College of Engineering
Department of Mechanical & Industrial Engineering

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School of Electrical Engineering & Computer Science

To Predict ▶ To Design ▶ To Perform

ME, ECE Capstone Design Programs

Project 46: Liquid Nitrogen Generator

William Abbott, Trent Andrus, Chase Ellefson, Juan Gomez-Pineiro, Grant Landwehr, Daniel Luu, Jonathan Mire, Jeffrey Simms

College of Engineering
Cain Department of Chemical Engineering

Objective

Design and build a liquid nitrogen generator that produces nitrogen with a purity equal to, or above, 99.9%.

Background

- Liquid nitrogen is useful in industrial and laboratory settings
- The LSU Cain Department of Chemical Engineering would like to have a liquid nitrogen generator to decrease need of nitrogen purchased from vendors

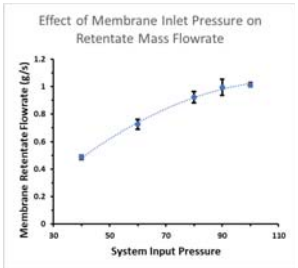
Engineering Specifications

Performance	Supplied Utilities	Size	Safety
▼1 Liter/Day of LN2	✖Compressed Air at 690kPa	▲1.5m (W)	✖Insulate surfaces below 275K
▼99.9% LN2 purity	✖Chilled Water at 283K	▲1.5m (L)	▲Sound level of 80dB
✖5 Liter storage capacity	✖Power: 120/208V, 20A	▲1.8m (H)	

✖- target value, ▲- maximum, ▼- minimum, red – specification not met

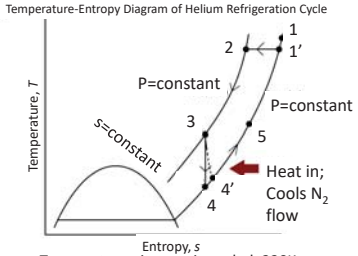
Testing, Analysis, and Results

Separation

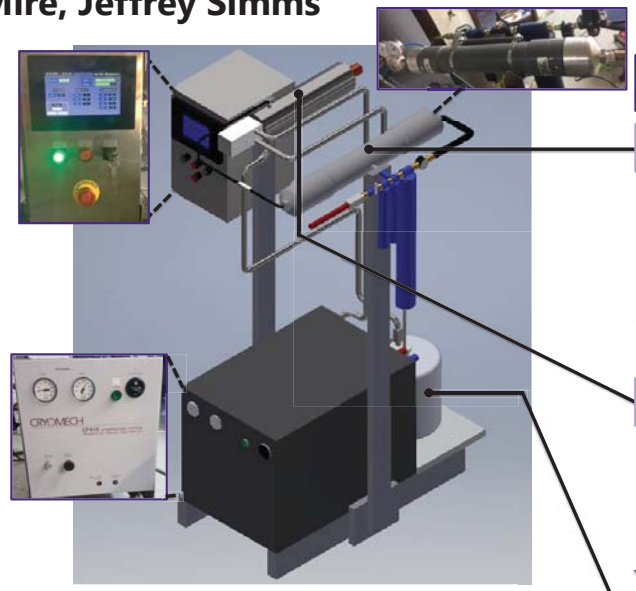


- Calculated assuming ideal gas: low P and T, minimal molecular interactions

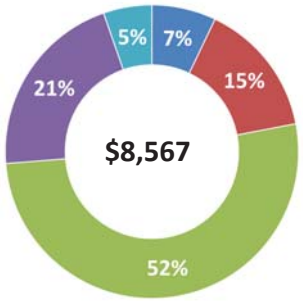
Liquefaction



- Temperature nitrogen is cooled: 220K
- 57 W of heat removal = 0.6 L/hour liquid yield
- Liquid yield = 58 %; 24 W of heat infiltration



Budget

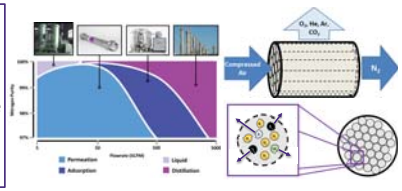


- **Filtration:**
  - 3-Stage Filter - $602
- **Separation:**
  - Membrane - $1263
- **Liquefaction:**
  - Condensing Unit - $563
  - Heat Exchanger - $731
  - Helium Compressor - $650
  - Helium Hoses - $690
  - Cold Head and Nozzle - $1561
  - LN2 Dewar - $196
- **Controls:**
  - O2 Analyzers - $777
  - Instrumentation - $695
  - Automation - $249
- **Miscellaneous** - $454

System Design

Air Filtration and Separation

A 3-stage filter will remove water, aerosols, and particulates from the inlet compressed air stream. A selectively permeable, hollow fiber membrane will then produce a high-purity nitrogen effluent and expel unwanted components of the inlet air.



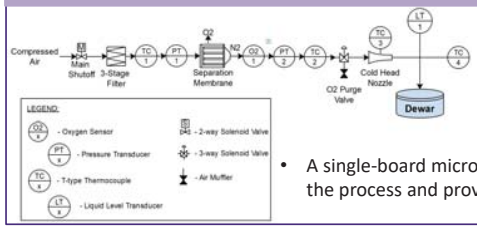
Nitrogen Liquefaction

1)Helium used as working fluid in cryogenic refrigeration cycle
2)Helium gets to below nitrogen's liquefaction point
3)Purified nitrogen enters cryocooler
4)Helium gas removes heat from nitrogen
5)Nitrogen will reach a saturated state forming some liquid and some vapor
6)Pressure forces nitrogen out of cryocooler, through hose, and into dewar
7)Cold nitrogen chills dewar and begins to pool

Nitrogen Storage

Nitrogen vapor will be safely vented to the atmosphere while the product liquid nitrogen stream will be stored in a 5 liter insulated dewar.

Controls and Automation



- Process information displayed on a digital touchscreen interface
- A single-board microcontroller will automate the process and provide continuous feedback

September | **November** | **December** | **January** | **February** | **March** | **April** | **May**

Define Objective – Research System Design – Finalize System Design and Analysis – Parts and Equipment Selection – Complete Assembly of Subsystems – Initial Tests and Analysis – Full System Assembly – Final Tests and Analysis

Sponsors: Dr. John Flake

Advisers: Dr. John Flake