Group 24

Magnetically Coupled Pump/Mixer System for Cryogenic Propellant Tank Destratification
Spring 2015 Project Update

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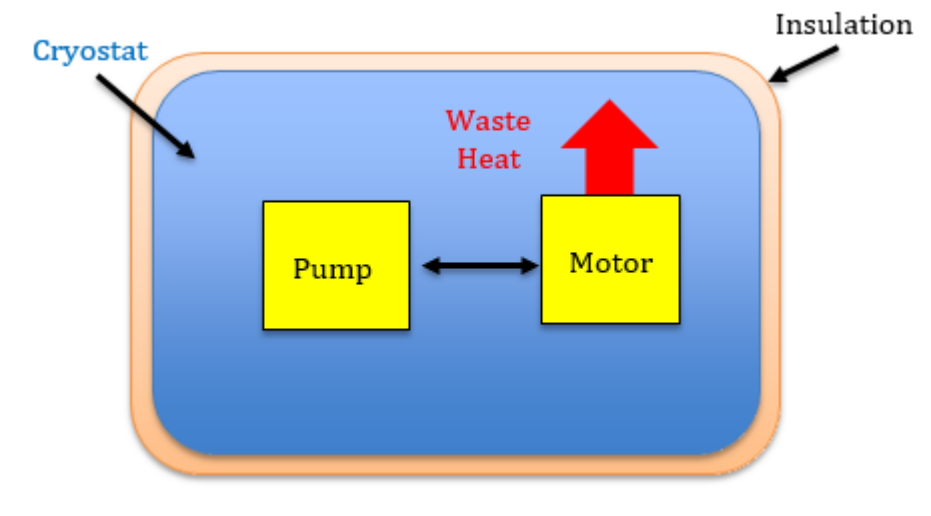
Agenda

- Background and Project Definition
- Approved Design
- Calculations
  - Pumping Capacity
- Budget and Procurement
- Future Plans
  - Fabrication and Testing
- Conclusion

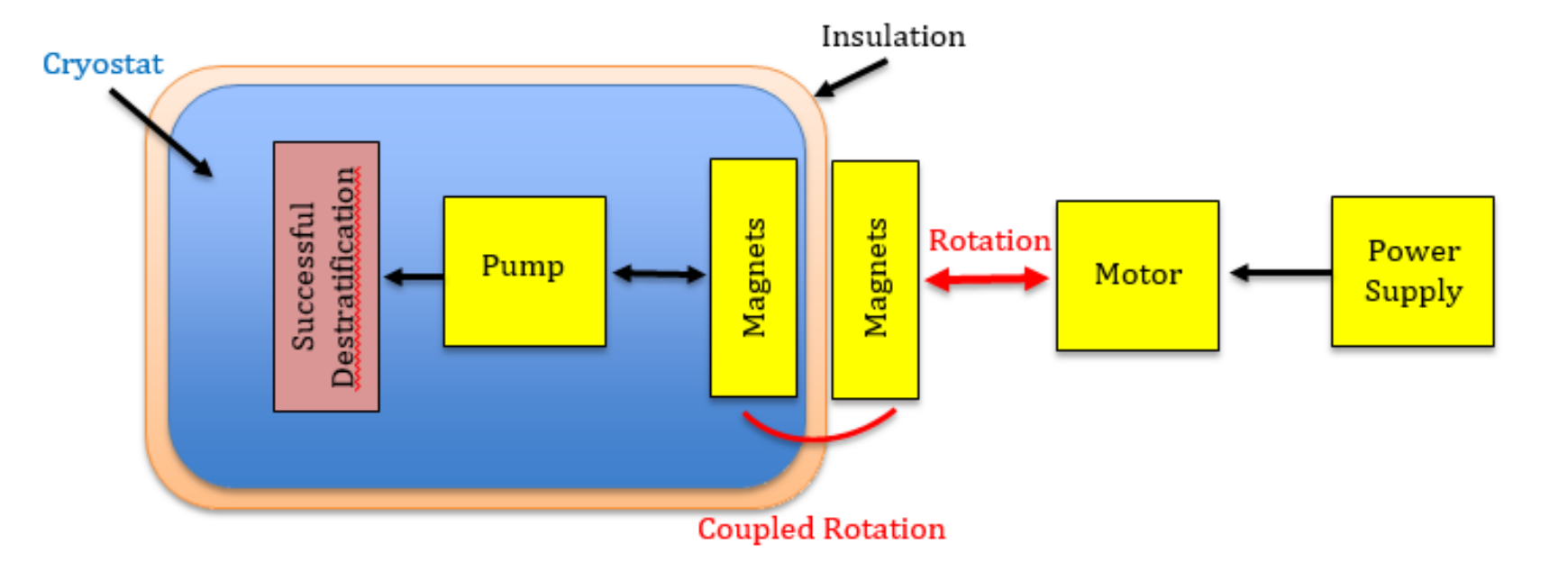
Background

- Long term storage of cryogens
  - Pressure control
  - Destratification
- Insulation
  - Prevent environmental
  - space/vacuum heat leak
- Mixing the propellants
  - More time before venting
- Current system
  - Foam and insulation
  - Various AC single and 3 phase motors
  - Motor couple to a pump operating in submerged conditions



Block diagram of current system

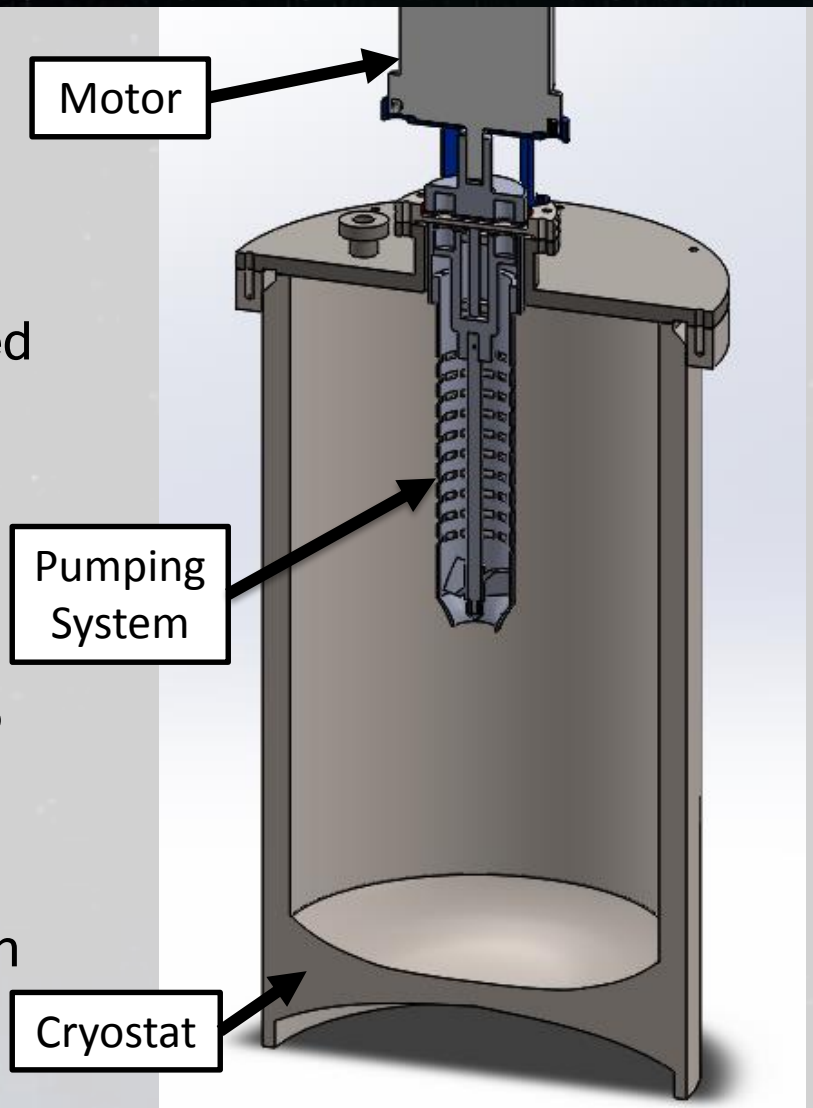
Project Description



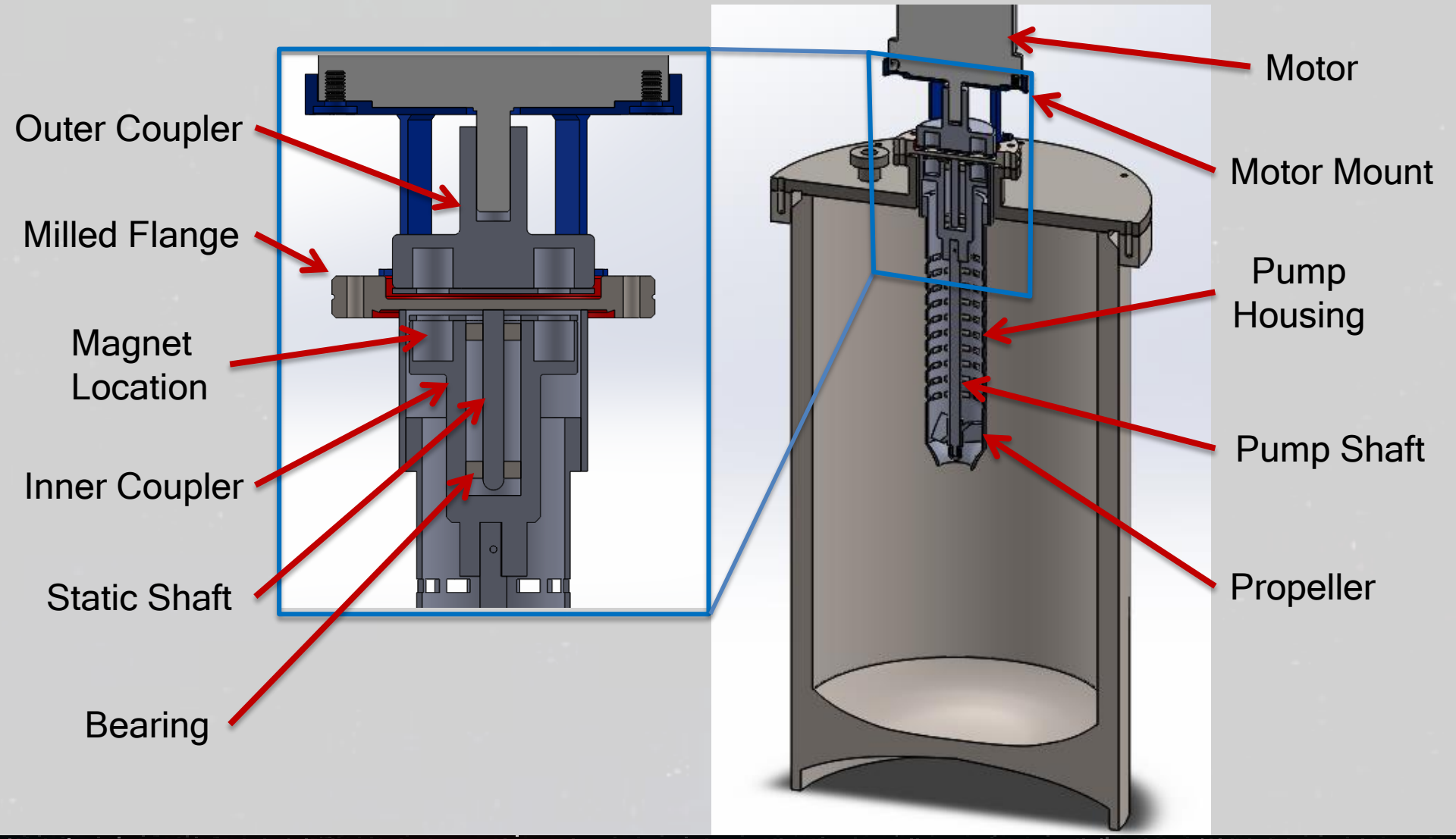
- Design an electric motor-pump/mixer unit that makes use of magnetic coupling technology.
  - The motor must be on the outside of the cryogenic tank
  - The entire pump system must fit through a 3.75 inch port on top of the tank

Approved Design

- Suspension
  - Bearing System
- Magnetic Coupling
  - Eight 0.75” diameter 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

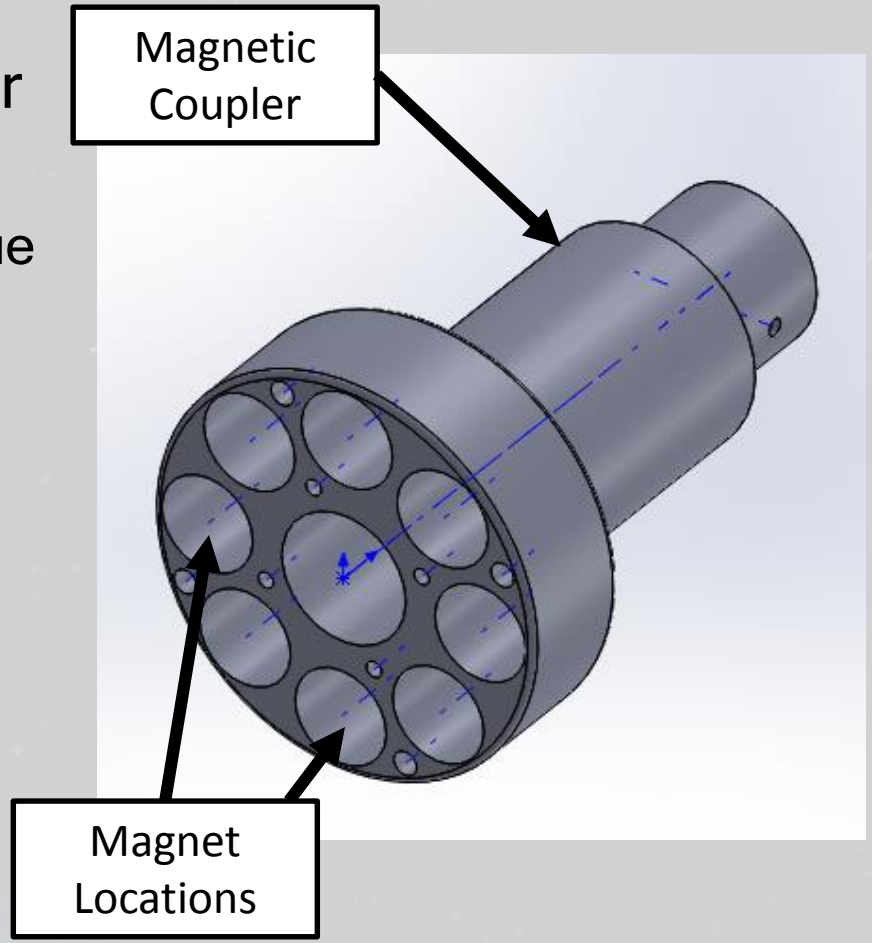


Approved Design



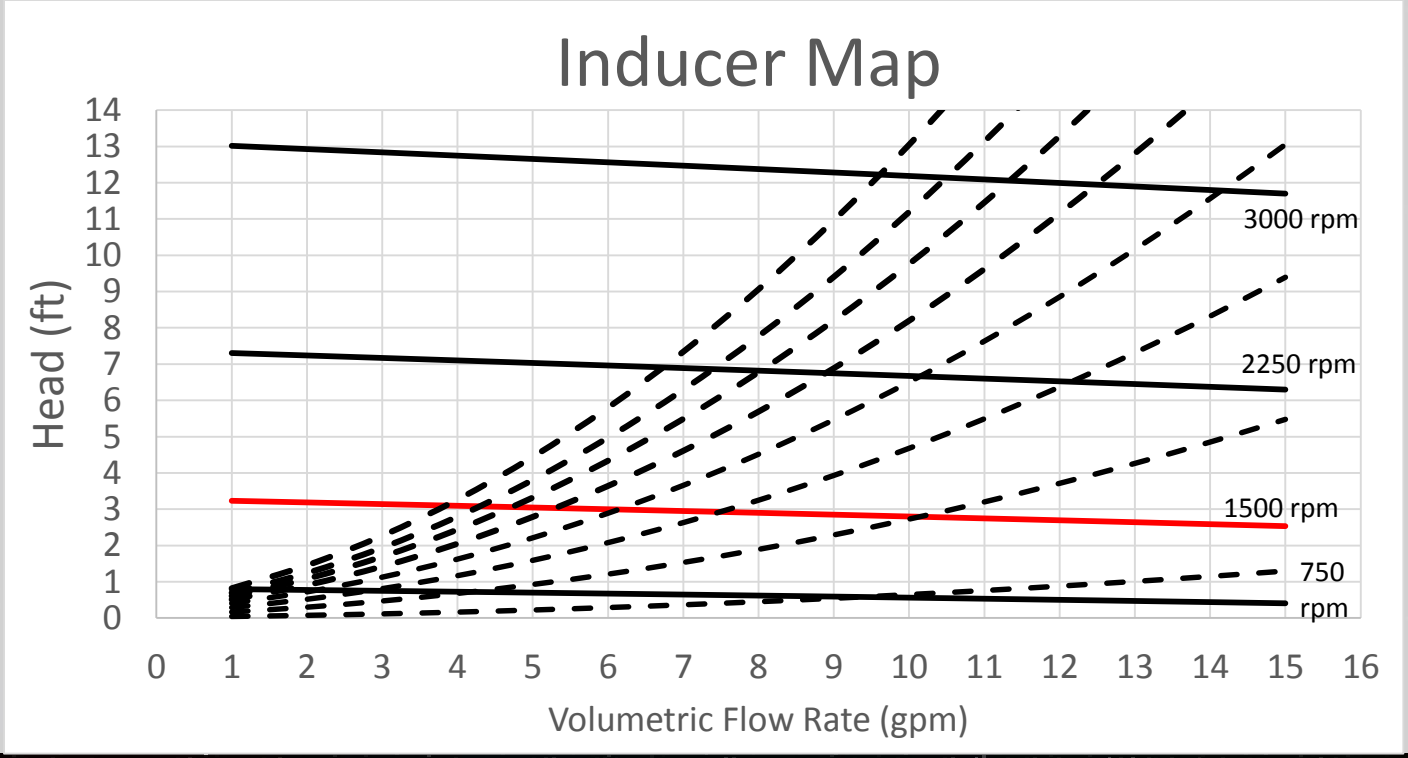
Bearings and Magnets Calculations

- Eight 0.75” diameter 1 T magnets used on each coupler
  - Largest possible magnets used
  - Strength of the Coupling > Torque
  - Maximum strength to be determined by spring gage test
- Suspension of inner component of design require use of ball bearings



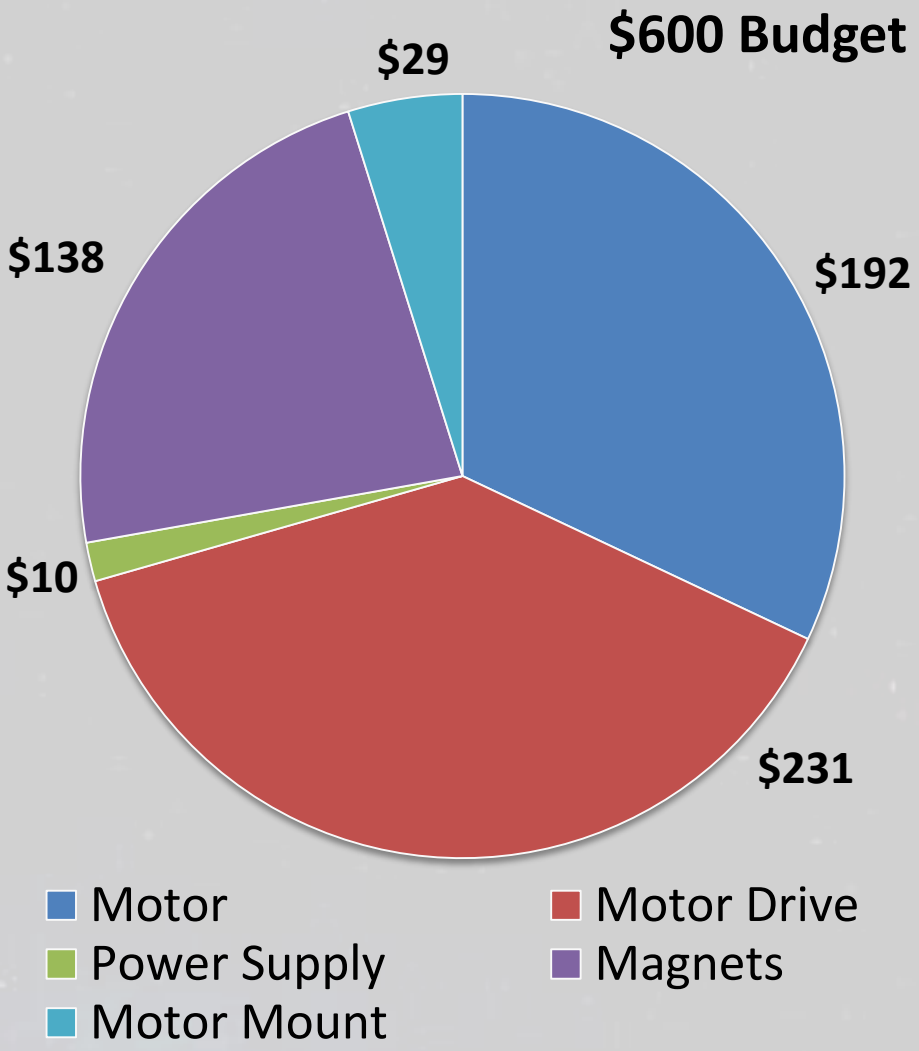
Pumping Calculations

- Head needed found to be 3 ft.
- Power of motor found to be 0.02 hp.
- Pumping calculations using non-dimensionalized flow coefficient and RPM
- Motor needs to output ~1500 RPM



Budget and Procurement

- Budget increased to $600
- Materials Purchased
  - Bearings
  - Magnets
  - Motor
  - Motor Driver
- Materials Supplied
  - Fabrication Materials
    - Aluminum
    - Stainless Steel
  - Cryofab CF 1424-F
  - 6” ConFlat SS flange
  - Propeller



Future Plans

- Determine strength of magnets
- Machining
  - Magnet housing, pump housing, motor mount, etc.
- Fabrication and building
  - Magnet safety
- Water Testing
  - Fabricate an open square tank
- Liquid Nitrogen Testing
  - Tested inside the cryostat
  - Fluid transfer between two cryostats or optics
  - NHMFL cryogenic safety procedure

Project Timeline

	Task Name	Duration	Start	Finish
1	Procurement	15 days	Wed 1/7/15	Tue 1/27/15
2	Finish Procuremnt/Order Raw Materials	5 days	Wed 1/7/15	Tue 1/13/15
3	Obtain Raw Materials	11 days	Tue 1/13/15	Tue 1/27/15
4	Fabrication	20 days	Tue 1/20/15	Sat 2/14/15
5	Wire motor to motor controller	5 days	Tue 1/20/15	Sat 1/24/15
6	Fabricate Flange	4 days	Tue 1/27/15	Fri 1/30/15
7	Fabricate Motor Mount	4 days	Wed 1/28/15	Sat 1/31/15
8	Fabricate pump housing anchor	11 days	Thu 1/29/15	Thu 2/12/15
9	Fabricate Couplers	12 days	Thu 1/29/15	Fri 2/13/15
10	Fabricate Static Shaft	9 days	Thu 1/29/15	Tue 2/10/15
11	Fabricate Magnet holder	4 days	Thu 1/29/15	Tue 2/3/15
12	Fabricate Pump shaft	13 days	Thu 1/29/15	Sat 2/14/15
13	Fabricate Pump housing	13 days	Thu 1/29/15	Sat 2/14/15
14	Assembly	8 days	Tue 2/17/15	Thu 2/26/15
15	Weld Static shaft and anchor to flange	4 days	Tue 2/17/15	Fri 2/20/15
16	Secure motor mount and motor to flange	3 days	Tue 2/17/15	Thu 2/19/15
17	Attach inner coupler to static shaft	2 days	Sat 2/21/15	Sun 2/22/15
18	Attach pump shaft to coupoler	2 days	Sun 2/22/15	Mon 2/23/15
19	Attach inducer to pump shaft	2 days	Mon 2/23/15	Tue 2/24/15
20	Attach pump housing to anchor	2 days	Sat 1/24/15	Sun 1/25/15
21	Attach motor to outer coupler	3 days	Thu 2/19/15	Sun 2/22/15
22	Testing	14 days	Thu 2/26/15	Tue 3/17/15
23	Test design in water	3 days	Thu 2/26/15	Mon 3/2/15
24	Test design in Liquid Nitrogen	6 days	Mon 3/2/15	Mon 3/9/15
25	Compile Data	6 days	Tue 3/10/15	Tue 3/17/15
26	Operation Manual	7 days	Thu 3/26/15	Fri 4/3/15
27	Open House Final Presentations	6 days	Thu 4/9/15	Thu 4/16/15

Summary

- Design an electric motor-pump/mixer unit that makes use of magnetic coupling technology.
- What we have done
  - Final design approved
  - Procured electrical and mechanical components
- Future Plans
  - Magnet testing
  - Fabrication and constructing of prototype
  - Water testing
  - 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