Recent Achievements on Solid Propellant Science for Space Propulsion

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In 2003, Hayabusa spacecraft was launched by M-V launch vehicle from Kagoshima-Space-Center to rendezvous with an asteroid named Itokawa. In 2005, the spacecraft reached to the destination and shot a sharp picture of the asteroid surface and sampled the ingredient directly. At present, the explorer is on the way to the Earth. The M-V launch vehicle, which launched the Hayabusa, consists of four solid motors loaded with high-performance solid propellants. Because of their simplicity, solid propellant rockets came into use long for both of military and space use. Modern solid propellants can be divided into two main groups, one is double-base propellant, and another composite propellant. The double-base propellant consists with nitrocellulose and nitroglycerin. The composite propellant consists with rubber and oxidizer particles. Most of large-scale solid rocket motors (engine) used for launch vehicles, both of main engine (motor) and booster, are loaded with composite propellants. The propellants loaded to M-V rocket motors consist mainly with hydroxyl-terminated polybutadiene (HTPB), ammonium perchlorate (AP) and aluminum (Al). Because solid propellant grain works as mechanical structure of rocket motor, the ingredients and chemical processes for producing the propellant are controlled high accurately . The combustion process of composite propellants is extremely complex, because of the multiple phenomena including melting and vaporation of binder, diffusive combustion between binder and oxidizer and metal combustion. In addition, the combustion characteristics are affected by internal flow in the motor, acceleration of fuselage and propellant producing processes. The understanding of the physicochemical phenomenon on producing process and combustion process is significant practically. In this talk, recent achievements on experimental works to investigate some significant phenomenon such as, relation between making process and burning characteristics, turbulent effect on combustion, aluminum combustion, combustion in very low pressure, are presented. In addition, a plan of next generation rocket, of which the development is under going, is presented.