Group 24

Magnetically Coupled Pump/Mixer System for Cryogenic Propellant Tank Destratification Interim Design Review

Group Members: Matthew Boebinger
Kahasim Brown
Anthony Ciciarelli
Janet Massengale

Sponsor: NASA Marshall Space Flight Center
Florida Space Grant
AME Center

Advisor: Dr. Wei Guo

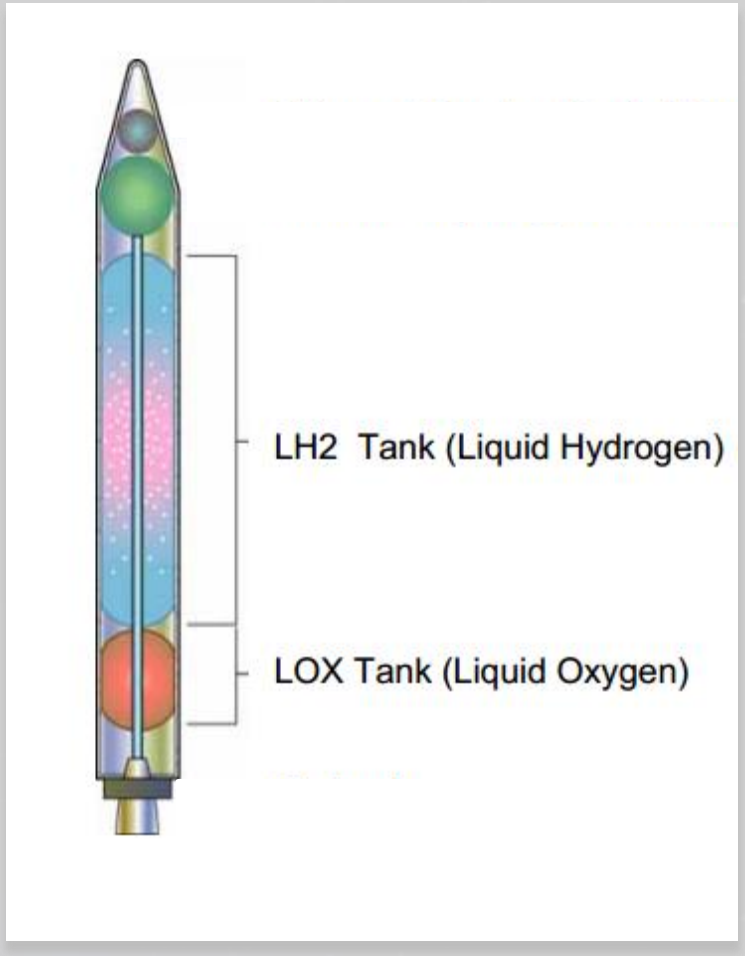
Instructors: Dr. Shih and Dr. Gupta

Agenda

- Background, Motivation, and Project Definition
- Approved Design and Assembly
- Calculations
- Challenges
- Budget and Procurement
- Future Plans
- Conclusion

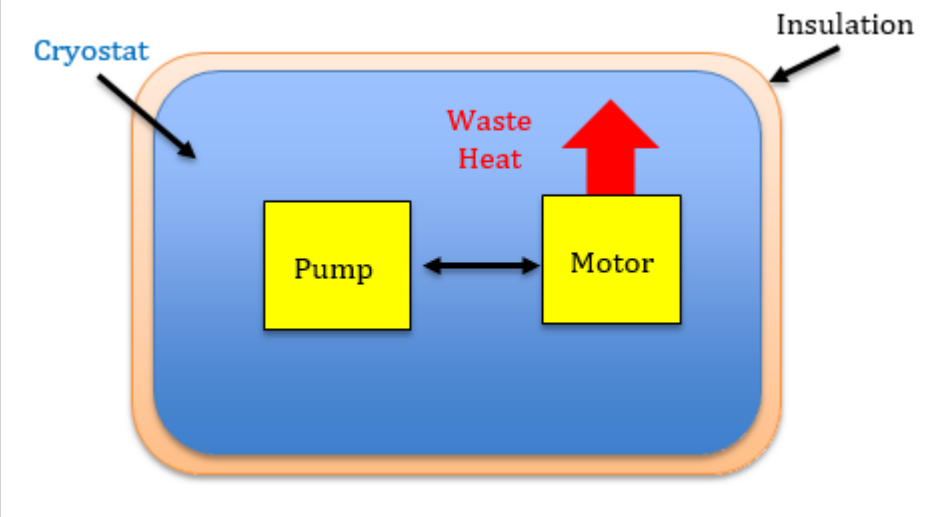
Background

- Cyrogens used as rocket fuel
  - Excess cryogens must be stored
- Issues with long term storage of cryogens
  - Stratification
  - Pressure control
  - Venting
- Mixing the propellants
  - Destratification
  - More time before venting



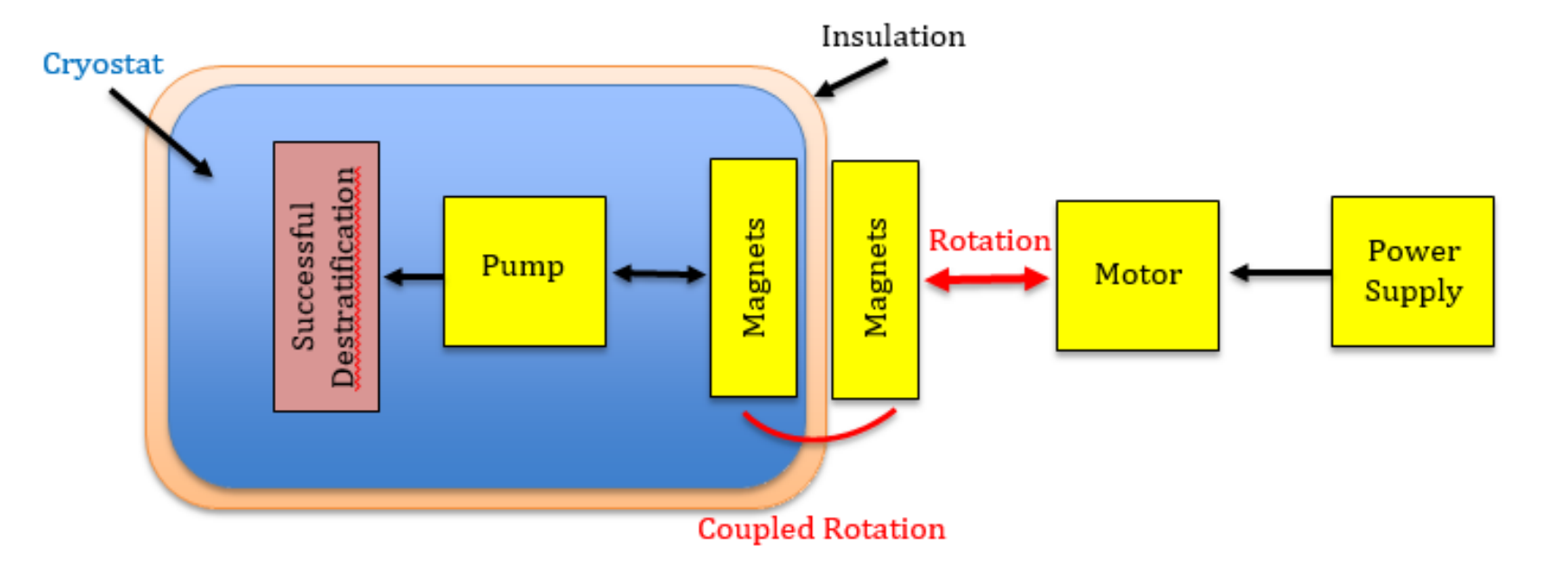
Motivation

- Current system
  - Various AC single and 3 phase motors
  - Waste heat added to cryogens
  - Motor couple to a pump operating in submerged conditions
- Designed system
  - Remove waste heat through magnetic coupling



Block diagram of current system

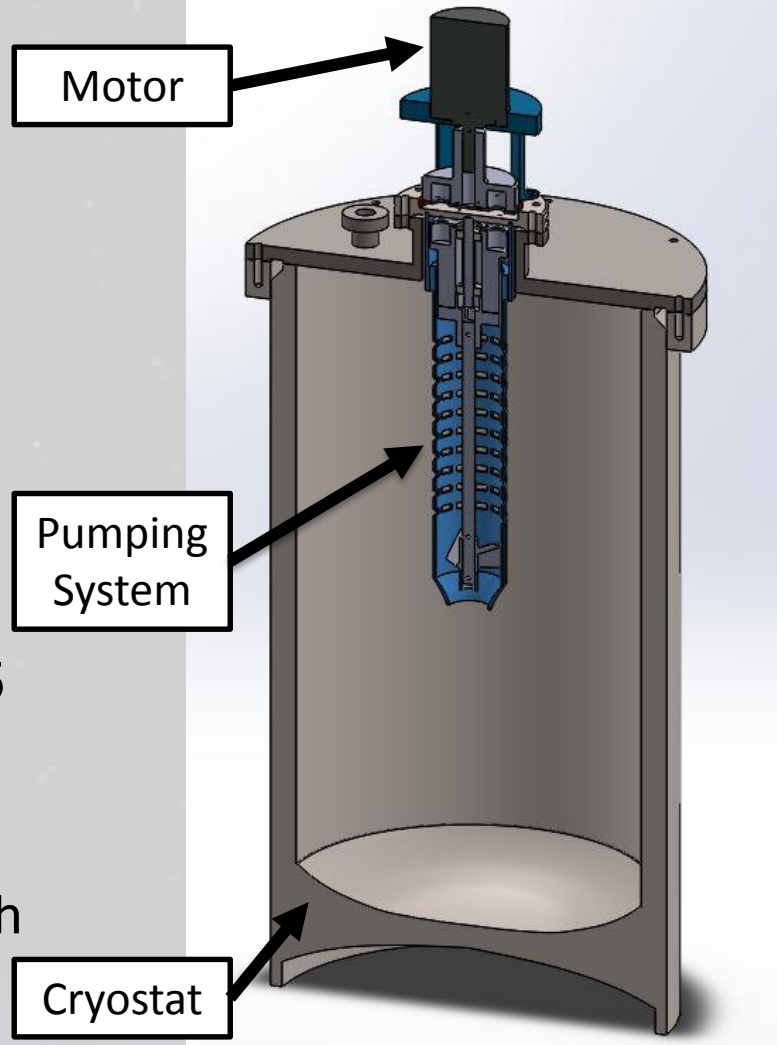
Project Description



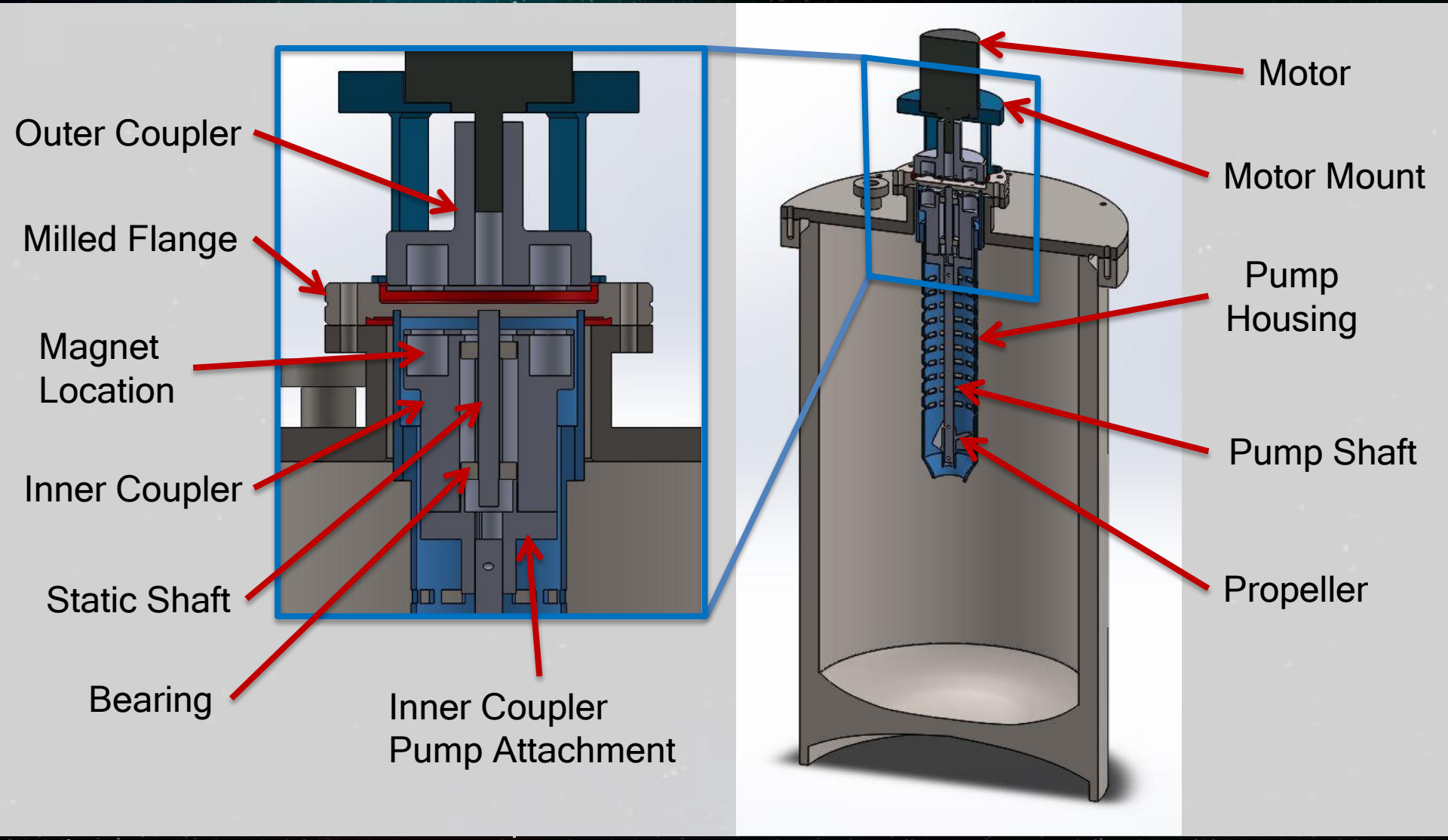
- Design an electric motor-pump/mixer unit that makes use of magnetic coupling technology.
  - The motor must be on the outside of the cryogenic tank
  - The entire pump system must fit through a 3.75 inch port on top of the tank

Design

- Suspension
  - Bearing System
- Magnetic Coupling
  - Eight 0.75” diameter 1 T magnets coupled through milled flange
  - Distance between the couplers <1.0 in
- Motor
  - Provides sufficient power to mix 5-15 gpm and pressure rise up to 5 psid
- Size Constraints
  - Coupler and Pump System fit through 3.75” port

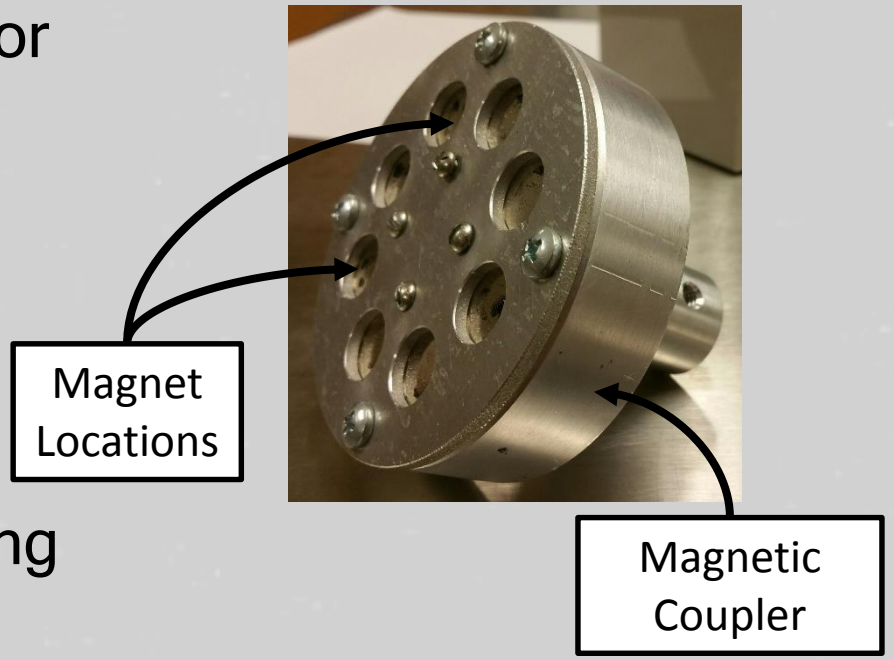


Approved Design



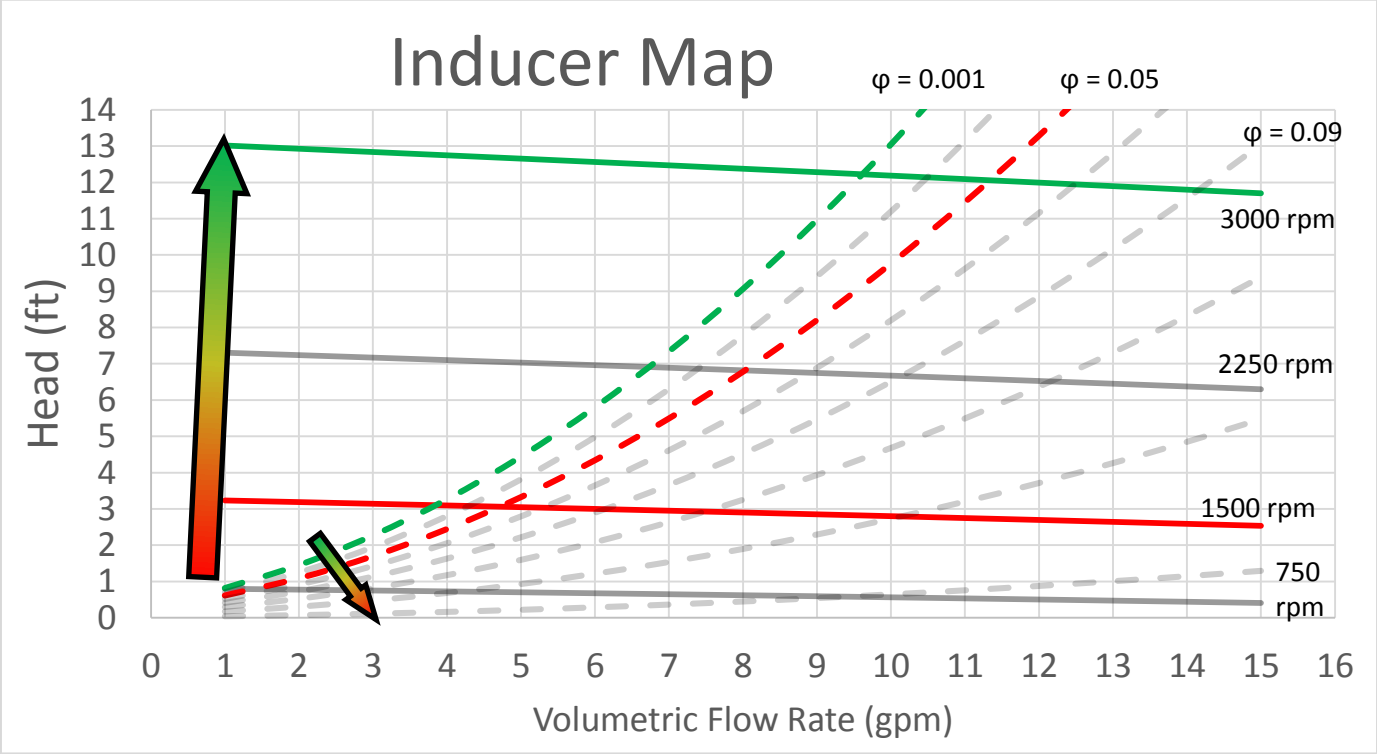
Coupler Assembly

- Outer coupler secured to motor right above flange
- Weld static shaft and pump anchor
- Attach Fully Assembled Inner Couple
- Press Fit Bearings and Bushing
- Connect Pump Attachment
- Attach Pump Shaft and Propeller
- Assemble Pump Housing



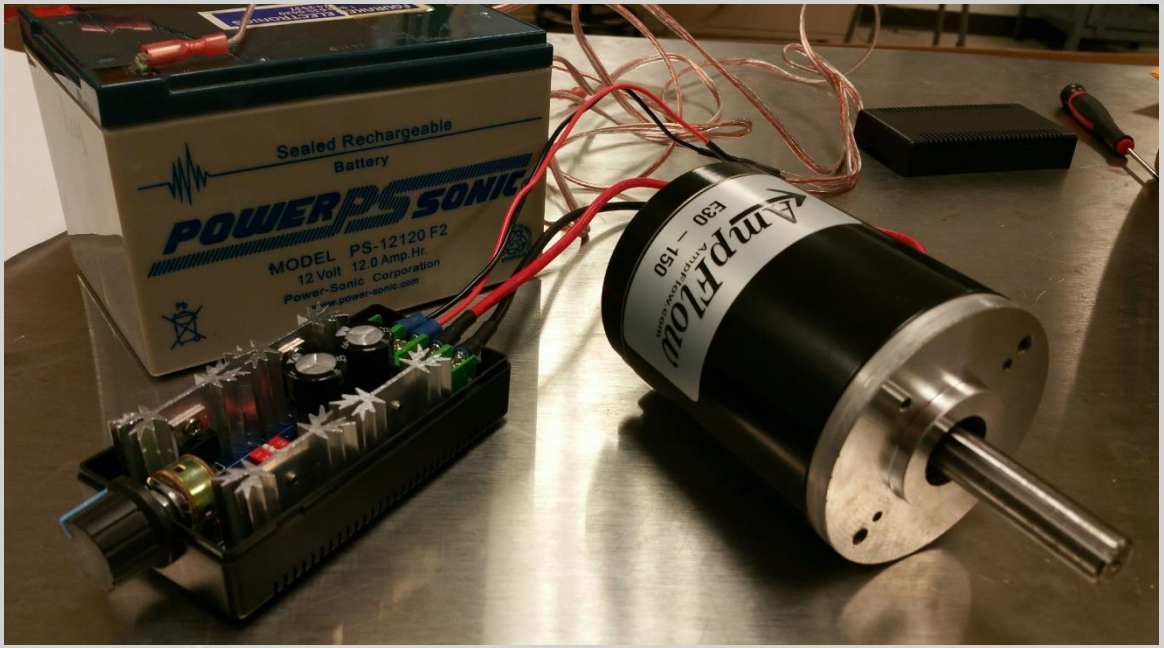
Pumping Calculations

- Head needed found to be 3 ft.
- Needed power of motor found to be >0.5 HP.
- Pumping calculations using non-dimensionalized flow coefficient (φ) and RPM.
- Lower flow coefficient, φ, wanted.
- Motor needs to output >2500 RPM.



Motor Specifications

- Motor purchased 24 V DC motor that provides a Peak HP of 1.0 and an RPM @24V of 5600.
- Motor controller using a potentiometer used to control motor speed.
- Using two 12 V DC batteries



Problems Encountered

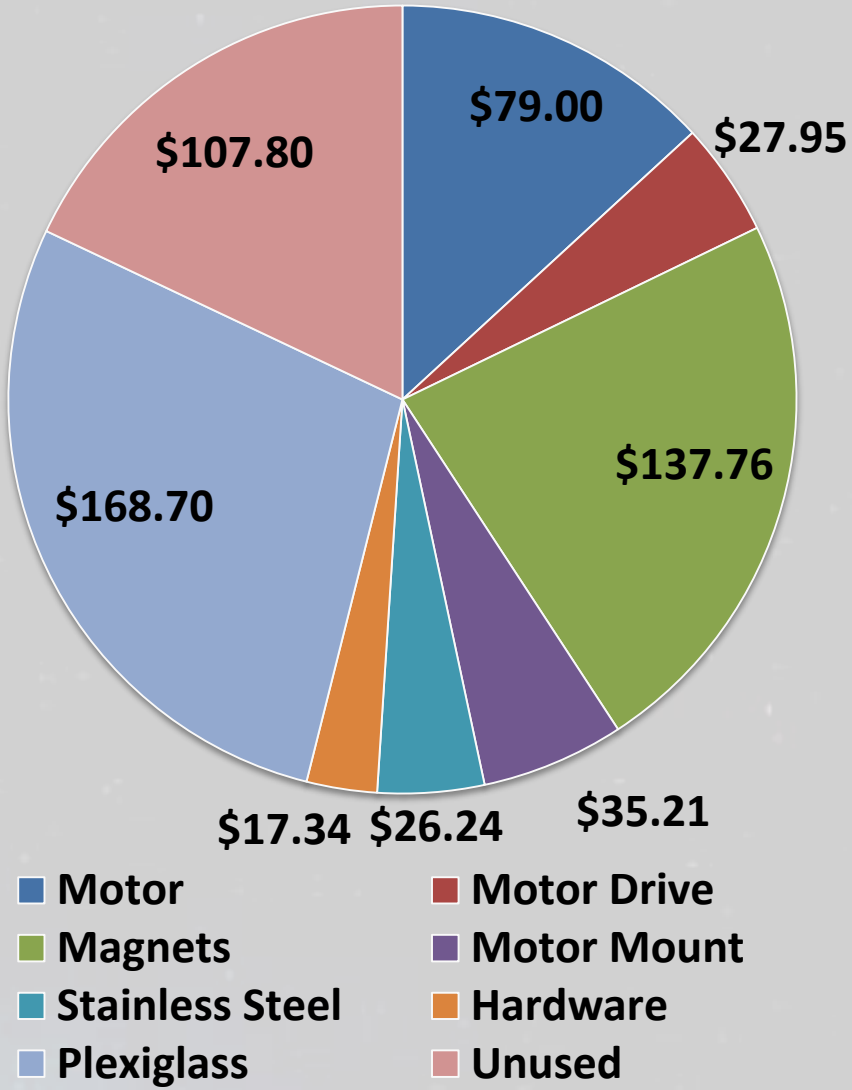
- Bearings
- Hardware
- Design changed to accommodate machine shop
- Difficulty with finding nonmagnetic materials
- Parts have not been finished

Prototype Testing

- Determine Strength of Magnets
  - Torsion Test with Dr. Kalu
- Water Testing
  - Fabricate a square testing tank
- Liquid Nitrogen Testing
  - Tested inside the cryostat
  - Fluid transfer between two cryostats or optics
  - NHMFL cryogenic safety procedure

Budget and Procurement

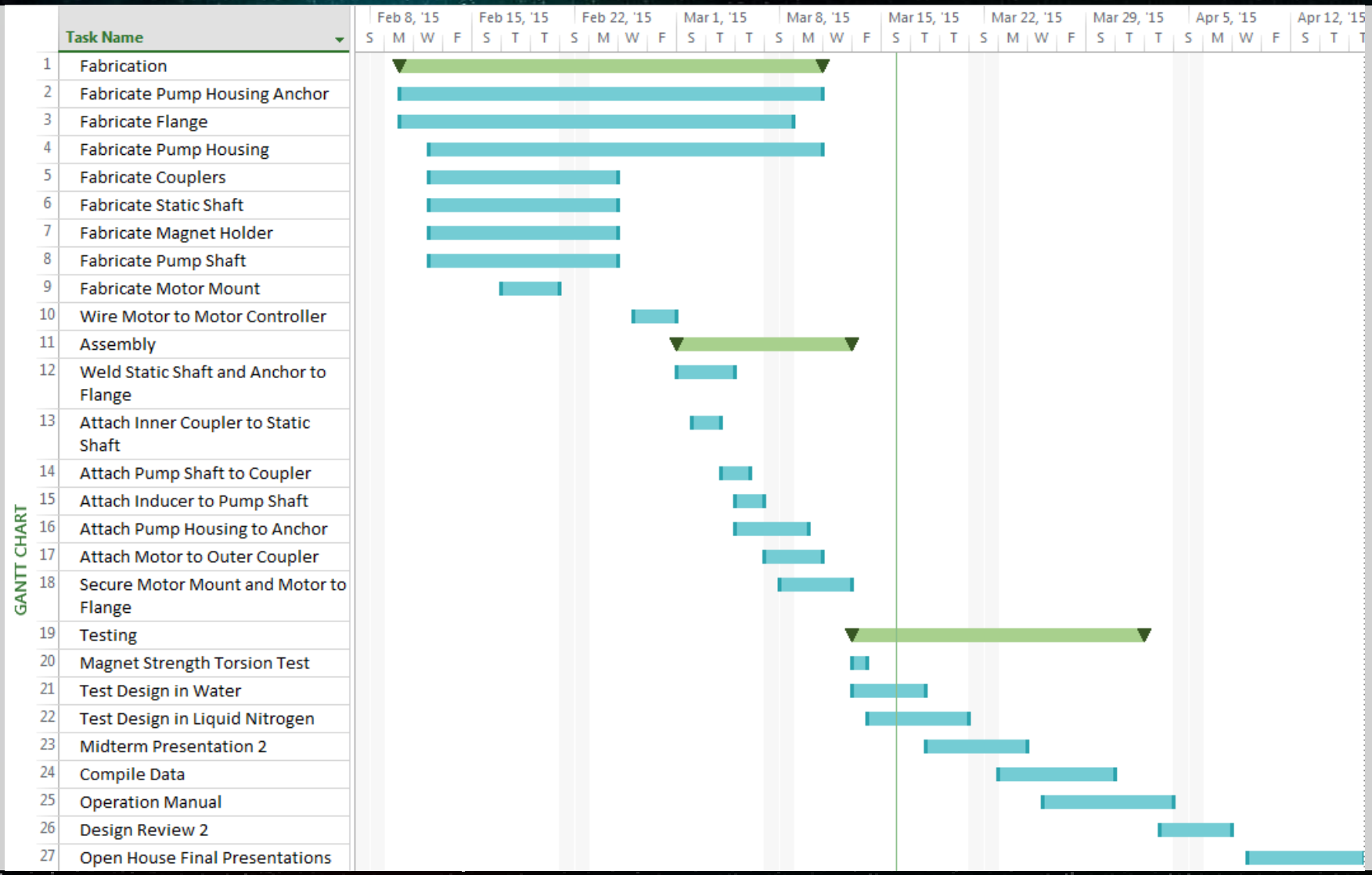
- Budget $600 Florida Space Grant
- Materials Purchased
  - Bearings
  - Magnets
  - Motor
  - Motor Driver
  - Plexiglass
  - Nuts & Bolts
- Materials Supplied
  - Fabrication Materials
    - Aluminum
    - Stainless Steel
  - Cryofab CF 1424-F
  - 6” ConFlat SS flange
  - Propeller



Future Plans

- Determine Strength of Magnets
  - Torsion Test with Dr. Kalu
- Finish Machining
  - Magnet housing, pump housing, motor mount, etc.
- Finish Fabrication and Assembly
- Water Testing
  - Fabricate a square testing tank
- Liquid Nitrogen Testing
  - Tested inside the cryostat
  - Fluid transfer between two cryostats or optics
  - NHMFL cryogenic safety procedure

Project Timeline



Summary

- Design an electric motor-pump/mixer unit that makes use of magnetic coupling technology.
- What we have done
  - Machining near completion
  - Assembly started
- Future Plans
  - Magnet testing
  - Finish construction of prototype
  - Water testing
    - Fabricate testing tank
  - Liquid nitrogen testing

References

- [1] Senior Design Project Definition Group 24. N.p.: n.p., n.d. PDF.
- [2] W., Van Sciver Steven. Helium Cryogenics. New York: Plenum, 1986. Print.
- [3] "Magnetic Couplings | Technology | Magnomatics." Magnetic Couplings | Technology | Magnomatics. N.p., n.d. Web. 25 Sept. 2014.
- [4] "HowStuffWorks "Parts of the Tesla Turbine"" *HowStuffWorks*. N.p., n.d. Web. 09 Oct. 2014.
- [5] Pump, Nikkiso Cryogenic. *NIKKISO CRYOGENIC PUMP* (n.d.): n. pag. Web.

Questions

For more information and updates:
http://eng.fsu.edu/me/senior_design/2015/team24/

Project Specifications

Requirement	Specification
Tank Size	• Height: 29 in • Outer Diameter: 16 in • Inner Diameter: 14 in • Gross Capacity: 60 Liters
Insulation	• 0.5 in of foam • >20 layers of multi-layer insulation (MLI)
Mounting	• Mounted to 6 in flange • Flange has 4 in port into tank
Pump Motor	• Variable Flow Rate : 5 - 15 gpm • Generates 5 psid rise in pressure • Mixer/Pump must reach 12 inches into tank
Additional Requirements	• Tank must be adiabatic to surroundings • Pump shaft must be magnetically coupled to the motor shaft • Friction must be held to a minimum • System must be compact • Materials used for the magnetic housing and flange must be non magnetic • Materials must withstand extremely cold temperatures between 63K - 77.2K