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MICROWAVE ROCKET WITH LONG-RANGE BEAM TRANSMISSION TECHNOLOGY

Abstract

Microwave Rocket is one of the Beamed Energy Propulsion (BEP) concepts, which uses microwave as a beam and consists of a reflector head and a tube body. Thrust impulse is generated by a high pressure sustained in the tube body. The high pressure is leaded backside of the shock wave generated by an atmospheric breakdown. The ionization front propagates toward the beam source by absorbing the microwave beam energy, and the propagation drives the shock wave. This propulsion system is expected to achive a 100 times lower launch cost than the convensional one. We already have technology of a MW-class microwave beam generator called "gyrotron" which is suitable for application to a Microwave Rocket.

The directionality of microwave is much worse than that of laser, however, millimeter wave band of microwave can be achieve the quality of the directionality for BEP use by using a long-range beam transmission technology. According to this technology, a wide beam diameter makes the directionality high enough, thus the beam diameter of microwave generated by a 170GHz gyrotoron was expanded to 6 times wider by using a set of parabolic mirrors on the transmitter side for the long-range beam transmission. The transmitted beam was narrowly collimated into the original beam size by using an on-board optical system on the vehicle side. When the original 40mm beam is used for transmission, the beam size will be diffused to about 3 times larger after 2m transmission. The expanded 240mm beam can be transmitted with less than 10% (actually designed to 7.3%) of diffusion after 10m beam transmission. As a result, the beam transmission and atmospheric breakdown were succeeded in the range of 1m to 5m.

The thrust obtained at the 2m transmitted area was measured by a laser displacement meter, and dependences on the tube length and the pulse repetition frequency were considered. The tube length was changed from 200mm to 500mm, and the pulse repetition frequency was changed from 20Hz to 200Hz. The high repetition frequency led to the lower thrust efficiency than expected by previous studies because of the incomplete air-breathing, and it can be recovered by using forced air-breathing system. The maximum value of the thrust was about 3N with the 2kg vehicle which has an on-board optical system and a forced air-breathing system.