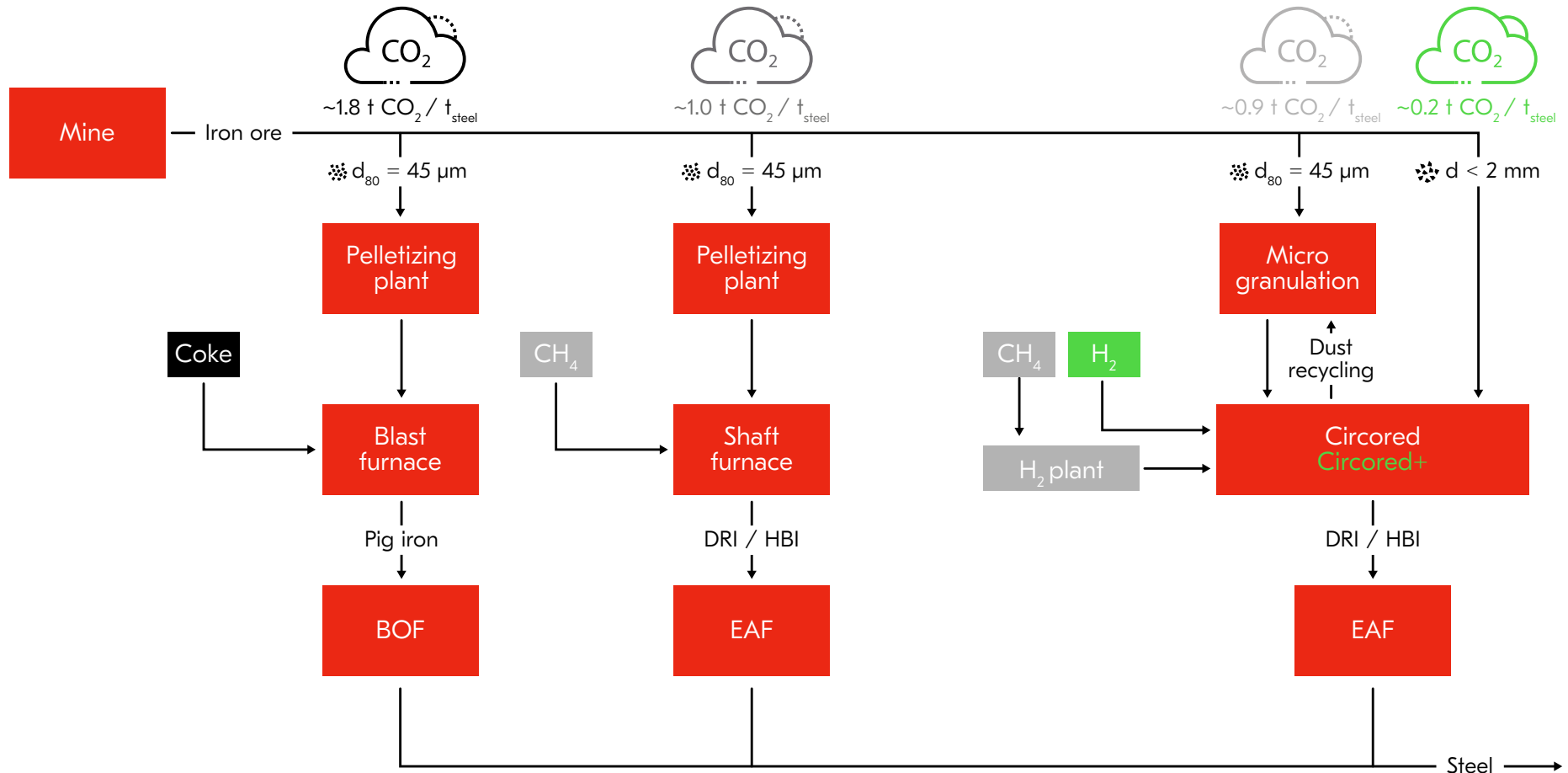
The Circored process can use a natural gas reformer to provide the hydrogen for reduction. For future scenarios, the Circored+ variant can apply green hydrogen and electricity produced from renewable sources for the reduction process and for heating purposes

Of the three routes, BF/BOF is by far the largest emitter of CO₂; furthermore, the technical solutions to minimize emissions are limited for this route. While the CO₂ emissions of the Circored process and shaft furnace direct reduction are in the same order of magnitude, Circored benefits from the omission of the pelletizing step. As the Circored+ process is designed to produce fully green steel, its CO₂ emissions are very small.

When it comes to cost, Circored+ can be considered as a very economic route, partly because the CO₂ taxes are lower than for the BF/BOF route and because there is no pellet premium (versus the shaft furnace route). The Circored+ process variant requires assumptions on future green hydrogen and green electricity cost. In summary, in terms of CO₂ emissions and cost, the 'regular' Circored process is already competitive today, and the Circored + variant predicted to be even more so.

Mine to steel

Comparison of the main components, feeds, and products of different steelmaking routes.



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