HALE – REGENERATIVE NOZZLE

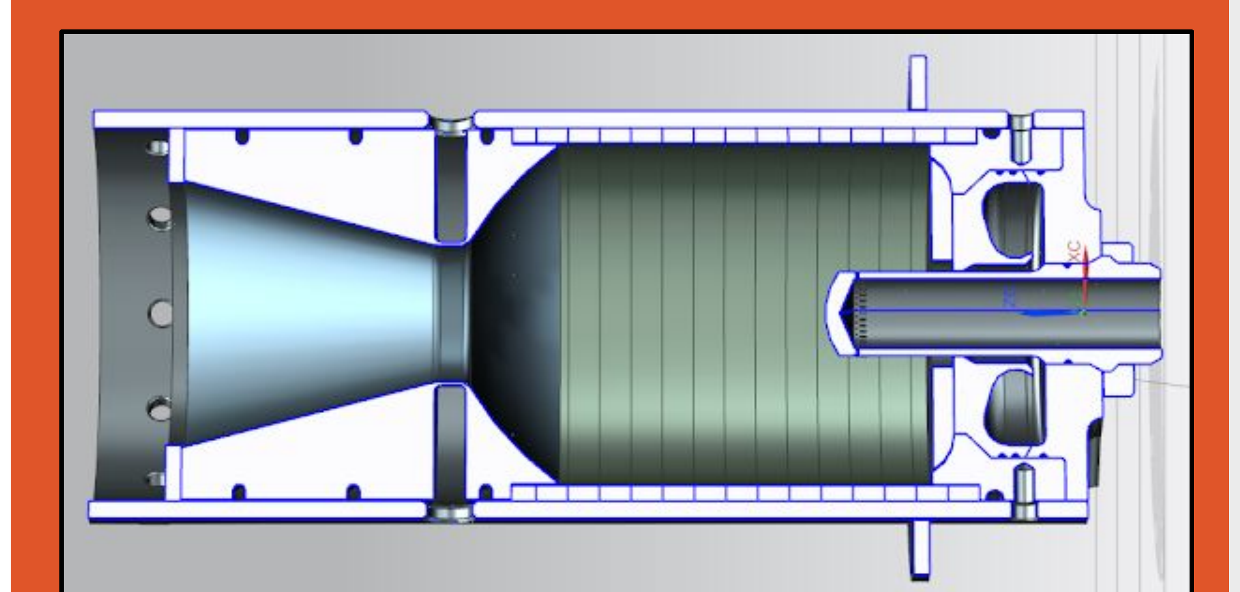
The Oregon State University (OSU) High Altitude Liquid Engine (HALE) rocket team is a student-led, multidisciplinary team comprised of students majoring in business, physics, biochemistry, computer science, and a variety of engineering disciplines. The team's primary focus is on liquid propulsion systems and related launch vehicles. The Regenerative Nozzle Sub-team will provide the HALE team with a prototype and data for cooling of a liquid engine system. Our project uses a water-cooled nozzle for our sub-scale system which will lay the groundwork for future development.

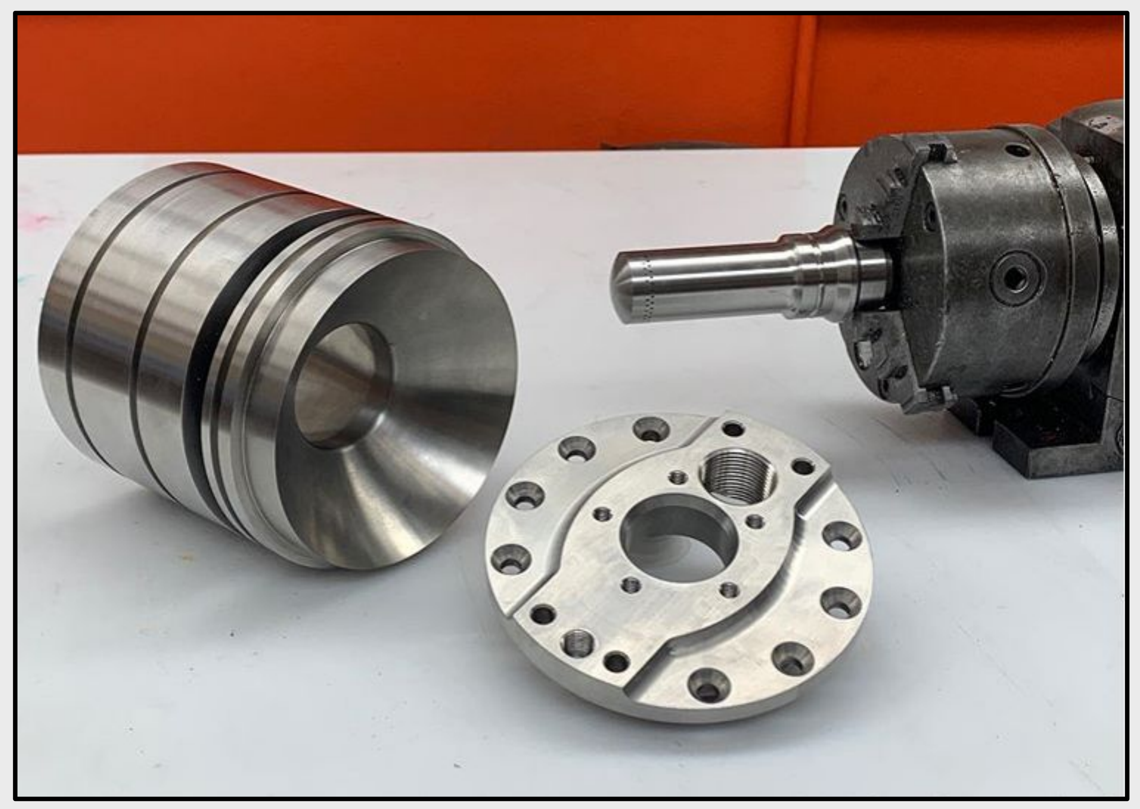
Technical Requirements

- Develop a fixture to measure heat flux at the nozzle throat
- Experimentally determine a heat flux value
- Determine the accuracy of Rocket Propulsion Analysis (RPA) as a design tool
- Complete the design for a regenerative nozzle

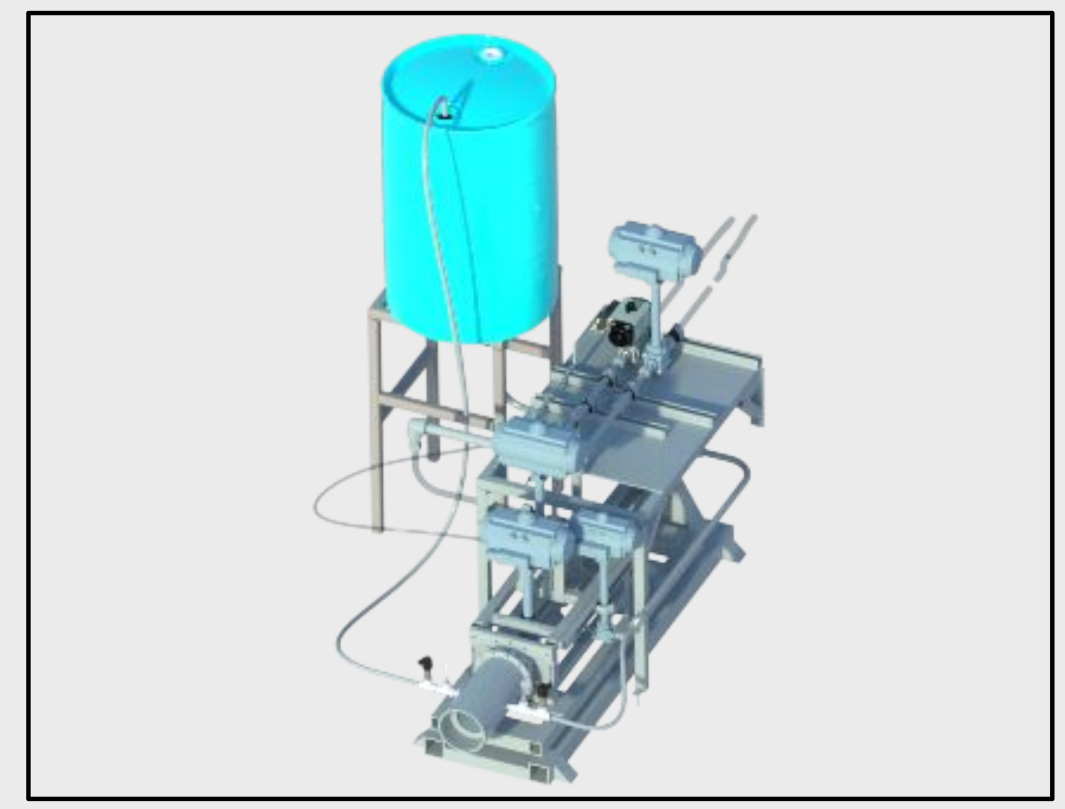
Design Selected

- Water-cooled test fixture
- Annular flow path focusing on nozzle throat
- Thermocouple placement at flow inlet, outlet, and throat wall
- LabVIEW data collection interface
- Heat flux estimation using the Bartz method to estimate hot-gas side convection

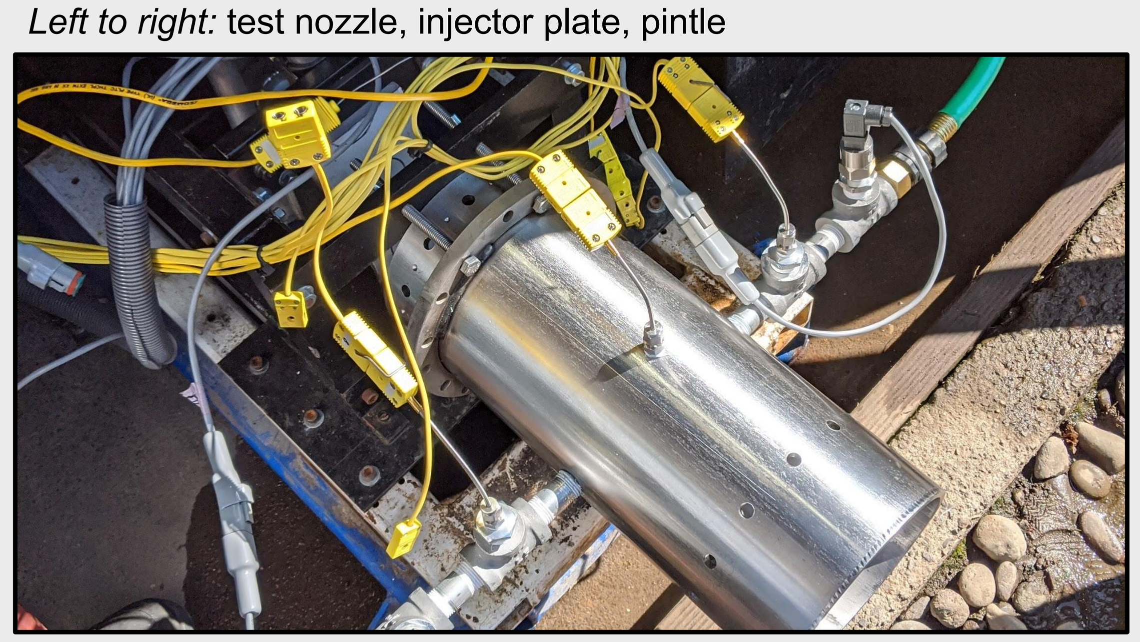




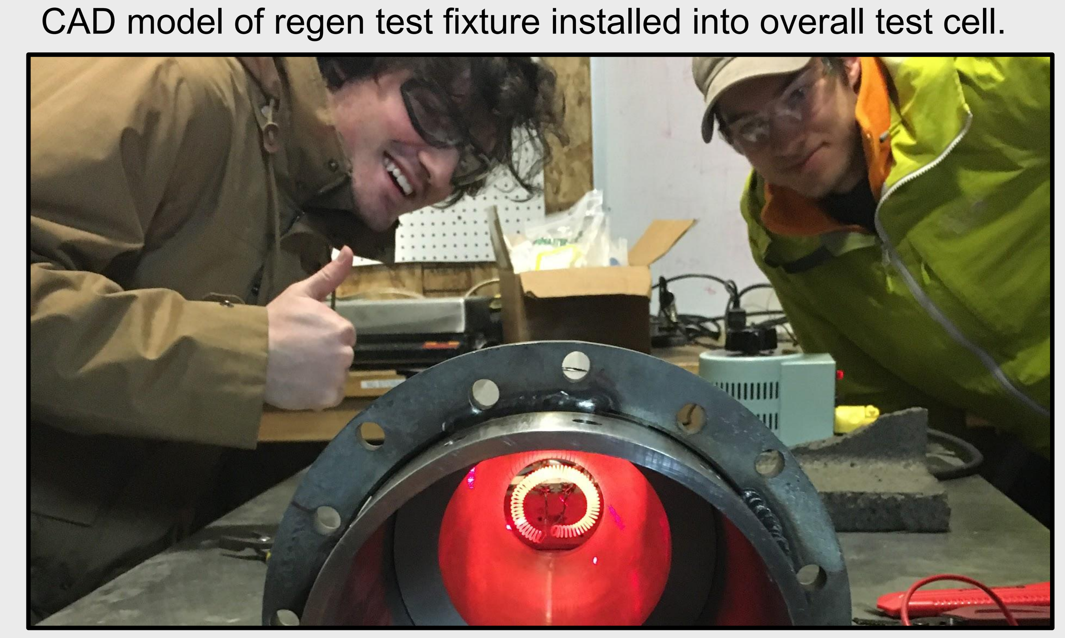
Left to right: test nozzle, injector plate, pintle



CAD model of regen test fixture installed into overall test cell.



Close-up of engine, water-cooling connections, and sensor array.



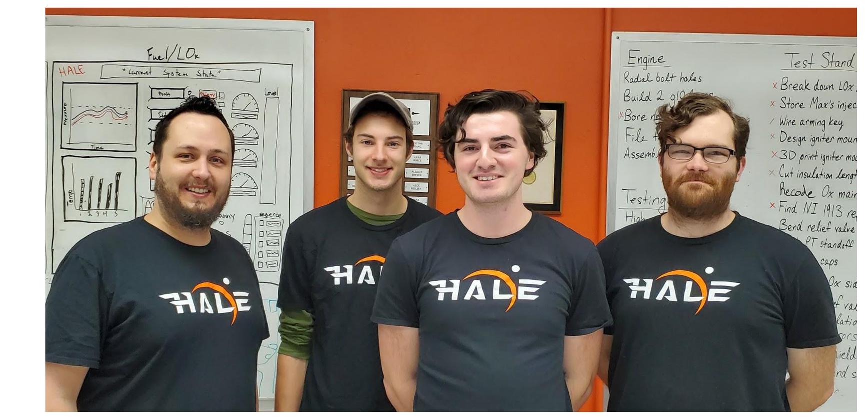
Manufacturing the test apparatus and supporting infrastructure

Testing Conducted

- Component fit checks and assembly
- Flowpath testing for presence of static bubbles
- Heating coil characterization
- System leak check
- Pump flow rate determination
- Flowpath convection characterization
- Sub-scale experimental heat flux test (solid motor)

Simulation Conducted

- Analytical heat flux calculations were done using product gas property software (CEA), material property curves, heat trasnfer relationships. The program allows the user to set the desired wall temperature and wall thickness and combustion chamber characteristics to output the estimated heat flow at the nozzle throat
- Throat wall stress was calculated by iterating across several design variables, including: internal pressure, wall thickness, desired safety factor, simulated material temperature, and combustion chamber pressures and thrust forces.



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PROJECT SPONSOR

base 11 SPACE CHALLENGE

PROJECT STATUS

- Continuing our work on gathering heat flux data and improving our models.
- Submitted static test fire approval report and awaiting Base 11 site visit and decision.
- Developing designs for a flight-ready regenerative nozzle.

MIRA OSU HALE REGEN 2019 2020

Oregon State University