GEN3D – Experimental and Numerical Development of GEN3 Durability Life Models

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Team Summary

- University of Tulsa
  - Home to Erosion/Corrosion Research Center, focuses on developing predictive tools and erosion characterization for oil/gas pipelines
  - Developed expertise in wide range of other solar thermal technologies and mechanical characterization
- Sandia National Labs
  - Leading particle pathway topic 1, as well as additional topic 2 awards on particle system

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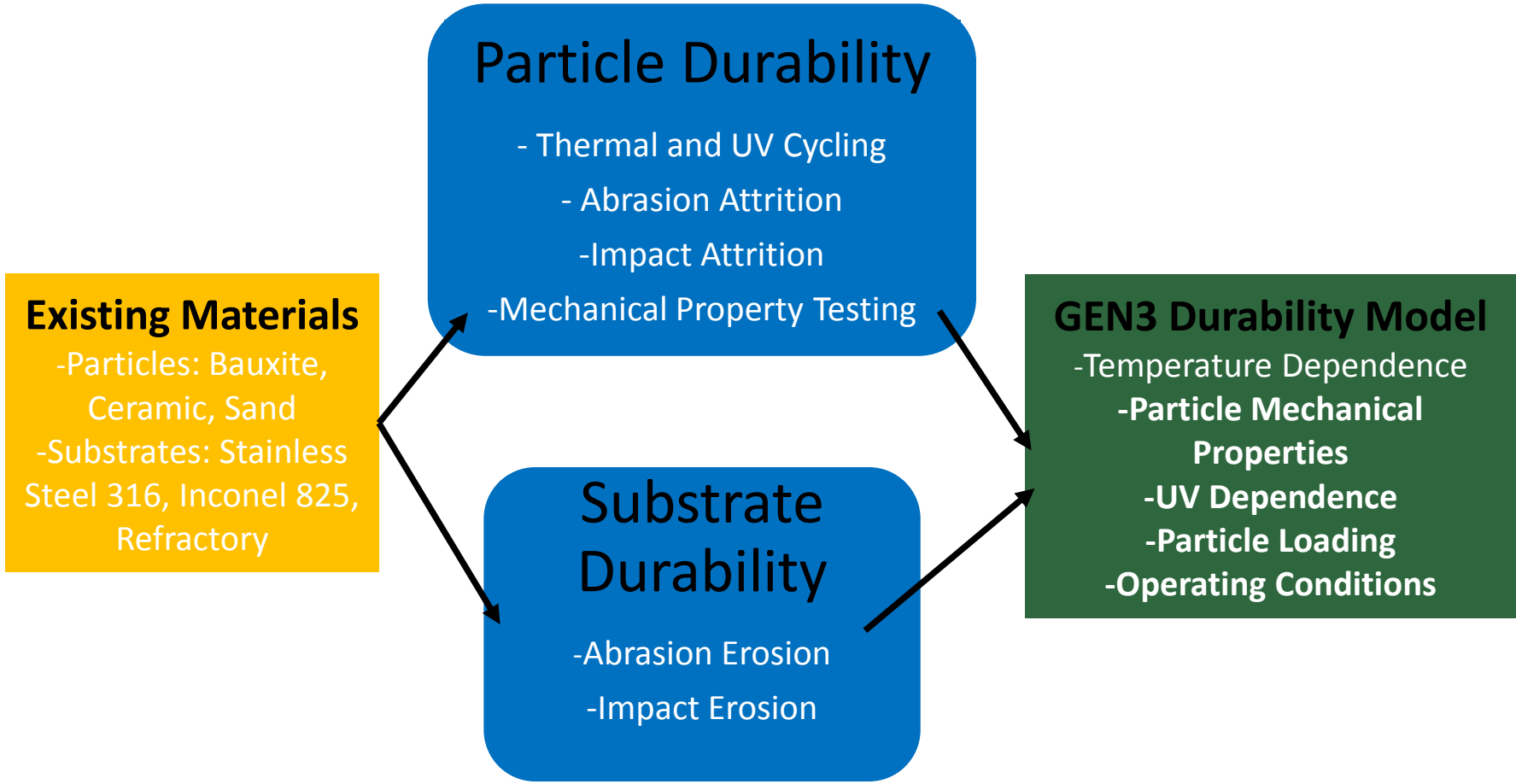
Project Summary: GEN3 Durability Models

- Development of experimental facilities
- Mechanical property characterization under relevant Gen3 conditions
  - High temperatures - 700 C
- Complete testing of 3 candidate particles and substrate materials
- Development of comprehensive durability model
  - Wear rates
  - Optical property changes



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Impact to GEN3 CSP Goals

Comprehensive study of particle and substrate degradation will provide:

- information to particle-based CSP component developers on erosion and attrition rates based on operating conditions
  - What conditions should be avoided to enable 30-year component lifetime?
- information to system-level technoeconomic studies on particle replacement and overhaul intervals
  - How does particle replacement/degradation due to attrition and optical properties influence LCOE?
- a database of particle and substrate durability to assist in particle selection and model development
  - What is the optimal particle material for a specific plant configuration?

Particle Optical Property Characterization

- Characterize particle optical properties over 1000's of thermal cycles with direct irradiation
- Utilize solar simulator with novel Automated Sample Handling and Exposure System (ASHES)
- Parametric analysis to consider the effect of particle material, temperature, and flux concentration on durability

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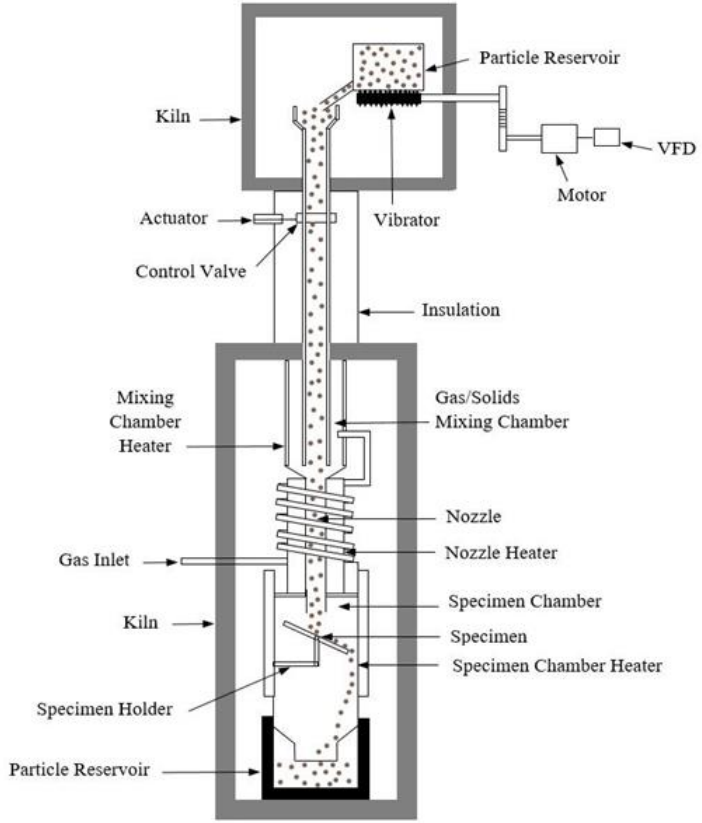
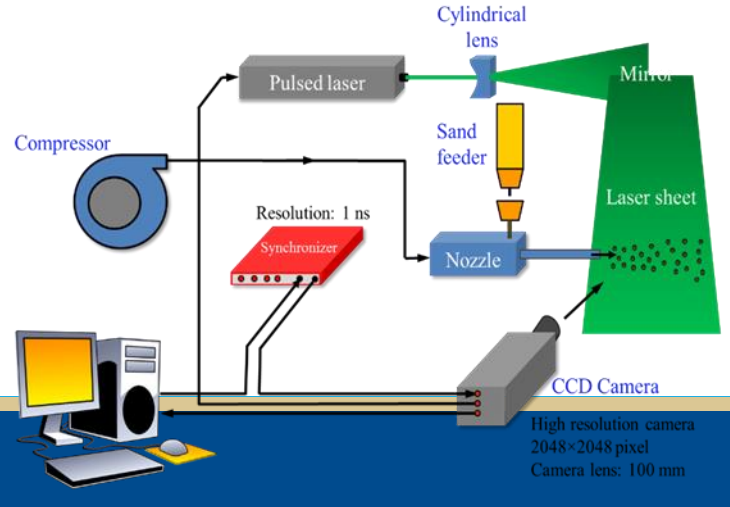
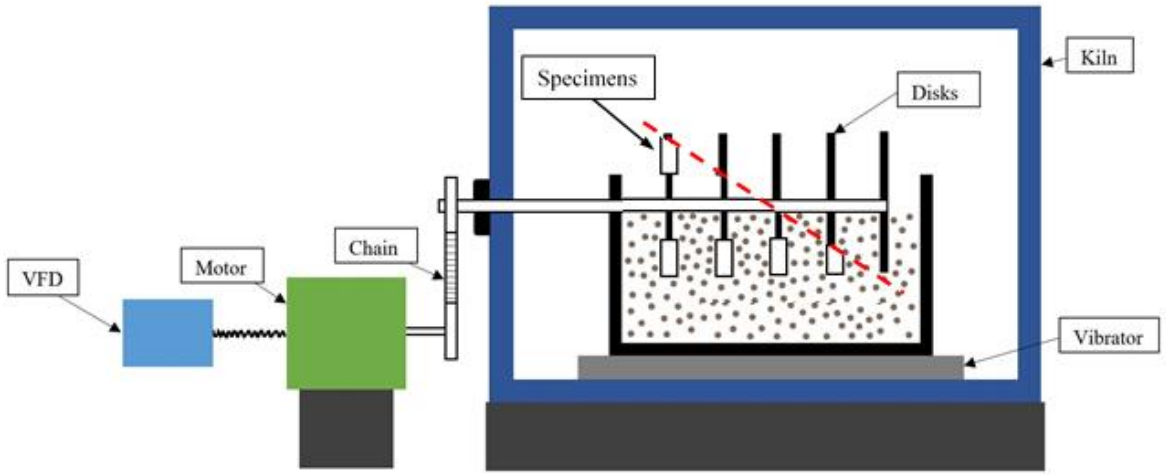
Impact + Abrasion Erosion

- Design and construction of novel experimental setups to simulate impact & abrasion erosion in GEN3 relevant conditions.
- Perform abrasion and impact erosion testing to quantify the changes in material behavior.
- Characterization of substrate and particle erosion associated with impact at temperatures up to 700 °C.







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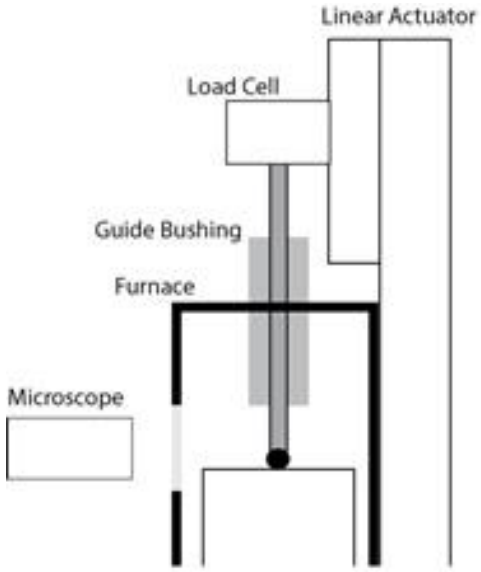
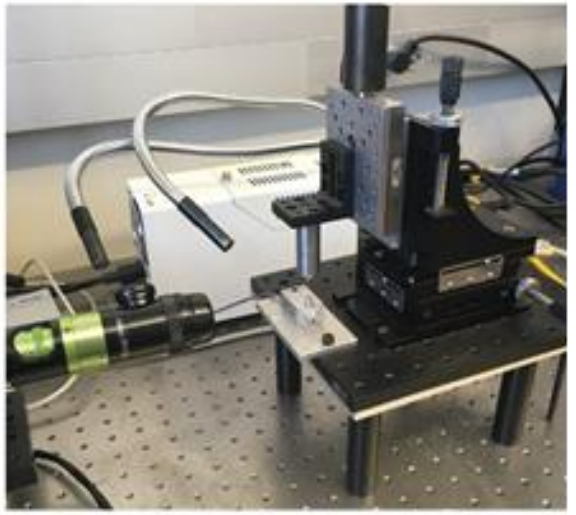
Particle Mechanical Properties

- Perform mechanical testing through direct micro-compression of the candidate material properties at low (25 °C) and high (700 °C).
- Compare the load-displacement responses of these materials with analytical or computational models to extract material modulus and strength.
- Perform statistical analysis to correlate material parameters with attrition rates measured in the abrasion and impact studies above.



Existing Low-Temp Micro Compression Setup



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Outputs

- Publicly accessible data set of off-the-shelf particles and substrate materials
- Testing facilities for new particles and materials
- Development of life model available for licensing

Areas for Collaboration

- Seeking input on particle, and materials for testing
- Joint efforts on utilizing particles/substrates after erosion
- Potential testbed for demonstrating in-situ characterization techniques
- Collaborative efforts on particle flow modeling with other projects (TU has developed tools for particle tracking/erosion for CFD)