SiC/SIC COMPOSITE THRUSTER FOR A NON-TOXIC LIQUID PROPELLANT ROCKET ENGINE

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Combustion chamber and nozzle for a non-toxic liquid rocket engine made by Tyrano ZMI SiC fiber reinforced SiC matrix composite were tested under sea level combustion tests. Combustion chamber and nozzle are the key hot parts for small liquid propellant engine, since chamber wall needs to be cooled by fuel rich low temperature gas. To create fuel rich low temperature gas, excess amount of fuel is consumed. Consequently, high temperature heat resisting material is indispensable to have better performance rocket engine. Nb based alloy are commonly used in combustion chamber and nozzle for a liquid propellant rocket engine for a satellite maneuver system with the maximum operating temperature around 1300°C. In this study, SiC/SiC combustion chamber with nozzle were examined and its performance was demonstrated by sea level static combustion tests in air and under vacuum. Tyrano ZMI SiC fiber (Ube Industry) was used as reinforcing fiber and carbon interface was selected to have higher temperature resistance. Fiber preform was fabricated by tri-axial braiding technique and carbon interface and SiC matrix were formed by chemical vapor infiltration (CVI). After CVI process, further densification was conducted by polymer infiltration and pyrolysis (PIP) process until no gas leak was detected under low pressure of 0.2 MPa. Largest inner diameter of the chamber was designed as 65 mm and the smallest inner diameter of 26 mm as a nozzle throat. Nozzle was designed with opening area ratio of 25 to investigate manufacturability. The combustion chamber and nozzle attached with a core engine as shown in Figure 1. Non-toxic fuel, ethanol, and oxidizer, N_2O, were supplied through the showerhead type injection into combustion chamber. Sea level static combustion tests were conducted both in air and under vacuum (1.3 kPa). The engine combustion tests were successful (30s in air and 19 s in vacuum) and no damage could be found. The performance of the engine improved to specific impulse of 290s with assumption of nozzle area ratio 100. The maximum surface temperature reached to 1250°C, where the inner wall temperature could be calculated about 1600°C. Prototype engine development program successfully completed and we are preparing to start real application project of this engine system as a final stage of solid propellant satellite launcher.

Figure 1 SiC/SiC combustion chamber and nozzle equipped with core engine.

Figure 2 SiC/SiC combustion chamber and nozzle operating under vacuum.