Group 24

Magnetically Coupled Pump/Mixer System for Cryogenic Propellant Tank Destratification

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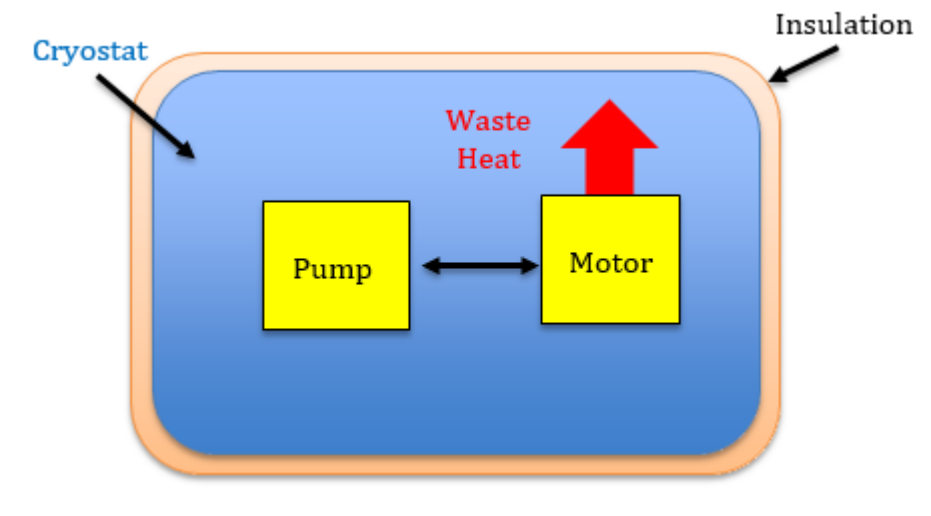
Agenda

- Background
- Project Description and Objectives
- Proposed Design and Materials
  - Component Analysis
  - Provided and Required
- Budget
- Summary

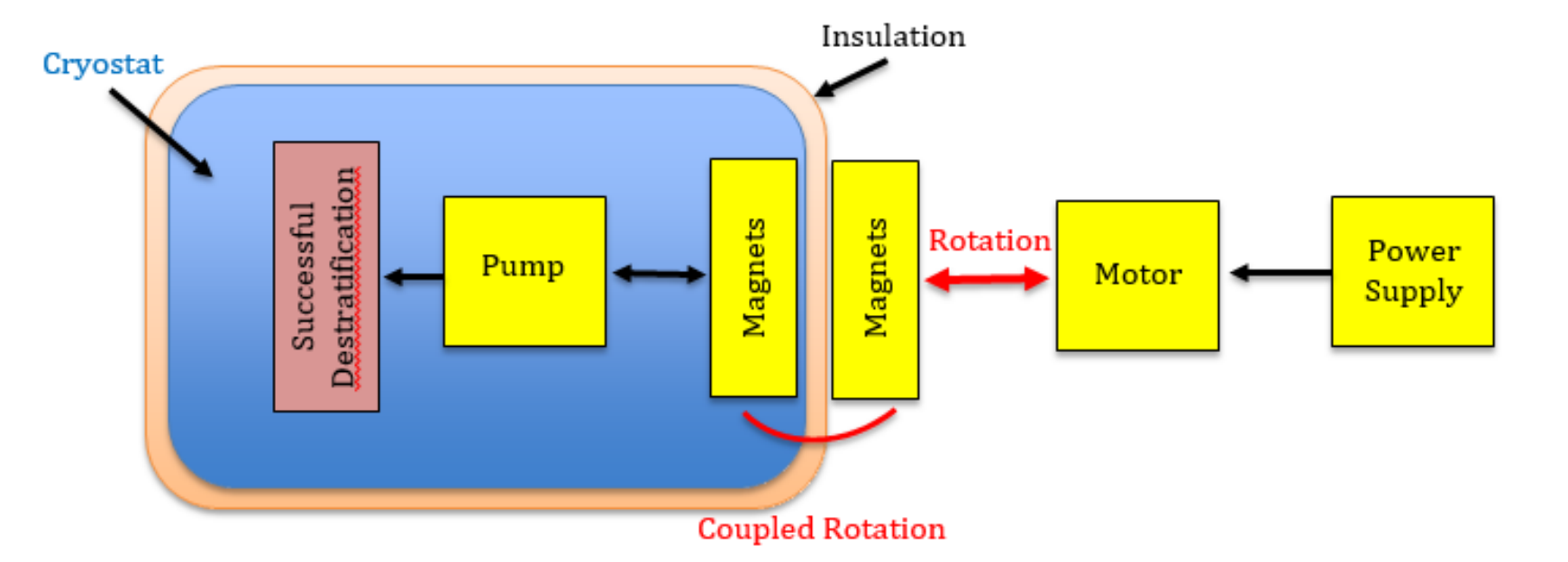
Background

- 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 Insulation and MLI
  - Various AC single and 3 phase motors
  - Motor couple to a pump operating in submerged conditions



Block diagram of current system

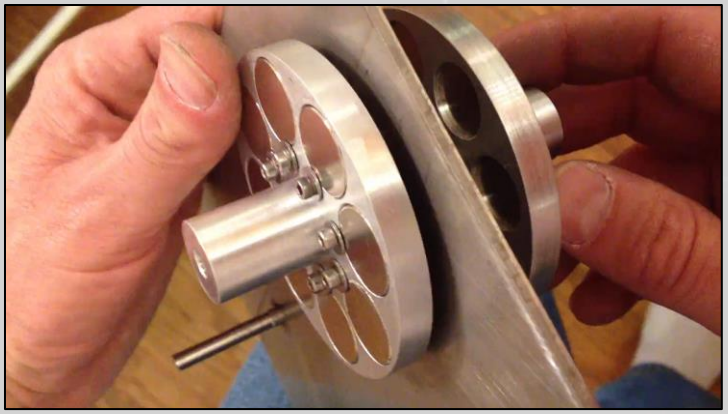
Project Description



- 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
  - Incorporate insulation between the coupling and tank wall

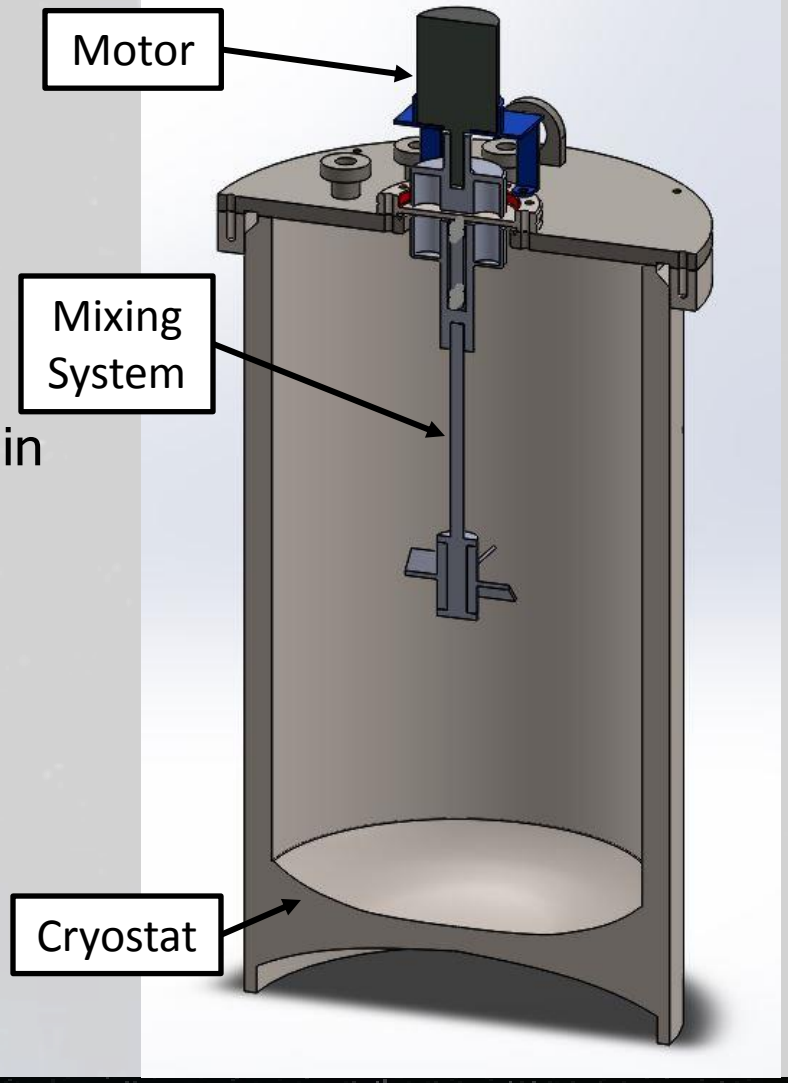
Objectives

- Minimize heat addition
- Must produce volumetric flow rate of 5-15 gpm
  - The pressure rise due to the pump must reach 5psid
- Magnetically couple motor shaft to mixer shaft
- Must be compatible with current tank model
- Minimum number of parts and be compact in design

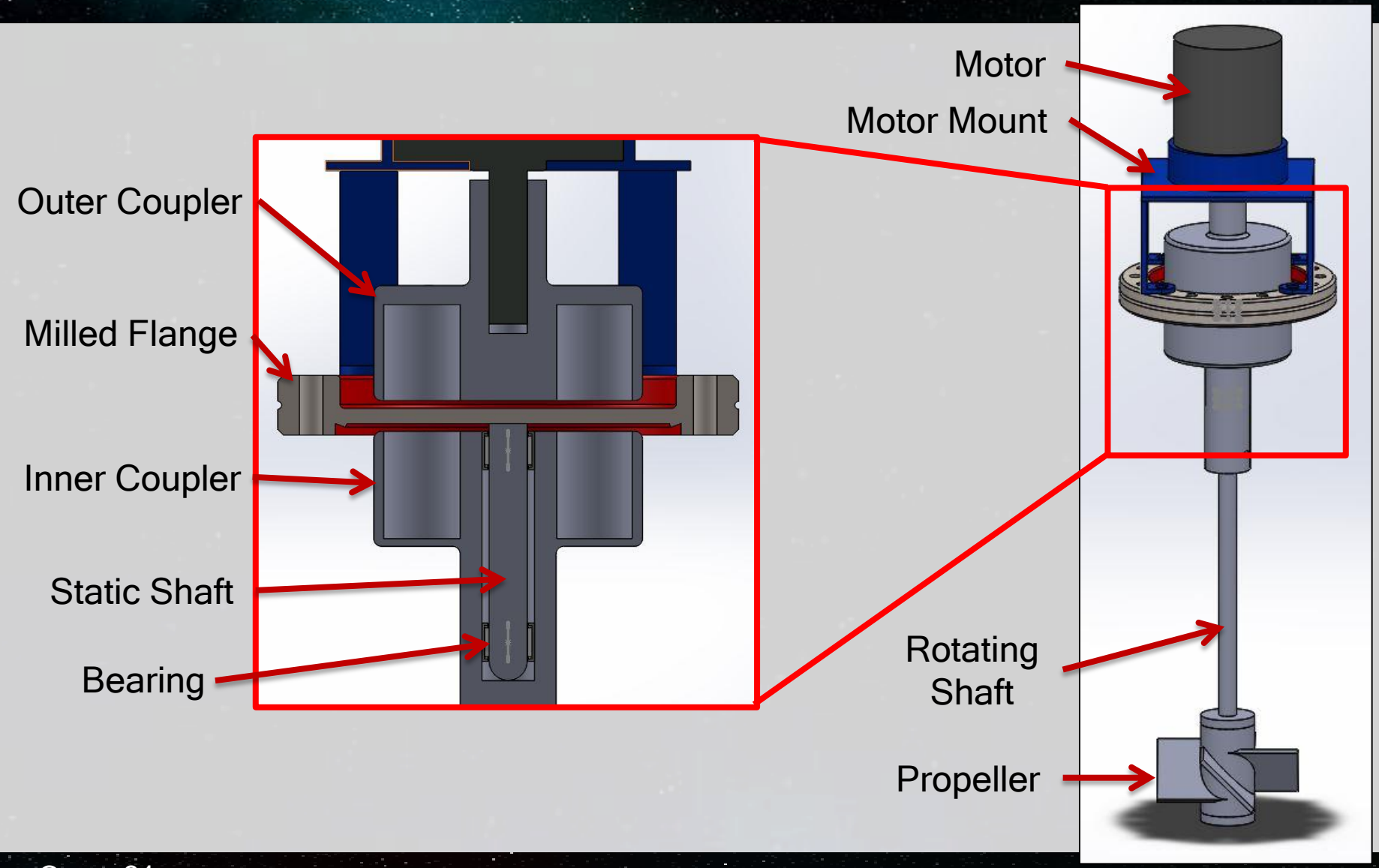


Proposed Design

- Suspension
  - Bearing System
- Magnetic Coupling
  - Six 1” diameter magnets coupled through milled flange
  - Distance between the couplers <0.5 in
- Motor
  - Provides sufficient power to mix 15 gpm and pressure rise up to 5 psid
- Size Constraints
  - Coupler and Propeller fit through 4” port

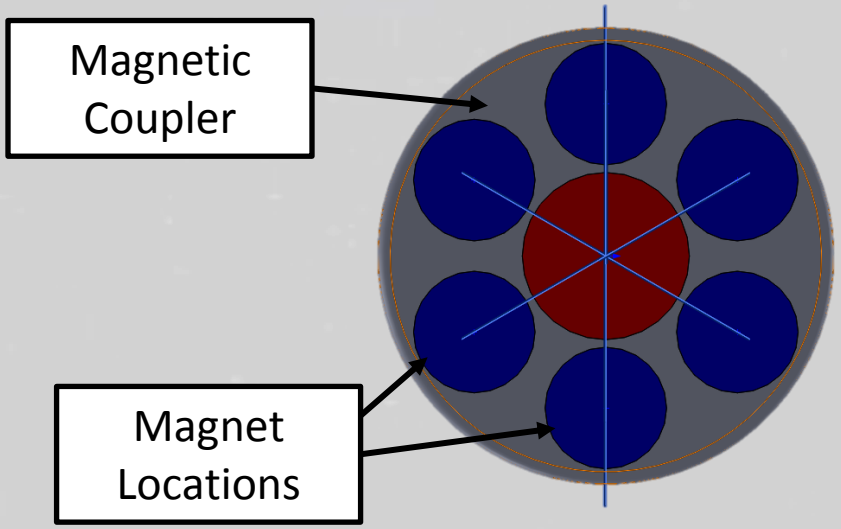


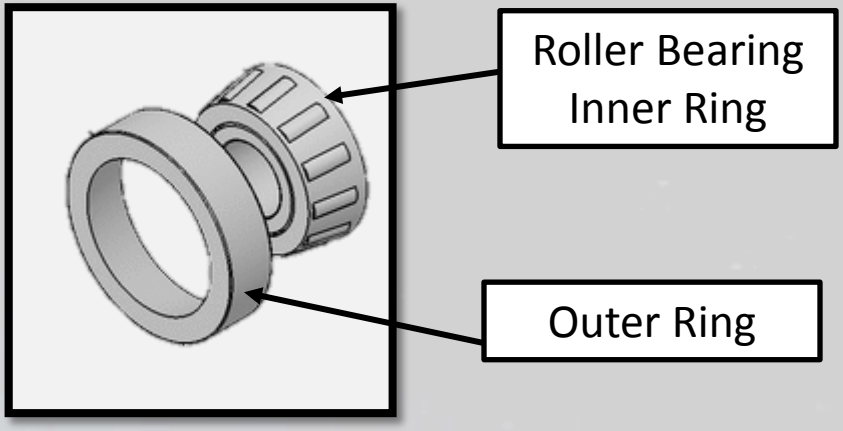
Proposed Design



Bearings and Magnets

- Six 1” diameter magnets used on each coupler
  - Largest possible magnets used
  - Strength of the Coupling magnets must be much greater than the produced Torque
- Suspension of inner component of design require use of Tapered-Roller Bearings
  - Can handle both radial and thrust loads





Pumping Capacity

- From the given volumetric flow rate of $15\ gpm$
  - The pump shaft angular velocity found to be $115\ rpm$
- The Head, $h = 12.45\ ft$, of the pump was calculated using the density of LN ($\rho_{LN} = 57.8\ \frac{lb}{ft^3}$) and the desired pressure differential of $5\ psid$
- From this Head the Power will be determined, $P = 0.044\ hp$
- Using this Power and the angular velocity of the shaft the motor will be selected

Provided Materials

- NASA
  - Cryofab CF 1424-F
  - 6” ConFlat stainless steel flange
  - Copper gasket (sealing)
- NHMFL
  - Indium wire (sealing)

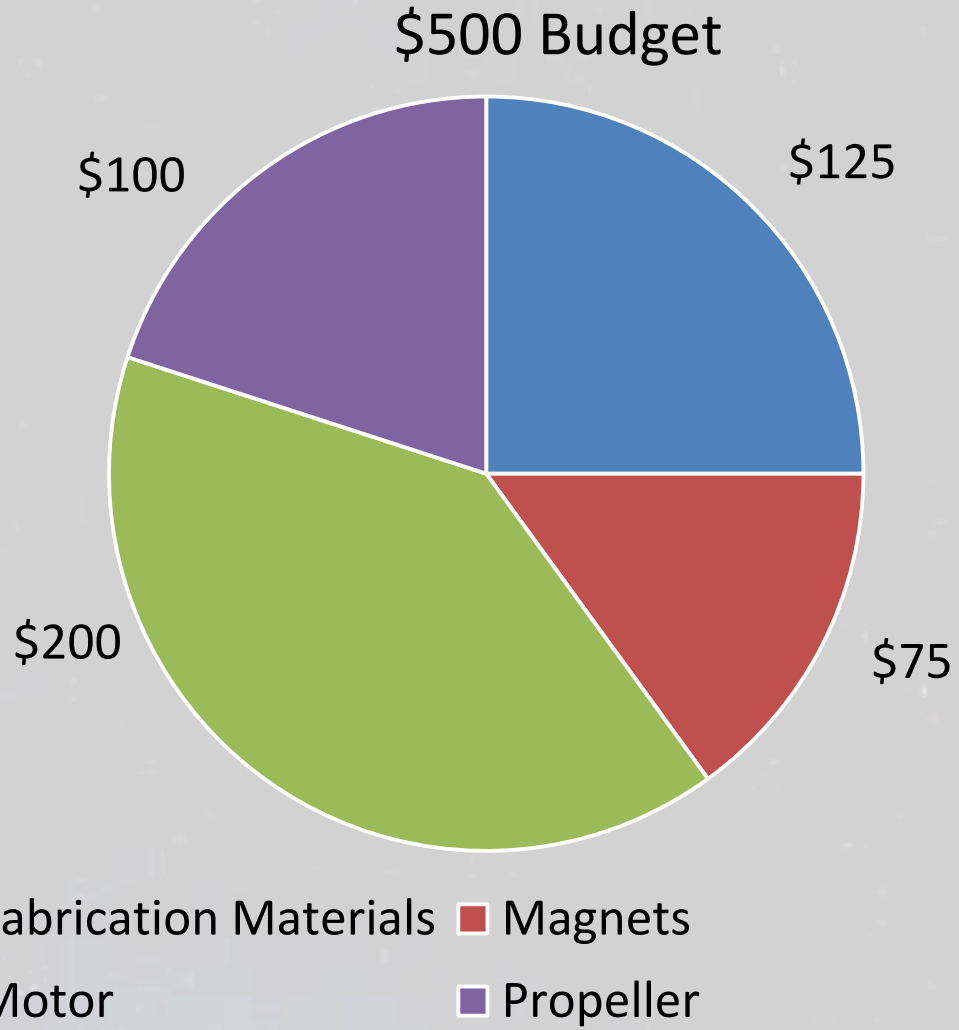
Indium Wire

6” ConFlat stainless steel flange

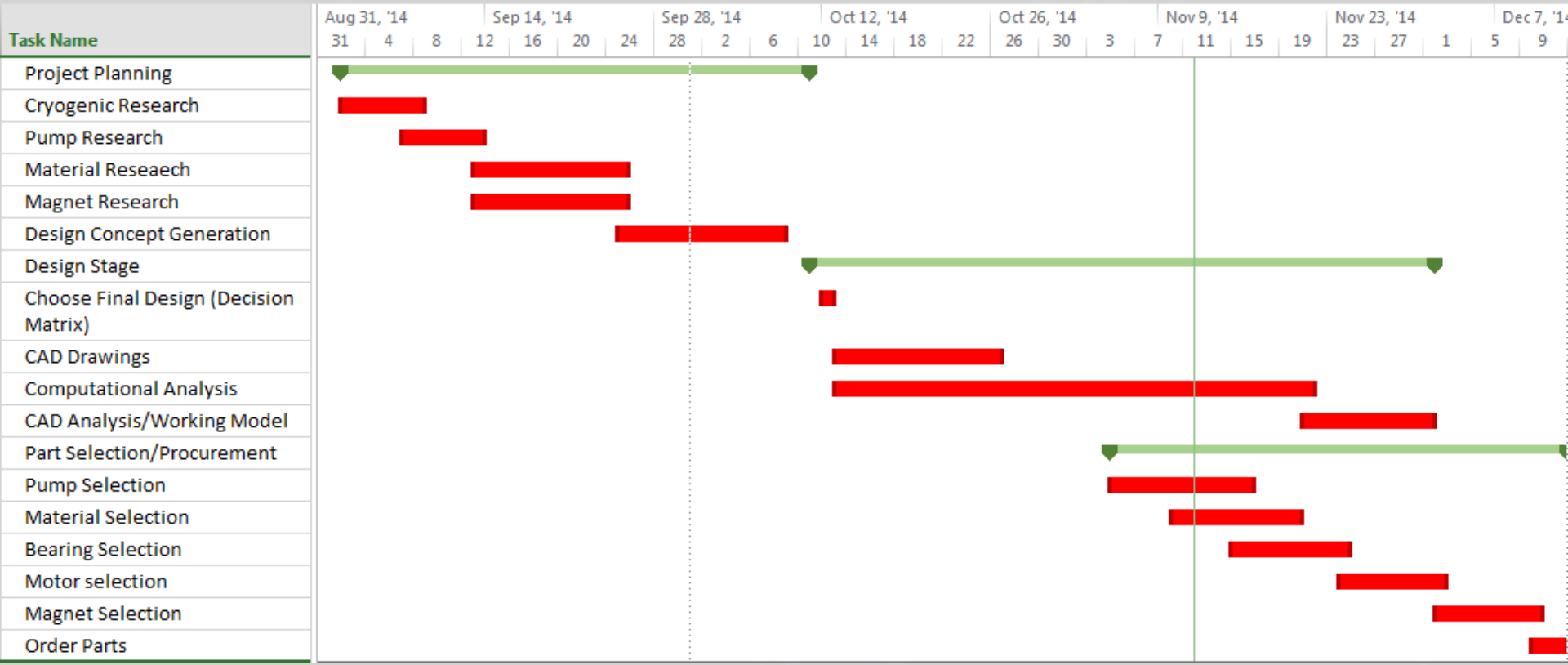
Cryofab CF 1424-F model cryostat that will be used in the project

Required Materials and Budget

- Fabrication Materials
  - Aluminum
  - 304 Stainless Steel
  - Bearings (Tapered Roller)
- Magnets
- Motor
- Propeller



Project Timeline



Summary

- The Project
  - Reduce heat addition
  - Magnetic coupling technology
- Design proposal
  - Solves the issues of heat addition
  - Satisfies the objectives
- Challenges
  - Sealing, Size, and Supporting the rotating Shaft
- Future Plans
  - CAD Analysis
  - Fabrication and 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

Prototype Testing

- Preliminary Magnet coupling test
  - Build a square tank for water tests
- Pressure tests
  - Fitted pressure gauge on the cryostat
- Flow rate
  - Fabricated square tank (Water)
  - Fluid transfer between two cryostats (Liquid Nitrogen)