

## Applying the Fundamentals

### PSRI and Biomass Process Technology



PSRI has over 200 years of experience in design, development, and troubleshooting with over 250 reviewed publications, most of which focus on feeders, conveyers, fluidized beds and circulating fluidized beds as related to biomass gasification and pyrolysis. We understand each operation associated with feed delivery and char separation. We have been solving problems in these areas for over 45 years. The benefit of such is being on the cutting edge of the most effective technologies and design concepts.



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## Challenges in Process Engineering for Gasification and Pyrolysis Operations

At PSRI we understand that biomass processing is dealing with bulk densities. It controls your supply chain, feeding capabilities, and fluidized bed performance. Biomass cannot be treated like coal in fluidized bed operations. Supply chain limitations can limit reactor sizes. Variability in particle sizes, shapes and moisture levels leads to challenges in feeding and mixing and dictates that injection points need to be well placed.



PSRI has been part of this. Our research and technical knowledge base provide solutions to our clients that directly impact the bottom line. For example, we have state-of-the-art design procedures for feed injection, gas distributors, bed internals and cyclones. We pioneered the development of non-mechanical devices for solids flow (L-valves, J-valves and loop seals) that provides precision feed control and seals. PSRI has investigated the effects of high pressure and high temperature on bed hydrodynamics and has developed a novel dipleg configuration to prevent blockage of secondary cyclone diplegs by discharging the first stage cyclone dipleg into the second stage cyclone dipleg. We have demonstrated the world's tallest fluidized bed operation for catalytic gasification at high pressures with an 80 ft (24-m) tall bed (at rest). Similarly, we have helped develop moving bed looping technology including reliable feeding into these units as well as the effective removal of fines<sup>1</sup>.

At PSRI, technology is available for biomass preparation, handling, conveying, feeding, etc. We have developed technology specifications to fluidize binary Group A and Group D solids. We know and understand the challenges of getting it there and getting it in. Particle properties such as particle size, shape, elasticity and moisture need full consideration with any delivery system. Similarly, the feed locations into the reactors are one of the most essential scale-up considerations for biomass gasifiers and pyrolysis units. Reactor designs have to be evaluated



with large-scale, cold-flow testing to characterize the biomass feed zone in fluidized beds. PSRI has determined the RTD curves for biochar in fluidized beds. We have provided performance testing for the development of technical specifications of cyclones with respect to the capturing of binary solids contained in the biochar. In addition, we have determined the technical specifications for a granular bed filter for removing biochar fines along with specifications for the supporting technology involved.

<sup>1</sup> <https://arpa-e.energy.gov/?q=slick-sheet-project/syngas-fuel>

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## PSRI Process Development Experts



**Dr. S.B. Reddy Karri, Consulting Director:** Reddy has 28 years experience in particle technology and fluidization. He has worked on FCC technology, cokers, polyolefins, methanol to olefins, maleic anhydride, acrylonitrile, TiO<sub>2</sub>, polycrystalline silica, gasification, pyrolysis, sulfur capture, CO<sub>2</sub> capture, biomass and radioactive materials.



**Dr. Ted Knowlton, Fellow:** Ted has 46 years experience in particle technology. He has worked on FCC technology, cokers, polyolefin, MTO, maleic anhydride, acrylonitrile, TiO<sub>2</sub>, polycrystalline silica, gasification, pyrolysis, sulfur capture, CO<sub>2</sub> capture, and mining. He has developed well-known processes such as HYGAS, U-GAS, PEATGAS, RENUGAS, HYTORT, PFH and is the developer of the L-valve.



**Mr. John Findlay, Technical Consultant:** John has 34 years of experience in particle technology and fluidization. He has worked on FCC technology, cokers, polyolefin, TiO<sub>2</sub>, coal gasification, pyrolysis, sulfur capture, CO<sub>2</sub> capture, and biomass.



**Dr. Ray Cocco, President and CEO:** Ray has 27 years experience in reactor engineering, modeling, fluidization, and particle technology. He has worked on ceramic processing, oxydehydrogenation, pharmaceutical hydrogenation, catalytic oxidation, hydrogenation, hydrodesulfurization, composite materials, biomass, chemical looping, polyolefin, chlorination and oxychlorination.



**Dr. Greg Mehos, Technical Consultant:** Greg has 20 years of experience in hopper and feeder design, design of gravity reclaim systems, spray dryers, and analysis of purge columns.. He has worked with pharmaceutical formulations, wet granulation, fumed metal oxides, biomass gasification, pigments, and emulsification.



**Dr. Ben Freireich, Technical Director:** Ben has 8 years of experience in particle technology and has recently been listed as one of AIChE's 35 under 35. He has worked on a wide range of reactor engineering and solids processing problems including catalyst deactivation and attrition, bin design, fluidized beds, pneumatic conveying, mixing and blending, segregating systems, size reduction, etc.



**Dr. Manuk Colakyan, Technical Consultant:** Manuk has 30 years experience in reactor engineering and solids processing. Notably, he was instrumental in the R&D efforts for the commercialization of the Unipol process. He also has experience with multiphase flow systems, heat and mass transfer and super critical fluids.



**Dr. Ulrich Muschelknautz, Technical Consultant:** Ulrich has 27 years experience in particle technology with emphasis on cyclone design and optimization as applied to the energy and chemical sectors. Of late, he has been involved in the R&D efforts for the next generation of axial separators.

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