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PHOTOGRAPHIC INVESTIGATION OF IMPINGING COMBUSTION FOR THE HYDROGEN PEROXIDE AND AMINE-BASED HYPERGOLIC PROPELLANT

Abstract

The high test peroxide as an oxidizer has been proposed as a promising alternative for the green space propulsion applications. The special interest has been noted on the implementation of the auto-ignitable propellant based on the hydrogen peroxide by imposing hypergolicity due to its exothermic interaction with fuel containing reactive or catalytic additive. The high test peroxide-based hypergolic propellant may provide essential benefits in terms of reduced-toxicity, safe handling, and reduction in the cost compared to the hydrazine or its derivatives and nitrogen tetroxide. Therefore, the high test peroxide for the hypergolic bi-propulsion system is extensively researched for an application of space exploration. Investigation in the high test peroxide-based hypergol has not yet been examined enough on the combustion instability, such as reactive stream separation or popping that occurs during the impingement of the propellant, although a massive number of drop tests are undergoing in many institutes around the world.

Thus, this study addressed particular attention on hypergolic flame development during the jet impingement of the 95 wt. % of high test peroxide and amine-based fuel. Visualization on the reaction zone was carried out through the quartz window mounted on the combustion chamber. A 200 W blue LED floodlight was used to suppress the flame, which occurred by the hypergolic reaction. The photographic observation on flame development was observed with a high-speed camera mounting blue optical band-pass filter. Each momentum of the high test peroxide and amine-based fuel was manipulated by using flow rate control devices (i.e., cavitating venturi valve and pressure compensated control valve) from low to high momentum. Moreover, the ignition delay of the propellant was controlled by varying concentration of the additives to investigate the relationship between physical residual time and chemical reaction time. The flame of each test was successfully suppressed, and the obtained images showed clear shadowgraph discerning combustion instability within the reaction zone. The flame development was a direct function of ignition delay of the hypergolic propellant and physical momentum of the impingement jet as well. The atomization during the impingement can substantially affect the hypergolic ignition characteristics and combustion stability.