Estimation Of Hybrid Rocket Chamber Temperature Via Temperature Measurements of Nozzle Outer Wall

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A hybrid rocket is a novel type of propulsion that utilizes a solid fuel and liquid oxidizer. While only having a few commercial applications, this type of rocket engine is popular for academic research due to the relative ease of construction compared to bipropellant liquid rocket engines. The main advantage of a hybrid rocket engine is that it can be throttled like a liquid rocket engine, but it retains the simplicity of a solid rocket motor. Currently, the Mechanical Engineering department of North Dakota State University is conducting research with a lab-scale prototype of a hybrid rocket engine that utilizes optically clear polymethyl methacrylate (PMMA) as the fuel grain and gaseous oxygen as the oxidizer. 3 tests have already been conducted with the rocket and some useful data has been recorded. A paper presenting the results of the first two tests was published to AIAA's SciTech Forum in January 2021. Currently, temperature measurements of the exhaust and the pre-combustion region of the rocket have been made utilizing type-K thermocouple probes. However, attempting to measure the post-combustion region of the rocket has been problematic due to the very hot temperatures. The theoretical chamber temperature has been calculated to be 3196 °C. For the first test, the thermocouple probe that was used to measure the chamber temperature completely melted away due to the intense heat. A thermocouple probe that was used to measure the exhaust temperature also suffered damage. The exhaust thermocouple probe suffering damage can be remedied by moving the probe further away from the nozzle exit, where the temperature of the exhaust is cooler. However, it is not possible to measure the chamber temperature directly by utilizing probes. The outer wall of the nozzle, however, is a lot cooler than the internal exhaust stream, cool enough to possibly allow thermocouples to measure the temperature. If the outer wall temperature of the nozzle is known, then the internal chamber temperature can be estimated by utilizing numerical models obtained from coupled CFD-thermal simulations. Preliminary results from these coupled CFD-thermal simulations suggest that the temperature of the nozzle outer wall is within the range of a type-K thermocouple. However, these models need to be refined. More test firings where the temperature of the outer nozzle wall where will be measured are planned.