5-24-2016

A twin-bed test reactor for characterization of calcium looping sorbents

Antonio Coppola
Istituto di Ricerche sulla Combustione, Consiglio Nazionale delle Ricerche, Italy., coppola@irc.cnr.it

Fabrizio Scala
Dipartimento di Ingegneria Chimica, dei Materiali e della Produzione Industriale, Università degli Studi di Napoli Federico II, Italy.

Piero Salatino
Dipartimento di Ingegneria Chimica, dei Materiali e della Produzione Industriale, Università degli Studi di Napoli Federico II, Italy.

Liberato Gargiulo
Istituto di Ricerche sulla Combustione, Consiglio Nazionale delle Ricerche, Italy.

Scuola Politecnica e delle Scienze di Base
Università degli Studi di Napoli Federico II

Istituto di Ricerche sulla Combustione
Consiglio Nazionale delle Ricerche

Fluidization XV

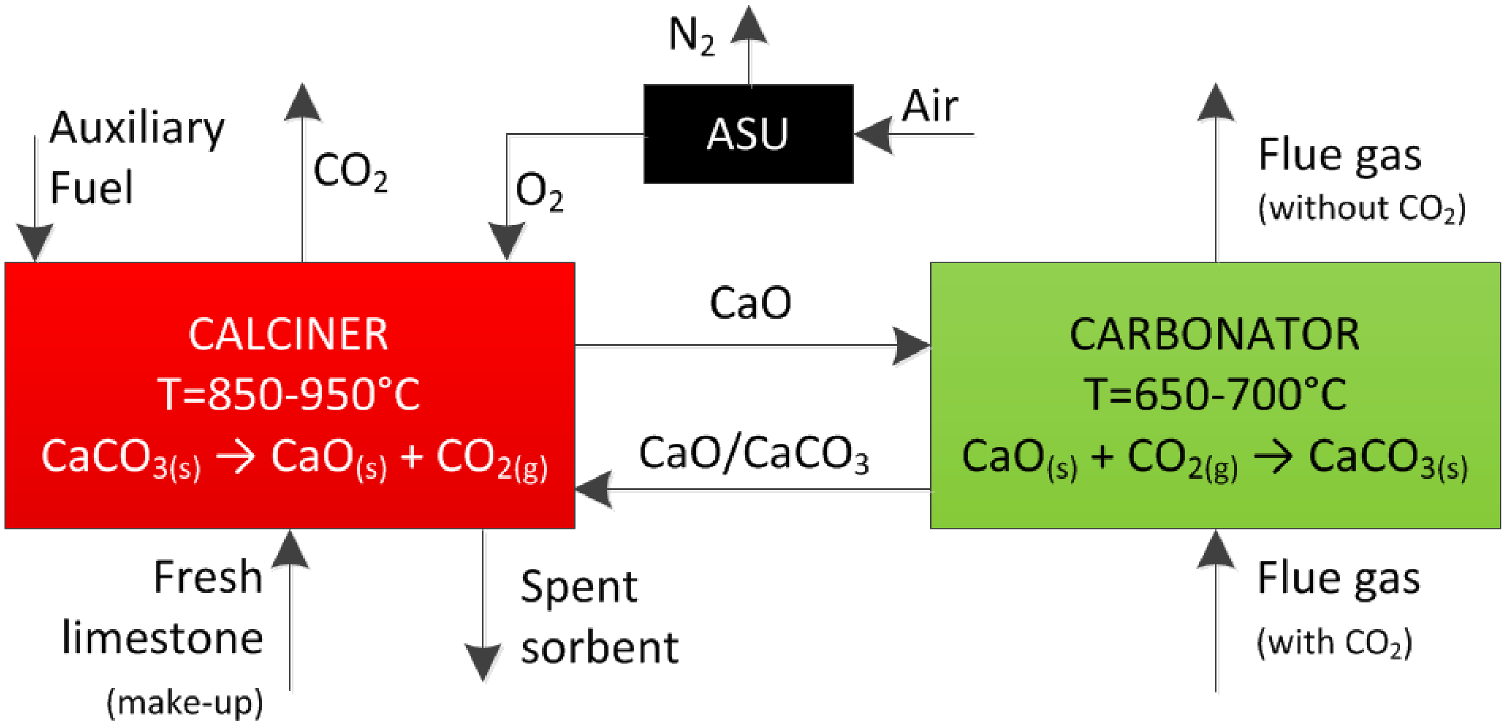
A ECI Conference Series

May 22-27, 2016
Fairmont Le Chateau Montebello
Quebec, Canada

A TWIN-BED TEST REACTOR FOR CHARACTERIZATION OF CALCIUM LOOPING SORBENTS

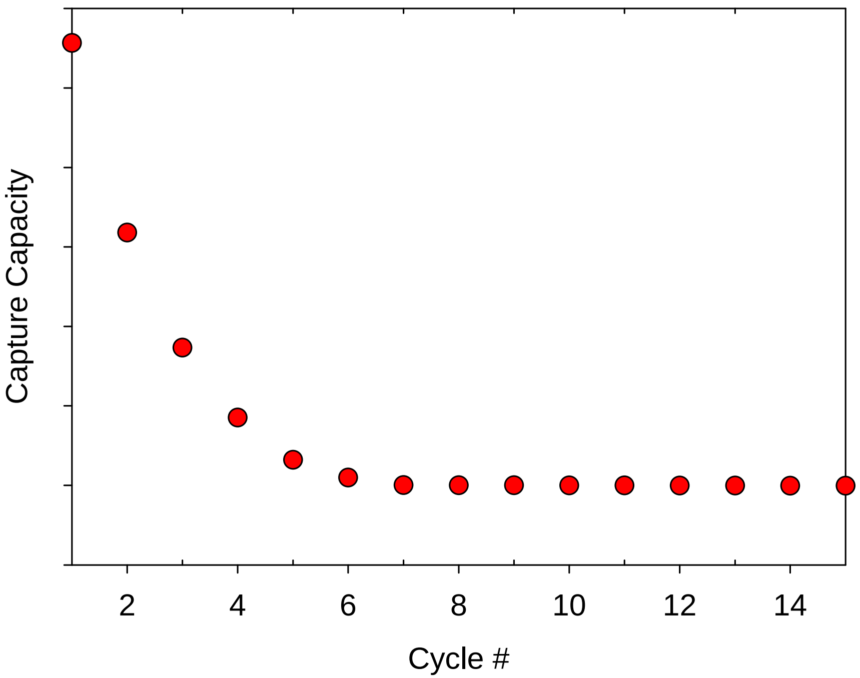
*Antonio Coppola, **Fabrizio Scala**, Liberato Gargiulo, Piero Salatino*

Overview: the Ca-looping concept



Overview: the Ca-looping concept

Sorbent-related Issues (1/2)



Decay of CO_2 Capture Capacity of the sorbent

- *Sintering*
- *Presence of SO_2*

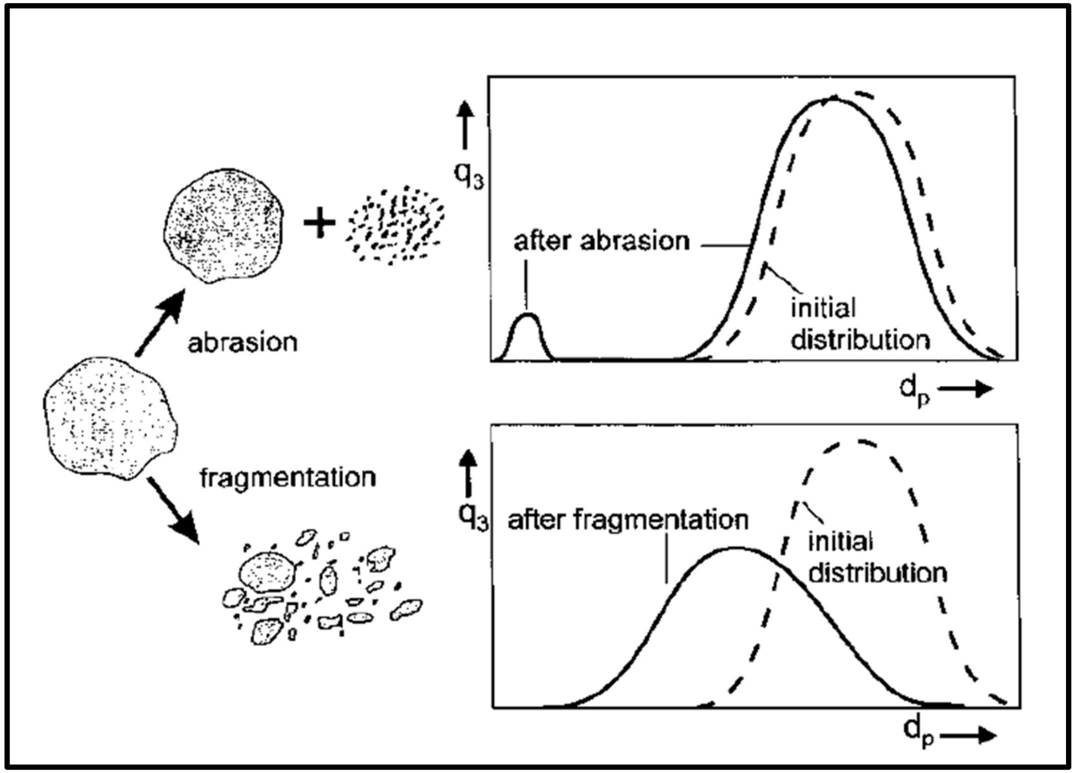
$$CaO + SO_2 + \frac{1}{2}O_2 \rightarrow CaSO_4$$

Overview: the Ca-looping concept

Sorbent-related Issues (2/2)

Attrition/Fragmentation Phenomena

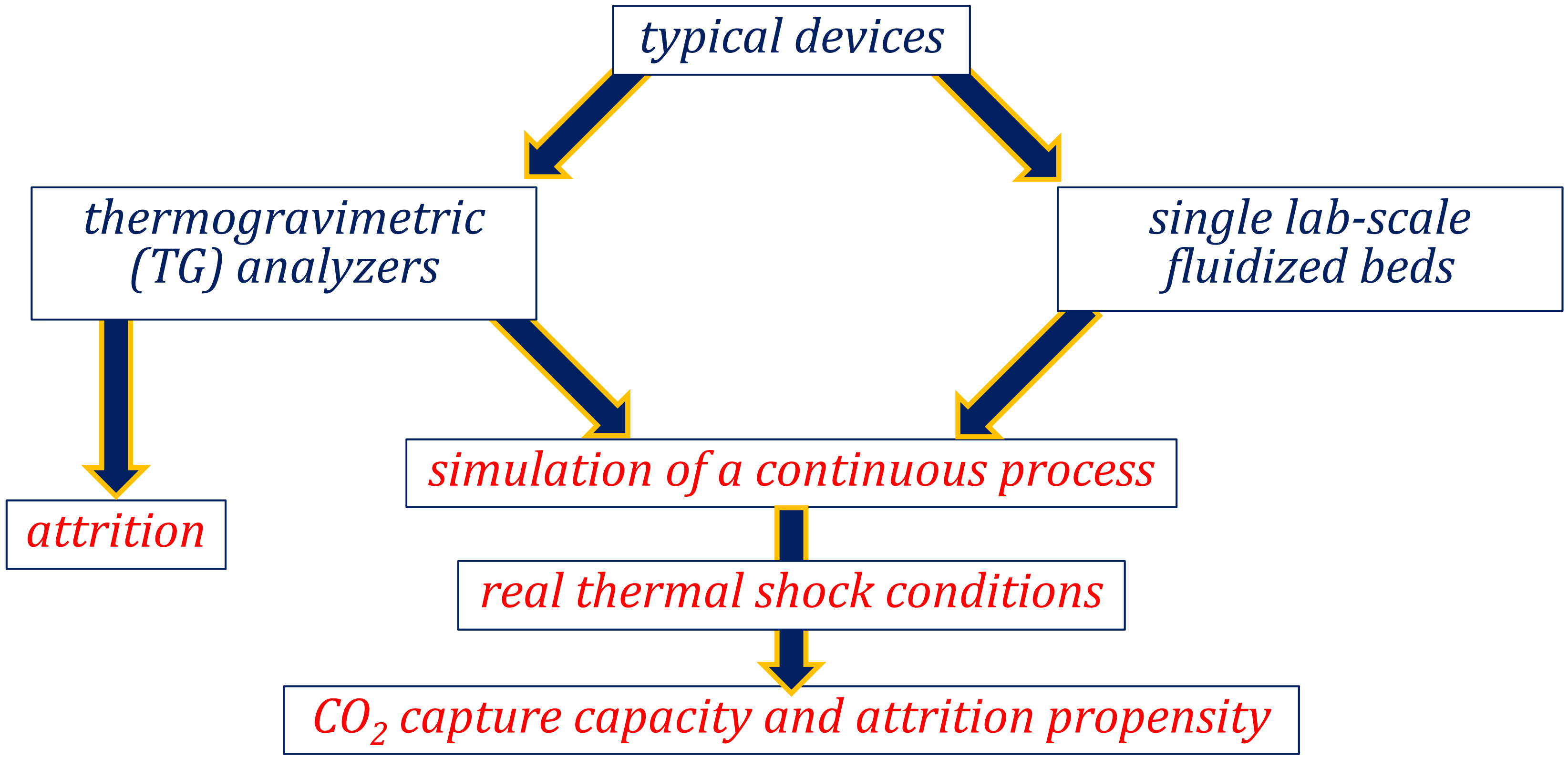
- *Primary Fragmentation*
- *Secondary Fragmentation*
- *Attrition by Abrasion*



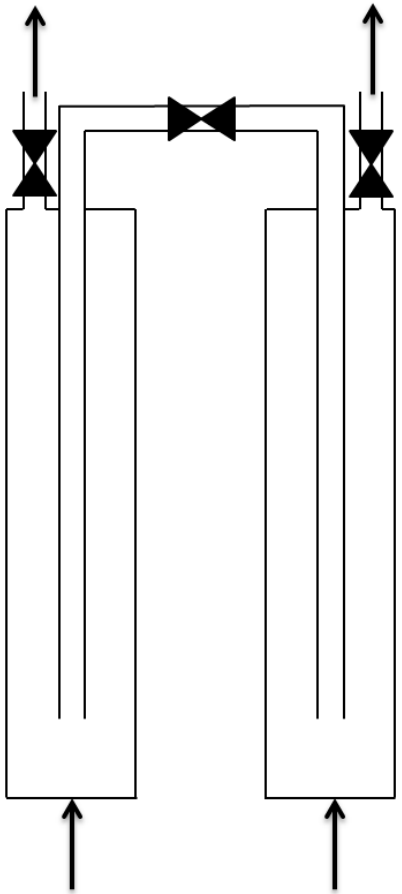
Few data on attrition of limestone during carbonation/calcination cycles are available in the literature (Blamey et al., 2010)

Overview: the Ca-looping concept

Lab-scale sorbent characterization studies



Aim of this work



a novel batch lab-scale apparatus is presented

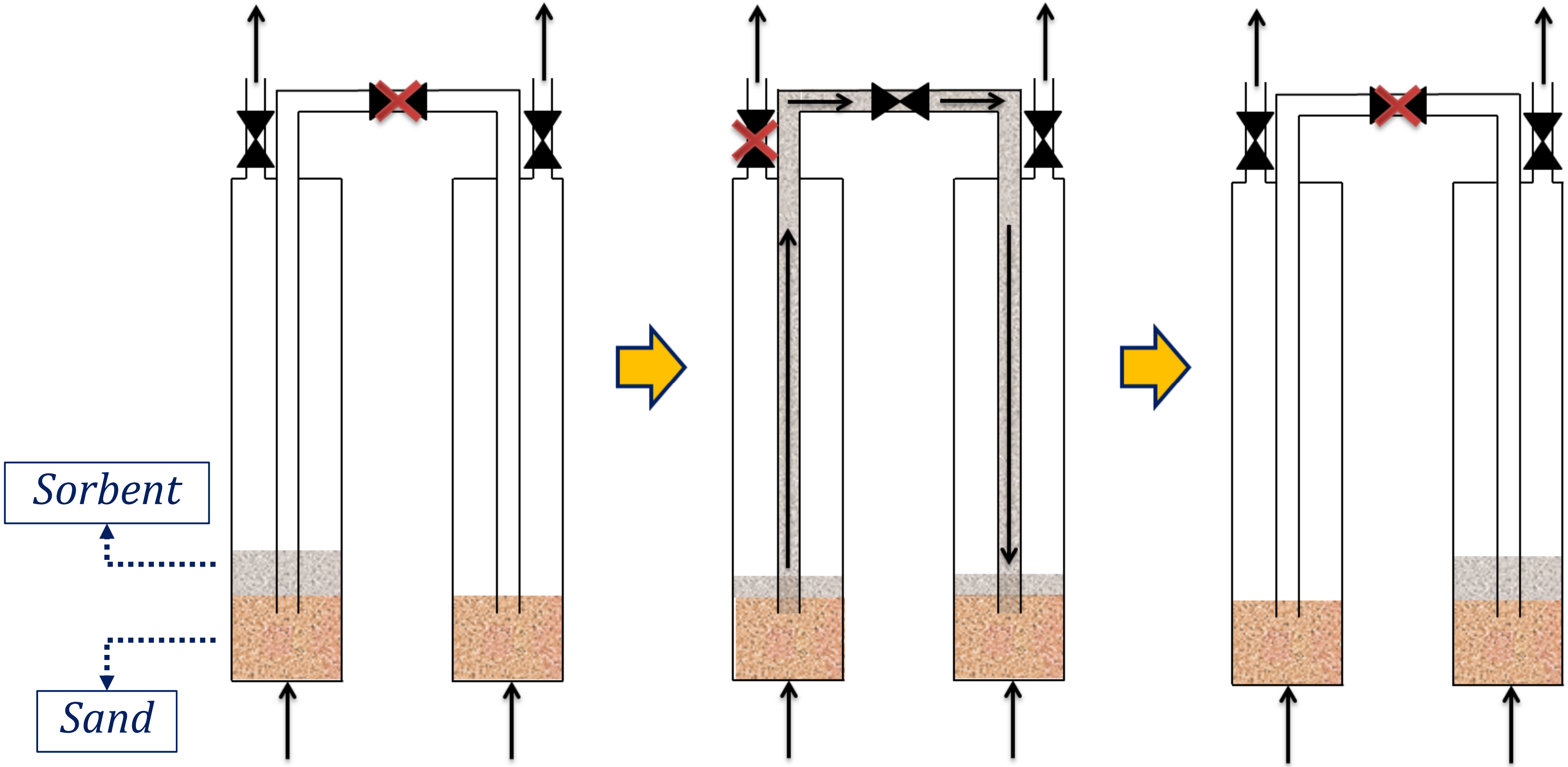
realistic sorbent thermal history

two twin lab-scale bubbling fluidized beds

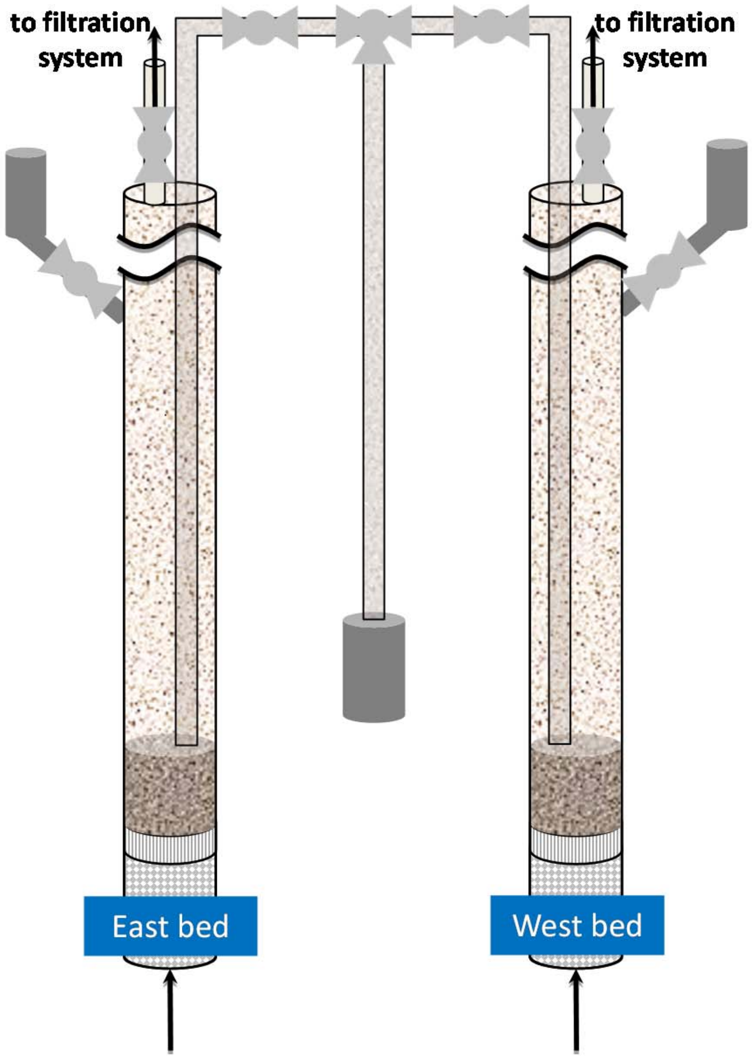
connected by a duct

Experimental

Scheme of the solid transport procedure between the two fluidized bed reactors



Experimental



Experimental

Procedures and materials

	Limestone	Sand
Mass, g	20	150
Size, mm	0.4-0.6	0.9-1.0
v_f, m/s	0.4, 0.5, 0.6	
h_D, mm	60, 55, 50, 45	
h_B, mm	27, 32, 37, 42	

German limestone (EnBW)

15 minutes for each stage

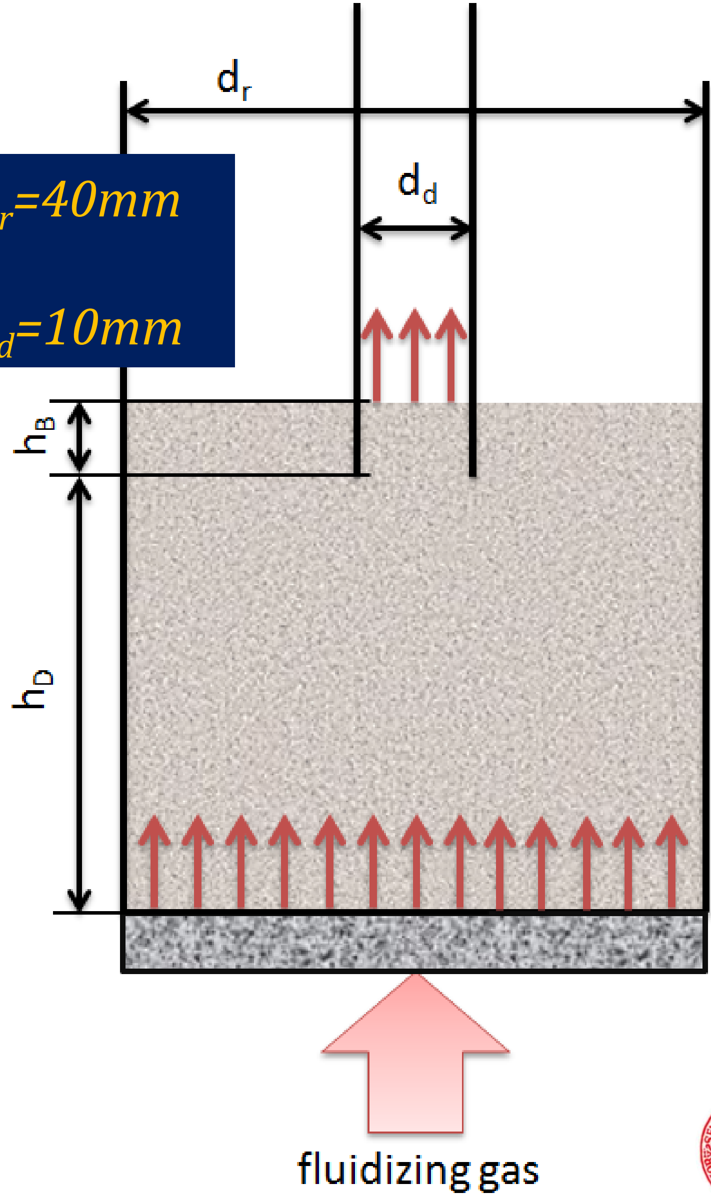
Evaluation of collection efficiency by PSD of the discharged material (by sieving)

$$\eta, \% = \frac{\text{the amount of the transported material}}{\text{total amount initially charged in the bed}}$$

Mass of transported sand

d_r=40mm

d_d=10mm



Experimental

Procedures and materials

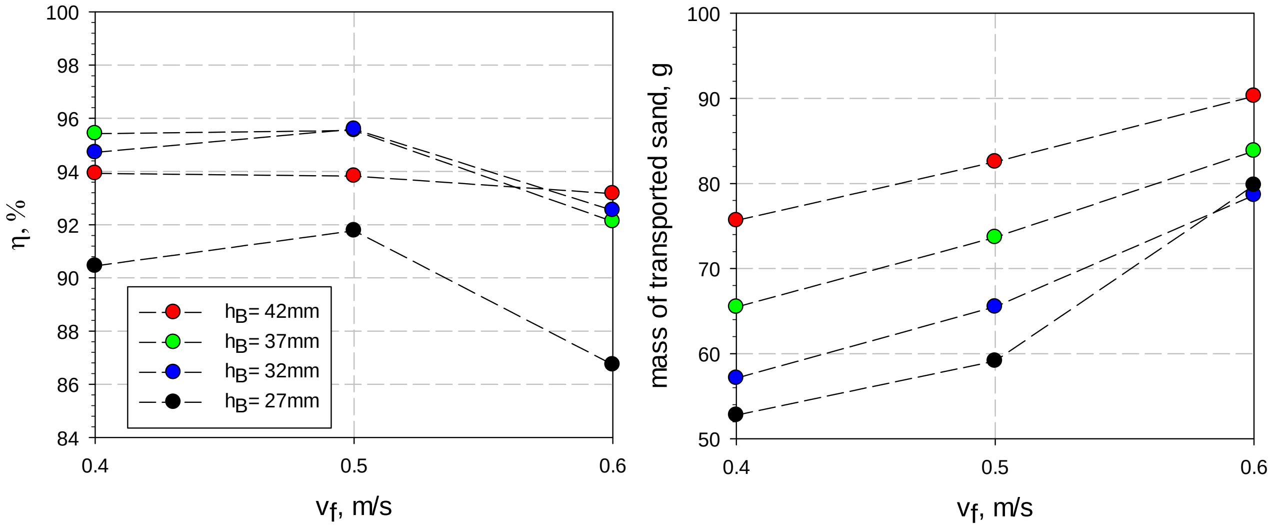
	N-RC		RC
Sorbent	Limestone	Lime	Limestone/Lime
Temperature, °C	870/650	940/650	940/650
CO_2 concentration, %vol	100/100	0/0	70/15 (rest air)
N_2 concentration, %vol	0/0	100/100	0/0
v_f, m/s	0.5		

Operating conditions for hot tests

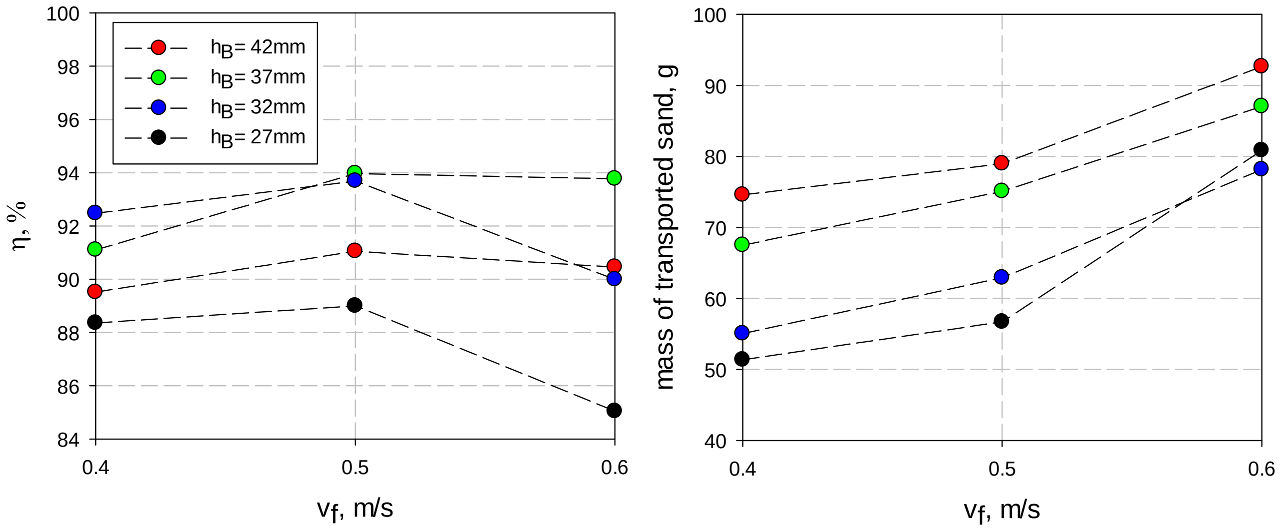
Results

Transport efficiency results – ambient conditions

East bed



West bed



Results

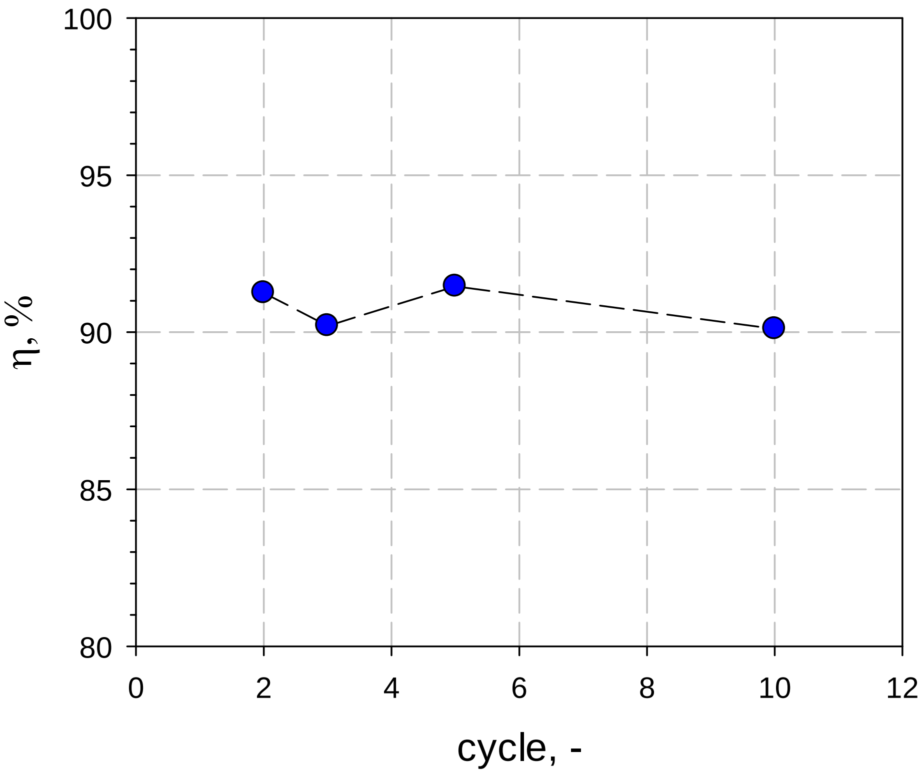
Transport efficiency results – ambient conditions

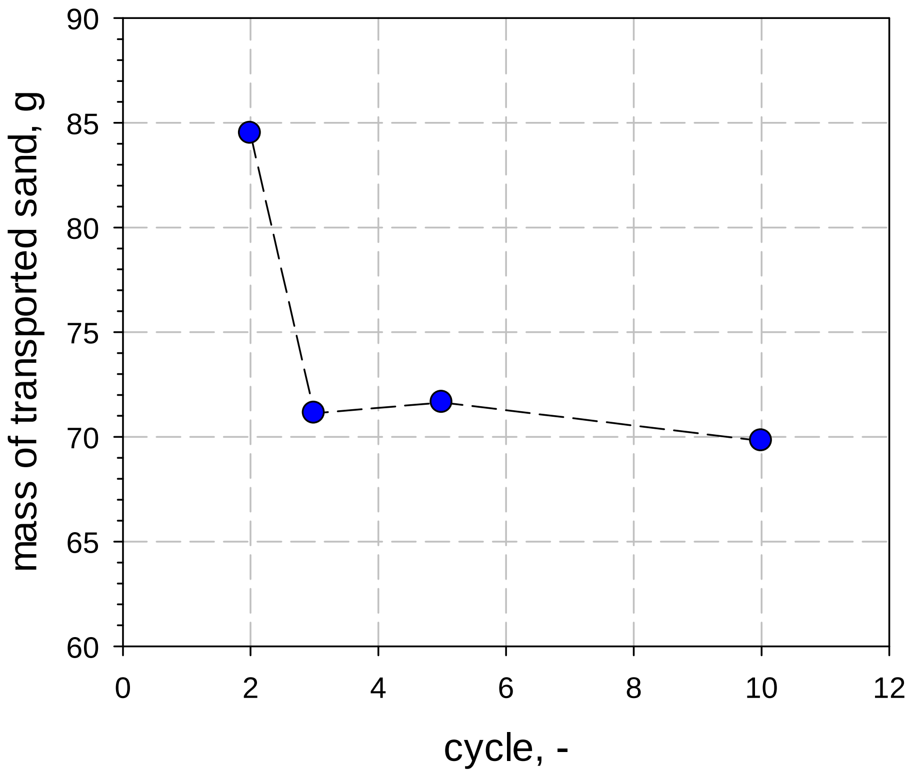
v_f = 0.5m/s
h_B = 32mm

η ~95%
transferred sand ~ 64g

20g of limestone and 150g of sand into the West Bed

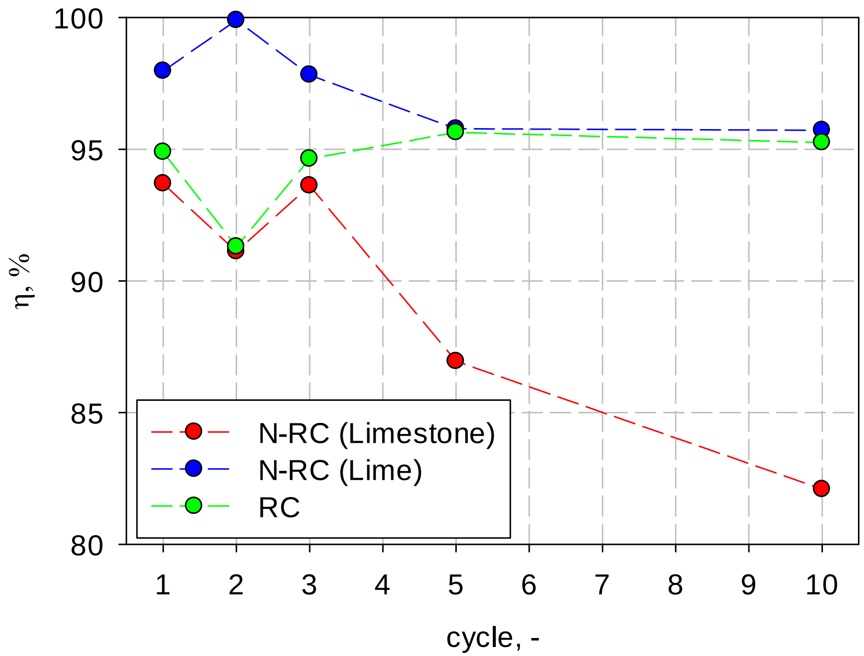
86g of sand into the East Bed

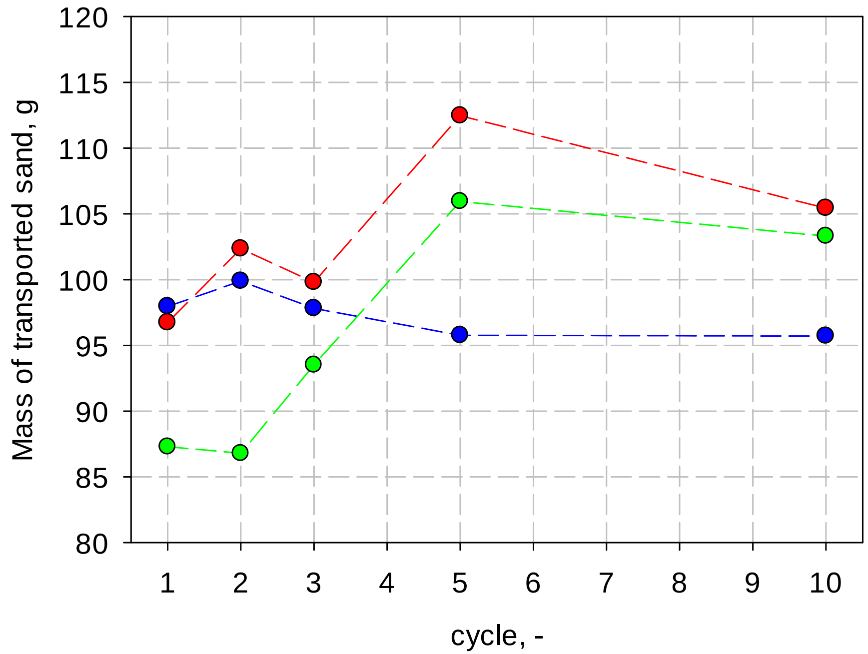




Results

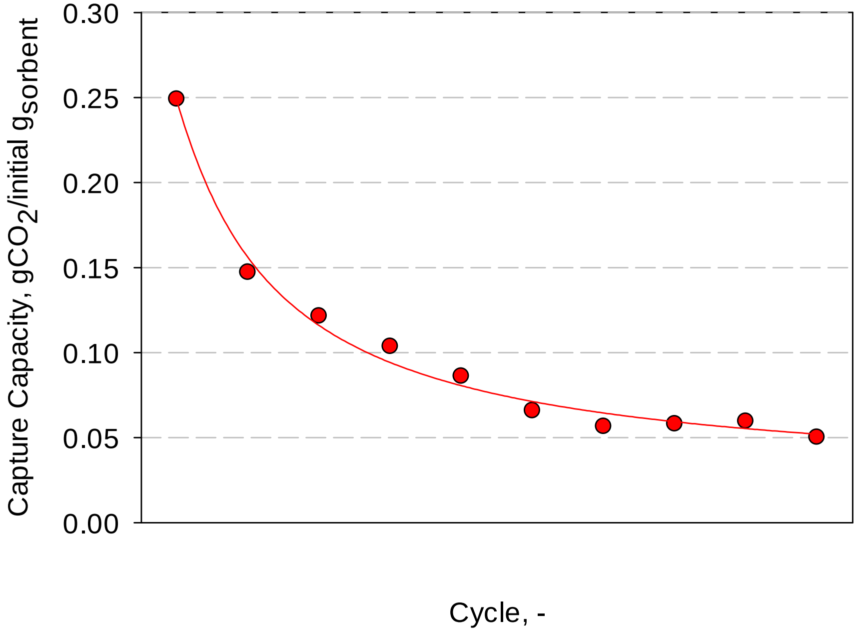
Transport efficiency results – hot conditions

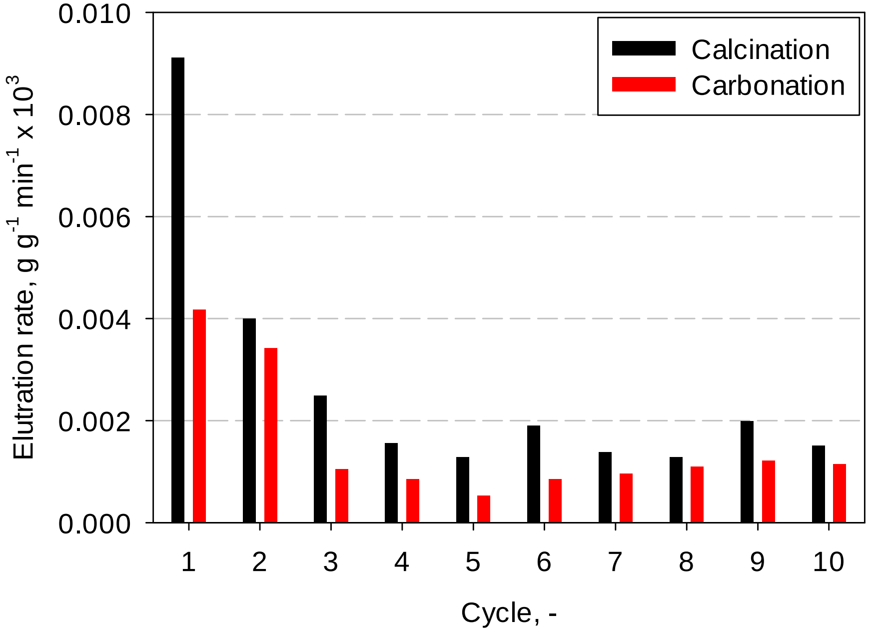




Results

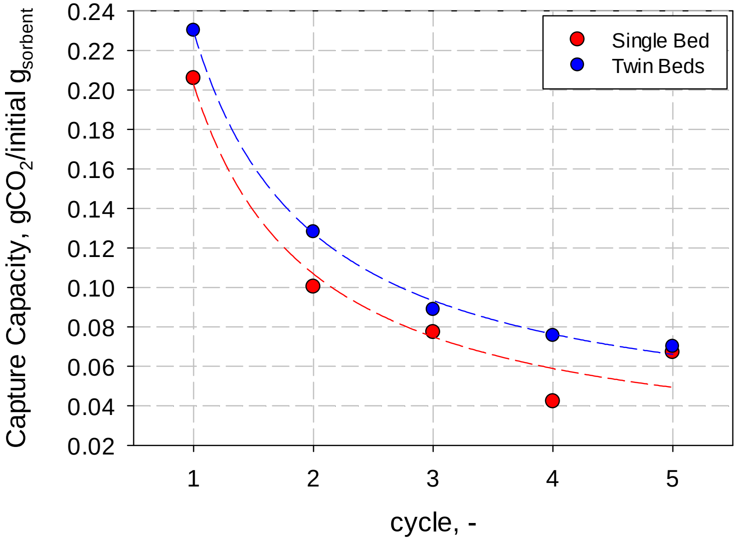
CO_2 capture and attrition results





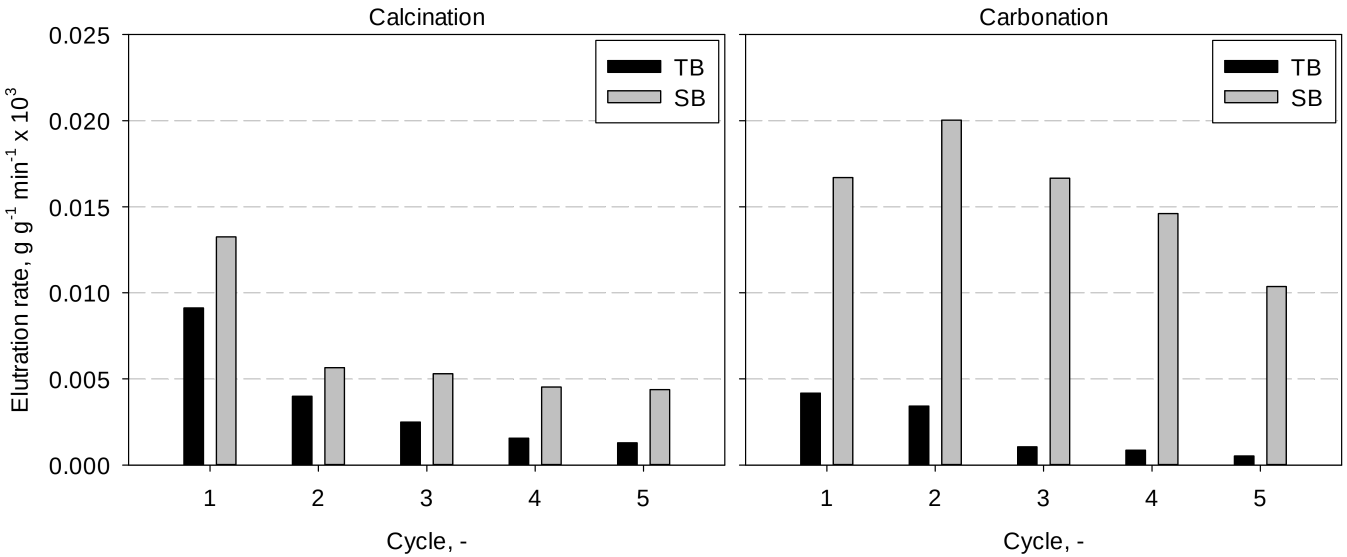
Results

CO_2 capture and attrition results – comparison with single FB experiments



TB = Twin beds (this work)

SB = Single FB experiments



Conclusions

Preliminary single-cycle and multi-cycle tests (at ambient temperature) showed good solid transfer efficiency results and the overall stability of the system.

Also at high temperature the system showed good stability both in terms of sorbent transfer efficiency and sand transportation.

Tests under non-reactive conditions pointed out the relevant role of the density difference between sorbent and sand.

The CO_2 capture capacity results exhibited a typical decay trend with the cycle number, as expected in a Ca-L process.

The comparison of these results with those previously obtained with the same limestone under comparable operating conditions in a single-bed apparatus pointed out capture capacity values higher than those of the single bed.

The particle attrition tendency is significantly dependent on the thermal history experienced by the sorbent. The absence of strong thermal shocks in the TB experiments leads in general to a decreased generation rate of fines.

Scuola Politecnica e delle Scienze di Base
Università degli Studi di Napoli Federico II

Istituto di Ricerche sulla Combustione
Consiglio Nazionale delle Ricerche

Fluidization XV

A ECI Conference Series

May 22-27, 2016
Fairmont Le Chateau Montebello
Quebec, Canada

A TWIN-BED TEST REACTOR FOR CHARACTERIZATION OF CALCIUM LOOPING SORBENTS

*Antonio Coppola, **Fabrizio Scala**, Liberato Gargiulo, Piero Salatino*

Thank you for your attention

Acknowledgment:

The Authors wish to thank Mr. Domenico Tinna (UniNa) for his support in carrying out experimental tests.