**Past, present and future of a Spouted Bed reactor**

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The use of biomass to produce renewable energy and new bio-materials can provide a sustainable and low-carbon alternative to traditional fossil fuels based technologies. This is one of the main research areas of the Process Engineering Research Team (PERT) at the University of Genova. The group applies a multiscale-based approach to evaluate new and traditional technologies through a complementary experimental and theoretical point of view.

This approach is widely applied by the group in the study of Spouted Beds (SB) [1]. In contrast with traditional fluidization, the fluid flow enters the SB through a single central inlet orifice creating three well differentiated zones: the central core of the reactor through which air flows is the spout, the surrounding annular region is the annulus and the solids above the bed surface entrained by the spout and going down the annulus form the so-called fountain. This configuration promotes mass and energy transfer phenomena and makes them suitable for a wide range of industrial applications as drying of solids, coating or chemical reactors [2].

Several lab and pilot-scale SB have been developed by the group in collaboration with both academic and non-academic research teams to perform thermo-chemical conversion of biomass and other residuals as textile waste. A first lab-scale device (Figure 1a) working at room temperature permitted to optimise its fluid dynamic properties through the combination of experimental data [3] and validation of developed numerical models using Ansys Fluent© (Figure 2a)[4, 5] and MFIX [6]. In a successive step, the best fluid dynamic configuration led to the construction of a pilot plant (Figure 1b) able to treat 200 g/min of biomass with a potentiality of 200 kWth [7]. Again, the experimental activity was complemented with models using Aspen Plus© (Figure 2b) [8] and COCO [9] to optimise the operational conditions and maximise the target outputs. Recently, the pilot unit has been successively scaled up to design and construct a plant with 4x4 units (Figure 1c) combining pyrolysis and gasification reactions with a potentiality of 0.5 MWth. Its fluid dynamic properties have been optimized (Figure 2c) [10, 11] and now an extensive experimental campaign to maximise the production of H2 is ready to start.

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| (a) | (b) | (c) |

**Figure 1.** Experimental SB devices: (a) lab-scale; (b) pilot plant (20 kWth); (c) scaled-up plant (0.5 MWth)

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| (a) | (b) | (c) |

**Figure 2.** Results of simulation activities of the SB: (a) spouting phenomena using Ansys Fluent©; (b) distribution of gas products from the gasification of apple pruning using Aspen©; (c) residence time using Ansys Fluent©

The importance of valorising second-generation residues (i.e., by-products of valorisation technologies: char) has been identified and highlighted in all the developed systems. The different recovered biochar types (Figure 3a) have been used as an adsorbent for the removal of H2S (Figure 3b) [12] and CO2 (Figure 3c) [13] from exhausted gas.

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| (a) | (b) | (c) |

**Figure 3.** (a) apple pruning char; (b) breakthrough curves of H2S adsorption on char from the gasification of biomass; (c) CO2 uptake on chemically activated char from the pyrolysis of palm tree.

Within this framework, the present work aims to provide a description of all the above-mentioned research activities highlighting their most relevant outcomes and opportunities and providing an overview of the main challenges that the current state of the art is facing.

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