Jordan A. Raymond

M.S. in Mechanical Engineering jordan.raymond@wsu.edu
Expected Date of Graduation: **May 2021** (425) 591-4803

Graduate Degree Focus

- Designing, manufacturing, and installing a small-scale heat exchanger for hydrogen liquefaction based on entropy minimization.
    - Also considering ortho-para conversion and tracking both temperature and pressure profiles.
    - Early calculations suggest a 30% difference in entropy generation in optimized and non-optimized models.
- Working on a DOD contract to create the first small-scale, portable hydrogen refueling station for drones.
    - Responsible for all dewar components including a heat rake, superconducting wire level gauges, cryocooler, and novel heat exchanger.

Engineering Experience

Research Assistant, Washington State University **September 2017 – August 2019**

- Explored the practicality of extracting liquid oxygen from a gaseous air mixture using a vortex tube with an induced magnetic field. The oxygen purity increased from 21.1% to 42.096%.
    - Theoretically verified experiment practicality, designed, built, and ran experiment.
    - Developed cryogen handling skills and gained experience with plumbing and fixtures.
    - Published results and patent pending on technology.

Smith Brothers Farms (SBF) Associate **May 2018**

- Designed an experiment to model thermal trends in SBF porch boxes and used the data to code a thermal model in Engineering Equation Solver with predictive qualities.
    - Using sun exposure, surrounding temperature, and box contents the code predicts the number of ice packs necessary for food products to remain below FDA food safety temperatures over a variety of dwell times.
    - Model predicted final temperature within 10%.
    - Easy to use matrix cards created for milkmen to determine necessary ice packs on the job and are currently in use.

Pipeline2Space R&D Intern **June 2018 – September 2018**

- Designed, wired, and programmed a magnetometer and accelerometer to be attached to the wall of a projectile for more efficient tracking and monitoring.
    - Created a custom circuit board that held an Arduino Nano, an accelerometer, and a magnetometer to allow for better tracking of the projectiles.
    - Wrote code using Arduino IDE to aide with data collection.

Activities and Awards

Donna Jung Scholarship Award July 2019

- Awarded to the top female student in cryogenics in the United States by the Cryogenic Society of America

Passed the **Fundamentals of Engineering Exam** (FE) for Mechanical Engineering May 2019
President's Honor Roll Fall 2015 – present
Member of **Tau Beta Pi** National Engineering Honor Society 2017 – present
SolidWorks Certified Associate Mechanical Design (CSWA) August 2017

Skills and Proficiency

Thermal Modeling **Thermodynamic Analysis**
Engineering Equation Solver (EES) **MATLAB**
C/C++/Java **SolidWorks**

Education

- **Pursuing Master's Degree in Mechanical Engineering (Thesis)** **August 2019 – May 2021**
    - Washington State University (3.93 GPA)
- **Completed Bachelor of Science in Mechanical Engineering** **May 2019**
    - Washington State University (*Summa cum laude* – 3.97 GPA)

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Heat Exchanger Optimization for Hydrogen Liquefaction — August 2019 - Present

I designed a heat exchanger for a small-scale hydrogen liquefier based on the principles on entropy minimization. Manufacturing and installation will occur in January 2021. Early calculations suggest a percent difference in entropy generation between optimized and non-optimized models of over 30%, indicating notable increases in system efficiency. The thermal mass of the optimized model is about 90% less than to non-optimized.

- ❖ Heat exchangers have one of the lowest component efficiencies in a hydrogen liquefier, generally only 20-30% of the Carnot efficiency.
- ❖ The heat exchanger I designed in Engineering Equation Solver (EES) uses a branching structure to determine optimum lengths and diameters for a given mass flow rate, resulting in a minimization of entropy generation. This pattern is also seen in tributaries and leaf veins.
- ❖ The input to the system is gaseous hydrogen at room temperature. The output is liquid hydrogen at the system's saturation temperature.

Oxygen Separation in a Vortex Tube with an Applied Magnetic Field — September 2017 – May 2019

I investigated the practicality of using a vortex tube with an induced magnetic field to more efficiently extract oxygen from a gaseous air mixture. I modeled the influential forces, designed and carried out the experiment, and presented the data at the 2019 Cryogenic Engineering Conference. The oxygen purity was increased from 21.1% to 42.096%. A patent is pending.

- ❖ In its liquid form, oxygen is paramagnetic and can therefore be influenced by a magnetic field. Previously, vortex tubes have been used for gas separation, and researchers have manipulated oxygen's magnetic properties, but no one had done both in combination.
- ❖ After describing the forces acting on a droplet of LOX in a vortex tube, I generated a mathematical model of the forces using Engineering Equation Solver (EES). The generated model showed that the outward forces on the droplet would be larger than the inward, therefore the droplet would be pulled to the outer edge of the tube and could be siphoned out. With a proven model, an experiment has been designed and data has been collected.
- ❖ It currently costs about $10,000 to put one pound of material into space. This technology could be used for in situ oxygen extraction on spacecraft which would greatly decrease the weight and cost of takeoff. In addition, it could be used for portable oxygen tanks for medical purposes, and as a replacement for distillation columns.
- ❖ Raymond, J., Leachman, J., Bunge, C., **Oxygen Separation in a Vortex Tube with an Applied Magnetic Field.** *Cryogenic Engineering Conference.* 2019. In press.

Smith Brothers Farms Thermal Modeling — May 2018

I designed an experiment to monitor thermal trends of products in Smith Brother Farms porch boxes and used the collected data to code a thermal model in Engineering Equation Solver.

- ❖ Smith Brothers Farms decided to add raw meat to their list of products, and this necessitated the need for a thermal model to predict the number of ice packs needed to keep the products under FDA designated temperatures for safe consumption in a variety of environmental conditions.
- ❖ I designed and ran an experiment using Smith Brothers Farms porch boxes to gather data concerning the thermal resistances and trends of both raw ground beef and milk.
- ❖ Using the collected data, I generated a thermal model in Engineering Equation Solver which predicted temperatures within 10% of the actual values. This model was then used to generate matrices with external temperature, dwell time, product type, and sun exposure as inputs and the number of ice packs necessary to stay below a target temperature as an output. These matrices are currently being used by the milkmen.