

Applications of Acusolve and Optistruct in the High-Temperature Reformation of Biomass

Dr. Timothy Laska

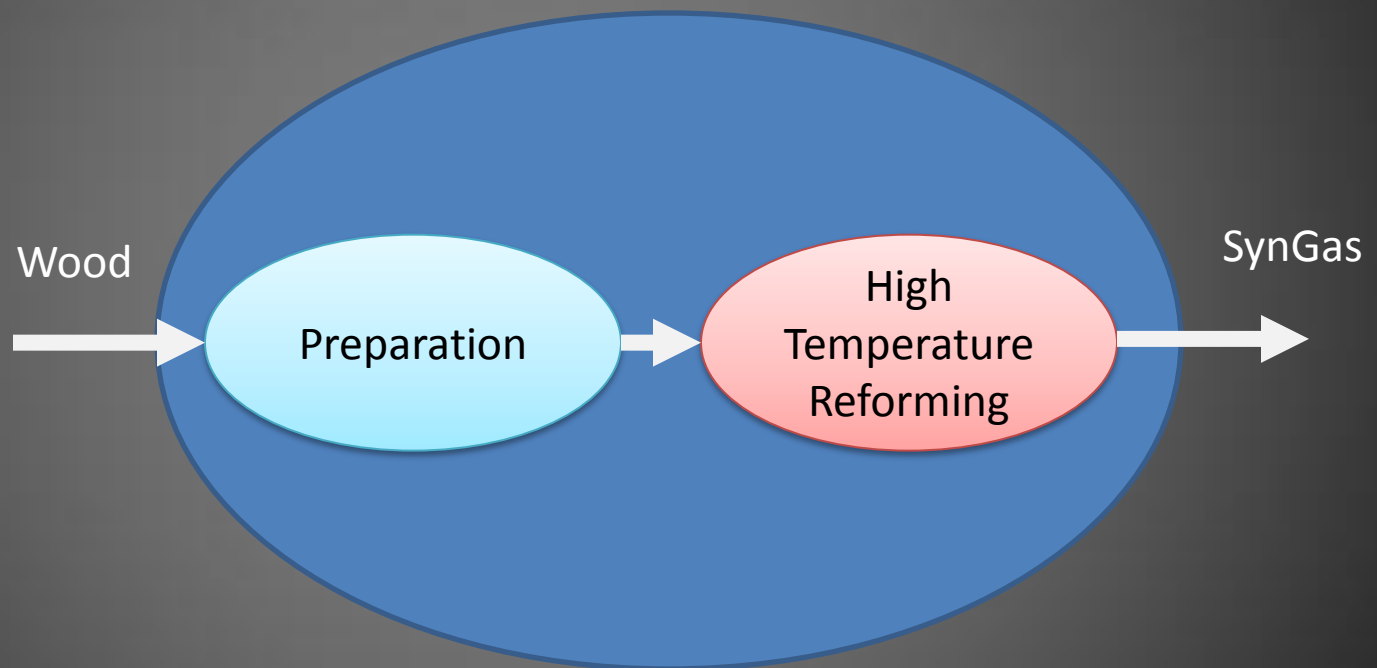
- Biofuels company based in Longmont, CO.



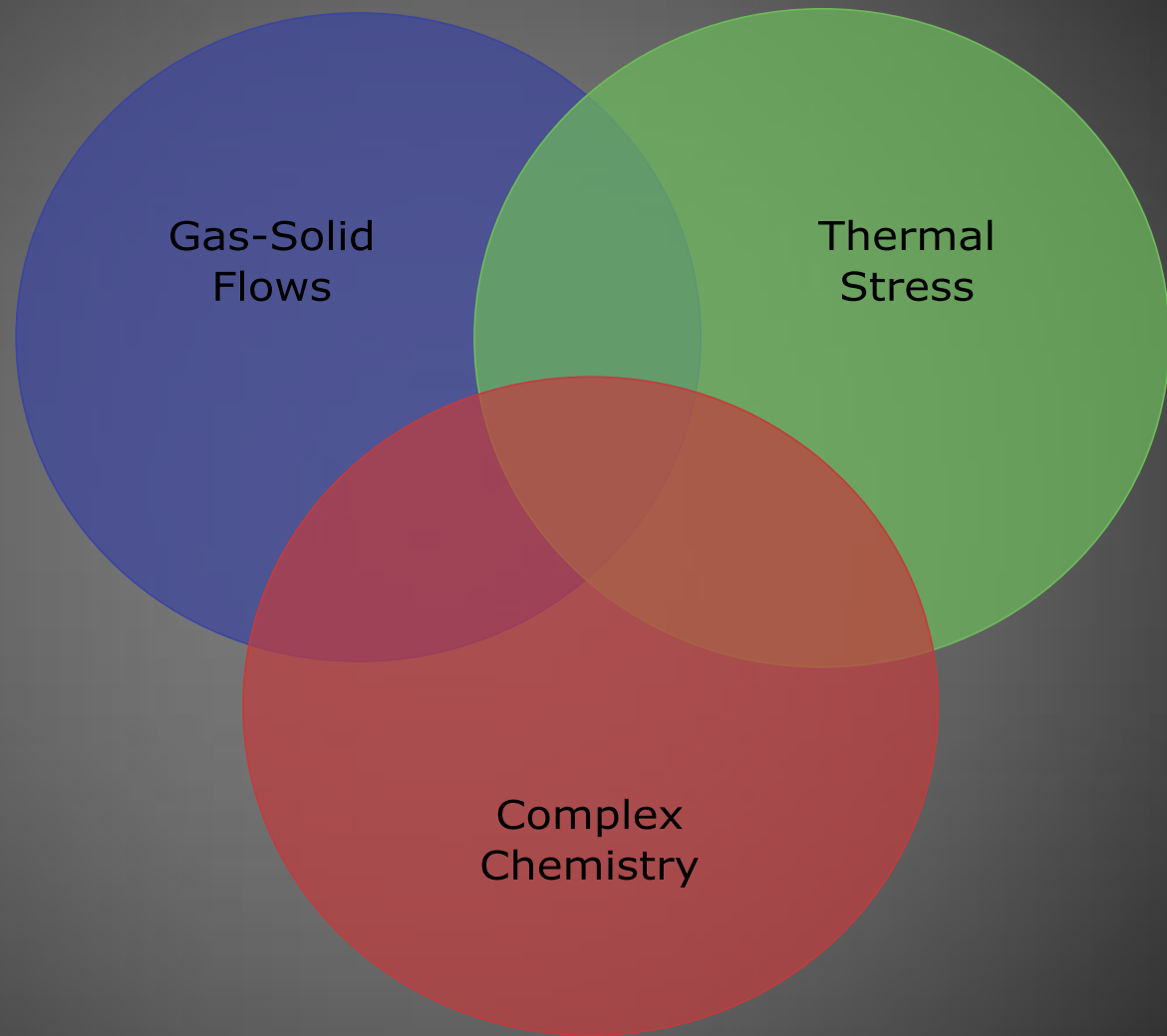
Why are we here?

- To be the leader in converting woody biomass into drop-in transportation fuels.



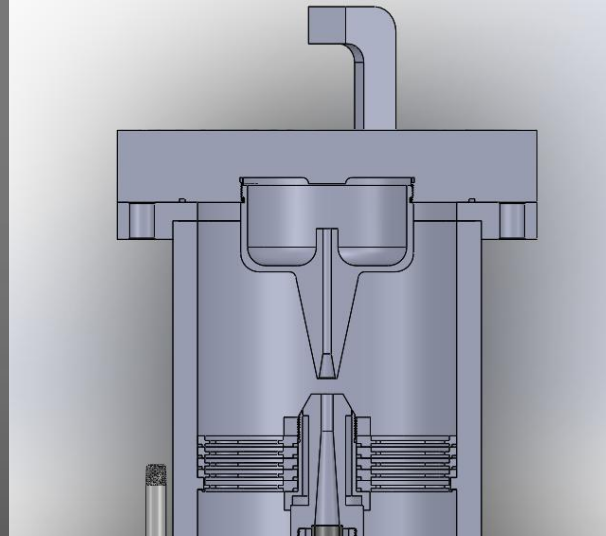


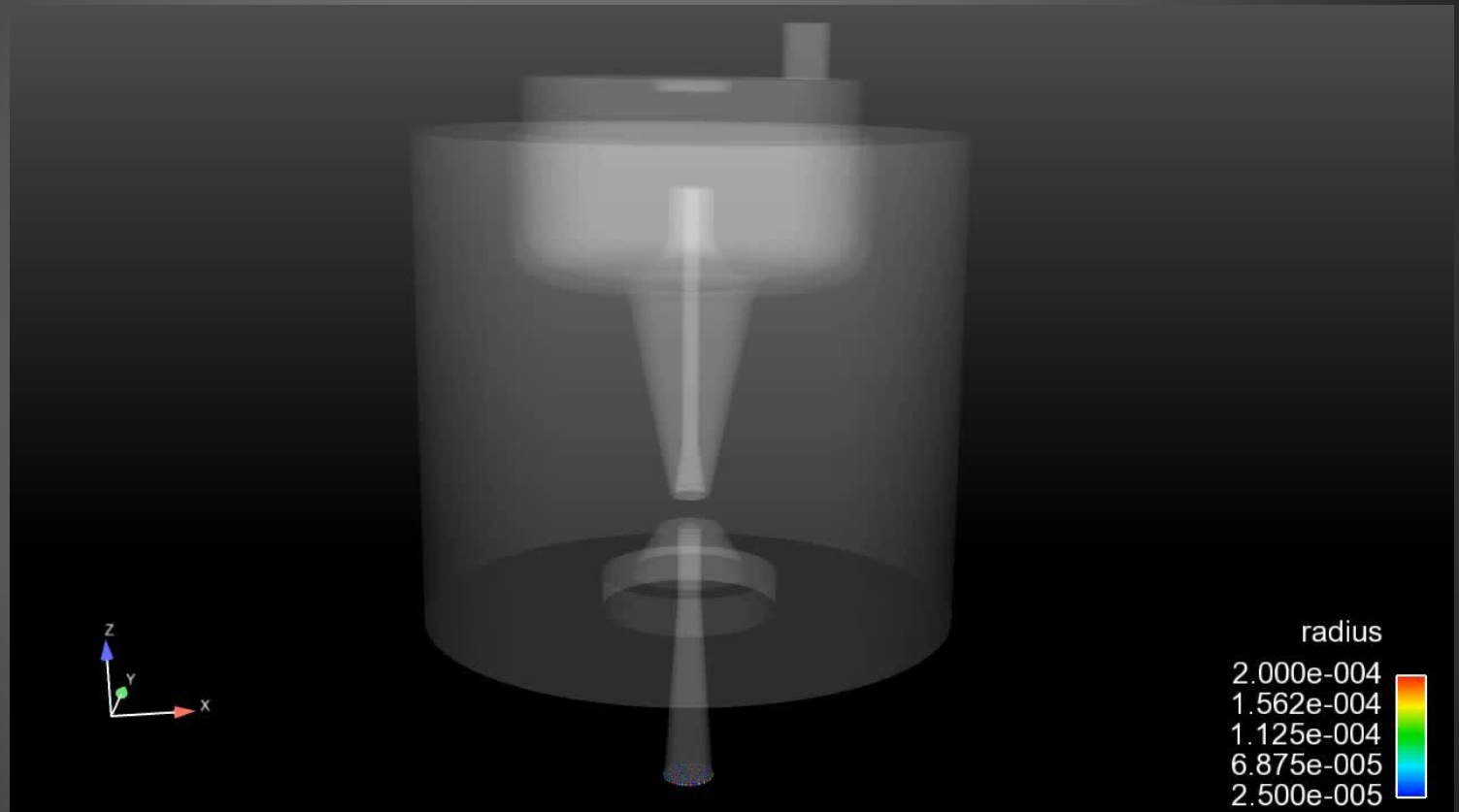
Key Challenges In High T Bioreforming



Small Scale Gas-Solid Separator Classifier

- Purpose: To separate particles from gases by size from a product stream for subsequent analysis
- Altair Technologies: AcuSolve, AcuTrace one-way coupling finite-massed particle tracing.

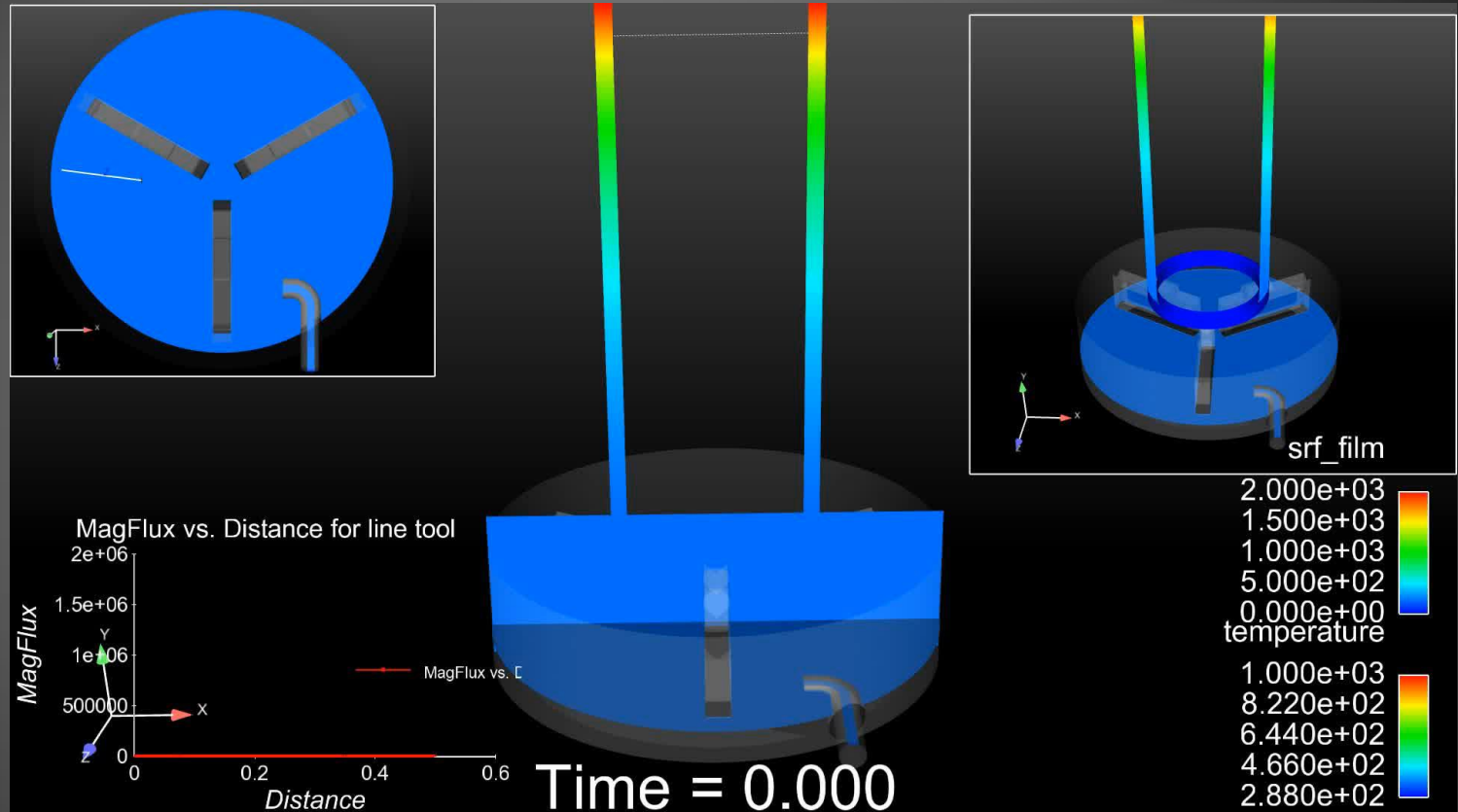




Thermal Stress Apparatus 1

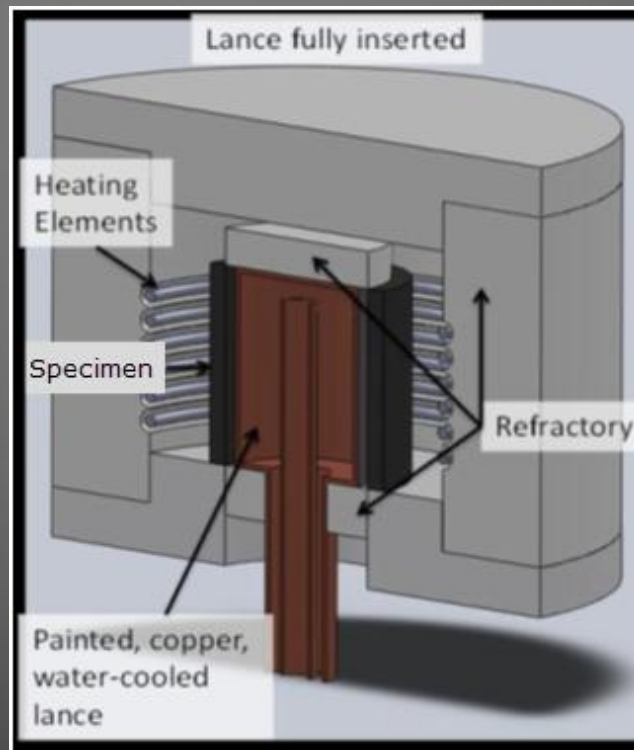
- Purpose: To determine a material's resistance to thermal stress.
- Altair Technologies: AcuSolve sliding-deforming mesh, dynamic LES turbulence model, conjugate heat transfer, and variable physical properties.





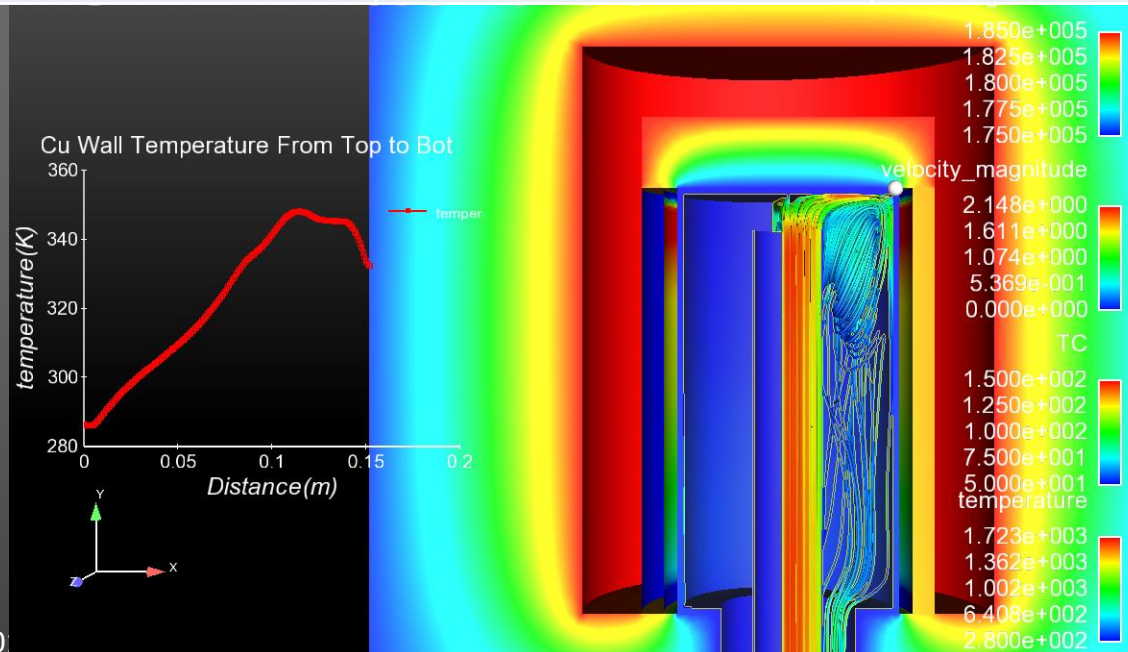
Thermal Stress Apparatus 2

- Purpose: To determine a material's resistance to thermal stress.
- Altair Technologies: AcuSolve Spalart-Allmaras turbulence, conjugate heat transfer, surface-to-surface radiation, OptiStruct thermal stress.



- Excellent heat flux agreement to experiment.
- Low steady-state stress predicted.

Case/Measurement	Experimental (kw/m ²)	Simulated (kw/m ²)
Unshielded	186.8703 (5)	184.723
Shielded	142.15127(5)	140.383



- Rapid insertion of a cold lance into a hot chamber would create a stress spike sufficient to break specimen.

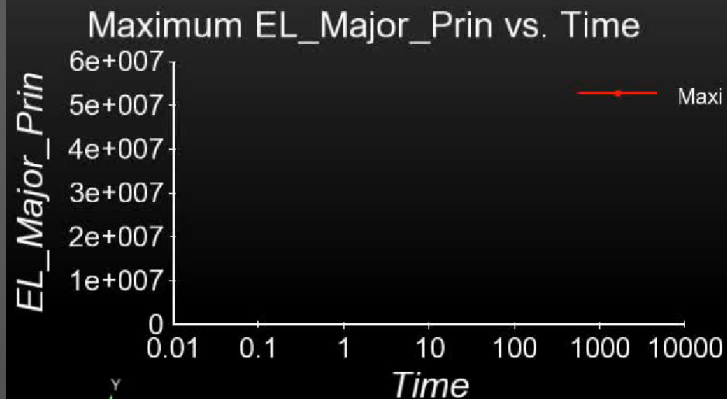


Coupling CFD to FEA

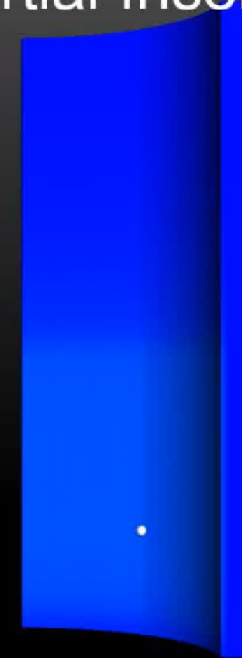
- Map transient temperature fields from CFD to an FEA mesh of specimen using acuProj with elemental interpolation.
- Conduct linear static stress analysis with Optistruct.

- Peak transient stress similar to steady state.
- Insufficient to break specimen—Consistent with observation.
- FEA only simulations from another code predicted breakage.

MTS Transient Analysis Partial Insertion



Time = 0.0000



EL_Major_Prin

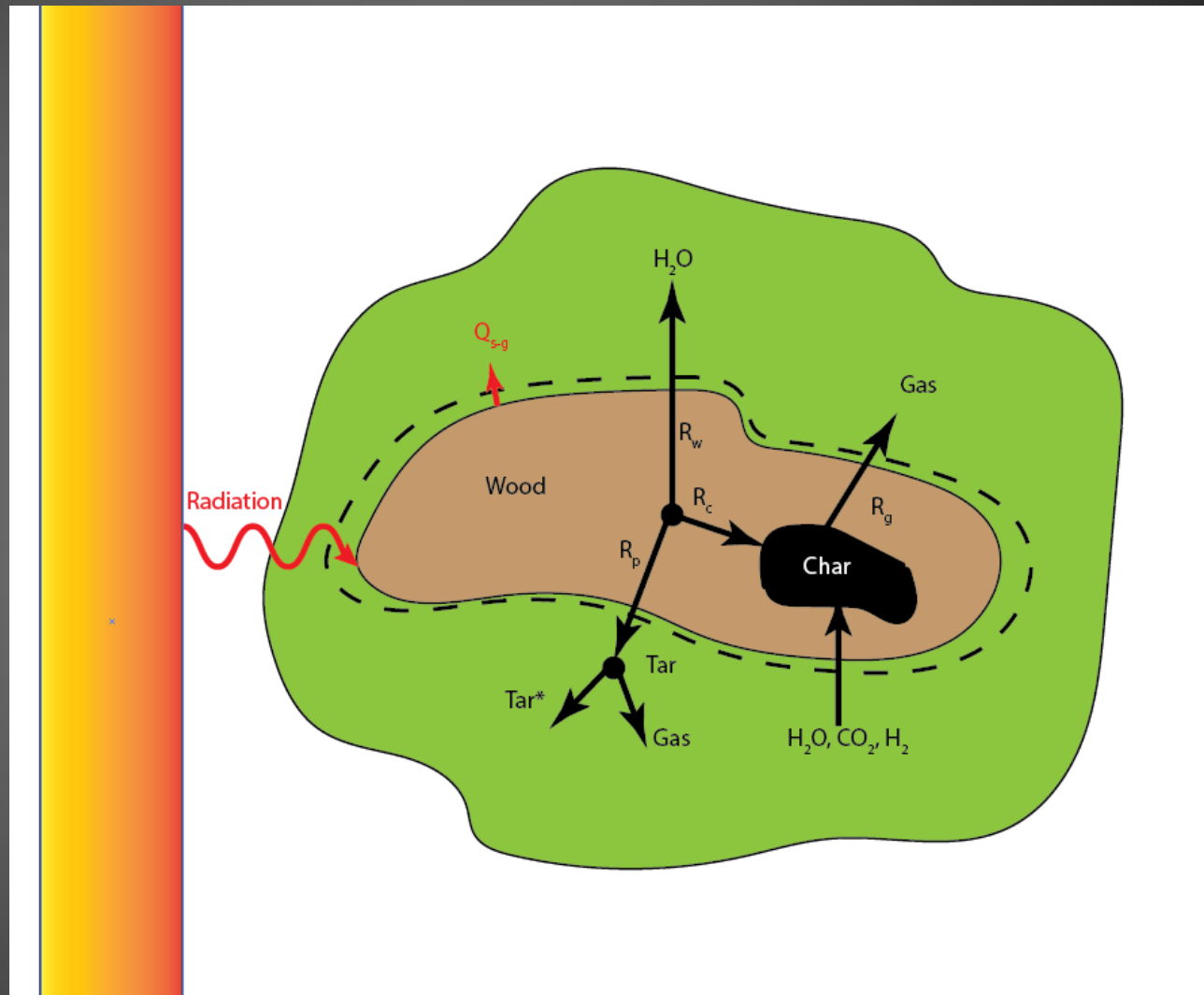
5.100e+007
3.827e+007
2.554e+007
1.280e+007
7.448e+004





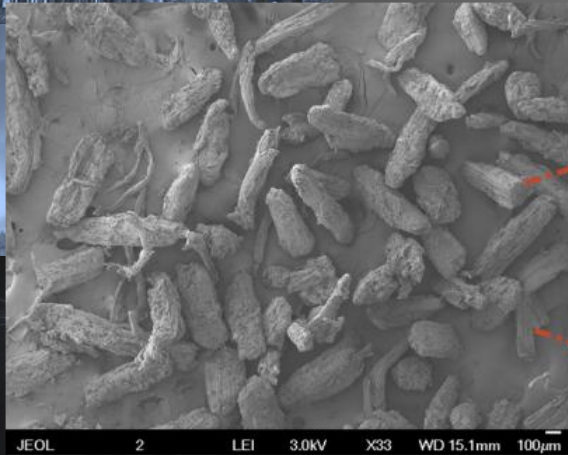
SIMULATING EFFECTS OF CHEMISTRY

Biomass Particle Gasification Model



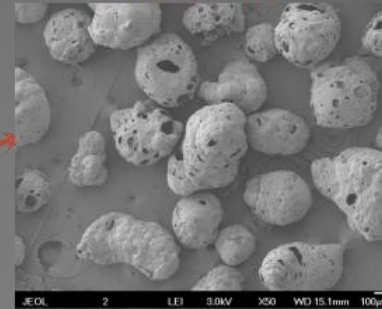
Particle Morphology Evolution - Shape

Feedstock >180 micron

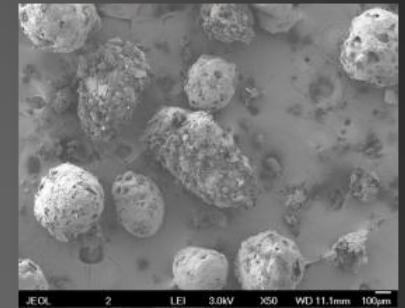


Pyrolysis
2000 ms

Primary Char

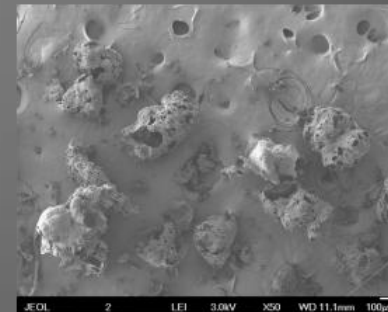


Secondary Char

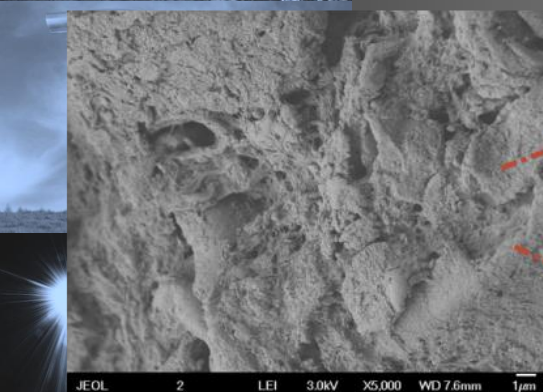


Gasification
3000 ms

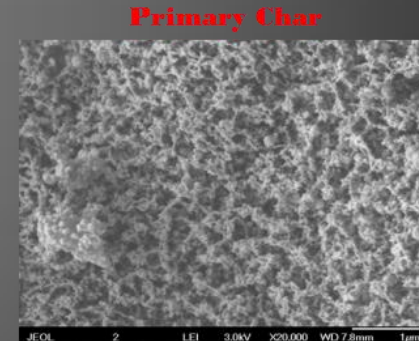
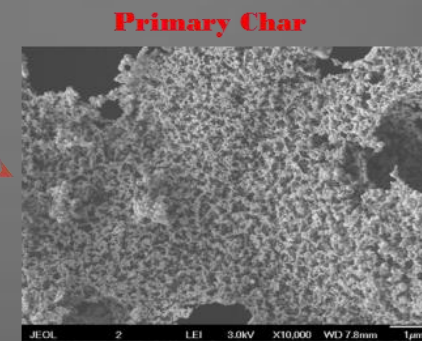
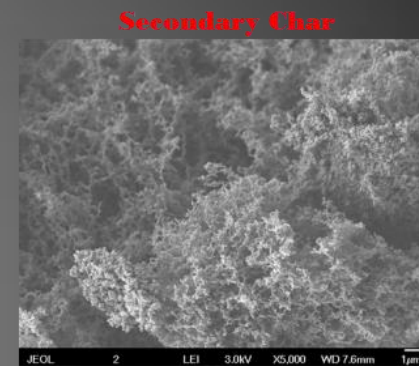
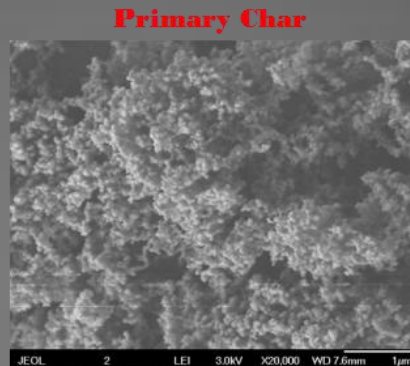
Primary Char



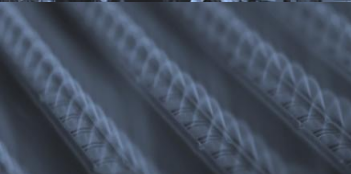
Particle Morphology Evolution - Surface



**Pyrolysis
2000 ms**



**Gasification
3000 ms**



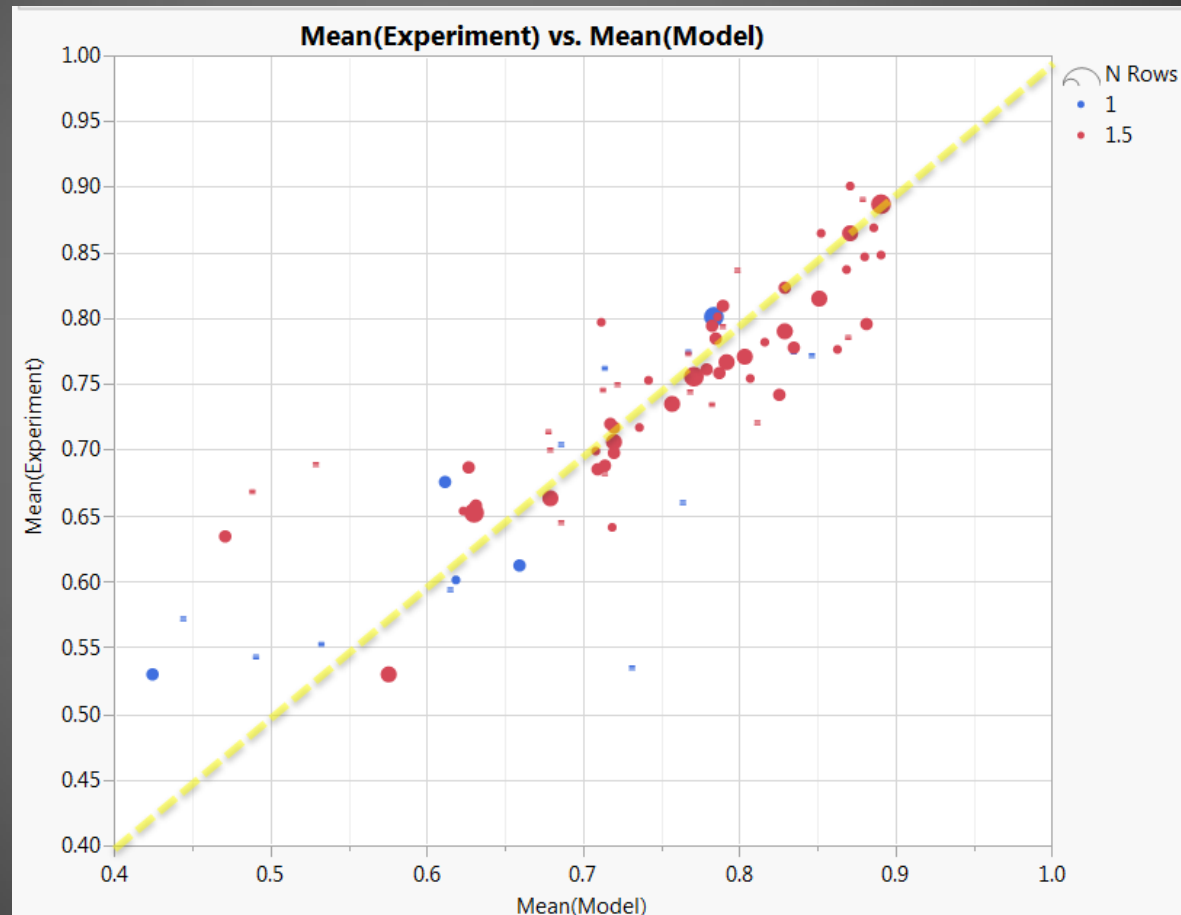
Biomass Conversion Rates

- Depend on reaction mechanism.
 - Current mechanism employs 400 species and 10,000 reactions!
- Depend on an evolving particle size distribution.
 - Proportionally, the mass ratio of largest to smallest particle is the same as a blue whale to a hamburger.
- Depend on evolving particle shape and porosity.
- Physical properties used in CFD depend on temperature, pressure, and composition!

LOGESoft/Sundrop Partnership

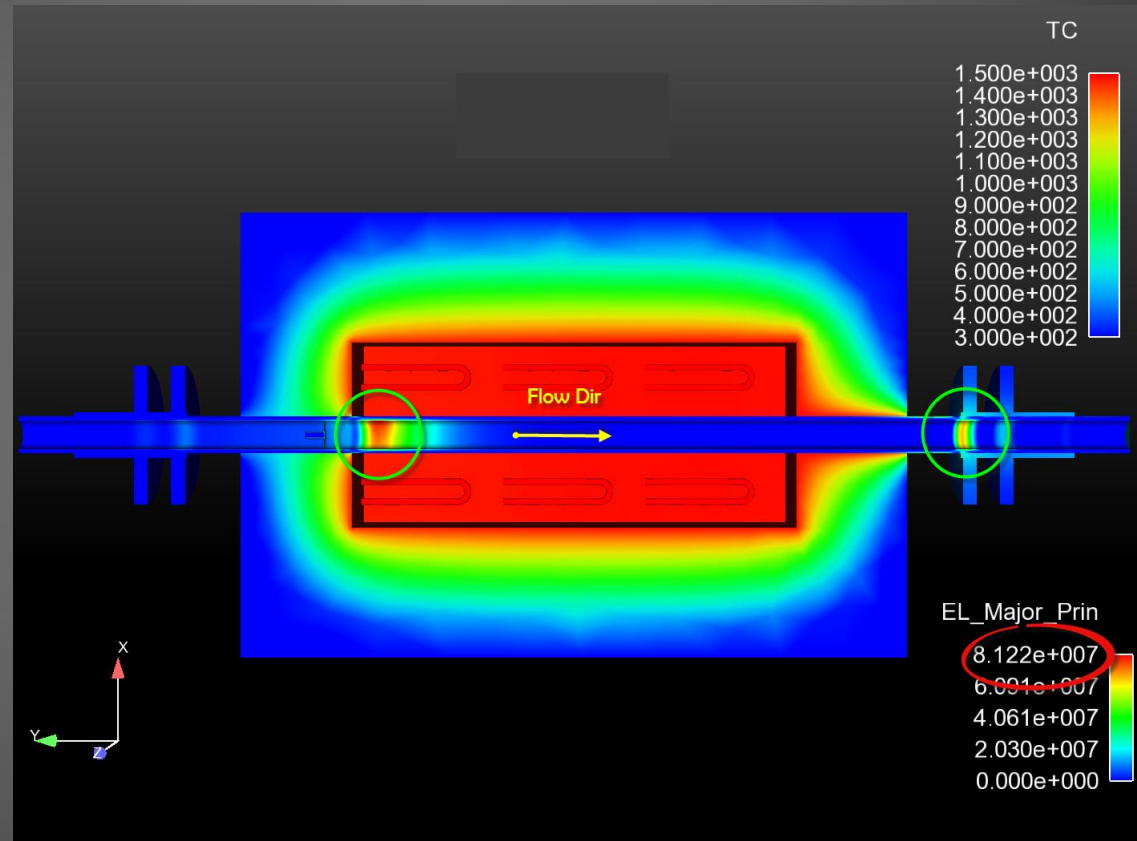
- LOGESoft
 - Creator of the DARS kinetic plug-in to Star CCM+
 - Vast expertise in internal combustion engines.
 - Stochastic reactor allows simulation of mixing effects without CFD simulation
- Sundrop funded development to add gas-solid chemistry to their solver.

- Excellent agreement over a wide range of inputs.



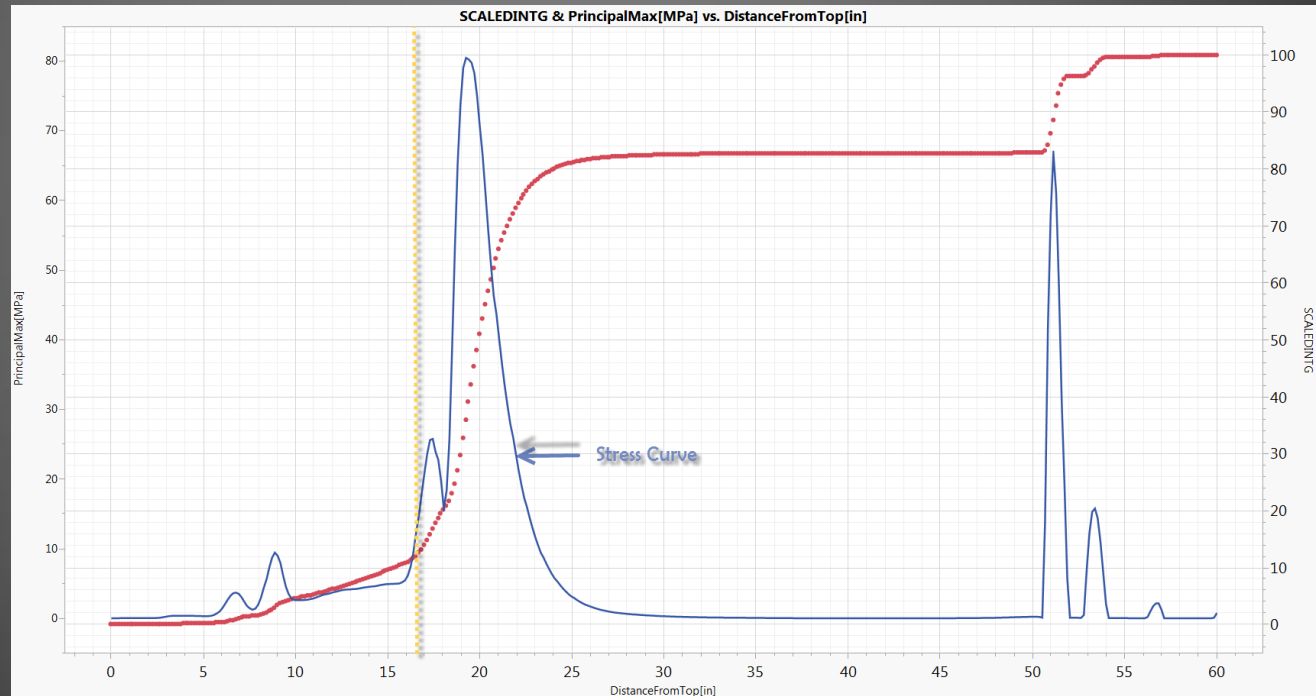
Coupling Chemistry, CFD, and FEA

- Purpose: To model thermal stresses in a laboratory bioreformer.
- Technologies used:
 - LOGESoft to estimate temperature dependent density, viscosity, and enthalpy for the fluid.
 - Altair: AcuSolve Spalart-Allmaras turbulence, conjugate heat transfer, surface-to-surface radiation, user Rosseland radiation model for particle laden fluid, Optistruct for thermal stress.



Surface Stress Distribution

- The distribution of stress cracks is consistent with the OptiStruct surface stress distribution.



- Altair's Hyperworks is:
 - Our work horse for a wide variety of complex multiphysics models relevant to biomass reforming.
 - Fast, accurate, and robust.
 - Easily scalable to larger problems.
 - Coupleable.



THANK YOU!