Altitude Control System for High Altitude Helium Weather Balloons

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Background

The goal of this project was to develop an altitude control system for a latex balloon, which could be used to achieve what is known as stationkeeping. Stationkeeping allows the balloon to maintain approximately the same position over the Earth by ascending and descending to catch different wind layers and float in different directions. When latex balloons are filled with helium, they are typically overfilled to provide positive lift as they rise through the atmosphere. As the balloon ascends it expands due the decreasing atmospheric pressure and ultimately bursts when the balloon volume exceeds its critical size. The first step in altitude control requires that the excess helium be released so that the system becomes neutrally buoyant. Weight can then be released in order to allow the balloon to rise again, and the cycle can be repeated until the balloon runs out of ballast. This project focused on the design of the valve system, which will be described in more detail. For balloon flights, the FAA requires two independent methods of cutdown. Opening the valve qualifies as one cutdown mechanism, but a second needed to be designed. The final valve design is composed of a collar, four clamps, and the valve body. The collar is permanently attached to the balloon neck, and secured to the valve body by the set of clamps. The clamps are held closed by a length of nylon string that is passed through a small length of nichrome wire. The second cutdown mechanism involved running current through the wire, causing the string to be cut and the valve to separate from the balloon.

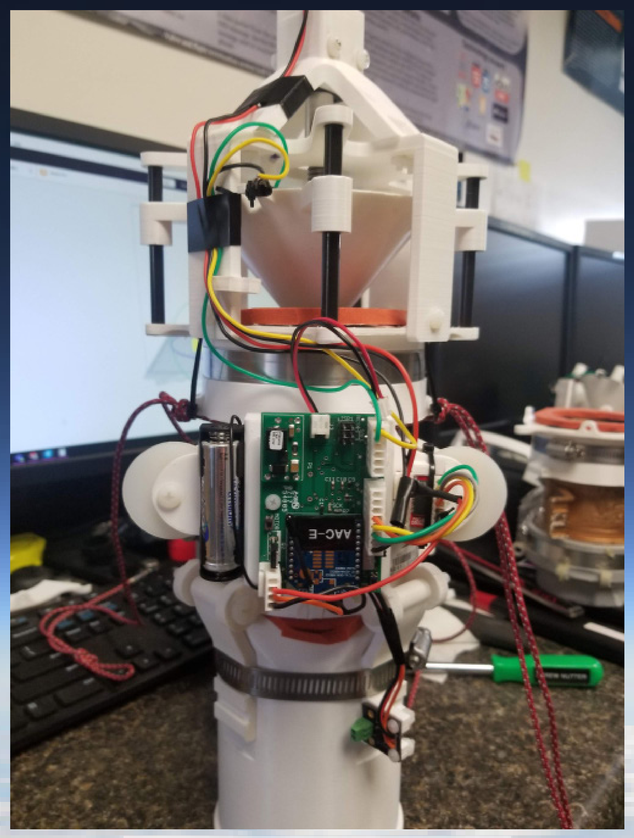

Figure 1: Completed Valve Assembly

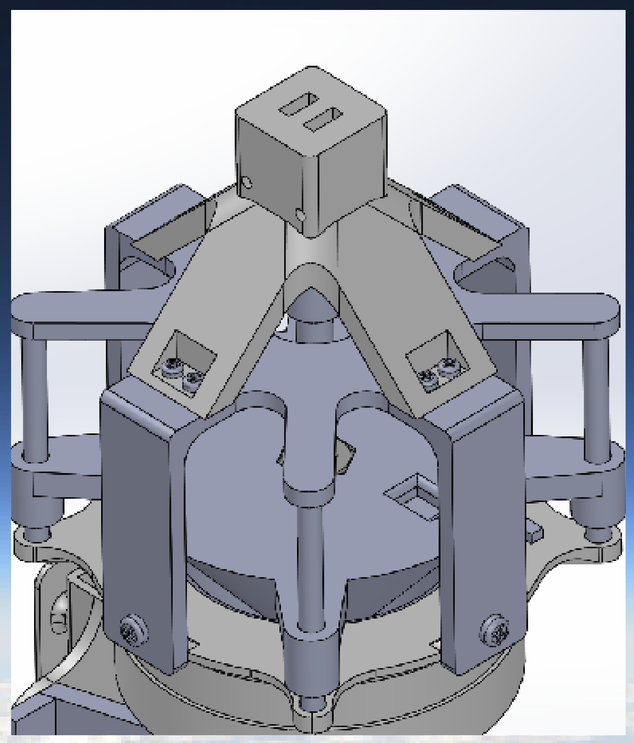

Figure 2: Isometric view of Valve Mechanism

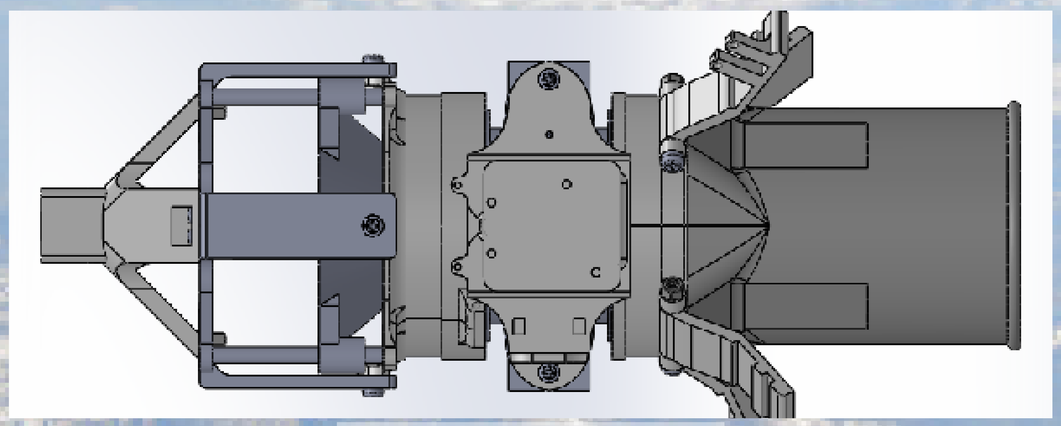

Figure 3: Render of full valve system

Objective

The objective of this project is to create a valve system capable of releasing helium and cutting away from a latex balloon at altitude. Since such a system will be attached to the neck of the balloon, a specialized cutdown system will be developed. The new design for the venting system will improve upon previous designs. This system will be controlled by a microcontroller board and a motor controller, and receive commands through an XBee Radio. The first major improvement will be the ability to reliably cut away from the balloon. This subsystem will use a collar compressed into a gasket by a set of angled brackets, and retained using small gauge string looped around the collar. To achieve separation, the string is cut by running high current through small gauge nichrome wire to melt through the string. Once the string is severed, the hinges will be allowed to rotate out of the way to allow the payload string to fall away from the balloon. The valve subsystem is improved through the use of linear rails, a threaded rod drive shaft instead of a power screw, and a larger diameter opening.

Results

The valve system was flown on two flights, with mixed levels of success. The most important component, the cutdown, worked both times, and the valve system was recovered each flight. However, the valve itself had mixed levels of success. A synopsis of each flight and outcomes are recorded below.

Flight 1:
07/26/2019
The first flight of the venting system resulted in a complete failure of the venting system. However, the termination system was successfully implemented on this flight. It was determined that this failure was most likely caused by a loose connection on the control boards.

Flight 2:
07/31/2019
The second flight resulted in a partial opening of the vent and another successful termination. After opening, the vent became stuck approximately half way through its cycle. When recovered, we found that the current limiting circuit on the LipO battery had triggered. While the cause of this malfunction is not certain it is believed to have originated with a temperature limiting function on the motor controller.

Future iterations of this project will seek to improve the motor driver selection, as well as cut weight from the overall valve system.

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