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THE HYBRID SOUNDING ROCKET OF “BEIHANG-2”

Abstract

The sounding rocket “Beihang-1 (BH-1)”, the first meteorological rocket designed, built and tested by undergraduates at Beihang University (BUAA) in China, was successfully launched on November 1st 2006. The project of “Beihang-2 (BH-2)” hybrid sounding rocket was put on schedule in Beihang University immediately on December 2006 to cultivate and train students through large technology project. It also wanted to make breakthrough in the field of employing hybrid rocket motor in China.

“BH-2” was designed and fabricated by 15 undergraduates (graduated on September 2007) from School of Astronautics at BUAA. The major objectives of the rocket were evaluation the hybrid rocket motor technology as well as measurement and store the parameters of the stratosphere. The rocket was 3.42 m in length with the outer diameter of 0.22 m and weights 110 kg. The requirement of “BH-2” was capable of reaching the altitude of 10 km with a 15.5 kg payload. The rocket system was composed of five subsystems: structural subsystem, propulsion subsystem, separating-recovery subsystem, parameter-measuring subsystem and launch subsystem. The structural subsystem included the rocket structure, aerodynamic shape, and etc. The rocket structure can be divided into three main parts, namely, the equipment cabin, the separation-recovery cabin and the hybrid rocket motor.

The propulsion subsystem was a hybrid rocket motor. Nitrous oxide (laughing gas) and HTPB were chosen as propulsions. According to the different characteristic of liquid oxidizer and solid fuel, the subsystem can be divided into liquid delivery system and solid-fuel chamber. The average N₂O flow rate was approximately 3.5 kg/s and the mixture ratio was approximately 7.7. The average thrust was approximately 7800 N and the operational duration was 4 seconds. The motor adopted a pressure-feed method without extra pressure system. It controlled the oxidizer flow rate by the regulating valve designed by the students, which could sustain a steady supply of oxidizer flow when the pressure was dropping in the tank in the absence of pressurized gas. The thrust chamber was the union of liquid oxidizer injector, combustion chamber, uncooled expansion nozzle, star-shaped grain and BKNO₃ ignition system. A modified injector was designed to avoid convective instability, and a post-combustion chamber was designed to improve the combustion efficiency.

The separating-recovery subsystem consisted of two parts: the separation mechanisms and ignition device. The main crisscross parachute made the nose cone equipment cabin land at about 10m/s. The parameter-measuring subsystem was the payloads that installed in the instrument module to measure and store the pressure, temperature and humidity of the stratosphere after separation. The launching subsystem consisted of the launch vehicle and the oxidizer filling and pressurizing system.

Through the efforts for 2 years, the team had finished the investigation, design, test, debugging and final assembly of all the five subsystems. The “BH-2” hybrid rocket was successfully launched at Jiuquan Satellite Launch Center on Dec.5th 2008. It reached the altitude of 3 km because the total mass of oxidizer was 12 kg (the maximum oxidizer containing capability was 27kg). Every subsystem was validated during the flight test and the “BH-2” hybrid sounding rocket performed successfully in ignition, launch, separation and landing.

The abilities of innovation, investigation, engineering practice and cooperation have been improved for the students through this project. This project is an advanced test on training the aerospace reserving staff at BUAA after success of the “BH-1” one.