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PERFORMANCE INCREASE OF LIQUID ROCKET MOTOR THROUGH PUMP MODIFICATION FOR HIGHER INJECTION PRESSURE OPERATION

Abstract

Most of the current pump fed liquid rocket motor designs use independent pumps for oxidizer and fuel. Pumps should maintain a relatively high pressure of 100 bars; obviously, this pressure should be higher than the pressure in the combustion chamber. Generally, the higher the pressure in the combustion chamber, the higher the specific impulse for a certain fuel/oxidizer pair; however, this implies a higher pump feeding pressure and heavier fuel/oxidizer lines in order to withstand the higher pressure coming from the pumps. We propose a different approach by implementing a "2-stage" pump. The first stage pressurizes the fuel and oxidizer at 4-6 bars just enough to move it from the fuel/oxidizer tanks to the liquid rocket motor injector head while the second stage of the pump is designed within the injector head plate. This second stage pump further increases the pumping pressure from the 4-6 bars to 1000 bars. The advantage would be that the injection pressure for both oxidizer and fuel components could be higher than in a traditional design without the penalty of heavy fuel/oxidizer lines because the very high pressure (1000 bars) is encountered locally within the injector head and not on the entire circuit from the fuel/oxidizer tanks to the motor as it happens in the traditional designs. At the same time the higher injection pressure leads to better vaporisation of the fuel and oxidizer components which increases the combustion efficiency. On the other hand a higher injection pressure creates the capability of operating higher combustion chamber liquid rocket motors without the penalty of heavy fuel/oxidizer lines which otherwise would be needed in a traditional design. Hence, a higher injection pressure increases the performance of a liquid rocket motor both through better vaporisation and higher specific impulse due to higher combustion chamber pressure. We present an internal ballistic model for a typical liquid rocket motor as well as the conceptual designs for the new pump equipment. We also present the performance difference obtained through simulation under various injection pressures for a typical fuel/oxidizer pair. Detailed discussion on material choice as well as limitations is performed in order to fully characterize the injector based pump concept.