Deliverable #6:

EML4551C-Senior Design Spring 2014

Team 20- Direct Drive Solar-Powered Arcjet Thruster

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Group Members

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Griffin Valentich

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Due : January 17, 2014

Project Scope

The project scope is to design, fabricate, and test an electric arcjet thruster within a vacuum chamber that will be designed to simulate the space environment at which the thruster will operate. The arcjet thruster will operate on a direct drive system eliminating the need for a power processing unit (PPU), thereby reducing the weight of the system, its complexity, and most importantly cost while maintaining efficiency. The use of solar panels as the arcjet's source of energy will be used since the abundance of solar energy is present in the space environment.

Work Statement

During the spring semester the fabrication, testing, and troubleshooting of the design is to be executed. During the fall semester the thruster and circuit was designed and simulated using Comsol and MATLAB respectively. Basic circuit components as well as materials for the physical thruster were ordered and received. Some other components will have to be ordered early in the Spring Semester once the testing apparatus design has been finalized. These include hoses, fittings, PCB (printed circuit board), a balance to measure thrust, and various other small components. The main focus of this semester's work will be to design and implement a testing plan to prove the concept of direct drive for arc-jet thrusters.

Goals/Objectives for Spring 2014

Below are the major goals and objectives for this spring semester.

- Fabricate Thruster
- Test Circuit for voltage spike
- Finalize and fabricate testing apparatus
- Develop testing plan and matrix
- Quantify maximum thrust and operating conditions

Modifications of Design

Mechanical

After receiving feedback from our sponsor, Dr. Polzin, he was concerned about the excess material we had on our design as well as the overall length of the arcjet thruster. As a result we shortened the overall length of our nozzle and the housing chamber, ultimately reducing the material used. Once these components were updated, we sought manufacturability advice from Jeremy in the Machine Shop. This guidance allowed us to further improve our thruster by changing the way the housing chamber was designed to account for the threaded hose fitting needed to inject the argon into the housing chamber at an angle.

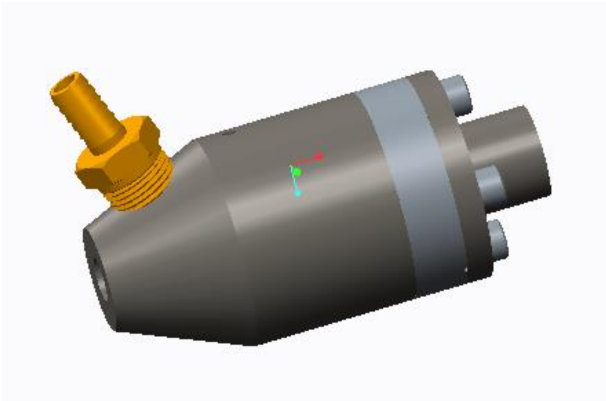


Figure 1. Redesign of Thruster

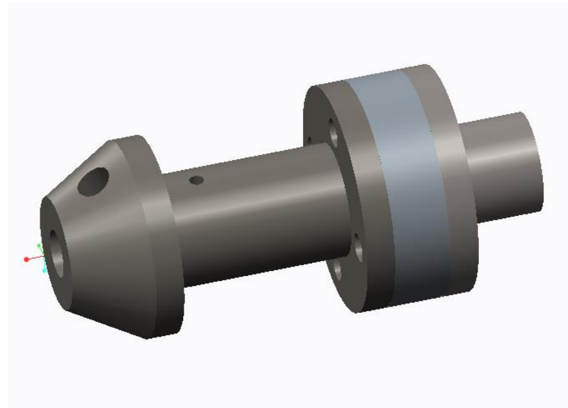


Figure 2. Old Design of Thruster

The comparison of the updated thruster design to our previous design is shown above in Figures 1 and 2. Other than the overall length of the arcjet thruster, another noticeable difference is the fact that the old design's housing chamber was turned down to a smaller diameter. Compared to the housing chamber for our new design which was kept at two inches. As previously stated this was done to help with the manufacturability. The internal characteristics of both designs are the same

Electrical

The electrical design changes dealt with the magnets, while the circuit and solar power integration remained the same. We originally planned to use three magnets: one around the anode/cathode, and two around the nozzle. We needed to shorten the nozzle and therefore didn't need two magnets around the nozzle, instead one magnet around the anode/cathode will suffice. This is because the purpose of the magnets are to make sure the Argon ions don't come into contact with the walls of the thruster. As we shorten the length of the nozzle, the magnetic field due to the anode/cathode magnet gets stronger, and we calculated it should confine the Argon ions to be less than the radius at the end of the nozzle.

Newly Developed Concerns

Some concerns for the implementation for this project include ensuring high vacuum sealing, wire and hose connections to the arc jet through baseplate, trouble-shooting direct drive operation of thruster, and quantifying operating conditions. Another concern in measuring thruster is to determine the best way to mount the device securely and accurately measure the thrust produced. Yet another concern with the project is the fact that the vacuum pump switch is currently frozen. It has been planned to disconnect the old switch and install a new inexpensive toggle switch.

Updates of Procurement

Below, in Table 1, are the items already purchased in order to build the physical thruster and the circuit.

Table 1. Money Allocated for Arc-Jet Project

Component	Description	Quantity	Cost	Manufacturer
Cathode	Tungsten Rod, 3/16" x 6" P#8788A153	2	$ 33.24	McMaster Carr
	Stainless Steel 303, 3/16" x 6' P#8984K93	1	$ 7.77	McMaster Carr
Anode	SS Steel Tube 1/2 OD, 0.37 ID 3' P# 9220K461	1	$ 8.79	McMaster Carr
Housing/Nozzle	Stainless Steel 303, 2' Diameter, Stock P#8984K573	1	$ 79.64	McMaster Carr
Gasket	All Purpose Sheet Gasket 6"x6" P# 9470K26	2	$ 6.02	McMaster Carr
Bolts (Anode)	P# 92185A078	1	$ 3.23	McMaster Carr
Mating Bolts	P# 92185A546	1	$ 5.43	McMaster Carr
Nuts for Mating Bolts	P# 91845A029	1	$ 4.57	McMaster Carr
Insulation	Macor Rod P#8489K81	1	$ 72.95	McMaster Carr
IGBT	Part# IRG7PH30K10DPBF	1	$ 8.73	Digi-Key
Inductor	100.0 µH, 6 A PART#1410460C	1	$ 2.62	Digi-Key
Switch	PART# C3900BA	2	$ 8.92	Digi-Key
Potentiometer	Part# AVT20020E200R0KE	2	$ 31.24	Digi-Key
		Spent	**$ 273.15**	
		Budget Remaining	**$ 226.85**	

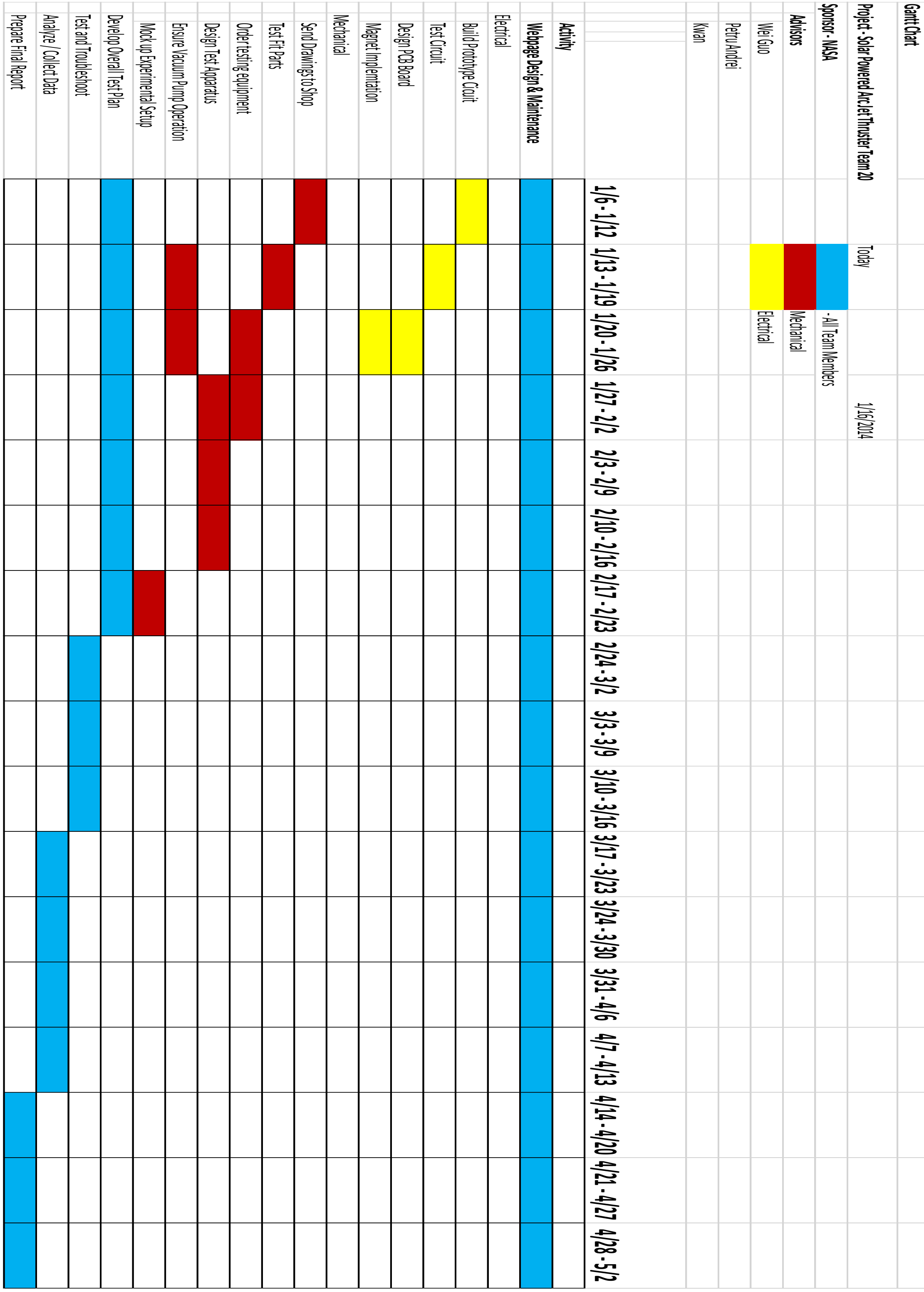
The remaining budget will be used to procure the other necessary materials to complete the project. These components include

- Hose fittings
- Through wall wire connectors
- Hoses
- Vacuum pump switch
- PCB
- Electrical wire
- Baseplate material
- Test stand material

- Thrust measurement balance
- Magnets
- Pressure measurement device

Specifications for the components listed above will be researched and budgeted in a future report once designs are finalized.

Gantt Chart



Gantt Chart
Project - Solar Powered Arc Jet Thruster Team 20
Today
1/16/2014
Sponsor - NASA
- All Team Members
Advisors
Mechanical
Wei Guo
Electrical
Petru Andrei
Kwan
1/6 - 1/12
1/13 - 1/19
1/20 - 1/26
1/27 - 2/2
2/3 - 2/9
2/10 - 2/16
2/17 - 2/23
2/24 - 3/2
3/3 - 3/9
3/10 - 3/16
3/17 - 3/23
3/24 - 3/30
3/31 - 4/6
4/7 - 4/13
4/14 - 4/20
4/21 - 4/27
4/28 - 5/2
Activity
Webpage Design & Maintenance
Electrical
Build Prototype Ciruit
Test Circuit
Design PCB Board
Magnet Implemtation
Mechanical
Send Drawings to Shop
Test Fit Parts
Order testing equipment
Design Test Apparatus
Ensure Vacuum Pump Operation
Mock up Experimental Setup
Develop Overall Test Plan
Test and Troubleshoot
Analyze / Collect Data
Prepare Final Report