Advanced Concepts for Small Satellites: Materials, Ejectors and Formations

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Abstract

Since 1999, over 40 universities have participated in the Cubesat program developed by California Polytechnic University because of their flexibility and lower fabrication cost. Although CubeSats have come a long way since 1999, successful Deployment Mechanisms for these devices are still in the beginning stages of development.

Cube Satellites

•A basic 1U CubeSat measures 10x10x10cm and weighs 1kg
•Fabrication cost range from $40,000 - $60,000

Figure 1: Basic 1U CubeSat

Deployment Mechanisms

•Deployment Mechanisms for CubeSats are still in the early stages of development
•Standard propulsion system : The Poly Picosatellite Orbital Deployer (P-POD)

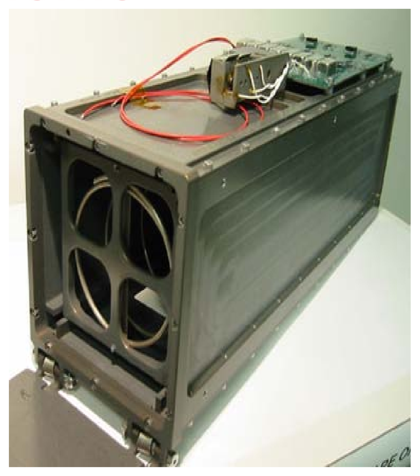

Figure 2: CalPoly P-POD Mk.I

RAMPART

•Future 3U CubeSat planning to be fabricated and launched

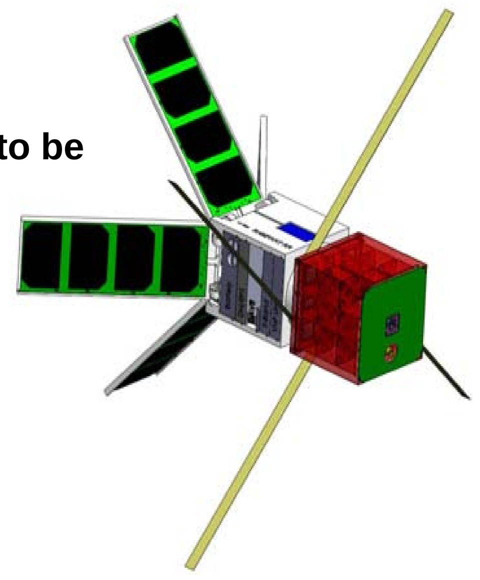

Figure 3: RAMPART 3D Sketch

Research Objectives

•Perform 3D Burst Test on test materials used to fabricate RAMPART; materials will be tested at various temperature and pressure combinations which will determine the materials sustainability
•Perform 3D Tensile Test on the materials that will be used to fabricate RAMPART to determine the amount of stress and force the material can sustain
•Research Deployment Mechanisms that would allow a CubeSat to achieve a higher deployment velocity

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EXPERIMENTAL WORK

3D BURST CUBE TEST

•Materials tested: Windform XT (carbon fiber filler) & Windform LX-2 (glass fiber filler)
•(8) 1in hollow cubes were made of the XT and LX material with either 1/8in or 1/16in walls which were either filleted or non-filleted
•(4) 1.5in hollow were made of the XT material with either 1/8in or 1/16in walls which were either filleted or non-filleted
•Each of the test cubes underwent testing of their ability to survive in temperatures ranging from -70 C to 80 C and pressures up to 1000psi simultaneously
•The cubes were attached to a stem in a MCBH Temperature Chamber then enclosed in another container (for safety reasons in case of a cube bursting). The stem then made a pathway to the outer portion of the chamber where it connected to several valves and a tank of compressed nitrogen.

Figure 4: 1in. XT Hollow Test Cube vs. 1.5in. XT Hollow Test Cube

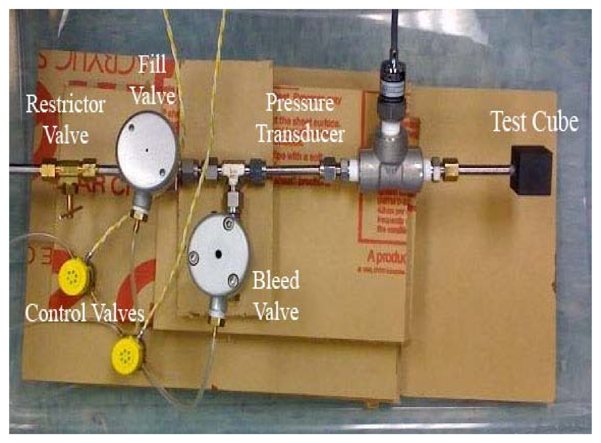


Figure 5: 3D Burst Test Fluidics

Figure 6: Contained Test Cube Attached to Stem in MCBH Temperature Chamber

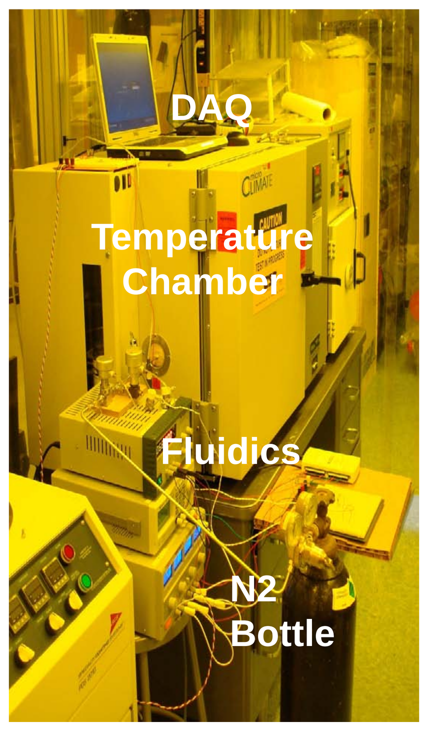


Figure 7: 3D Burst Test Setup

3D TENSILE TEST

•Materials tested: Windform XT (carbon fiber filler) ;density =1.101 g/cm^3 & Windform LX-2 (glass fiber filler);density=1.309 g/cm^3
•Materials were then made into ISO 527 – Flat "Dog-Bone" Standard and placed on a Tinius Olsen H50KS and had their stress, force and strain endurances tested

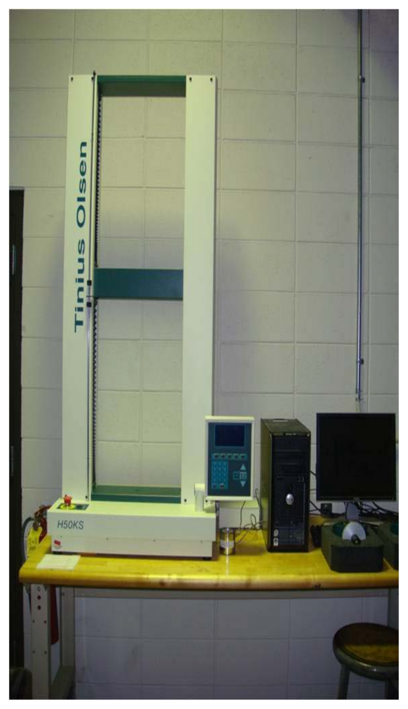
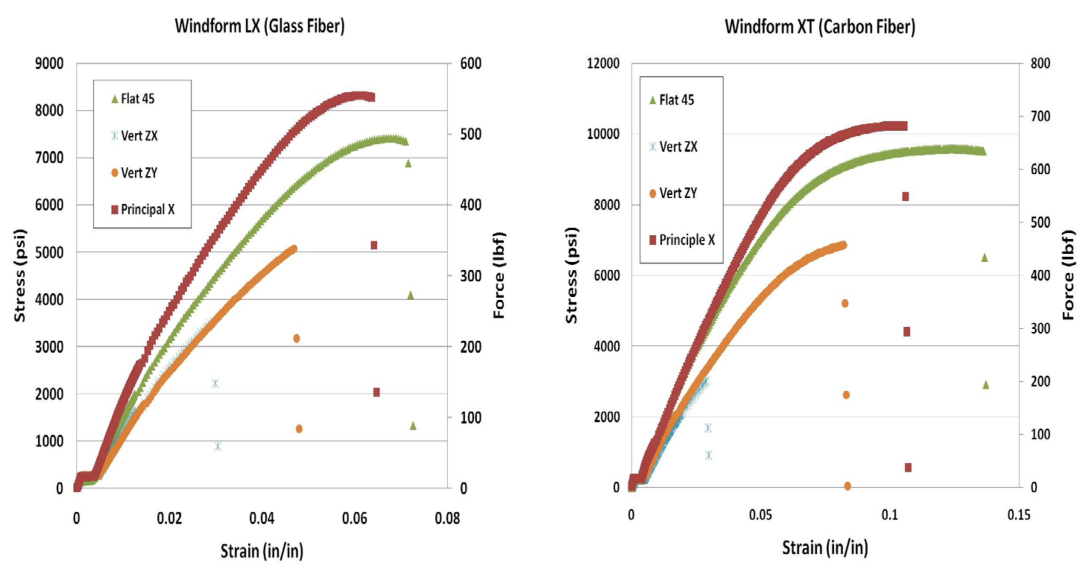


Figure 8: 3D Tensile Test Setup

Figure 9: ISO 527-Flat "Dog-Bone" Standard

3D Tensile Test Results

Stress-Strain Data Charts



RESEARCH WORK

Deployment Mechanism

•Research shows that by making the Deployment Mechanism pneumatic, secondary payloads and so on will have a higher deployment velocity which could enable them to reach different orbits than their primary payloads
•Pneumatic launchers are propulsion mechanisms that are able to achieve higher deployment velocities because they are controlled by pressurized air.
•In a pneumatic launcher, there is normally a release valve separating the built up air from the item being launched. When the desired pressure is set, the release valve is opened releasing the pressure and (depending on how high or low it is set) launches the item
•By using STK (Satellite Tool Kit), various mission simulations were ran to learn the outcomes and orbits that a CubeSat with a faster propulsion velocity would achieve

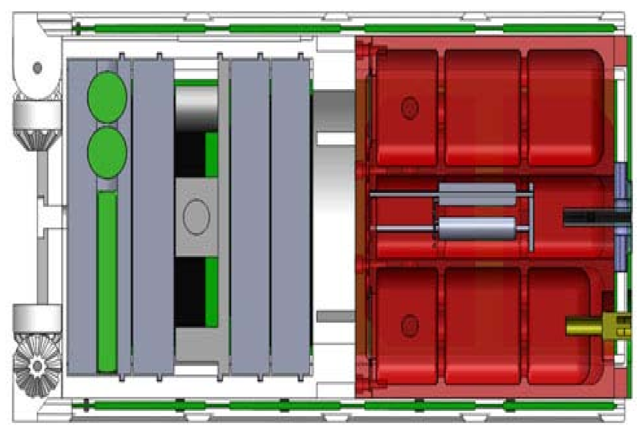
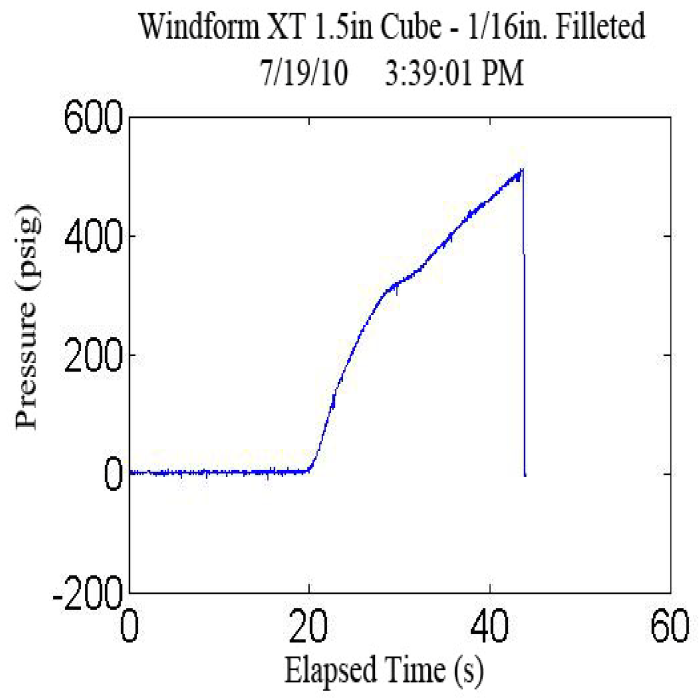


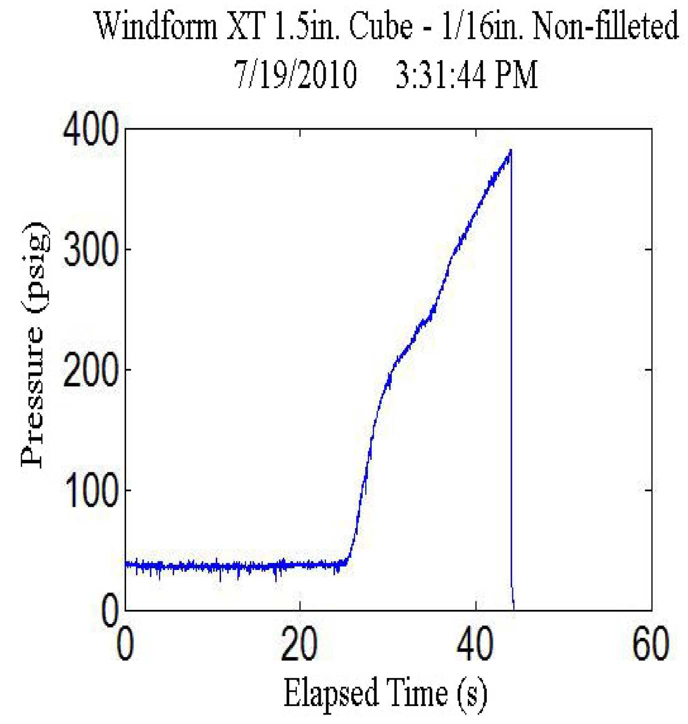
Figure 10: 3D RAMPART Sketch with Deployment Cube

3D BURST CUBE TEST

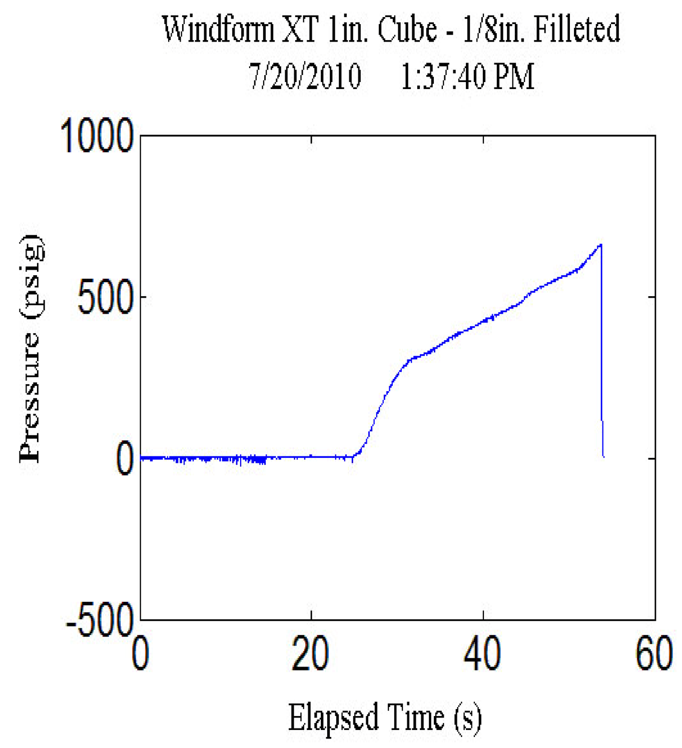
•The cubes made of the XT material were able to withstand more pressure and larger ranges of temperature.



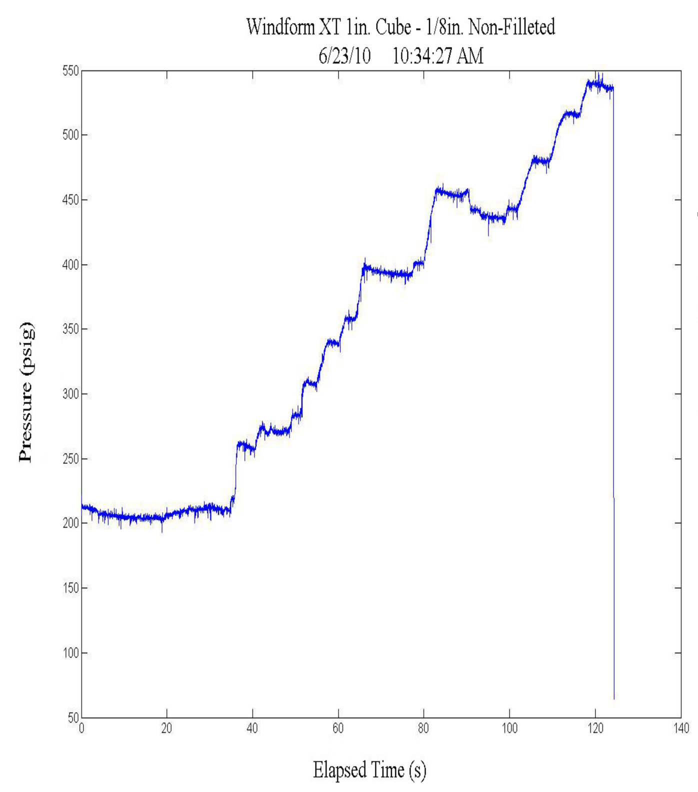
Temperatures Survived: -70°C - 80°C
Max Pressure: ~ 500 ≤ psi



Temperatures Survived: -70°C - 80°C
Max Pressure: ~ 380 ≤ psi



Temperatures Survived: -70°C - 80°C
Max Pressure: ~ 525 ≤ psi



Temperatures Survived: -70°C - 80°C
Max Pressure: ~ 500 ≤ psi