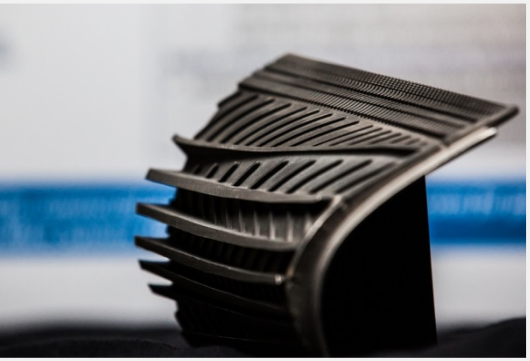
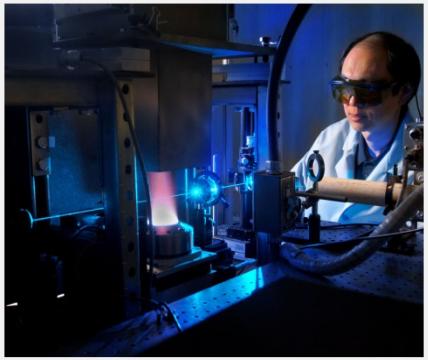
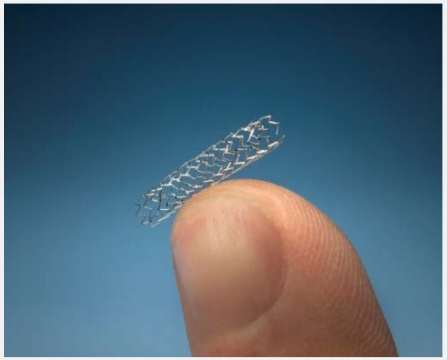
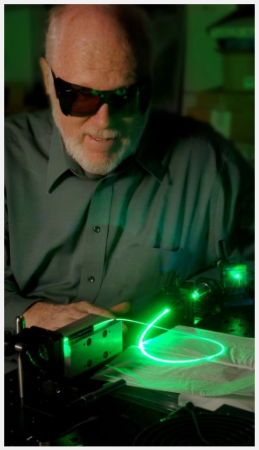
Driving Innovation ♦ Delivering Results



REMS Activities in the Thermal Science Team

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The 41st International Technical Conference on Clean Coal & Fuel Systems

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U.S. DEPARTMENT OF ENERGY | National Energy Technology Laboratory

Thermal Science Team: The Mission

The mission of this team is to support ORD's ongoing research and FWP activities associated with Thermal Sciences focusing on advanced energy conversion processes. This includes understand the needs/opportunities of the existing FWP portfolio and suggestion solutions based on the teams expertise with homogeneous and heterogeneous reactor configurations for applications ranging from pressure gain combustion to chemical looping. The team will also consider cutting-edge reactors that aren't being currently funded as future projects or supplemental externally funded proposals.

What we actually do

- **Characterize reacting and non-reacting, homogeneous and heterogeneous flows in reactors from about 1 inch in diameter to about 24 inches in diameter.**

Aerothermo-Dynamics & Heat Transfer

Conceive and test aerothermo-dynamic and heat transfer systems

Design, build and test thermal management concepts for advanced power systems

Innovative Energy Concepts

Conceive, model, test and prototype energy-conversion systems

Capability to design, build, and test prototypical advanced energy conversion systems

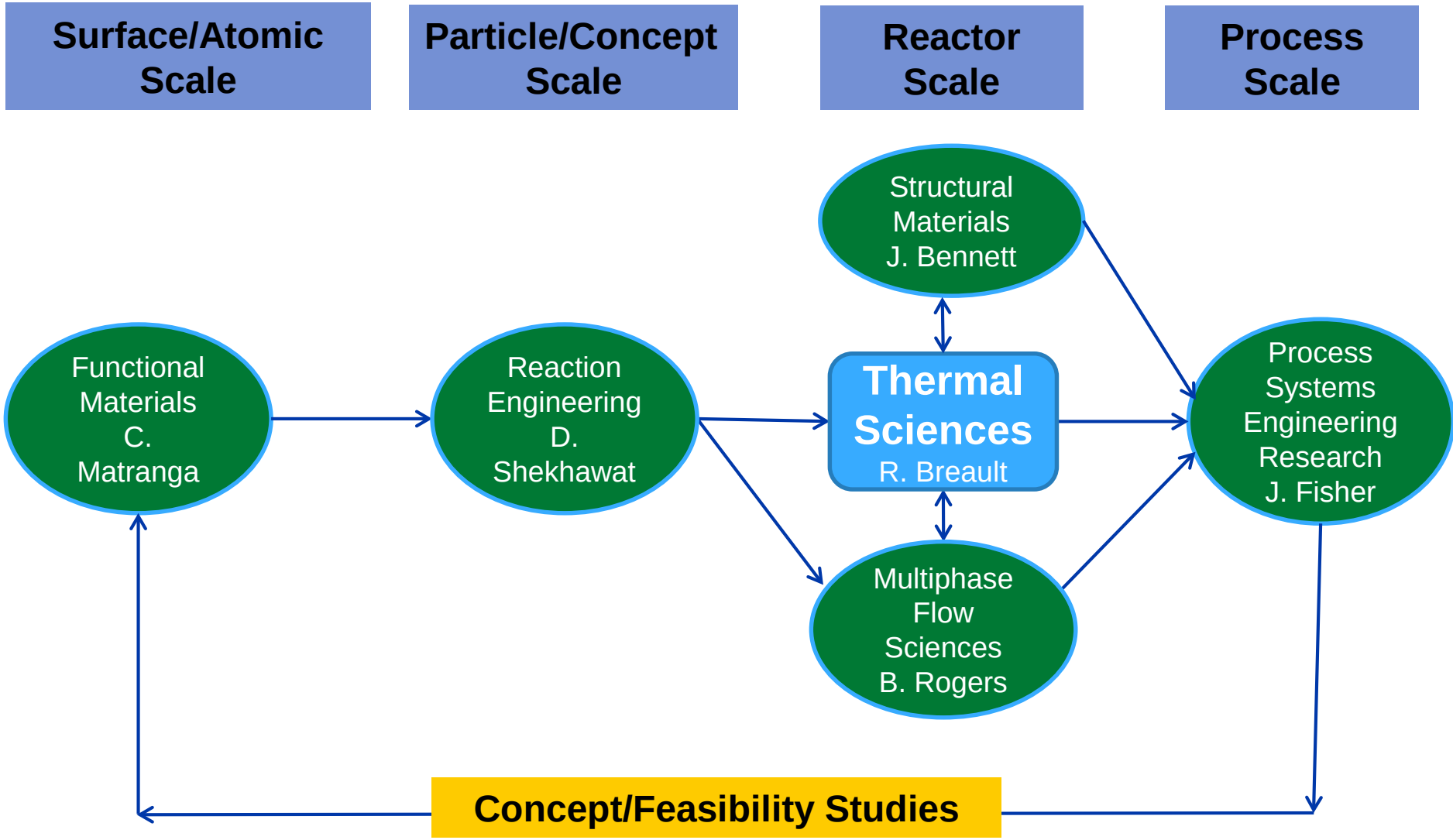
Multiphase Flow Hydrodynamics

Develop necessary fundamental relationships for multi-phase fluid dynamic systems that can be used to better understand requirements for reactor development

Multiphase Flow Reactors

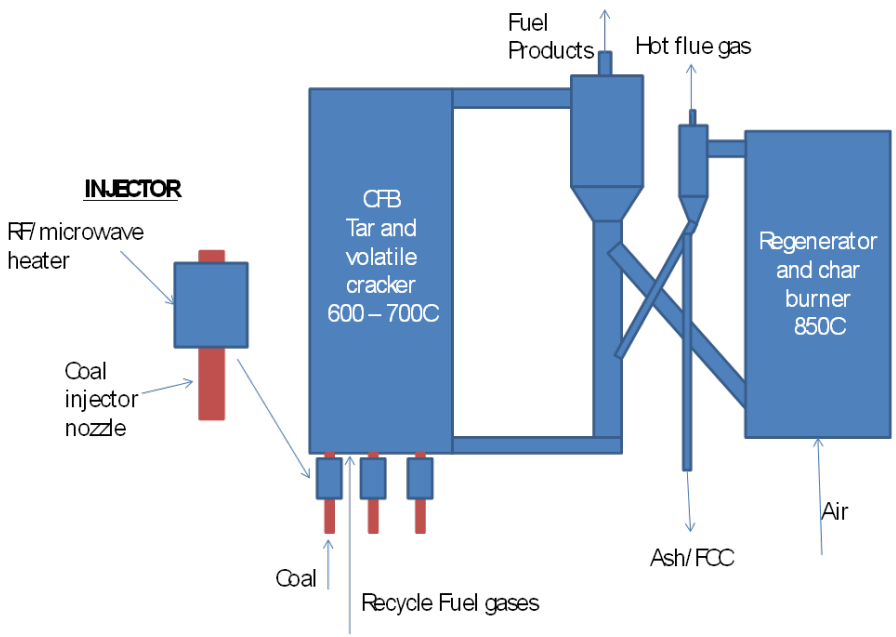
Understand application requirements that would benefit from fluidization technology and then conduct the necessary R&D for successful process development of fluidized reactor systems.

REMS Team Integration and Lead



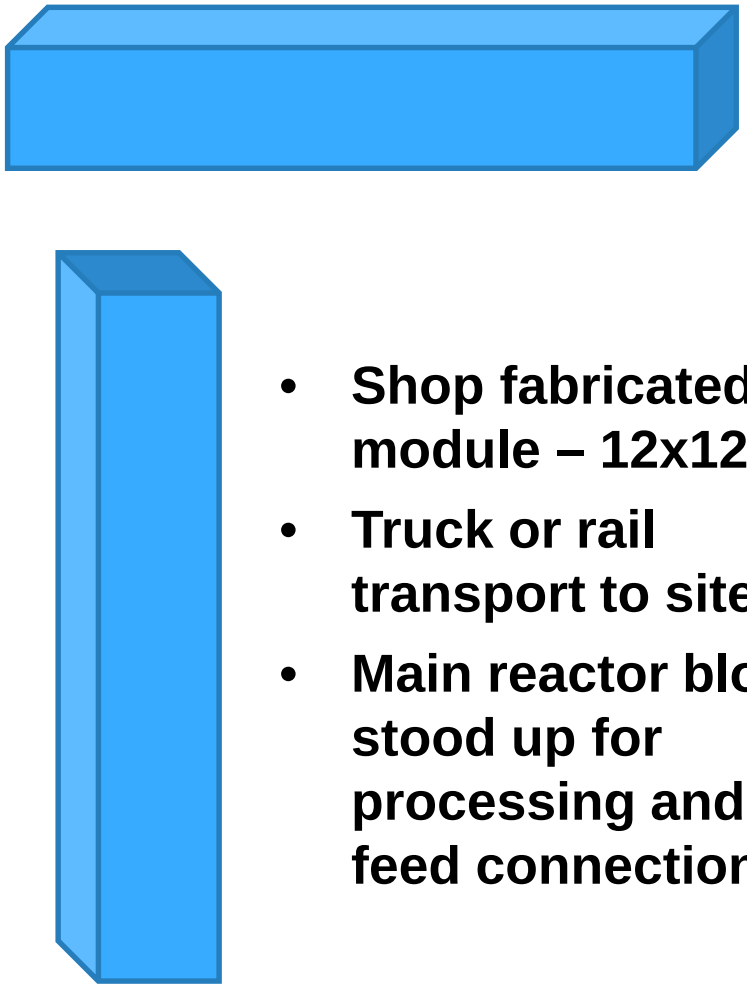
Current REMS Focus within the TST

Concept – Modular Coal to Fuels



- This configuration showing two interconnected circulating fluidized beds.
- Coal and/or biomass is fed through microwave injectors where it is heated at a very high rate to produce a devolatilized mixture of tar and char which is fed into the CFB cracker.
- The regenerator could be conducted in a moving bed or even in a chemical looping combustion system with pyrochlore (carrier and catalyst in one).
- Cyclic-rich compounds are evolved from the microwave interaction. Tars can be cracked and produce desired chemicals while char is transferred to catalyst regenerator for oxidation.
- An alternative configuration might include gas/particle separation between the microwave treatment unit and the catalytic reactor.
- This would eliminate ash fouling/posing of the chemical production catalyst.

Current REMS Focus within the TST -----Continued------



- **Shop fabricated module – 12x12x50**
- **Truck or rail transport to site**
- **Main reactor block stood up for processing and feed connection**

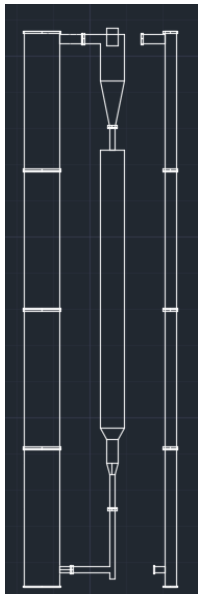
Research focus

- **Cold Flow Investigations**
  - Jet mixing in CFB product reactor
  - Solids separation between microwave injector and CFB
  - Riser internals to promote better reaction in “short” riser
- **Hot reactor investigations**
  - Sub-Scale Reactor/Component Evaluations in Reacting Environment
  - Full-Scale Reactor/Component Evaluations in Reacting Environment

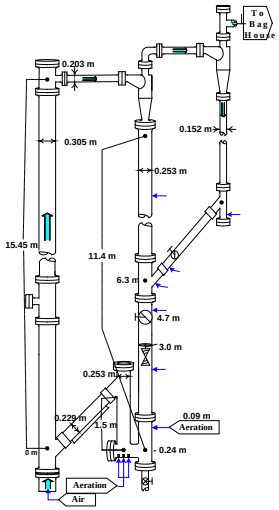
Current Activities: Characterization of Dense and Lean Feed Jets in Risers and Fluidized Beds

- Little is known about jet flows into risers and fluidized beds.
  - Therefore, the flow fields associated with dense and lean jets into risers and bubbling fluidized beds will be characterized to identify gas and solids velocities within the jets and in the surrounding beds.
  - Additionally, gas and solids dispersion (turbulent diffusion coefficients) will be measured as will the solids volume fractions at point locations and using the ECVT system for the compatible geometries. Interphase mass and heat transfer coefficients will be measured for these systems.
- A series of test will be conducted in a pseudo 2-D 3in by 12in riser and in the 12 in CFCFB riser.
- Initially, in FY 16 HDPPE material that is florescent will be used.
- Other material may be obtained in FY17 to understand density and/or particle size effects.
- The use of bed internals will be examined in FY17/18 to enhance flow field for active wall effects in future REMS systems.

New 2D/4in Riser CFB



Existing 12in CFCFB

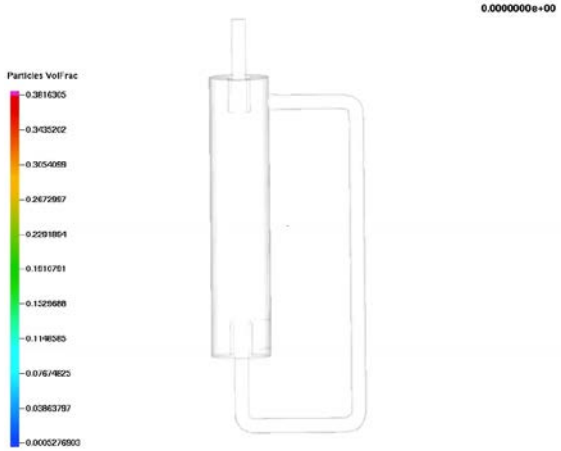


Current Activities: Rotating and Vortexing Fluidized Bed Characterization

- **The vortexing circulating fluidized bed uses the vacuum at the center to drive an external solids circulation stream.**
- **Little is known about these flows. Therefore, the flow fields associated with the rotating fluidized bed and the vortexing circulating fluidized bed will be explored.**
- **Additionally, gas and solids dispersion (turbulent diffusion coefficients) will be measured as will the solids volume fractions at point locations and using the ECVT system for the compatible geometries.**
- **Interphase mass and heat transfer coefficients will be measured for these systems.**
- **A series of test will be conducted in the rotating and vortexing circulating fluidized beds.**
- **Initially, in FY 16 HDPPE material that is florescent will be used. Other material may be obtained in FY17 to understand density and/or particle size effects.**

Rotating Bed

Vortexing Fluidized Bed Characterization



Future Work – FYs 17/18/19

- **Reacting Unit Characterization**
  - It is important to integrate the work being done in the cold flow, kinetics , and cfd groups into an integrated “small” or sub-scale reactor device and to scale this unit or at the least integrate it in a second reactor that is printed with the work the materials group is doing. Therefore, two integrated units are anticipated.
  - Sub-Scale Reactor/Component Evaluations in Reacting Environment
    - In this effort, using conventional or mostly conventional manufacturing techniques, a small sub scale unit will be developed and operated to provide an integrated reactor that can provide cfd validation and engineering data.
    - To that end, it is expected to build an integrated unit consisting of a microwave injector, a hot separator and a catalytic reactor for the production of cyclic fuels and chemicals.
  - Full-Scale Reactor/Component Evaluations in Reacting Environment
    - A second unit will be developed and built using advanced manufacturing techniques being developed in the project. 3-D multi material printers will be used to make the reactor system devices.
    - Tests will be conducted to evaluate the effect of these new techniques and compared with earlier tests, providing both validation and engineering data.

Disclaimer

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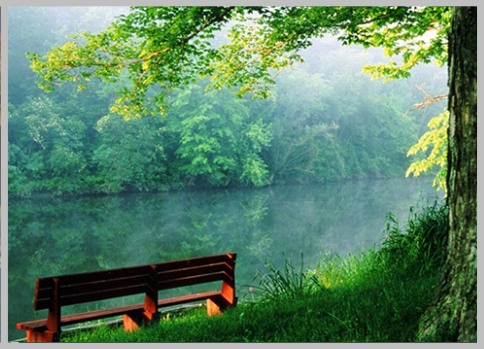
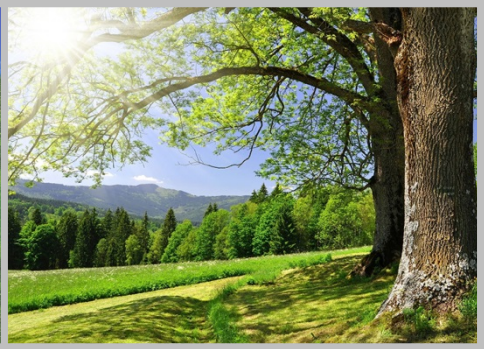
It’s All About a Clean, Affordable Energy Future



Questions