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Integrating biomass chemical looping and iron-making process for generating high-purity syngas

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Carbon Management Research Project Review Meeting Agenda
August 08, 2024

Our Approach: Multi-Scale, Multiphase Technology Development

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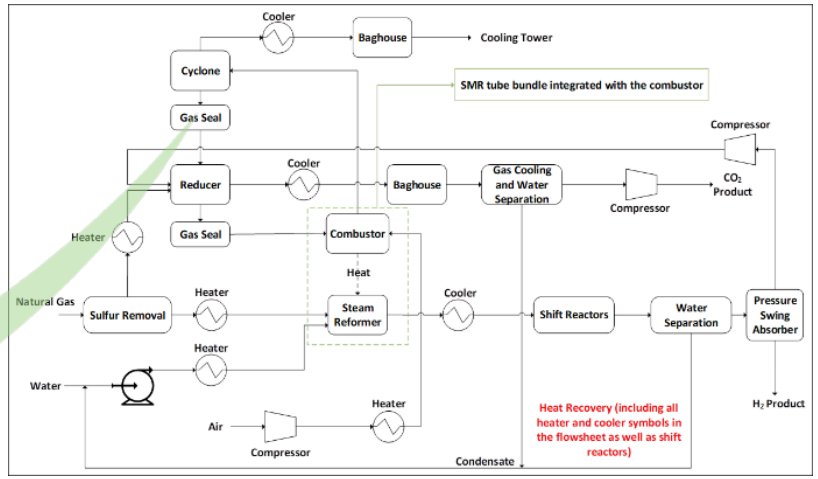
System scale (> 100m)

Chemical Looping H_2 Process system

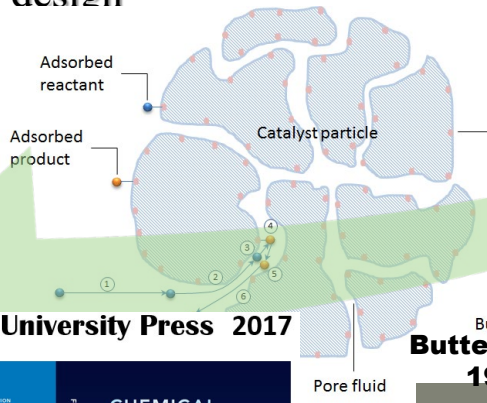
Reactor scale (m)

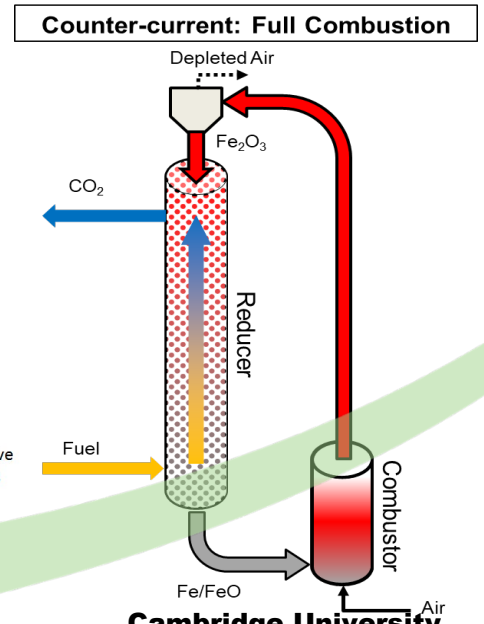
coupling of momentum, heat, mass transport



Particle, Droplet or Bubble scale (μm~mm)

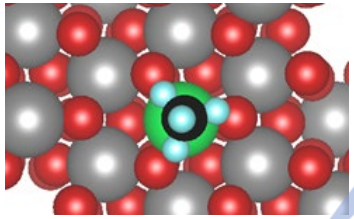
external/internal diffusion, reaction, size and shape design



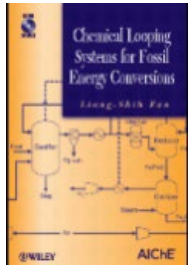


Molecular scale (Å)

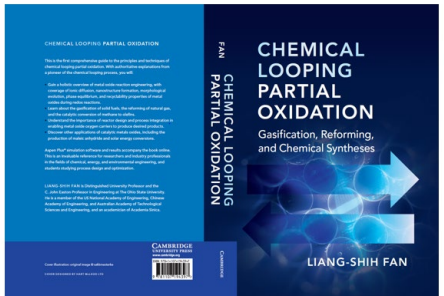
Surface chemistry, e.g., how chemical bonds are formed and cleaved. reaction mechanism, energetics, charge flow



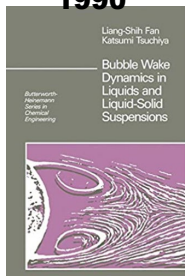
Wiley/AIChE 2010



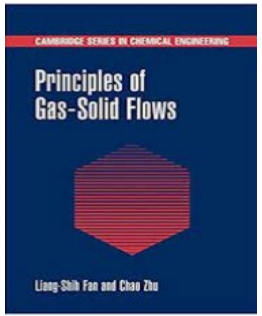
Cambridge University Press 2017



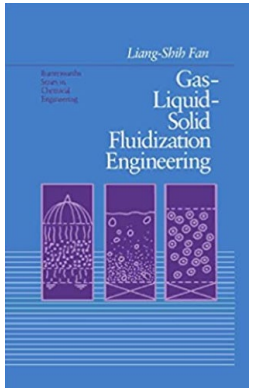
Butterworth, 1990



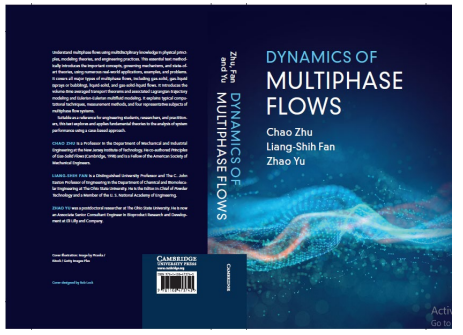
Cambridge University Press 1998



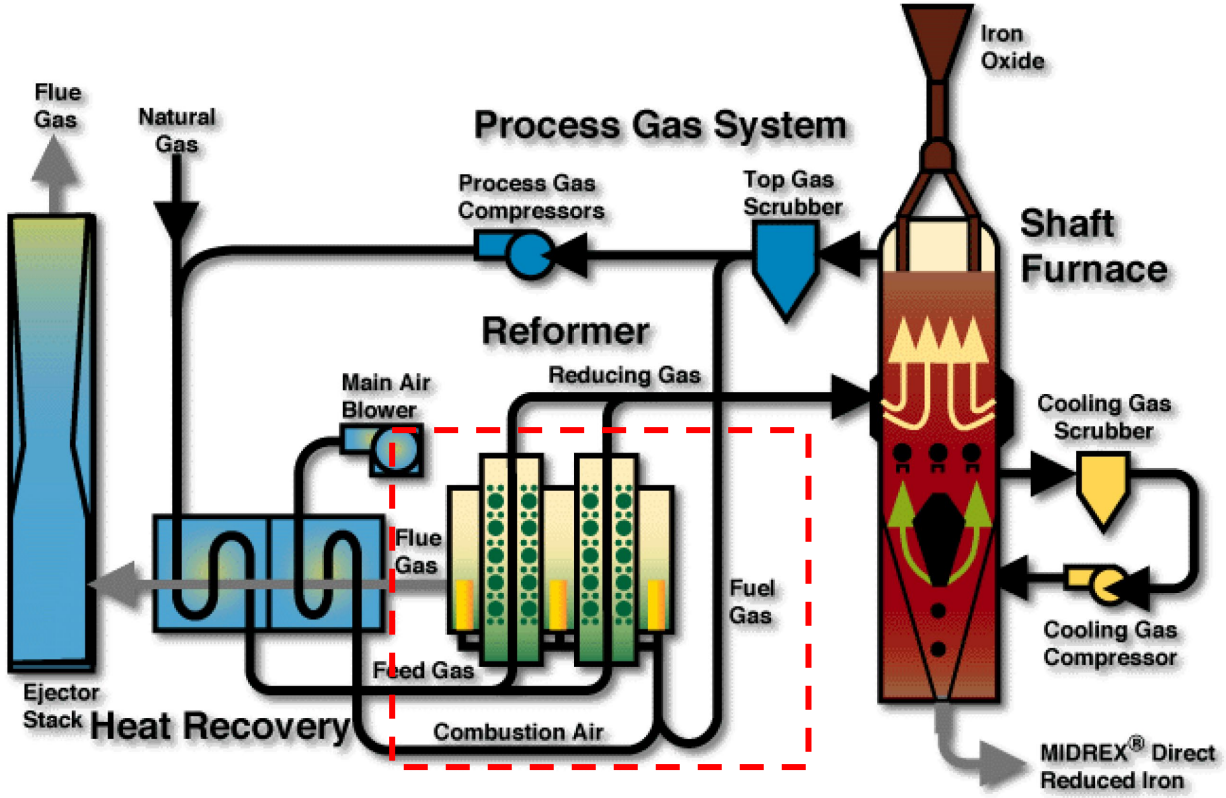
Butterworth, 1989



Cambridge University Press 2021



MIDREX process for direct reduction of iron ore (DRI):



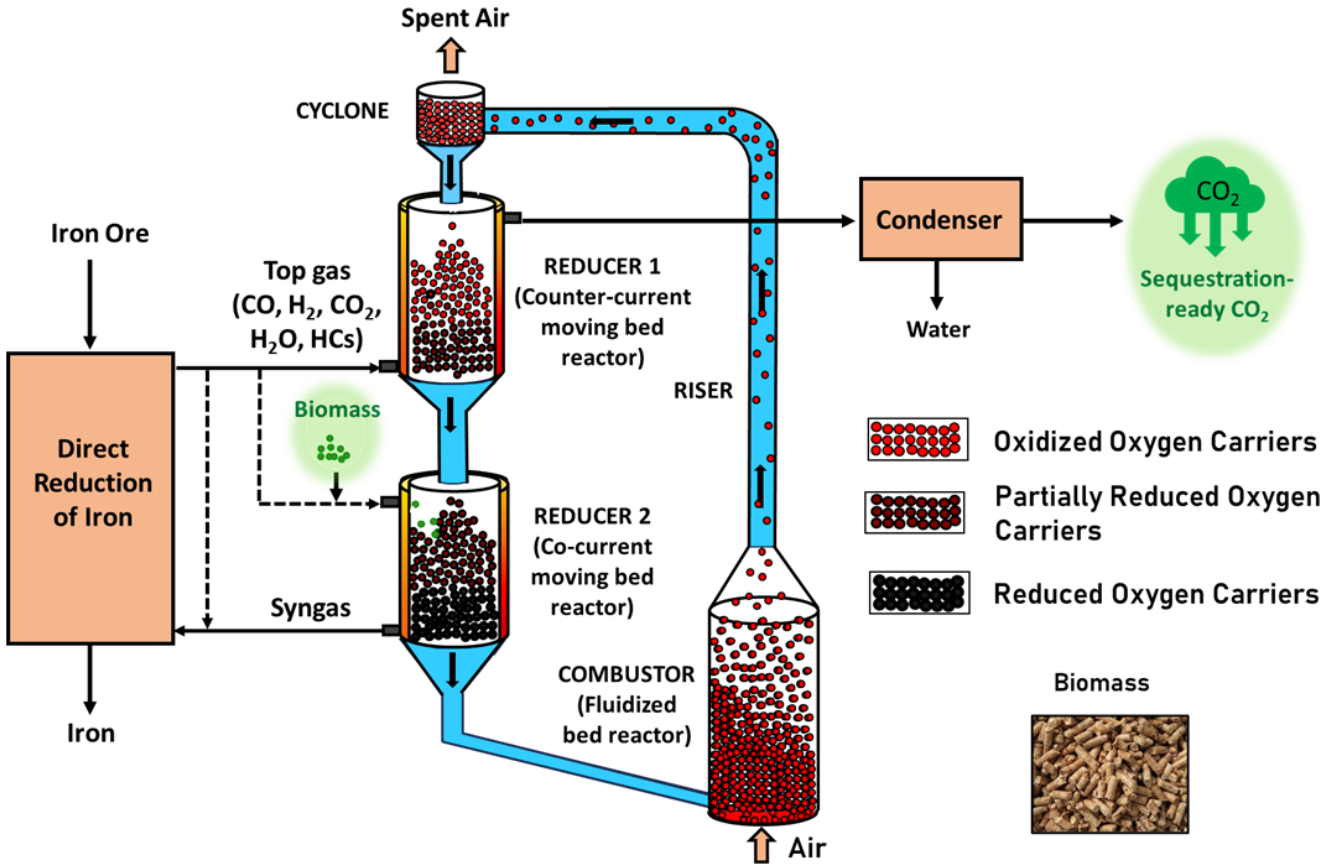
- Natural gas catalytically reformed to syngas ($CO+H_2$)

Overall reaction:

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$
$$Fe_2O_3 + 3H_2 \longrightarrow 2\,Fe + 3H_2O$$

*Béchara, R.; Hamadeh, H.; Mirgaux, O.; Patisson, F. Optimization of the Iron Ore Direct Reduction Process through Multiscale Process Modeling. Materials **2018**, 11, 1094. https://doi.org/10.3390/ma11071094*

Integrated chemical looping with DRI:



- Proposed process: 3-Reactor chemical looping system
- High purity stream of CO_2 from reducer 1
- High purity syngas >90%
- Autothermal operation

How to measure the quality of syngas?

- $\boldsymbol{Reducing\ Potential = \frac{H_2+CO}{H_2O+CO_2}}$

- Existing natural gas-based MIDREX process is known to have RP values higher than 9

Proposed Tasks:

- Task 1.0 - Project Management and Planning
- Task 2.0 – Project Scope and Design Basis
- Task 3.0 – Conceptual Sub-Pilot Unit Design
- Task 4.0 – Preliminary Techno-Economic Analysis and Preliminary Life Cycle Analysis
- Task 5.0 - Initial EH&S Risk Assessment and Technology Gap Analysis

Disclaimer:

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