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## DEVELOPMENT OF THE VARIABLE THRUST HYBRID SOUNDING ROCKET: BEIHANG-3

**Abstract**

The Beihang-3 sounding rocket is a student project developing in School of Astronautics at Beijing University of Aeronautics and Astronautics to demonstrate the hybrid rocket technologies including aerodynamics, structures, trajectory, propulsion, ground support and control subsystems. The program was kicked off in January of 2009 and several ground tests of the propulsion system have been conducted. The sounding rocket is designed to reach an altitude of 25km at an initial flight angle of 85 degrees and to achieve an overall propellant mass fraction of 52% with a total lift-off weight of 310kg. The Beihang-3 rocket consists of nose cone, payload module, hybrid rocket motor and four fins, and is 0.3m in diameter and 5.16m in length. The hybrid rocket motor uses metalized hydroxyl terminated polybutadiene (HTPB) as the solid fuel and 90% hydrogen peroxide as the oxidizer, with a boost thrust of 12.5kN working 3 seconds and a sustain thrust of 5kN lasting 42 seconds. A pressure regulated feed system which uses gaseous nitrogen as pressurant is incorporated to transfer the hydrogen peroxide from oxidizer tank to combustion chamber, and a throttling valve and two cavitating venturis are used to control the oxidizer mass flow rate. A dual-manifold injector is designed to maintain the satisfactory injector pressure drop and the thrust throttling is achieved by proceeding from two-manifold operation at high thrust to single-manifold operation at low thrust. The motor employs a star-shape fuel grain, solid propellant igniter and graphite ablative-cooled nozzle. Three full scale grounding hot-fire tests have been conducted during the developing process, and all of them obtained stable combustion with characteristic velocity efficiencies range from 90% to 94%. The paper details the design and development of the subsystems of Beihang-3 hybrid sounding rocket, with special focus on the design and testing of hybrid rocket motor.