GENERAL PROJECT OVERVIEW

- Determination of intrinsic heat transfer and mechanical properties over a range of temperatures and particle types and sizes
  - Determination of fundamental radiative heat transfer properties
  - Determination of effective thermal conductivity and thermophysical properties for the particle bed
  - Determination of fundamental mechanical properties related to particulate flow

- Heat transfer modeling and validation
  - Heat transfer modeling coupling flow and heat transfer properties
  - A range of flow experiments at temperatures without and with high-flux solar simulator

- Flow characterization and modeling for different flows, particles, and temperatures
TEAM AND ADVISORY BOARD

PIV Analysis & Flow Modeling

CSP

Heat and Mass Transfer Modelers

Radiative Heat Transfer

Advisory Board

Dr. Cliff Ho
Prof. Hany Al-Ansary
Prof. Sheldon Jeter

?
Accessible database/publications containing “first of their kind” results related to particulate flows as tools to catalyze next generation solar particle heat receivers/reactors:

• Intrinsic heat transfer and flow properties for particulate flows for a range of particles
• Particulate flow experiments and models
• Simple to complex experiments for a range of particles, temperatures, and flow configurations
• Validated heat and mass transfer models
Examine radiative heat transport through a range of packed beds between 25 – 800 °C and 0.35 to 16 μm and using a range of modeling techniques (e.g., Monte Carlo ray-tracing)

- Measure the spectral emissivity from the sample
- Measure scattering and determine the scattering phase functions
- Develop a method to characterize the boundary conditions
Specific heat, density, etc. would be measured in-house via heat lab user facility

Preliminary effective thermal conductivity correlations that have been validated flow characterizations up to 1300 °C

Effective thermal conductivity measurements:

• Prof. Shannon Yee’s Gen3 proposal to fabricate an inline immersion electrothermal instrument

Georgia Tech’s user facility: Mechanical Properties and Characterization Facility

• Young’s modulus
• Poisson’s ratio
• Dynamic coefficient of friction, etc.
Tilt flow rig modifications

- Tube furnace to heat particles
- Window to control environment
- Near-IR camera to measure spatial temperature
- Addition of impediments and upward flows to assess a range of flow configurations

Measurements

- Surface temperature (to assess heat transfer models)
- Surface velocity profiles and mass flow rate
- Validations for flow and heat transfer modelling

Modeling: Flow modeling with LIGGGHTS (a discrete element method particle simulation software)
Heat and mass transfer modeling with a commercial code using inputs from

- Radiative heat transfer characterization
- Thermochemical properties and effective thermal conductivity

Validation

- Tilt flow rig experiments using spatial temperature and velocity measurements and mass flow
PROJECT FLOW: YEAR 1

Baseline materials (Sintered Bauxite)

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>Carbo HSP</td>
<td>Sintered Bauxite</td>
</tr>
<tr>
<td>CarboProp 40/70</td>
<td>Sintered Bauxite</td>
</tr>
<tr>
<td>CarboProp 30/60</td>
<td>Sintered Bauxite</td>
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<tr>
<td>Accucast ID50K</td>
<td>Sinter Bauxite</td>
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<td>Accucast ID70K</td>
<td>Sintered Bauxite</td>
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<tr>
<td>Fracking Sand</td>
<td>Silica</td>
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</tbody>
</table>

Intrinsic property determination

Flow characterization and modeling

Advisory Board and Workshop

Report of results

Upload results to database

Journal/conference publications
PROJECT FLOW: YEAR 2

Advisory Board/workshop inputs

Intrinsic property determination

Flow characterization and modeling

Advisory Board and Workshop

Heat and mass transfer modeling & validation

Report of results

Upload results to database

Journal/conference publications

Advisory Board/workshop inputs
PROJECT FLOW: YEAR 3

Advisory Board/workshop inputs

Characterize and model advanced flows

Heat and mass transfer modeling & validation

Report of results

Upload results to database

Journal/conference publications
• We have proposed to extend the state-of-the-art for particulate flows related to CSP
• The proposed work addresses a **significant** gap related to particulate flows at elevated temperatures
• Our team combines expertise from CSP, fundamental radiative heat transfer, flow characterization to create important synergies for successful completion of project objectives