Team JUNK: Foam-Based Space Debris Removal

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Introduction

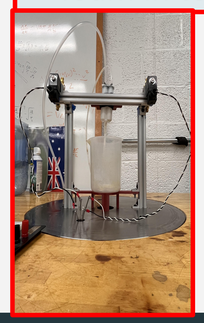
The rapid accumulation of space debris is an alarming problem. Space debris presents an inherent risk to our satellites which provide critical services such as GPS, internet, telephone communication, space research, environmental modeling, and other functionalities that are an integral part of everyday life.

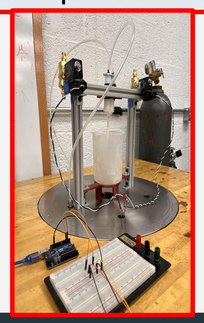
Research Problem

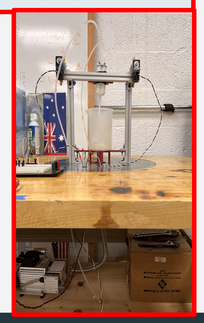
Little research exists on the use of foam to remove space debris, and this method has not been experimentally validated. Team JUNK aims to develop, design, and test foam-based space debris removal methods. By doing so, we can analyze the material properties of our foam to evaluate the effectiveness of such debris removal methods.

Research Questions

- What design for a static mixing nozzle fulfills the requirements of being able to mix and deploy our foam?
- How can we examine the feasibility of our foam in terms of space debris removal?



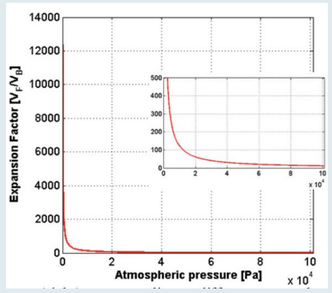




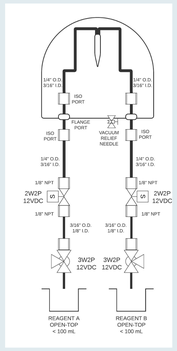
Methodology

Theory

The aim of this design process is to validate claims on whether the expansion ratio of spray foam matches the theoretical values (in the figure to the right). By designing a system that can measure the expansion, adhesion, and range of spray foam in space, we will verify the feasibility of a foam-based removal system.



Construction



Using an iterative, test-based design methodology, we progressively build our system part-by-part. Beginning with setting up electronics to actuate valves from outside the test chamber, then progressing to adding tubing that feeds into the chamber from underneath, and finishing with a combination of both subsystems, we construct our flow control system, as depicted in the figure to the left.

Validation

To validate our system, we design a series of tests that will determine the feasibility of the use of foam to remediate space debris. The key components we focus on for a successful system are: ability of foam to expand to the predicted volume, ability of foam to adhere to debris, and ability of the nozzle to eject foam at a reasonable distance from the debris surface. With these in mind, we design our tests to validate our system against the requirements of a successful system.

Results

A foam deployment system is constructed and testing of the reagents has begun. We have successfully pumped reagents through individually, but we are still trying to increase the efficiency with which they reach the nozzle. We have isolated the foams that we would like to use, based on design criteria, like viscosity, sourced from previous studies into the properties of foams.

Path Forward

As we continue developing our system we have many improvements planned, such as improving the cleaning procedure after testing to prevent clogging. In addition to our improvements to the system, we plan to start testing with various metrics of success which include:

1) Foam expansion ratio
2) Adhesiveness of foam reagents
3) Nozzle range

Acknowledgements

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