SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic and Combined Cycle Propulsion (5)

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NUMERICAL SIMULATION OF INLET STARTING CHARACTERISTICS IN ROCKET-RAM COMBINED CYCLE ENGINE

Abstract

For next generation re-usable launchers, rocket propulsion will remain essential. The major concepts currently under consideration for first generation, fully re-usable launchers still use rocket propulsion only. However, the utilization of atmospheric air is one potential solution to increase launcher performance and to change the space transportation paradigm. Rocket Based Combined-Cycle (RBCC) engines are currently being explored as advanced propulsion for space transportation. RBCC engines combine elements of rocket and airbreathing propulsion into a single engine, and are capable of multi-mode operations. RBCC powered systems can provide significant advantages in range, mission time, weight, payload, loadout, mission profile flexibility, and cost over competing conventional propulsion solutions. In Japan Aerospace Exploration Agency (JAXA), RBCC engines technologies have been studied for several years and the engine, which is nick-named as "E3" was designed to achieve four different combustion cycles, each of which covers the specific flight speed regime. The experimental results were obtained in Mach 4 flight condition by using the Ramjet Engine Test Facility (RJTF) at Kakuda Space Center. In this speed regime, the combined cycle engine is scheduled to shift its operation mode from the ejector-jet mode to ramjet mode[1]. Supersonic inlets decelerate and compress oncoming air before it enters the combustor. Starting a supersonic inlet can be a very complex process that is influenced by a variety of aerodynamic phenomena. Unstart is detrimental to engine performance because it severely increases drag, does not pass the necessary mass flow, and spills compressed air. It is therefore necessary to fully understand the flow phenomena that occur during this process. CFD simulation plays an important role to obtain numerical approximation of what happens in complex flows. In this study, numerical calculations were conducted for the analysis of the starting characteristics of the inlets under Mach 4 flight condition. It was found that CFD results showed good agreements with experimental data. The various inlets including the droop cowls and the extended cowls were studied numerically to further explore the better performance behind the starting and operating limits of the supersonic inlet.

[1] Tani, K., Izumikawa, M. , Saito, T. , Ono, F., and Murakami, A., "Ram and Ejector-Jet Mode Experiments of the Combined Cycle Engine in Mach 4 Flight Conditions," AIAA-2008-0103, 46th AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, Jan., 2008.