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Ore processing in fluidized bed technologies

Overview

- Fundamentals in fluidized bed technology.
- Outotec‘s experience in fluidized bed technologies.
- CFB/FB applications for iron containing ores.
- CFB aplications for alumina calcination.
- Technology and project development.

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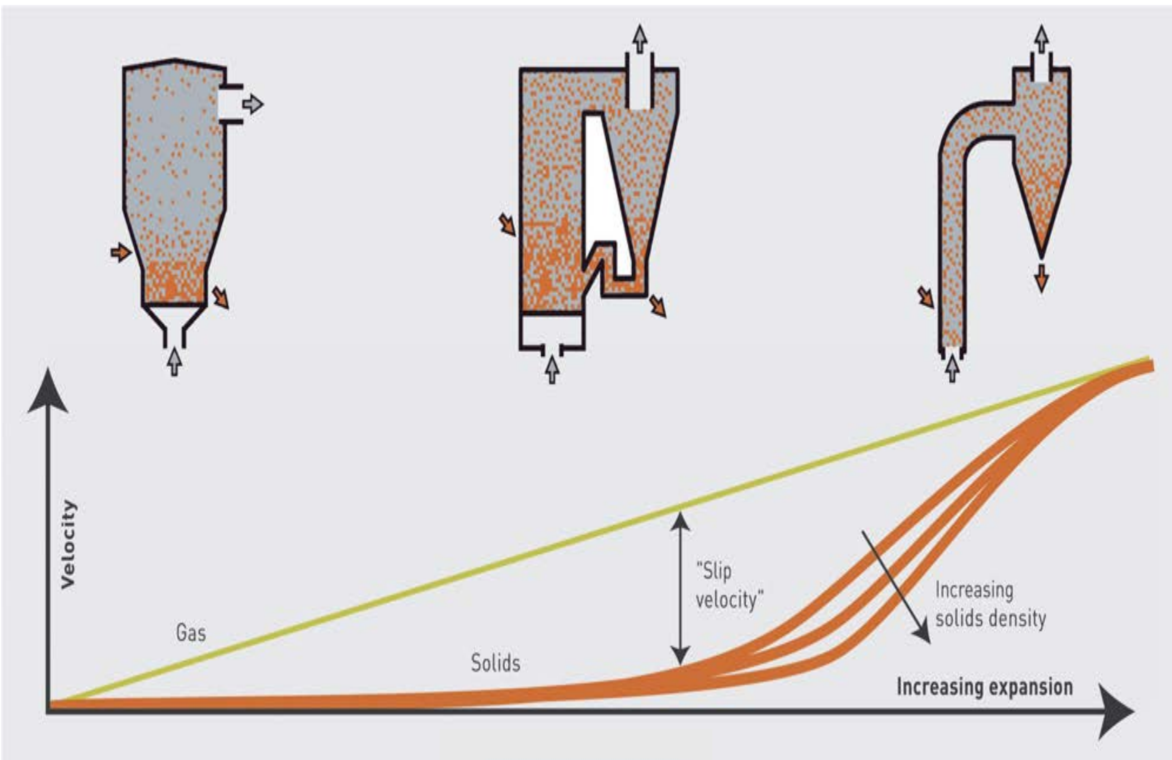
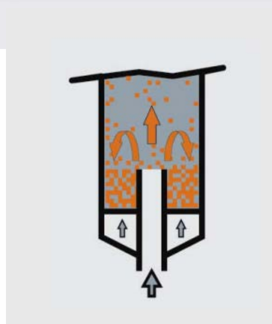
Fluidized bed systems - fundamentals

Bubbling fluidized bed (FB)

Circulating fluidized bed (CFB)

Transport or flash reactor (FR)





Annular fluidized bed (AFB)

- In a fluidized bed particles are held suspended by the upward.
- Increasing gas velocities will create different flow regimes.
- The highest slip velocity is reached in CFB, leading to high mass & heat transfer rates.
- Outotec has applied CFB, FB, AFB and FR for treatment of different fine ores.

Circulating fluidized bed advantages

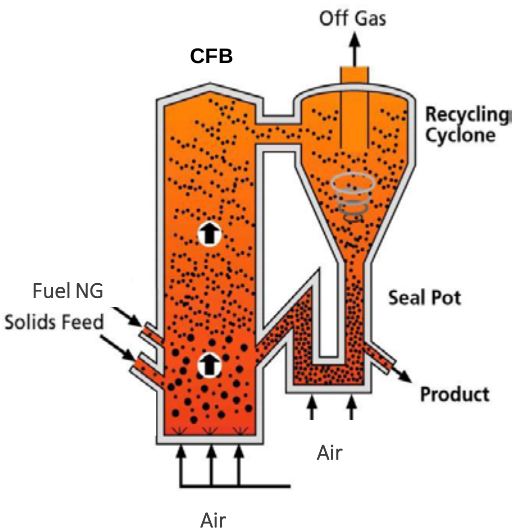
- High mass & heat transfer

  Uniform temperature, low energy consumption.
- Direct processing of fines

  Minimum fines losses and accretions.
- High productivity

  Minimum plant downtime & low specific investment costs.
- No heavy rotating equipment

  Easy and flexible control, low operation & maintenance costs.
- Easy and exact control of temperature and retention time.
- Direct combustion of natural gas in the CFB furnace.



Circulating fluidized bed

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Outotec‘s experience in fluidized bed technologies

CFB applications

	Number of Plants
<u>Industrial</u>	
Calcining of alumina	52
Calcining of limestone, clay etc.	4
Roasting of gold ores	7
Power plants	82
Adsorption of wastes / desulphurization	16
Fluorine adsorption (electrolysis)	10
Circored	1
Circoheat	1
Subtotal	***173***

Rio Tinto Alcan Gove 3 CFB calciners.

HBI Circored plant Trinidad.
Capacity 0.5 million t/a

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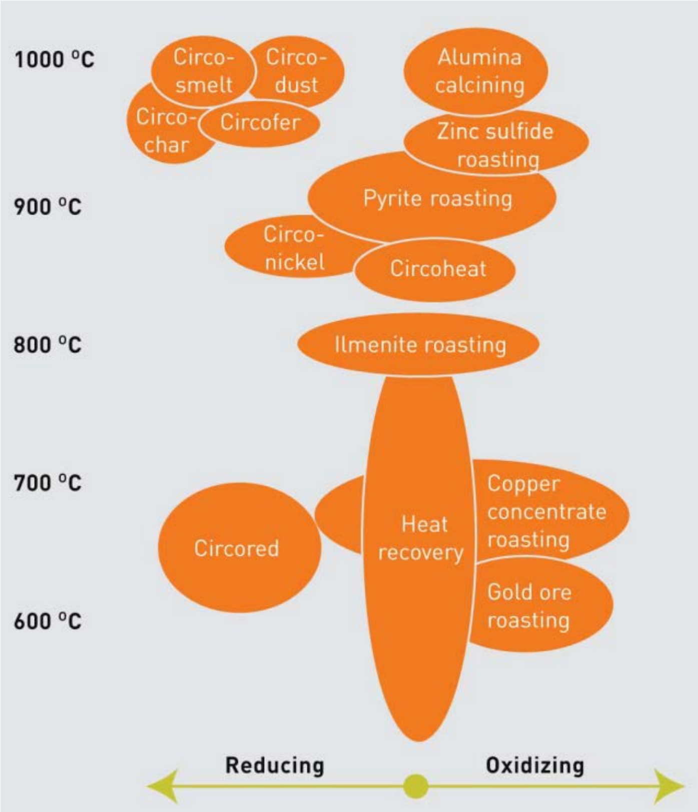
CFB applications

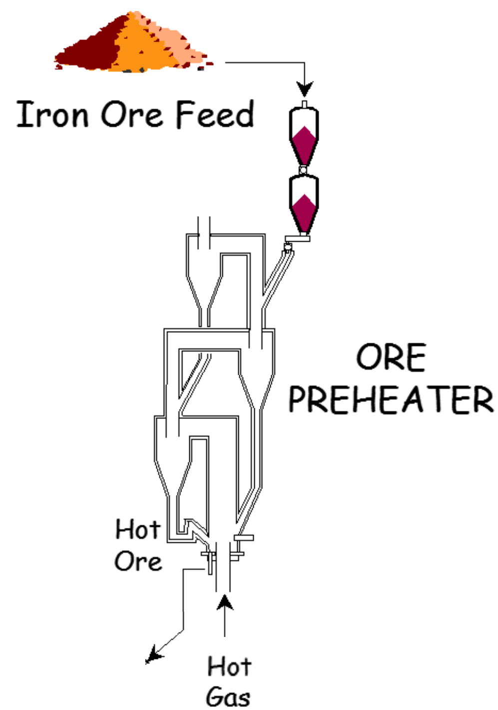
	Number of Plants
Semi industrial / pilot	
Circodust	1
Elred	1
Circofer	1
AIF3 synthesis	1
Pyrohydrolysis	1
Decomposition and recycling of salts	1
Subtotal	***6***
Total CFB references	**179**



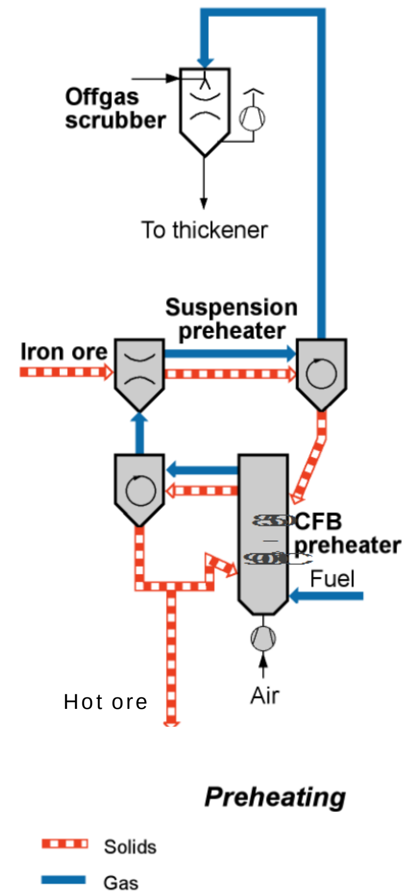
Outotec‘s fluidized bed applications

CFB applications – iron ore processing

- Outotec has built CFB plants for preheating, roasting and hydrogen based reduction of iron ores.
- In the case of iron ore preheating & calcination, the target is to remove LOI and to preheat the ore for down stream processes (e.g. direct reduction or smelting reduction).
- For ilmenite roasting the target is to change magnetic properties of the ore to allow the removal of chromite by magnetic separation.



CFB preheater with 2 stages suspension venturi.



CFB preheater with 1 stage suspension venturi.

CFB applications – iron ore processing

- One Circored plant for direct reduction of iron ore was built, using hydrogen as reductant: Circored plant Trinidad 1996.
- Two ilmenite roasters were built by Outotec: Exxaro 2001, Empangeni South Africa; and Moma Sands 2005 Mozambique.
- Two iron ore preheaters were built by Outotec: preheater for Circored plant Trinidad 1996 and preheater for HIsmelt Australia 2002.

Circored plant Trinidad

HBI stockpile at the Circored plant Trinidad

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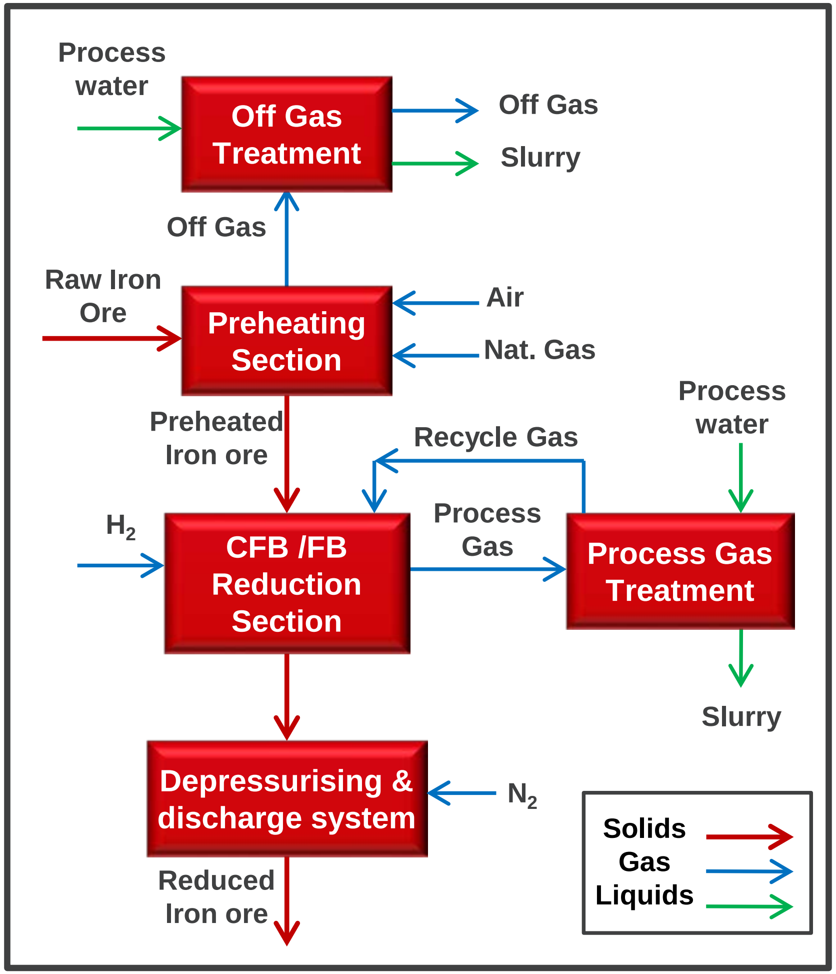
CFB/FB applications – DRI/HBI production

- Circored is the only hydrogen based direct reduction process for iron ores available in the market.
- Hydrogen is used as reductant, which is normally supplied from steam-methane reforming plant.
- Up to 95% metallization degree can be achieve using two reduction stages (CFB/FB).
- Final product could be HBI or DRI as feed to other processes (e.g. EAF steelmaking, BF ironmaking).

Circored process - Block diagram



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CFB/FB applications – DRI/HBI production

Circored plant Trinidad. 0.5 Million t/a HBI plant.

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CFB applications – iron ore preheating

Circoheat® iron ore preheater for HIsmelt

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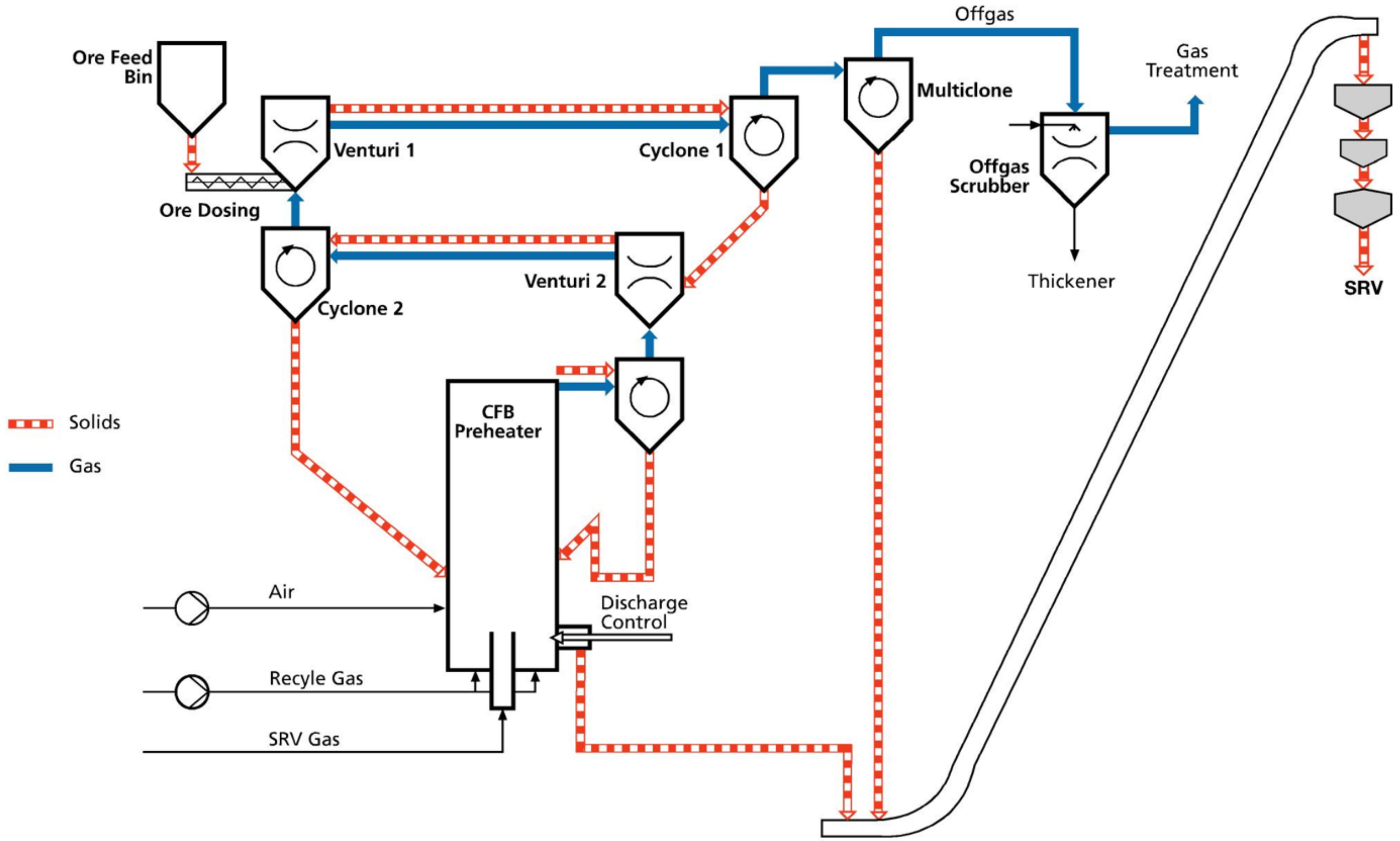
CFB applications – iron ore preheating

Circoheat® iron ore preheater



CFB applications – ilmenite roasting

Moma Sands 2005 – Mozambique, South Africa

- Capacity of roaster: 1200 tpd roasted ilmenite
- Roasting under reducing conditions at 800°C temperature.
- Ilmenite: 57 % TiO_2, 27 % Fe
- Circulating fluidized bed for optimal process control (temperature and retention time).
- External hot gas generator for substoichiometric combustion of diesel fuel oil.
- Reactor dimensions: ⌀ 3 m, 21 m high.

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CFB applications – ilmenite roasting

- Capacity of roaster: 1000 tpd roasted ilmenite.
- Start-up: 1999.
- Roasting under oxidizing conditions to be able to decrease the chromite content by magnetic separation before smelting.
- Ilmenite: 49 % TiO_2, 37 % Fe.
- Circulating fluidized bed with internal combustion of Sasol gas.
- Reactor dimensions: ⌀ 1.9 m, 12 m high.

Exxaro 2001 – Empangeni, South Africa

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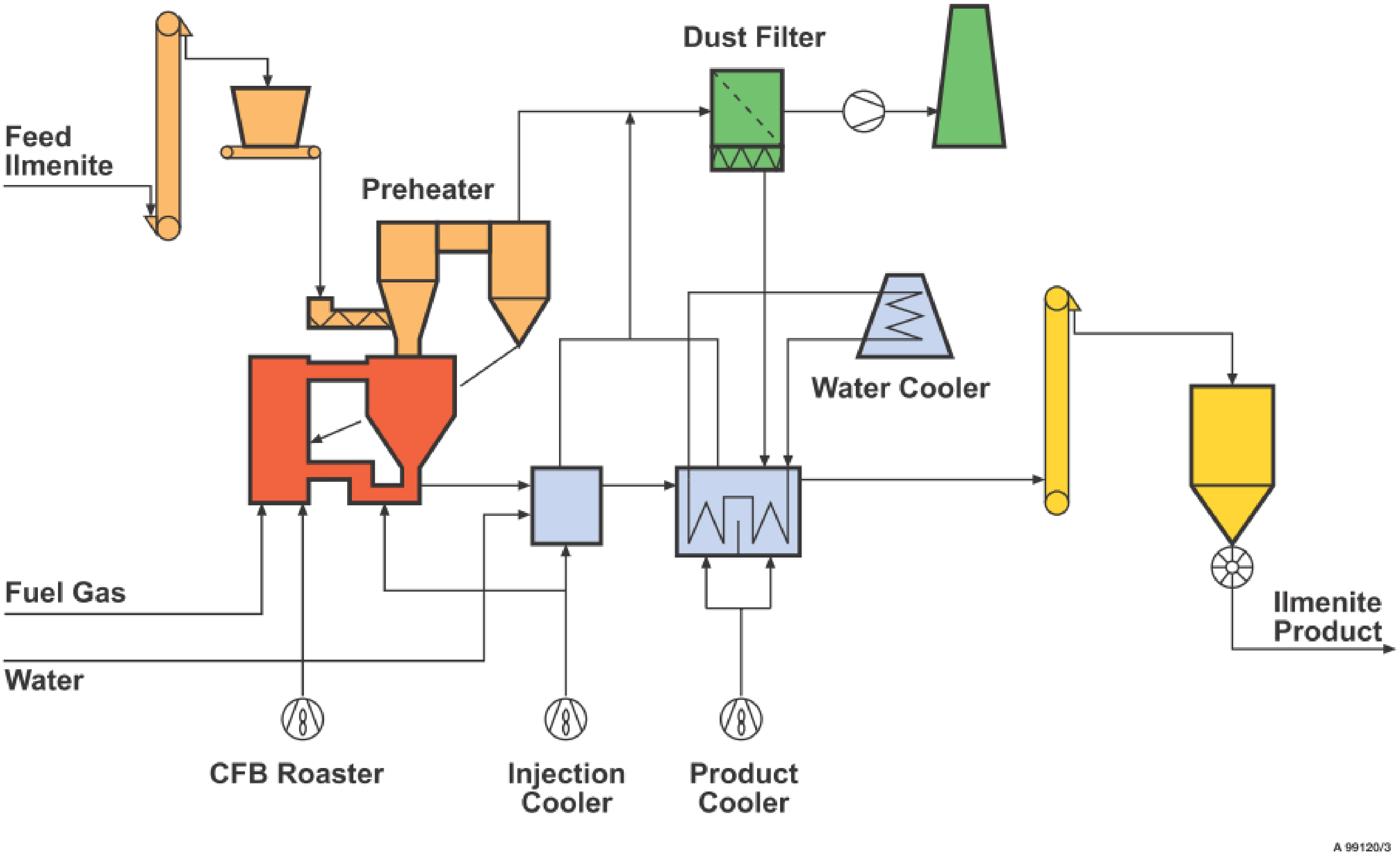
CFB applications – ilmenite roasting

Exxaro ilmenite roaster process flowsheet



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CFB applications: alumina calcination

- Calciners built: 52
- Calciners upgraded: 11
- Total CFB Capacity: >36 MTPY (40 % of world production)
- Under construction: 2 CFBs

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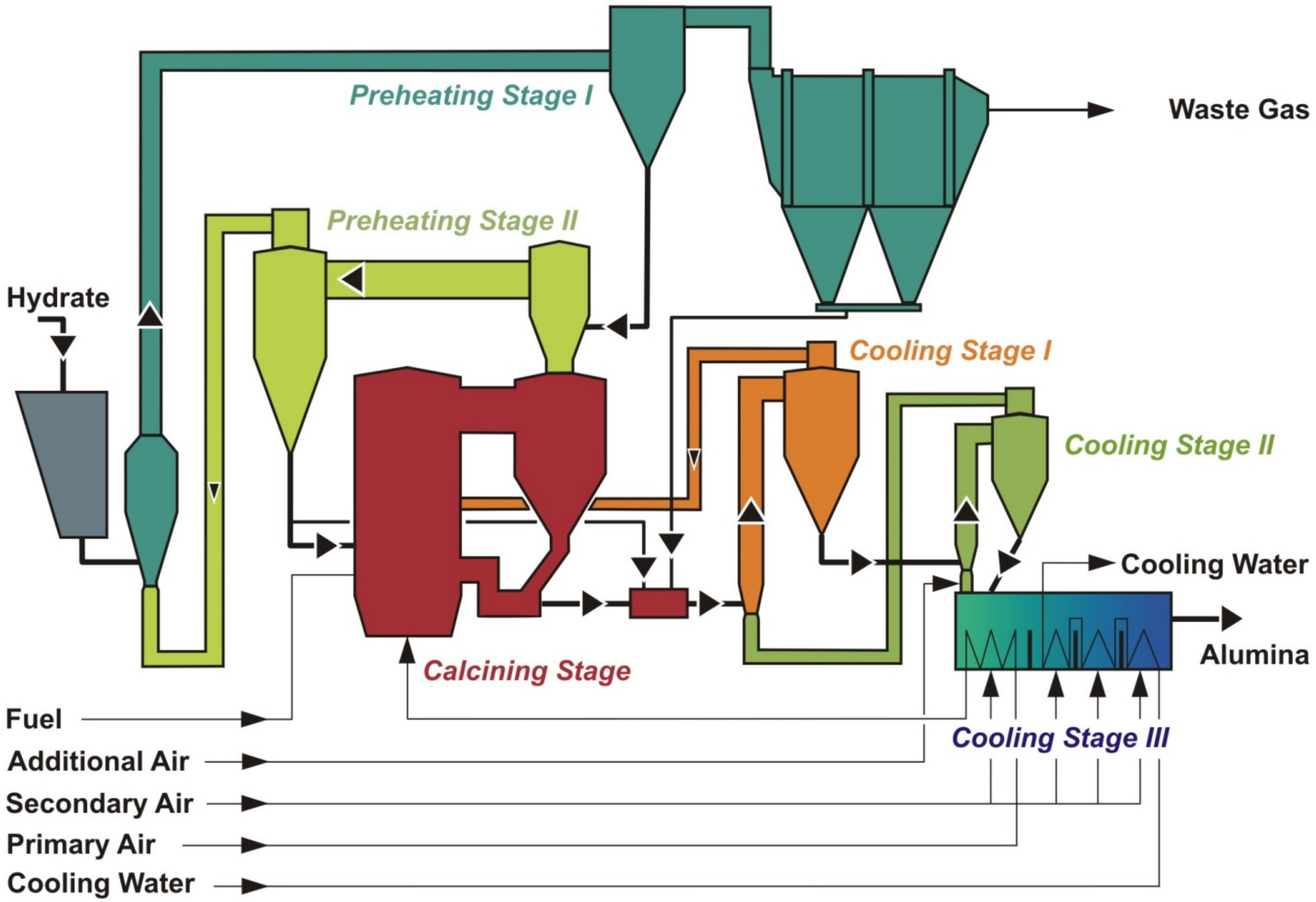
CFB Applications: alumina calcination



Technology and project development

Technology development

R&D Way of work
Iterative interplay between process design & test work

Complementary

- **Process design**
  - Process flowsheets, mass and energy balances of processes, operating points, sensitivity analyses.
  - Plant design: equipment dimensioning and functionality.

Test work (lab scale, batch, continuous, pilot scale):

- For plant design, scale-up and process guarantees.
- For production of material to be tested further.

Outotec R&D Center, Frankfurt, Germany.

Scale up experience

Process	Pilot plant size	Commercial plant size	Factor (approximate)
Alumina calcining 1966	125 mm Ø 5 kg/h	1.0 m Ø 1 t/h	1:200
Alumina calcining 1970	1,000 mm Ø 1,000 kg/h	3.6 m Ø 20 t/h	1:20
Coal combustion 1982	360 mm Ø 20 kg/h	5 m Ø 21 t/h	1:1,000
Gold ore roasting 1990	200 mm Ø 22 kg/h	3.8 m Ø 83 t/h	1:4,000
Circored 1999	200 mm Ø 18 kg/h	5.0 m Ø 63 t/h	1:3,500

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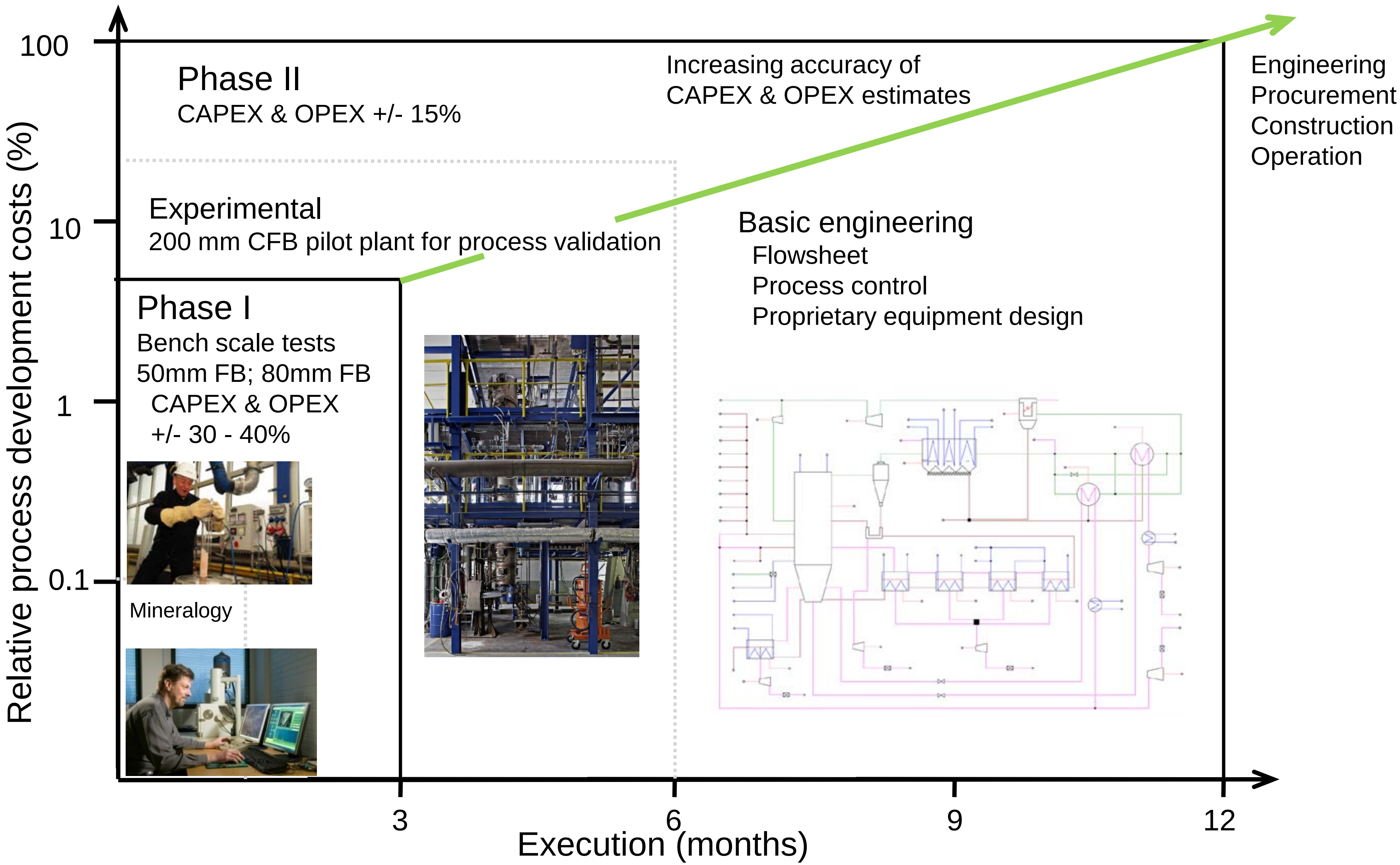
Project development time frame and costs



Conclusions

- Outotec‘s CFB technology presents several advantages for thermal treatment of different fine ores.

- The direct combustion of natural gas in the CFB furnace results in an efficient method for fine ore heating, minimizing fuel consumption.

- The use of hydrogen for DRI & HBI production has been demonstrated, and combined with EAF could represents an alternative route for steel production.

- Outotec has a vast experience accumulated for more than 50 years in different fluidized bed applications.

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Thank you