Additive Manufacturing Characterization in Suborbital Spaceflight and Re-entry

Stacie Barbarick, Bruce Bell, Cassidy Bliss, Barbra Sobhani
Red Rocks Community College, Colorado Space Grant, Lakewood, Colorado, USA

Abstract

The use of additive manufacturing in aerospace applications is revolutionizing the industry, making research tools more available and affordable. Flight components made from 3D printed filaments are significantly less expensive and weigh less than their metal, machine-milled counterparts. Since there is limited data on the thermal effects of re-entry from Low Earth Orbit on additive manufactured materials, we built a sounding rocket payload with the goal of testing and documenting of those key characteristic properties. We flew our payload on a Terrier-Malamute rocket at NASA Wallops Flight Facility on August 12, 2019 as seen in Figure 2 below. Upon recovery of the payload, we conducted post-flight analysis and found that changes in structures were nominal and all internally housed electrical components remained functional throughout the entire flight. These data are crucial for the next stage of additive manufacturing in suborbital space for research and educational institutions as well as commercial organizations.

Background

Our goal was to test and record the effects of thermal build up on the rocket and its payload during re-entry from suborbital space in order to determine the viability of common 3D printed materials. After initial testing, we determined that ABS and PETG were the most viable options and designed an interface of multiple 3D printed structures fitted with thermal sensors and 3D printed all the essential components of our payload.

Testing

Upon recovery of the payload, we were able to retrieve temperature data logged from all five probes, compare it with the flight altitude data from Wallops Flight Facility as seen in Figure 1, and conduct assessment of the 3D printed components on board.

Figure 2: The RockSat-X mission successfully launched at 5:44 a.m. EDT on August 12, 2019 from Wallops Island, Virginia.

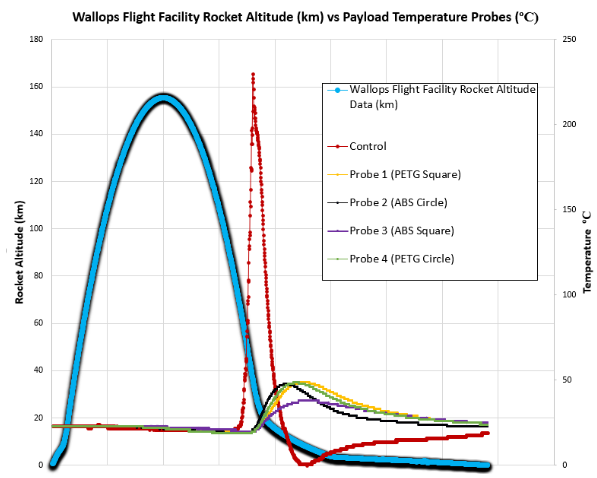

Figure 1. Flight altitude trajectory visualized with temperature probe readings onboard the rocket.

By making comparisons of measurements made in reference to the temperature profile we obtained from our sensors, we were able to document structural and weight material property changes. We used photo pixel measurements in the x-, y- and z-axis, in addition to weights to compare pre and post-flight components.

Conclusions

Companies and schools are investing in novel additive manufacturing techniques and specific designs to reduce launch requirements and costs, making suborbital research a more accessible possibility. Due to the inherent elastic and weight properties, 3D materials are also being considered to build orbital structures like satellite shields and deflectors to protect against space debris. Our experiment provides key characteristic material data on the effects of thermal re-entry on 3D printed structures demonstrating that use of these filaments in future experimentation is a viable option over other cost and design prohibitive requirements.