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

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MARS EXPLORATION: SILANES AS FUELS FOR MARTIAN RAMJET AND SCRAMJET ENGINES

Abstract

Mars is a rocky planet, with only half the diameter of Earth, a far thinner atmosphere (composed mainly of CO2) and a cold and SiO2-rich desert-like surface; moreover, from time to time, Mars dust storms start, growing thousands of kilometers across the atmosphere. These extreme conditions pose some questions about engines and fuels useful to Mars exploration. The density of Mars atmosphere being less than one-hundredth of a bar makes chemical ground propulsion difficult, and in any case very slow due to the rugged terrain. Rapid survey and excursions over significant planetary distances become feasible only by flying; however, the thin Mars atmosphere cannot provide sufficient lift, unless by flying sufficiently fast to collect the 'right' amount of CO2. The Martian CO2 collected could then be reacted with light metals, as already proposed by Shafirovitch et al in the US and by Golovitchev in Sweden. Here we propose instead to rely on combustion reactions between Martian CO2 and hydrides. In particular, this paper focuses on silicon hydrides ('silanes') because (assuming not so far a technology to produce them from silica and water) their interesting combustion and energetic properties; when used as fuels for ramjets and SCRJ, silanes in combination with atmospheric CO2 seem, at this preliminary stage of analysis, an intriguing conceptual alternative to a conventional LOX/LH2 or LCH4 'hopping' rockets. (Note gas-turbine propulsion should be excluded on Mars because of dust storms effects on blades.) Accordingly, this work explores the practical limits of application of silanes, including their performance for cruising and accelerating. Equilibrium composition of the combustion products of silanes, from monosilane up to pentasilane were calculated. Ideal ramjet and scramjet performance (specific thrust and specific impulse) were evaluated along constant dynamic pressure trajectories in the Mars atmosphere and compared to that with CH4/Air and H2/Air mixtures. High specific thrust is obtained as the equivalence ratio is increased; the Isp trend is the reverse, but still very appealing when weighted with the bulk density of silanes.