VDR 3 Write Up

FAMU-FSU College of Engineering

EML 4551C: Senior Design

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**Current State of Selected Design**

Our selected design is broken up into a 2-step cooling process. The first step is done at ambient pressure before the pump down of the vacuum chamber. This step uses two plates that are removable from the main bed and are connected by recirculation tubing. Liquid nitrogen (LN2) will be introduced into the top plate that has small circular holes that allows the LN2 to drip through. Since the LN2 will evaporate once it is introduced into our fixture, copper tubing will connect the top plate to the bottom plate. We’ll be using the 700x volume expansion rate of LN2 to gaseous nitrogen as the pressure to push the gas through the tubing and into the bottom plate. The bottom of the bed will also have holes extruded through it so that the now gaseous nitrogen can flow up through the regolith uniformly. There is tubing going from the fixture (above the regolith) to the outside that acts as a pressure release for the nitrogen gas. Once the desired temperature is achieved, then the top plate and tubing can be removed. For the second cooling stage the main bed is surrounded by a nitrogen jacket so that the temperature of the regolith can remain at the required temperature during the vacuum pump to high pressure. The main bed is a 2 ft by 1 ft by 1ft rectangle that will represent a scaled size of the 4 ft by 8 ft by 1 ft fixture that our sponsor would like to create in the future. Our prototype is made of styrofoam and carboard, but our final design will be out of vacuum safe materials such as aluminum 6061.

**Future Work**

After our materials are ordered and delivered, the aluminum sheets, along with our design drawings, will be given to the FAMU-FSU College of Engineering machine shop for fabrication. The controls components of our design will also need to be coded and integrated into our system. This includes the liquid crystal display (LCD), water moisture sensors, and thermocouples. These components will be controlled by an Arduino Mega 2560 microcontroller. Once this is completed, we’ll be able to assemble our design and run tests utilizing vacuum chambers and liquid nitrogen in the local Tallahassee area (MagLab). This will give us a chance to troubleshoot any potential problems that our design has before our final test at the Marshall Space Flight Center (MSFC) in Alabama. Before travelling to the MSFC, we will need to continue to meet with our sponsors to update them on our progress. This will also help us ensure that our tubing system will properly integrate into the PLANET chamber.

**Potential Problem Areas**

There are several potential challenges that we will face in the next phase of our project. Maintaining water composition (4-10%) and water phase being the main one. This was the main problem our sponsors were encountering in the past and is still relevant at this stage of the design process. While we do have an experimental process that was vetted by our sponsors, extensive testing will be needed to ensure everything goes according to plan. Our project incorporates experimental materials and fluids such as liquid nitrogen, so finding a facility that will allow us to run tests is another potential challenge. We have already begun the process of reaching out to facilities, like the MagLab, but have yet to reach a formal agreement. Our team also has limited experience working with vacuum chambers and cryogenics so training will be needed before we conduct any testing. We have reached out to experts in these fields such as Dr. Guo for guidance.

The utilization of nitrogen gas also creates some potential problems. The expansion of nitrogen from liquid to gas in a vacuum chamber could potentially cause an explosion if not properly contained. Our sponsors have ensured that our current design will not encounter these problems, but the severity of the problem requires more risk assessment and planning.