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MICROHYBRID ENGINE NUMERICAL AND EXPERIMENTAL RESULTS

Abstract

We show the development of microhybrid rocket engines primarily intended for attitude control of upper stages of both suborbital and orbital launchers as well as satellites. A series of microhybrid rocket engines have been developed with average total impulses are between 20 Ns and 200 Ns with burn times between 0.2 seconds and 5 seconds. They are build using lightweight aluminium allows with standard DeLaval carbon nozzles. A full internal ballistic model is developed assuming the oxidizer is self-pressurized and injected into the combustion chamber through one injector. The internal ballistic model takes into account both the geometry of the combustion chamber as well as the thermodynamics of the oxidizer/fuel pair used. A detailed description of the test stand, onto which the microhybrid engines were measured, is given in the paper. The test stand has been developed in-house with data acquisition capabilities with frequency of up to 1kHz. Thrust and temperature in several points can be measured. Video cameras complement the measurements with visual information during the firings of the microhybrid engines. Comparison between experimental and numerical results is done showing the performance variation for N2O oxidizer and fuels such as: paper, PVC, polypropylene. The average regression rates are shown to be around 2-4 mm/s for the various oxidizer/fuel pairs. Next the multiple injector schematics are discussed and how the multiple injectors can optimize the combustion in a microhybrid rocket engine. An experimental comparison between multiple injector and single injector is shown together with theoretical explanation. A modification of the internal ballistic model is proposed taking into account the multiple impinging injector geometries. A discussion is done regarding the optimization of the number of injectors both from the theoretical and the manufacturing point of views. While many injectors are preferred, the manufacturing limitations impose a limit on the size and the number of injectors that can be physically obtained without increasing the costs of a microhybrid engine at unreasonable levels. Last section of the paper outlines future improvements for the test stand facility including Doppler measuring device for characterization of the exhaust of the engines as well as pressure micro-gauges for both the oxidizer tank and the combustion chamber.