# Experimental characterization and cycle operation of a Directly Irradiated Fluidized Bed Autothermal Reactor

Stefano Padula [a], Maurizio Troiano [a,b], Claudio Tregambi [b,c], Roberto Solimene [a] & Piero Salatino [b]

[a] Istituto di Scienze e Tecnologie per l'Energia e la Mobilità Sostenibili (STEMS), Consiglio Nazionale delle Ricerche, Naples, 80125, Italy

[b] Dipartimento di Ingegneria Chimica, dei Materiali e della Produzione Industriale (DICMaPI), Università degli Studi di Napoli Federico II, Naples, P.le V. Tecchio 80, 80125, Italy

[c] Dipartimento di Ingegneria, Università degli Studi del Sannio, Benevento, 82100, Italy

E-mail: maurizio.troiano@unina.it

Concentrating solar thermal (CST) technologies are used today for heat and power applications. Integration of CST technology with Thermal Energy Storage (TES) systems allows to improve the stability and flexibility of power plants during off-sun periods. Thermochemical Energy Storage (TCES) would allow long-duration energy storage, to meet the long-term energy demand. In TCES systems, solar energy is used to sustain an endothermic reaction and then is recovered by carrying out the reverse reaction. Fluidized beds feature some practical advantages for TCES, as the possibility to transport solids at high rates from reactors to storage units and vice versa, and the excellent heat transfer properties.

A Directly Irradiated Fluidized Bed Autothermal Reactor (DIFBAR) has been proposed, able to operate as a "thermochemical battery" and to recover thermal energy from the temperature swing between the endothermic and exothermic step of a thermochemical cycle. The DIFBAR is composed of a particle receiver, a vertical double-pipe heat exchanger and a particle reservoir. During solar operation, particles are entrained from the reservoir to the receiver, passing through the central tube of the heat exchanger. The particles absorb solar radiation and undergo endothermic reaction. The product returns to the reservoir, passing through the annulus of the heat exchanger, while the solid reactant is preheated by countercurrent heat exchange. The reservoir can be operated as a fluidized bed reactor for the exothermic step. Experimental campaigns are carried out in a laboratory prototype to characterize the system under steady conditions with inert solids and demonstrate the operation of the CaL cycle with limestone or calcarenite particles mixed with inert black proppant particles to reach high absorptivity. The effect of different fluidizing gases and of the ratio of inert/reactant particles during CaL tests is studied. Finally, transient conditions are simulated on a reduced time-scale (8 h), showing the effect of an increasing/decreasing solar input. Results show that the gas properties have little influence on solar absorption of the solid particles and heat transfer within the heat exchanger. Heat transfer coefficients vary coherently with the solids volume flowrate and increase at higher operating temperature, ranging within 300–900W/($m^2$K). Complete calcination of limestone and calcarenite takes 5–6h at temperatures around 750–850°C. The results confirm the potentiality of the DIFBAR as a "thermochemical battery" and as solar autothermal reactor for diverse high temperature processes.

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