Innovation Type:
Process

Development stage:
Theoretical analysis supported by lab scale experiments

Remaining uncertainties at current stage: ***Some***

TRL: 2-3

Status: On progress

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HighEFF Overall Goals

Energy use & emissions	X
New solutions	
New methods and tools	

Relevant Sectors

Oil, Gas and Energy	**Metal and Material**
Food and Chemical	Industry Clusters

Simple concept sketch

Improving prereduction behaviour to decrease energy and carbon consumption

The ore-gas reactions occur in today's process at a temperature range favoring the occurrence of the Boudouard reaction causing increased energy and carbon consumption. It further leads to a high-energy off-gas rich in CO(g).

Challenge

The ore-gas prereduction reactions in ferromanganese production are well-known to be governed by kinetics and dependent on the characteristics of the manganese ores. Due to complex and multistep reaction schemes, in addition to a high number of commercial manganese ores, the behaviour of the ores in the furnace is not well understood. Promoting optimal reduction while still maintaining operational requirements (e.g. ore size due to decrepitation and fines generation during heating) is thus a complex affair.

Solution

Tailoring the sizing and feed location of the ores:
Size requirements for the ores may be specific for the given ore. Ores are less/more sensitive towards decrepitation, and the reaction rate is more/less promoted by the ores' particle size, so an optimum size range exist for each ore.

Introduction of pretreatment unit:
Utilization of the high-energy off-gas may be utilized through a pretreatment unit. This may also decrease the occurrence of the Boudouard reaction, as well as giving increased stability of the furnace, both resulting in lowered energy and carbon consumption. This is now currently being investigated in the EU HORIZON 2020 PREMA project, where data obtained in HighEFF is used to determine optimum conditions of such a unit.

Potential

Mass and energy balances show that the Boudouard reaction may typically consume 15-25% of the total energy consumption in production of HC FeMn alloys.

Further related HighEFF work

- Larssen, T. A., & Tangstad, M. (2021). Off-Gas Characteristics for Varying Conditions in the Prereduction Zone of a Ferromanganese Furnace–A Basis for Energy Recovery. Available at SSRN 3926228.
- Larssen, T. A., Senk, D., & Tangstad, M. (2021). Reaction Rate Analysis of Manganese Ore Prereduction in CO-CO2 Atmosphere. Metallurgical and Materials Transactions B, 52(4), 2087-2100.

Reference

Larssen, T. A. (2020). Prereduction of Comilog-and Nchwaning ore. Dr. Ing thesis, NTNU.

HighEFF definition of innovation:

Innovation can be a product, a technology, a component, a process or sub-process, a model or sub-model, a concept, an experimental rig or a service that is new or significant improved with respect to properties, technical specifications or ease of use. Innovation can also be new application of existing knowledge or commercialization of R&D results.

The innovation should be adopted by somebody, or be ready for utilization provided that it is made probable that the innovation will be utilized within a limited timeframe

List:

- Product
- Technology
- Component
- Process
- Sub-process
- Model
- Sub-model
- Concept
- Experimental rig
- Service
- New application
- Methodology
- Organisation
- Market

OWP2020	I4.1.1	Energy Cascading	Develop energy integration between energy intensive industry and other users (energy cascading)		SINTEF IND	Med	High	SINTEF IND, SINTEF ER, NTNU	FFF	Concept
OWP2020	I4.1.2	Off-gas recycling	Recycle off-gas from (ferro-)silicon furnace to increase CO2-content in off-gas and make CCS more applicable/economic	4.1	SINTEF IND			SINTEF IND, NTNU	FFF	Concept
AWP2018	I4.2.1	Novel heat recovery concept for Aluminium smelter off-gas	Novel design of efficient, robust and non-scaling heat exchanger concept for heat recovery from Aluminium smelter off-gas	4.2, 2.1	SINTEF ER			SINTEF ER	HYDRO; ALCOA, GE POWER	Concept
OWP2020	I4.2.2	Concept for heat recovery from metal casting	Design of heat exchanger capable of recovering predominantly radiative heat from molten metal.		SINTEF ER			SINTEF ER	ELKEM; FINNFJORD; WACKER; ERAMET	Concept
OWP2020	I4.3.1	Novel business models	Novel business models for sharing energy and materials resources in closely located industries		NTNU SR	Med	Med	NTNU SR; SINTEF ER	MIP	Market
OWP2020	I4.3.2	Optimal control strategies	New optimal control strategies for industrial thermal grids with thermal storage for reduced peak heating demand		SINTEF ER	Med	Med	NTNU, SINTEF ER	MIP	Model