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A NOVEL LIQUID ROCKET-RAMJET COMBINED-CYCLE ENGINE ENHANCED BY A COMPACT INTERNAL AIR TURBOROCKET

Abstract

In order to improve the low speed performance of the traditional rocket-ramjet combined-cycle engine characterized by specific impulse, a compact air turborocket (ATR), which is composed of a centrifugal-flow compressor and a coaxial single stage turbine driven by a kerosene/LOX gas generator, is introduced within the flowpath. Multiple operation modes can be achieved through matching operation of the engine components with flowpath control. For flight conditions with Mach numbers below 3, the ATR flowpath is open and the engine works in ATR mode. The original rocket engine for thrust augmentation is also available at this time according to the thrust requirement. For Mach numbers between 3 and 6, the ATR flowpath is shutdown and the engine works in ramjet mode. For a higher speed, the engine works in rocket-ramjet hyper mode and subsequent pure rocket mode out of the atmosphere, behaving like a traditional rocket-ramjet combined-cycle engine. An integrated flowpath plan was put forward, and the optimization on the matching between the ATR flowpath and the ramjet flowpath was carried out. The results indicate that the concept of tucking an ATR into a rocket-ramjet flowpath is feasible, and the specific impulses at low Mach numbers could be improved dramatically. Predicted performance data over a wide range were obtained by thermodynamic models and partially verified by CFD simulations of the flowpath. Further trajectory analysis of a lifting body vehicle propelled by this new engine demonstrated that it would be more efficient and practical to use this engine other than traditional rocket-ramjet combined-cycle engine to accelerate the vehicle from horizontal take off with zero speed to Mach 8. The overall great performances, compact structure and relatively high technology maturity makes this engine more competitive in near space missions and space transportation.