PSAS Composite Fuel Tank Team Capstone Project Proposal - “Team Rocket”

12/08/2016

List of team members

1. **Russell Berger**: berger3@pdx.edu (Primary Team Contact)

Experience with manufacturing composite airframe parts for Atomic Aviation, advanced fluid mechanics, phase transformation and kinetics of materials, SolidWorks, and owns a 3D printer. Experience with data analysis software (R & Matlab), as well as CAM software for CNC machining, and machining with emphasis on lathe.

2. **Alex Farias**: afarias@pdx.edu

Experience manufacturing carbon fiber composite airframe for PSAS rocket, solid Modeling, FEA, Advanced Fluid Mechanics, data analysis software (R and Matlab), is a PSAS member, and has machine shop access/experience.

3. **Weldon Peterson**: jwp2@pdx.edu

Experience with lathe and milling processes, Solidworks, machining design, geometric dimensioning and tolerancing, data analysis software (R and Matlab). Also previously experience with liquid oxygen as a fuel in glass studio and great group dynamic with the rest of the team.

4. **Christopher Wilson**: cw9@pdx.edu

PSAS member, GD&T and controls sequence, has experience with laser cutters and 3d printers, 1st level machine shop access with minor experience on the mill and lathe, data analysis software (R and Matlab). Lives on campus.

5. **Neil Benkelman**: nab2@pdx.edu

Past project experience developing autonomous navigation and hazard avoidance platform for use with a drone, fluid dynamics, heat transfer, FEA, data analysis software (R and MATLAB), machine shop basic access. Very personable and easy-going.

6. **Francesca Frattaroli**: ff2@pdx.edu

Experience designing and prototyping low-cost sensor apparati for environmental research, Biogeochemistry lab and field technician, data analysis software (R and Matlab), FEA, Advanced Fluid Mechanics and machine shop (mills and saws).

Summary of client needs

The Portland State Aerospace Society needs a cryogenic fuel tank prototype made of carbon fiber, nomex honeycomb, epoxy, and aluminum mating rings to test the feasibility of using composite material for hobby-sized liquid fuel rocket tanks. The tank will fit with the pre-existing modular airframe design and handle thermal stress between the composite (negative coefficient of thermal expansion) and the mating rings (positive coefficient of thermal expansion).
It is not necessary that the end caps be composite material. The fuel tank must be LOX (liquid oxygen) compatible and withstand 5 to 25 bar of pressure with a factor of safety of approximately 2.5. The epoxy reacts with LOX, and so an impermeable liner must be designed that withstands high pressure without allowing leaks. As much as possible, the design and manufacturing processes should be accessible on hobbyists levels as this is an open source project.

Summary of plans for completing the project

Project objective statement: Design document, and build a lightweight composite cryogenic fuel tank for a hobby rocket capable of reaching an altitude of 100 km between the months of January-June, 2017. The cost of prototyping, research, and final assembly will be constrained by the PSAS Sponsor budget yet to be defined.

Design techniques to be used:

- PSAS will be a primary resource for past materials testing and research related to the design of the composite fuel tank and interfacing systems.
  - PSAS github documents for liquid fuel test stand, liquid fuel engine, and carbon fiber airframe (CAD files, ipython notebooks, research papers, data, etc.)
- Pre-existing composite tank technology and testing will inform design (see appendix for reference list).
  - eg. Google Drive with 20+ documents including but not limited to thermal analysis, LOX safety handling, University of Colorado composite tank design, MIT tank design, and Georgia Tech thesis: "Permeability of Hybrid Composites Subjected to Extreme Thermal Cycling and Low-Velocity Impacts"
- Engineering analysis tools/methods to be used:
  - Use of NASA sp 8000 series documents to develop mathematical representation of our design
  - Use compression mold curing techniques developed by the 2015 PSAS carbon fiber airframe capstone team
  - Use 3D modeling to create test geometries
  - Apply appropriate manual stress/strain calculations to refine models and design appropriate test conditions.
  - Optimization using multiple iterations of prototyping and testing (multiple variables that interact with each other)
  - FEA of thermal stress loads
  - Utilize basic principles to provide open source tools for rocket enthusiasts

Physical and other resources needed:

- Carbon Fiber, Resin, Nomex Honeycomb
- Lab space with access to the curing oven (EB 480)
- Vacuum bagging for compression molding curing
- Access to space appropriate for performing hydro testing
- Access to a supply of Liquid Nitrogen for cryo testing (Physics/Chemistry Department)
- Aluminum stock and machine shop access for pressure cylinder end caps
- FEA modeling software
- Solidworks
- Polycarbonate liner material

Key milestones and deliverables for ME 492 and ME 493

Winter Term

Weeks 1-3

- Research polymers that could serve as a liner and choose one based upon cost and thermal expansion, reactivity, and strength properties.
- Perform manual stress/strain calculations on potential materials in various test geometries.
- Devise and test polymer deposition techniques with refined selection of materials

Weeks 4-6

- Create Solidworks design for pressure vessel end caps with easy access fill ports
- Design baffle to prevent resonance due to sloshing
- Manipulate design dimensions and perform manual thermal and mechanical stress/strain & vibration calculations (multiple iterations)
- Confirm results/perform additional analysis with FEA simulations of feasible geometries.

Weeks 7-9

- Perform hand calculations and FEA simulations of thermal loading at aluminum/composite interface
- Interface tank components and complete composite layup for tank prototype

Spring Term

Weeks 1-3

- Run cryo tests for multiple scalings of endcap to assess endcap-cylinder interface fit.
- Redesign as necessary

Weeks 4-6

- Perform hydro pressure tests using end caps scaled to the dimensions resulting from cryo-temp contraction.
- Redesign as necessary

Week 7

- If possible, test fill with LOX, pressurize, and test fire using PSAS 3D printed engine and liquid fuel test stand

Week 8-9

- Organize and complete documentation for final report and presentation

Appendix:

I. References:

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