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CO_2 capture using lime as sorbent in an entrained mode

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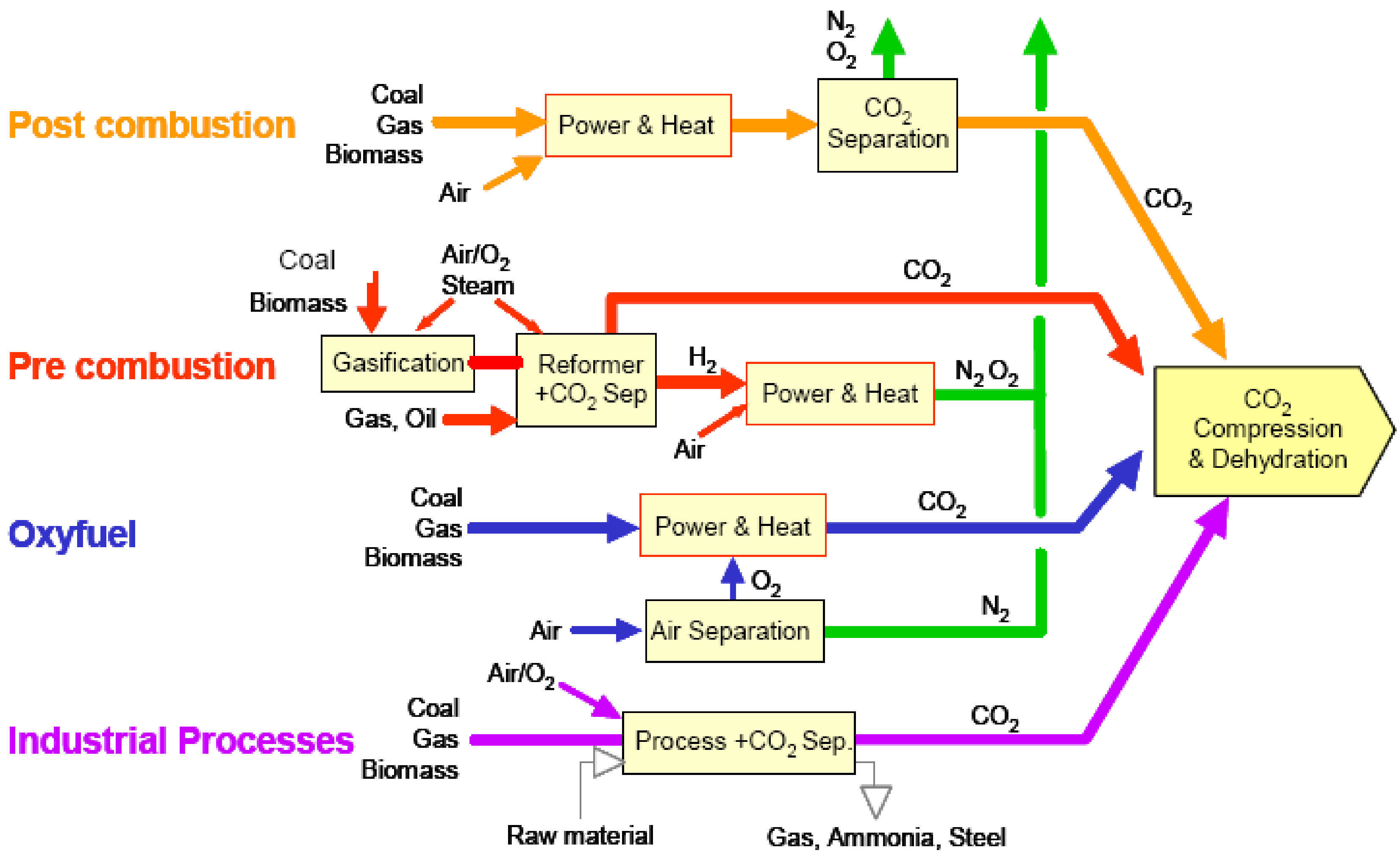
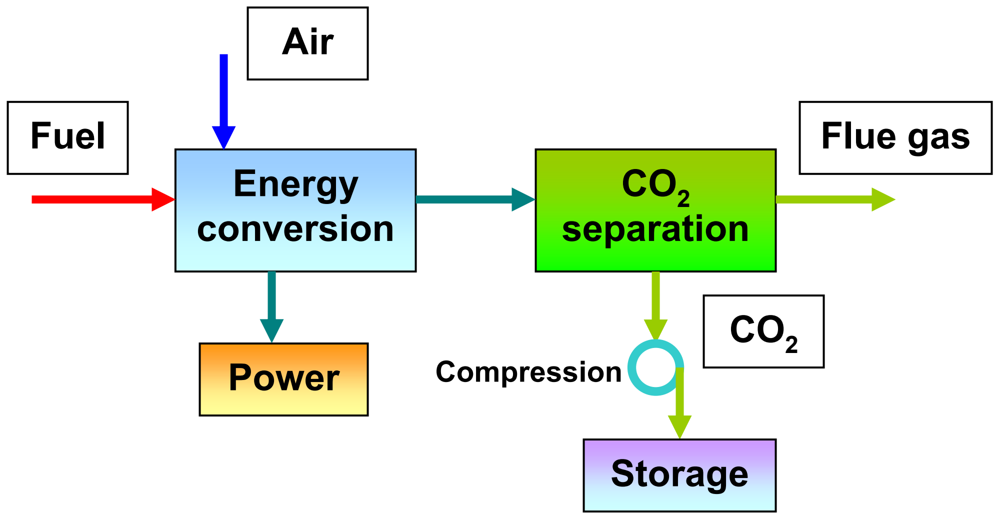
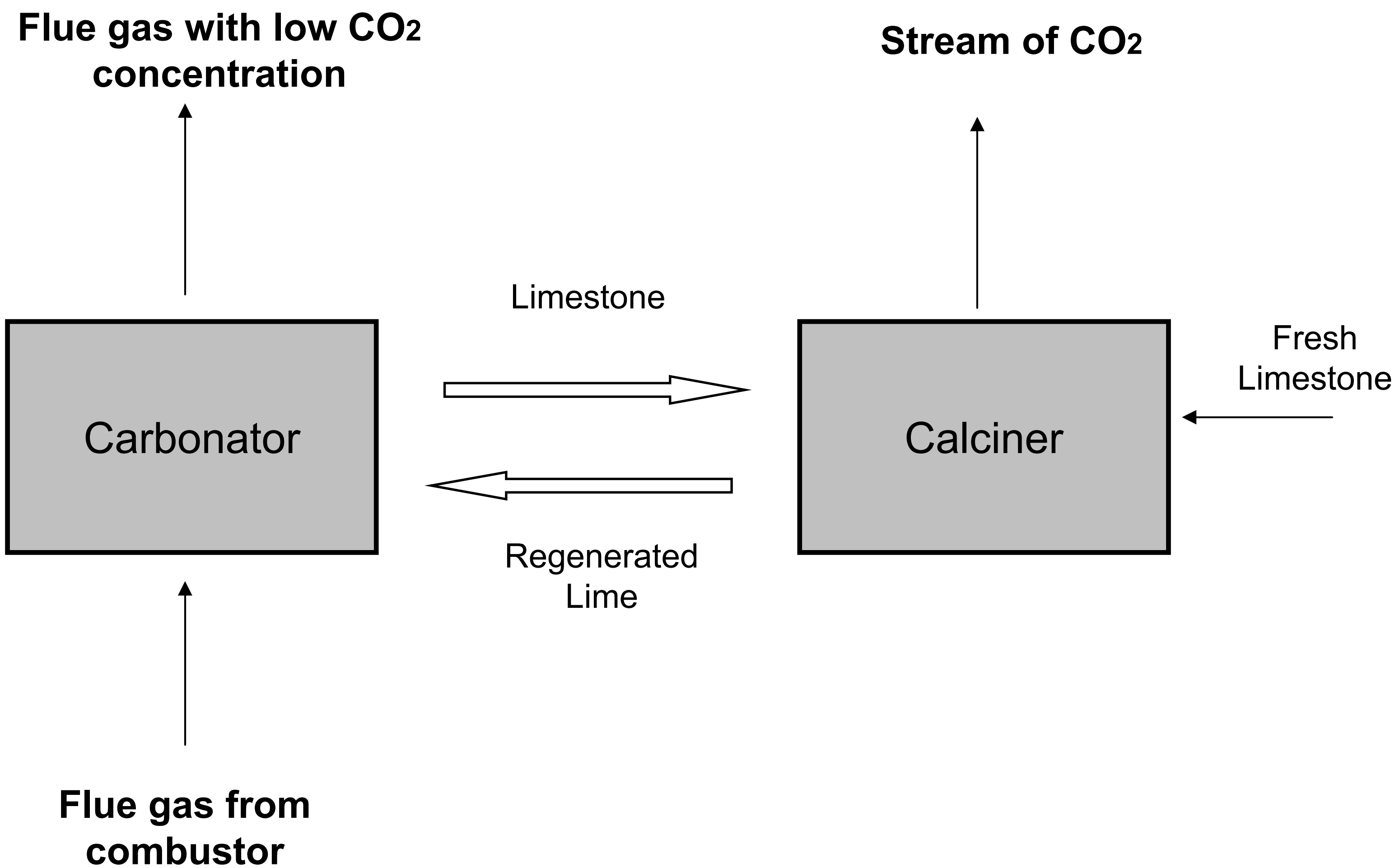
How to capture CO_2



Post-combustion capture



Basic concept of Carbonation/Calcination cycles to capture CO_2



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Benefits

- Efficiencies penalties intrinsically low
- Cheap and widely available CO_2 sorbent
- No hazardous materials involved
- Several options are suitable for retrofitting
- It can be integrated with O_2 combustion
- It can incorporate sorbent reactivation
- It can be applied to any fuel (natural gas, **biomass**, pet coke, etc)

Potential for low capture costs

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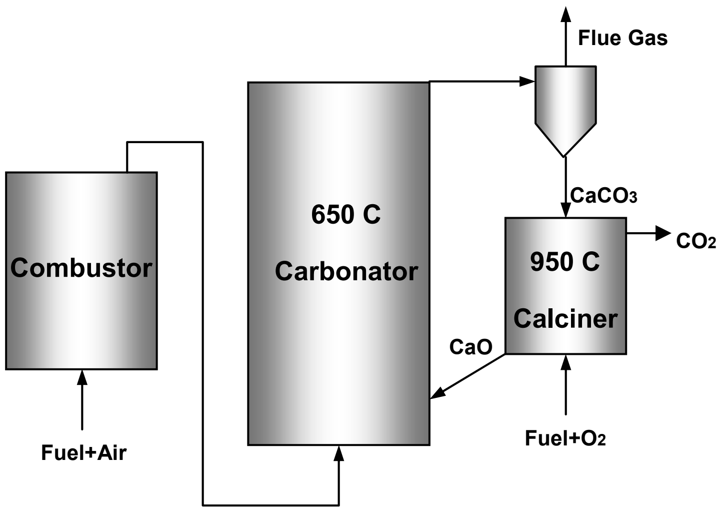
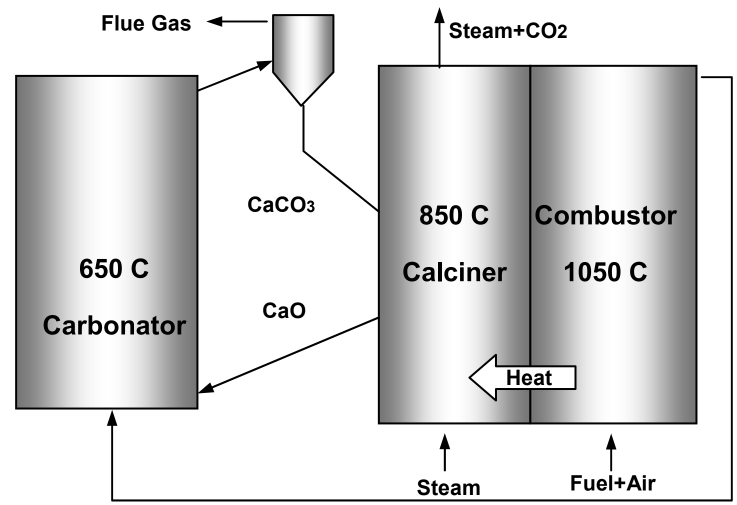
Possible Carbonation/Calcination Process Configurations to Capture CO_2

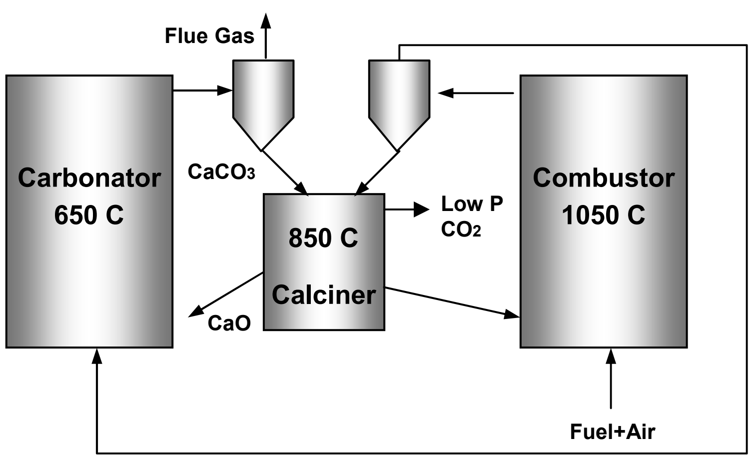
Carbonation-Calcination cycle separated from the combustor chamber



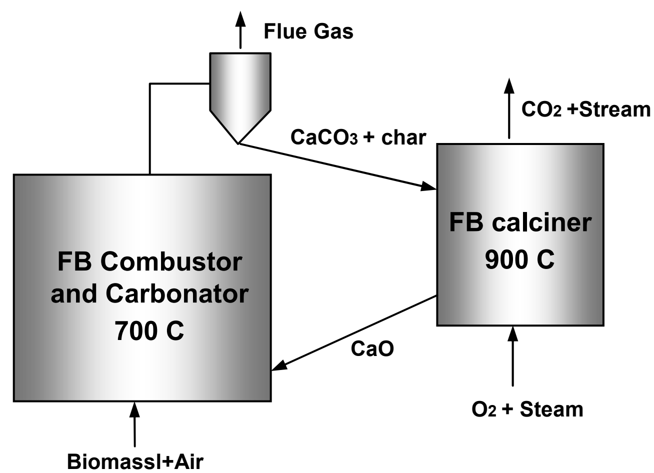
Carbonation-Calcination cycle with direct heat transfer form the combustor to the calciner



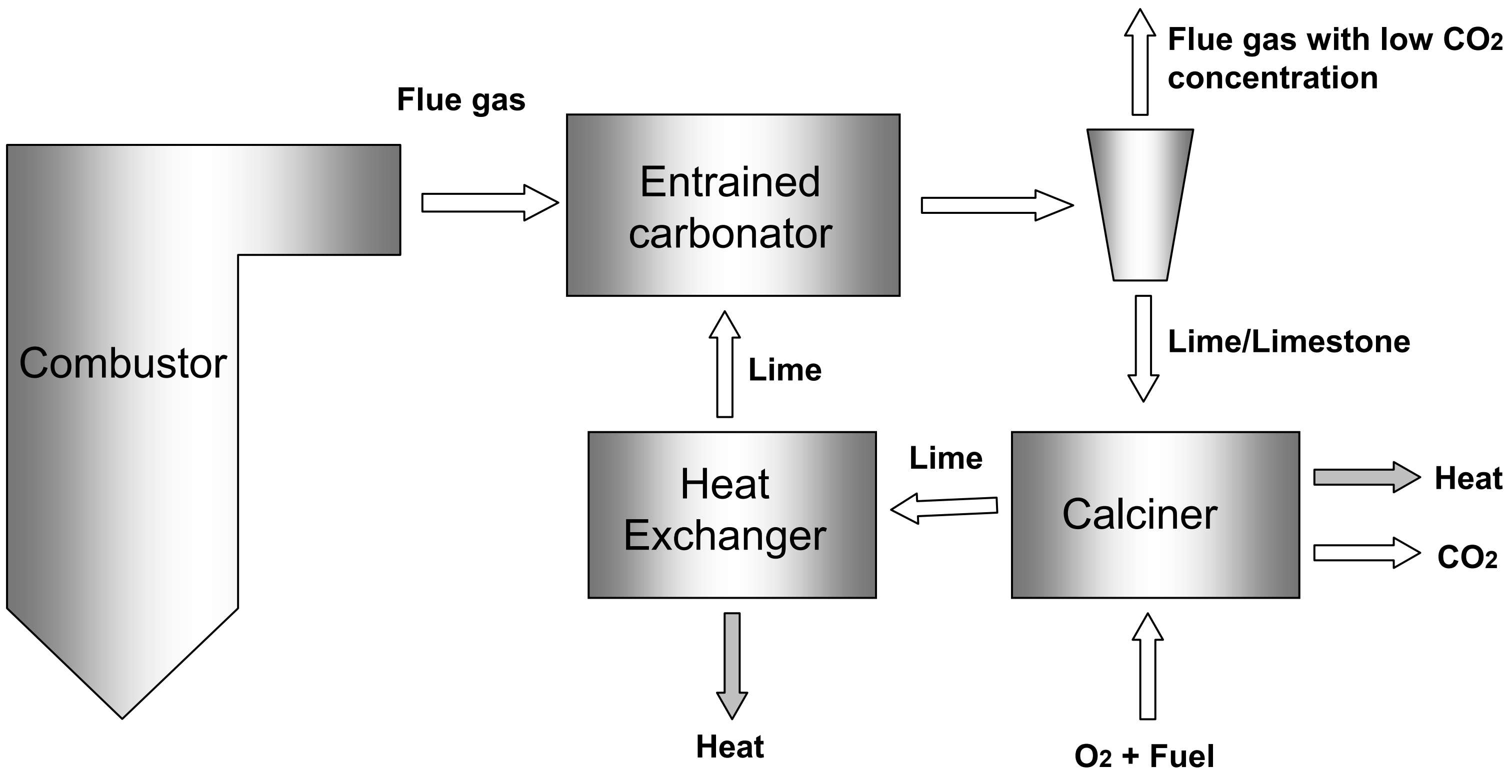
Carbonation-Calcination cycle with indirect heat transfer from the combustor to calciner by means of a dense solid heat carrier



Carbonation-Calcination cycle with biomass burner in a low-T bed combustor

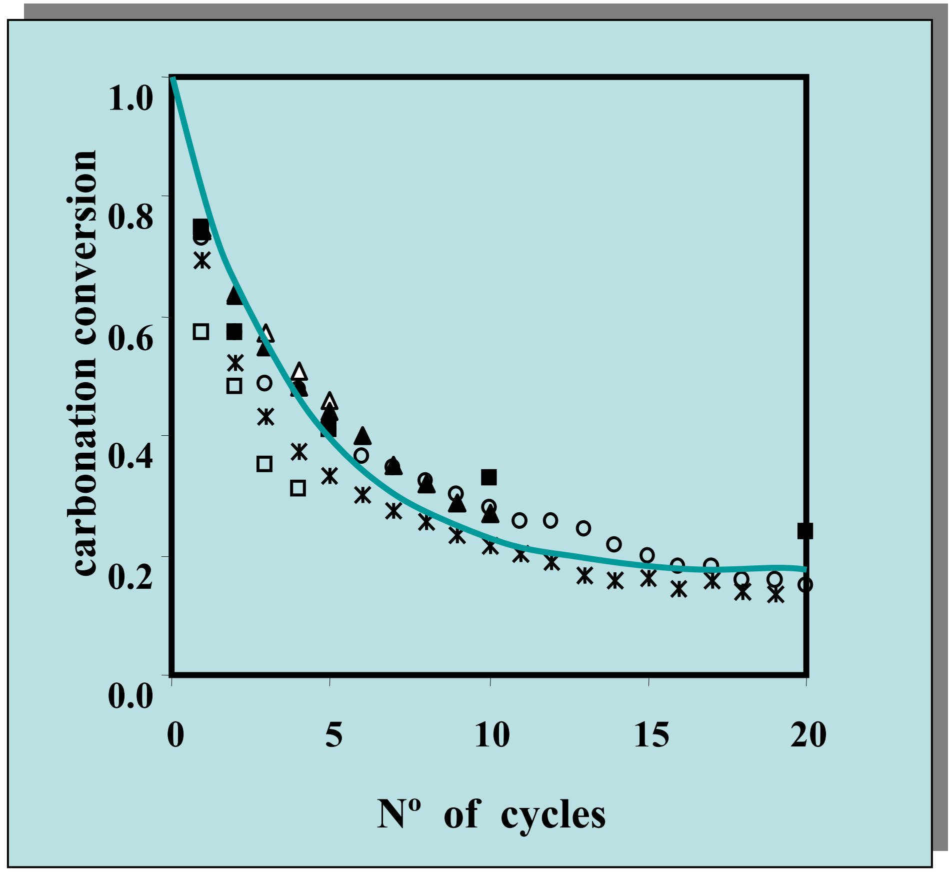


Capture of CO_2 Concept in an Entrained Mode



Issue/Concerns

- Sorbent reactivity
- Effects of SO_x in the flue gas
- Sorbent durability



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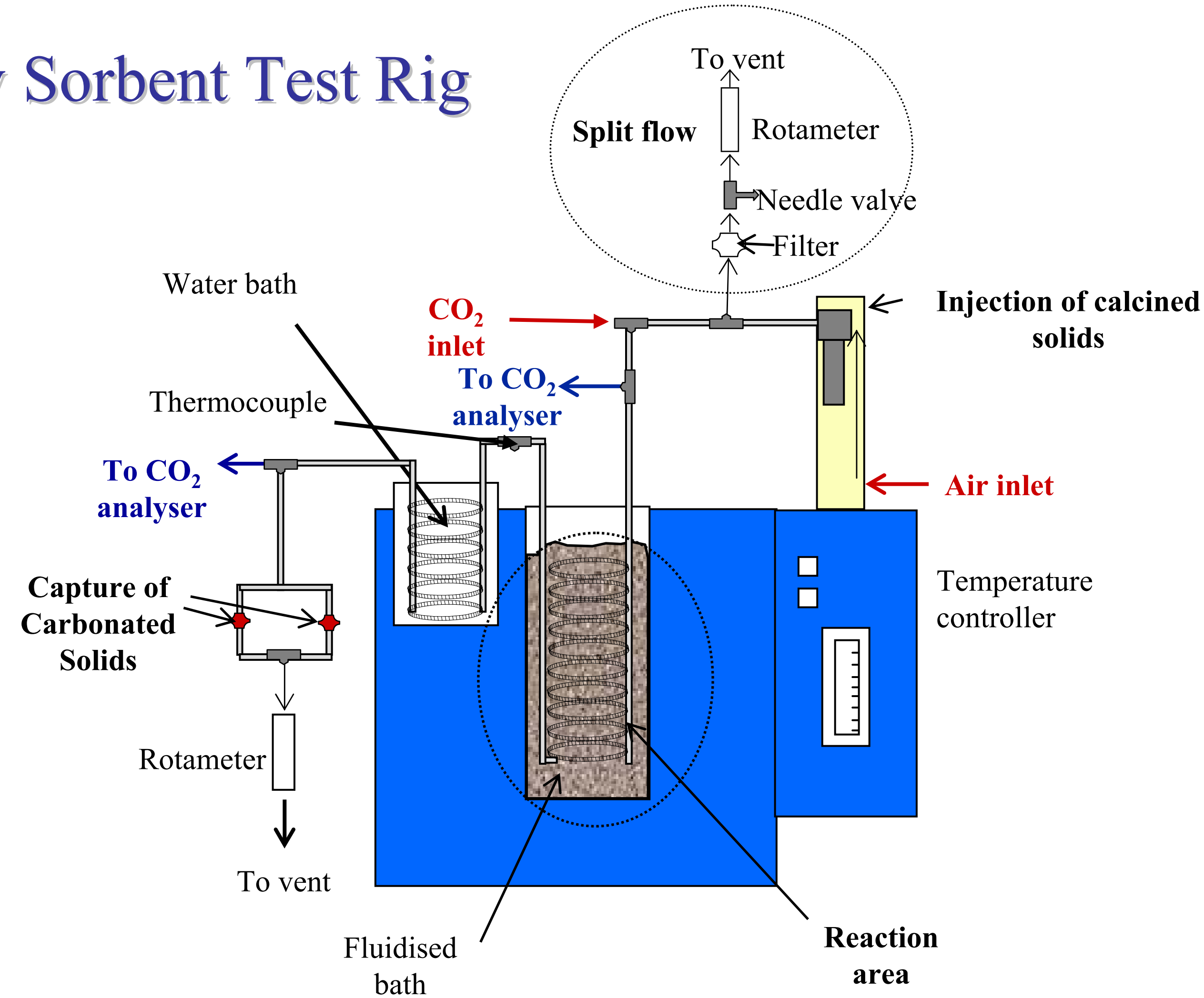
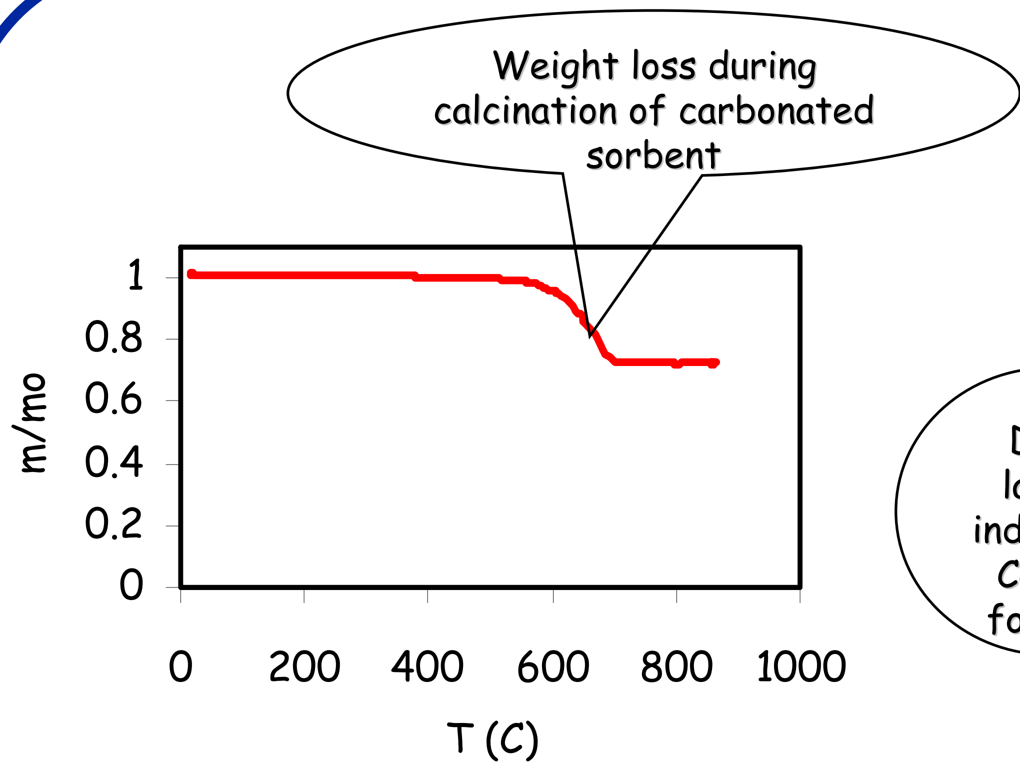
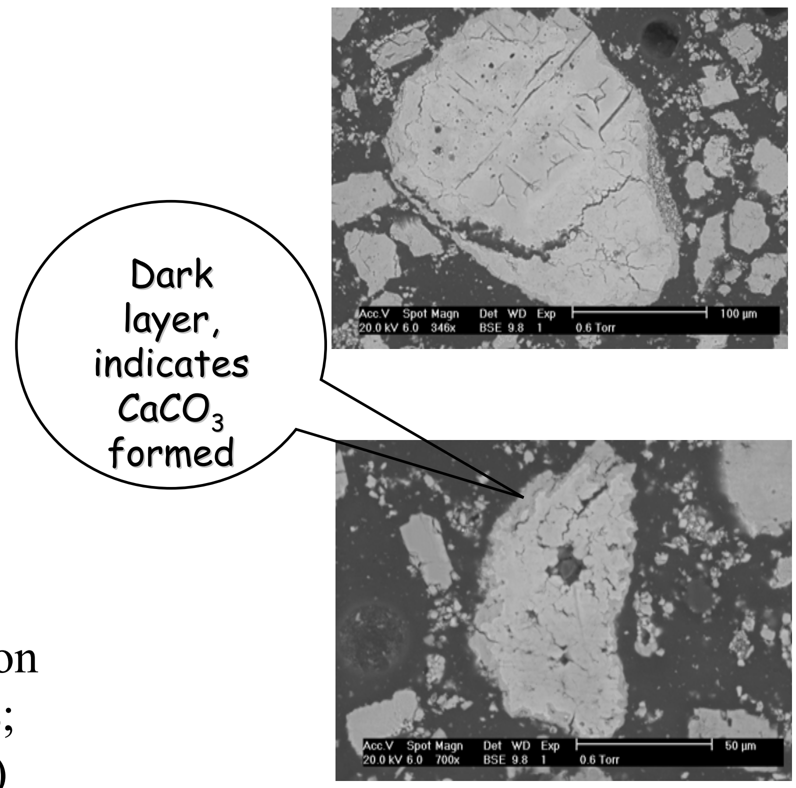
Entrained Flow Sorbent Test Rig





a) Mass loss in thermobalance, calcination in N_2. Mean particle conversion 27.5 %; CO2 capture 29.4 %; CaO/CO_2 (molar) 1.21.



b) SEM images of carbonated particles, particle conversion 22.9%, CO_2 capture 29.3%, t_r 2.59 s, CaO/CO_2 (molar) 2.16.

Entrained flow calcination results

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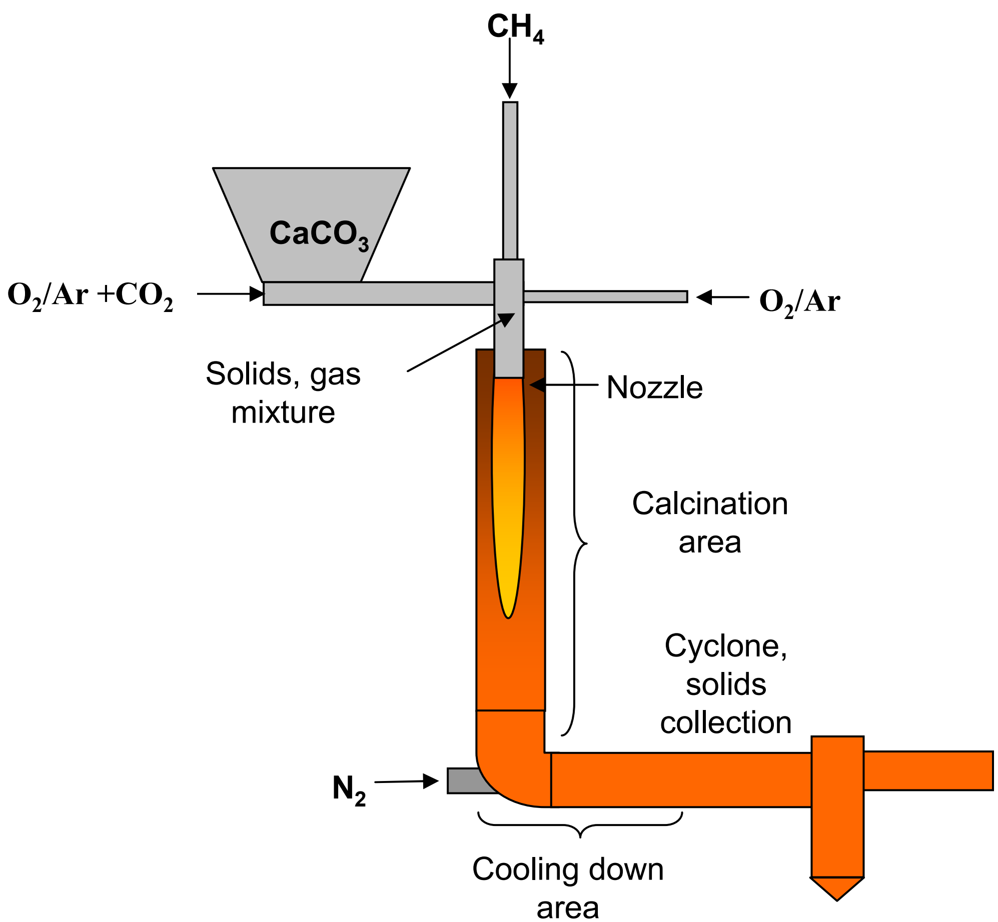
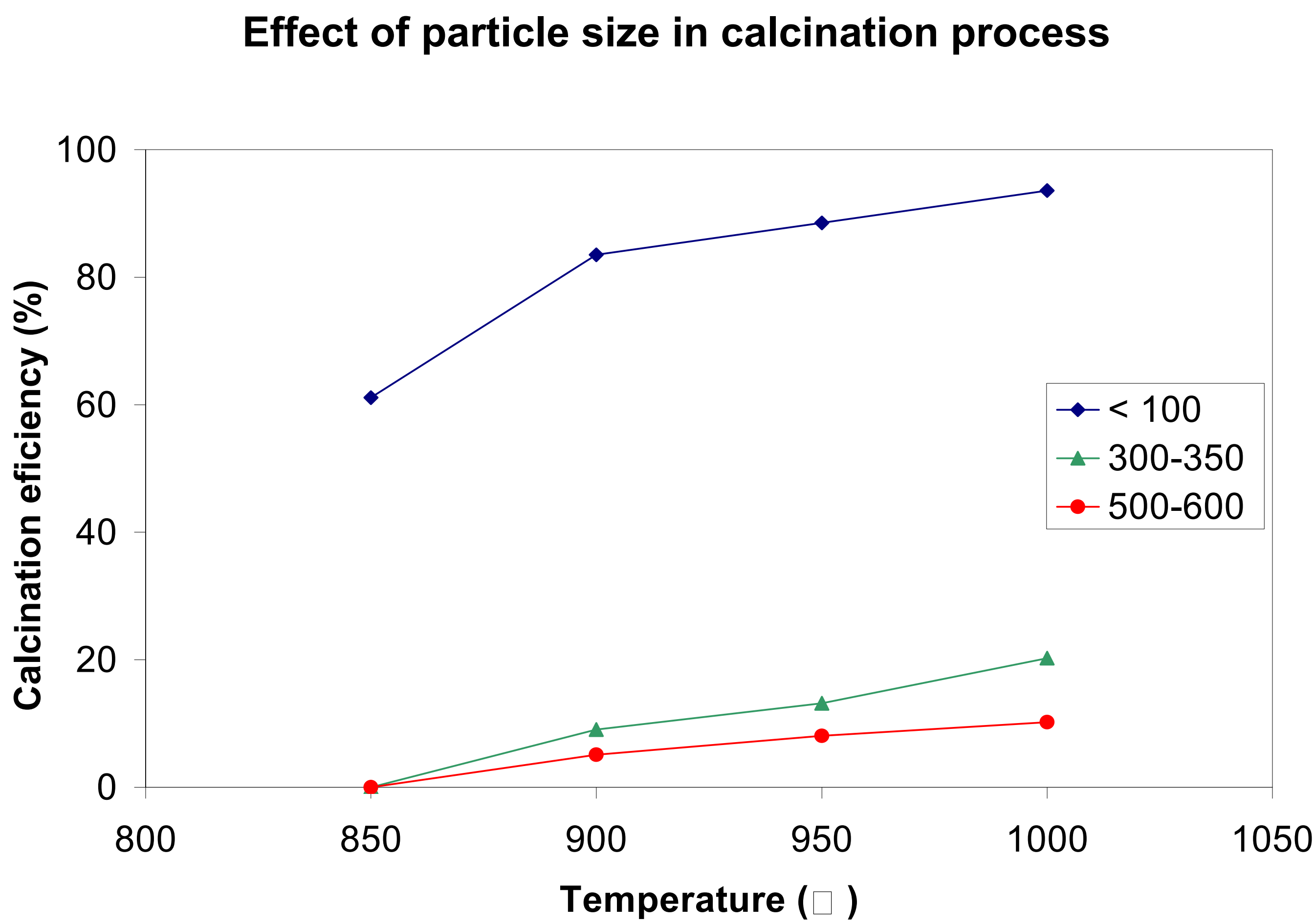
Entrained Flow Calciner



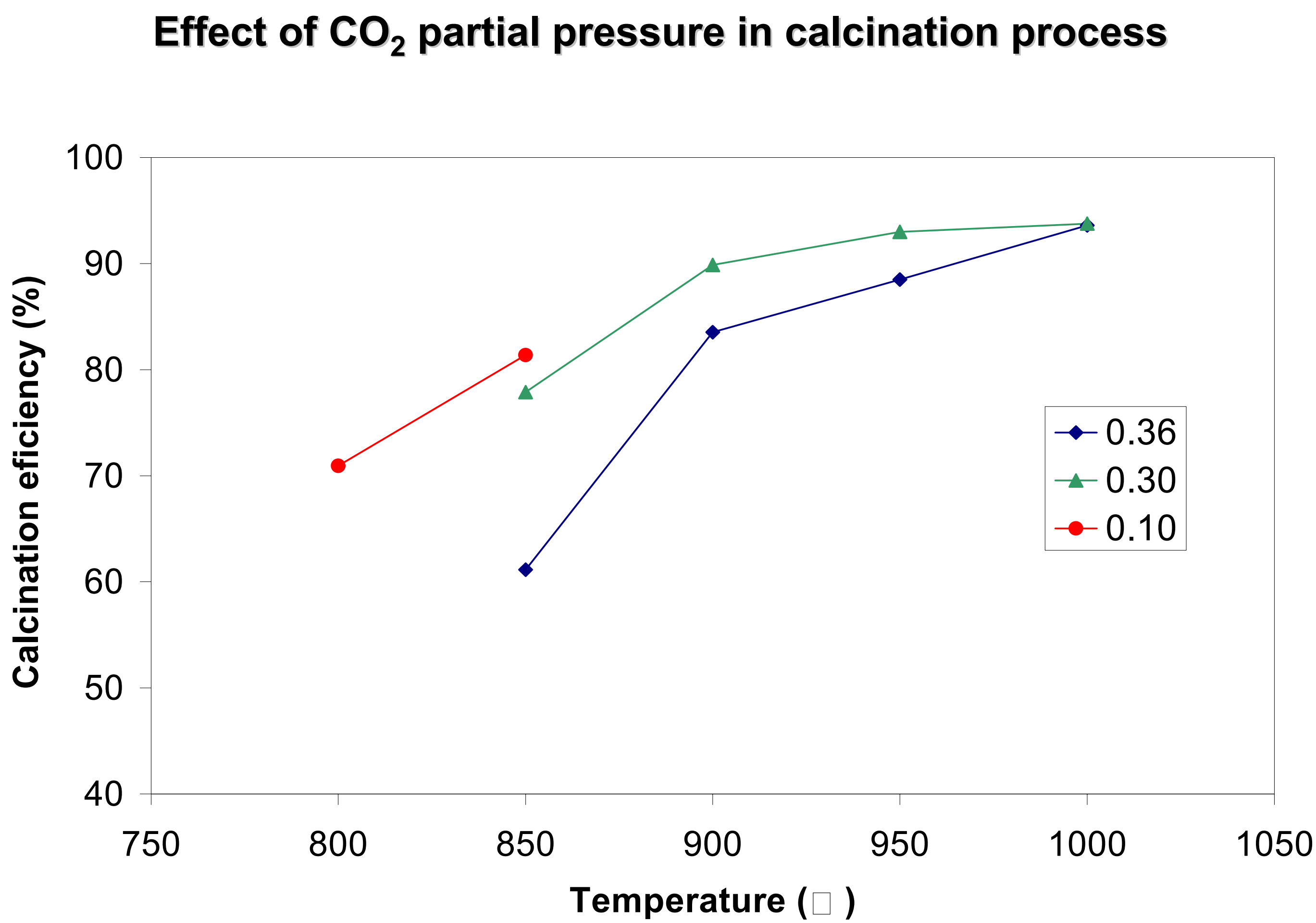
Characteristics

- **Calcination length 0.5m**
- **Internal diameter 0.01 m**
- **Operating temperature 850-950 C**
- **Gas flow 25-40 L/min**
- **Gases used: Air, CO_2, O_2, CH_4**
- **Typical limestone flow: 10g/min**

Entrained flow calcination results



Entrained flow calcination results



Entrained flow carbonation results

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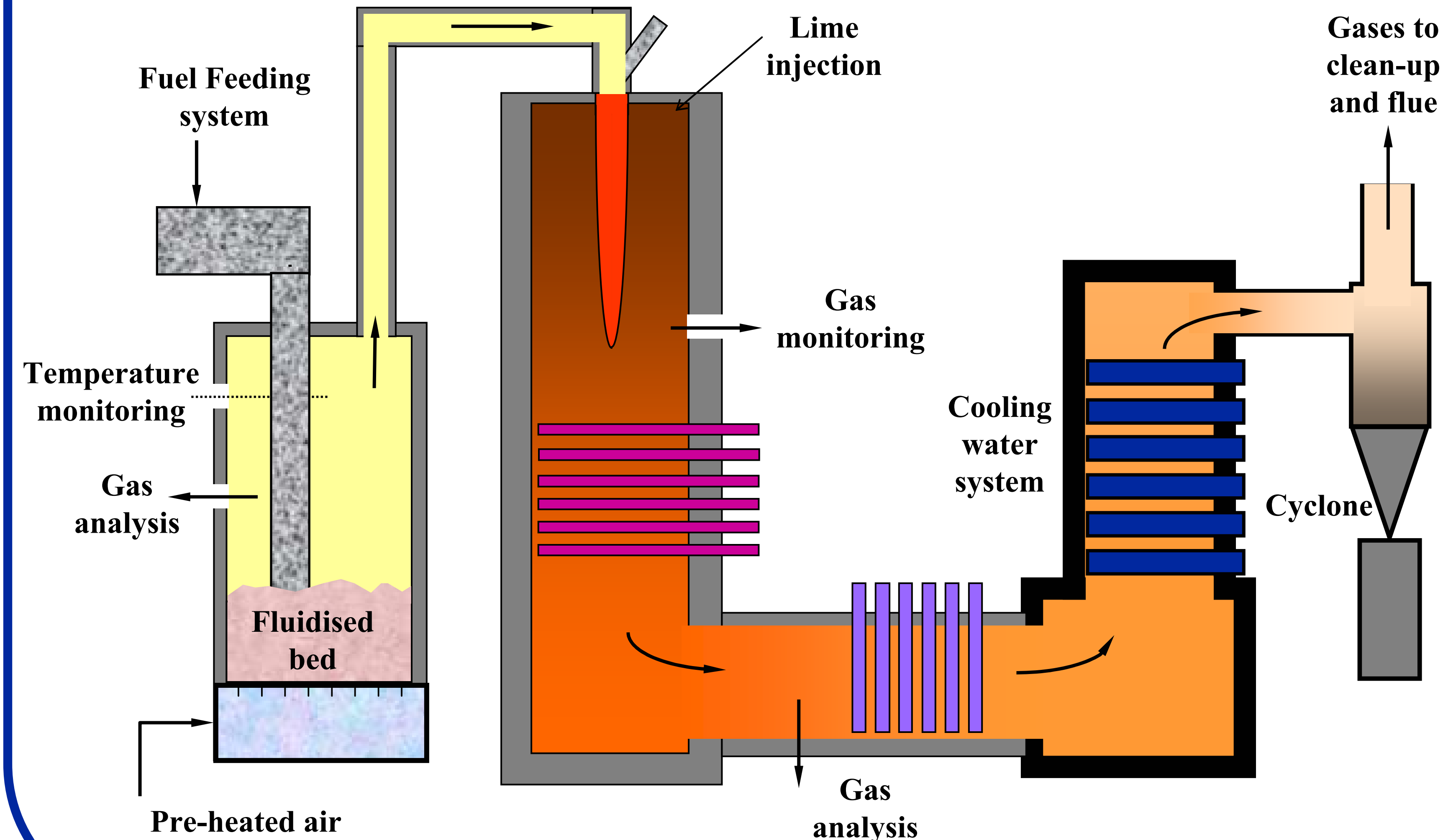
Entrained flow carbonator facility



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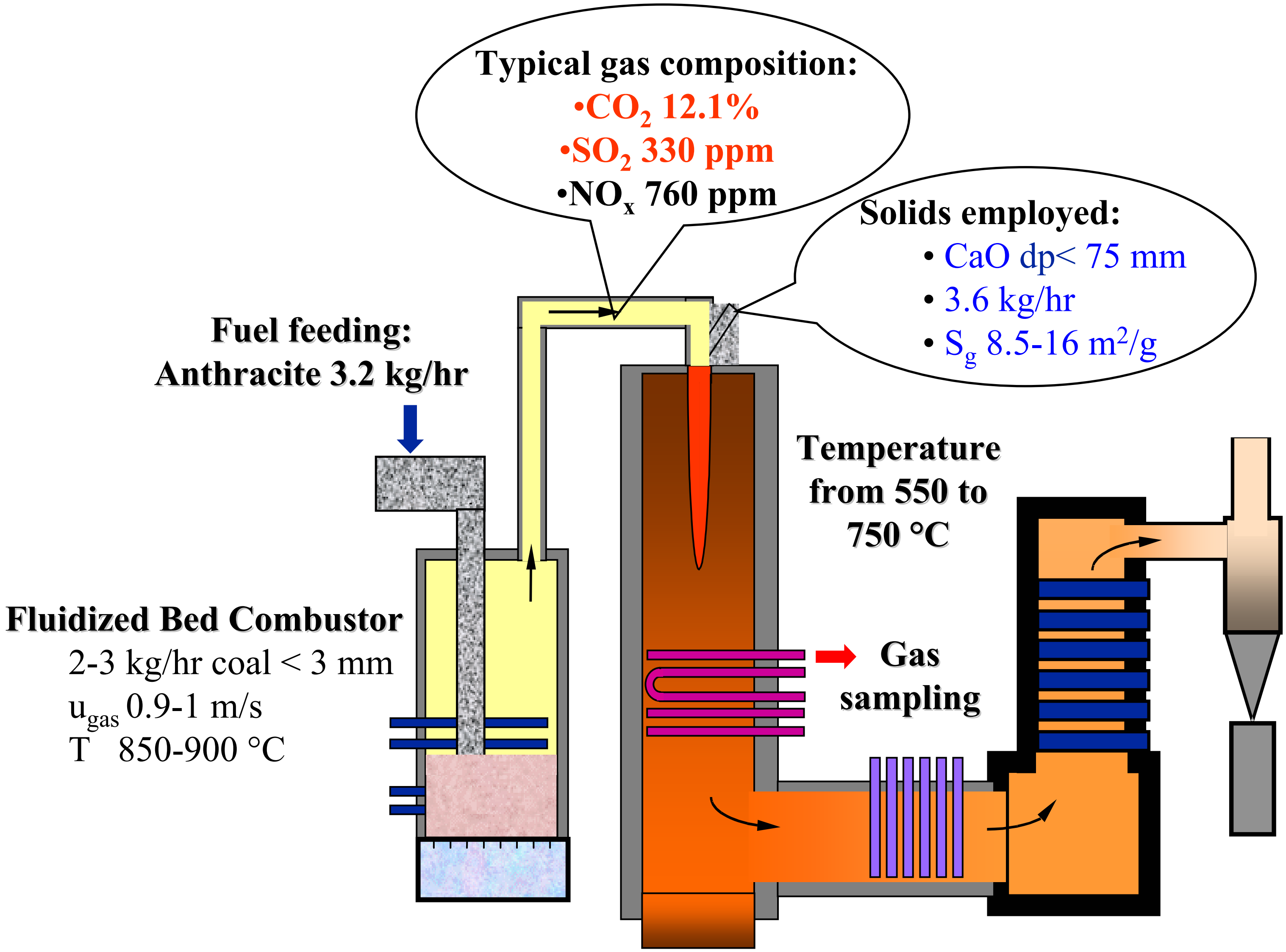

Entrained flow carbonation results

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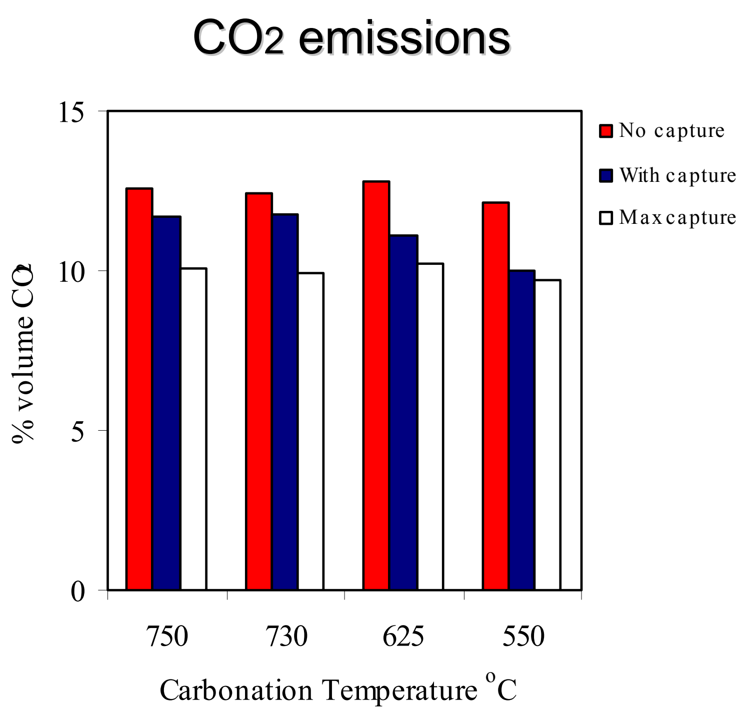
Characteristics

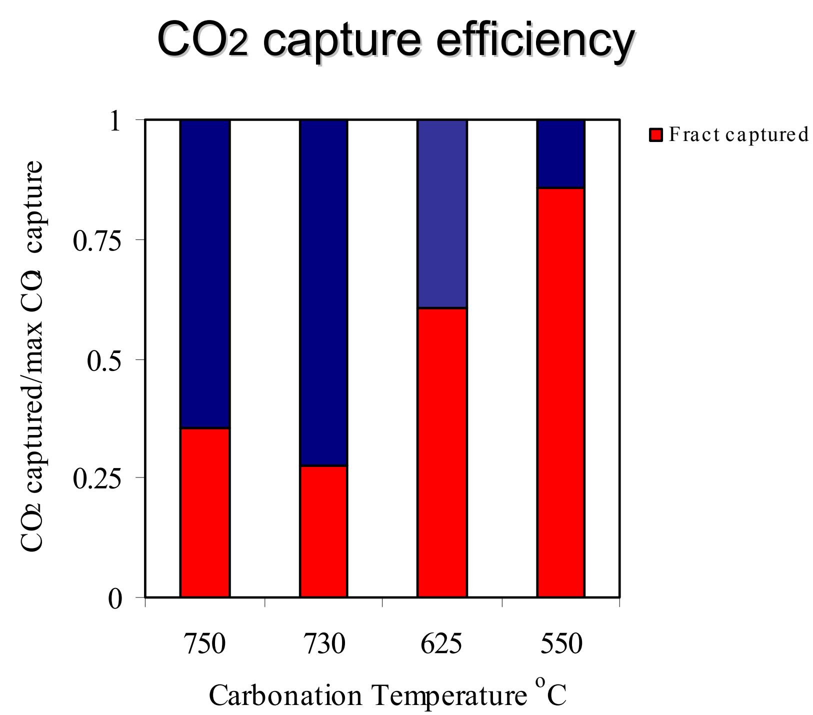
- Operating temperature 550-750^{o}C
- Air flow in the fluidized bed 1200 l/min
- Lime characteristics:
  - 96 % CaO
  - Particle size <75 mm
- Coal used: Anthracite
- Carbonation length: 2m

Tests Conditions

Temperature(°C)	Coal flow (kg/h)	CaO flow (kg/h)	CO2 in (%)	CO2 fin (%)	CaO/CO2
550	3.2	3.6	12.1	10.0	0.2
625	3.2	3.6	12.5	11.1	0.2
730	3.2	3.6	12.3	11.7	0.2
750	3.2	3.6	12.6	11.7	0.2

Entrained flow carbonation results





Conclusions:

Calcination Tests

- Particle size plays an important role in calcination in flame
- High calcination temperatures needed
- As the temperature increases the effect of CO_2 is less important

Carbonation Tests

- CO_2 capture in entrained mode is strongly affected by the temperature
- Best results obtained at 550^{o}C
- Reasonable levels of CO_2 capture can take place in real combustion environments

Future Work in Cranfield University on CO_2 capture using Lime

- Impact of flue gas contaminants
- Effect of the pressure in calcination process in fluidized beds
- Effect of the steam in calcination process in fluidized beds
- Testing of the coupled carbonation/calcination cycles

Coupled carbonation calcination process