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ATMOSPHERIC BREATHING SOLID-FUEL RAMJET FOR MARTIAN DESCENT MISSIONS

Abstract

One of the challenges of manned and unmanned Mars missions resides in the low-density atmosphere of Mars, which prevents conventional Entry, Descent, Landing (EDL) concepts to land larger payloads. In an attempt to solve this problem, a student team at Purdue University designed a ramjet demo cruise vehicle which uses a solid-fuel ramjet cycle with CO2 as the oxidizing in-situ agent. To provide a throttling ability independent of combustor conditions, a positive displacement fluidized bed (PDFB) injects solid particles using Argon as the fluidizing gas. After radial fuel injection via a manifold, the mixture is ignited using four pyrogen igniters in a circular arrangement. A flameholder vigorously recirculates the flow to achieve better mixing and guarantee ignition. To achieve the 90-degree turn required by the mission, rotating contoured jet tabs were designed to significantly reduce the form drag of the vehicle while providing strong control authority in pitch, roll and yaw throughout the flight. The current design is graded to fly at Mach 2.7 at an altitude of 2 km and an angle of attack of 8 degrees. The large surface area of the vehicle will increase drag quadratically and may be a limiting factor to scaling up the payload. Although the design's attainable latitude is slightly under the 10 degrees required by the mission, range and fuel usage is far less than alternative EDL concepts with the necessary plane-change maneuvers. Overall, this design study highlights the potential benefits and challenges of a Martian ramjet and may serve as a resource for future mission designers.