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Development of Ionic Liquid Monopropellants for In-Space Propulsion

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A family of new, low toxicity, high energy monopropellants is currently being evaluated at NASA Marshall Space Flight Center for in-space rocket engine applications such as reaction control engines. These ionic liquid monopropellants, developed in recent years by the Air Force Research Laboratory, could offer system simplification, less in-flight thermal management, and reduced handling precautions, while increasing propellant energy density as compared to traditional storable in-space propellants such as hydrazine and nitrogen tetroxide. However, challenges exist in identifying ignition schemes for these ionic liquid monopropellants, which are known to burn at much hotter combustion temperatures compared to traditional monopropellants such as hydrazine. The high temperature combustion of these new monopropellants make the use of typical ignition catalyst beds prohibitive since the catalyst cannot withstand the elevated temperatures.

Current research efforts are focused on monopropellant ignition and burn rate characterization, parameters that are important in the fundamental understanding of the monopropellant behavior and the eventual design of a thruster. Laboratory studies will be conducted using alternative ignition techniques such as laser-induced spark ignition and hot wire ignition. Ignition delay, defined as the time between the introduction of the ignition source and the first sign of light emission from a developing flame kernel, will be measured using Schlieren visualization. An optically-accessible liquid monopropellant burner, shown schematically in Figure 1 and similar in design to apparatuses used by other researchers to study solid and liquid monopropellants,[1-3] will be used to determine propellant burn rate as a function of pressure and initial propellant temperature. The burn rate will be measured via high speed imaging through the chamber's windows.

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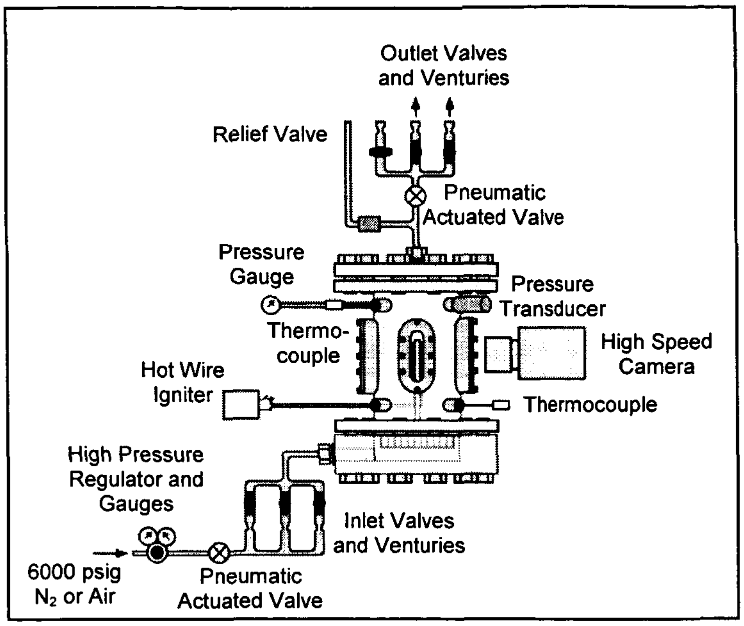

Figure 1. Schematic of MSFC liquid monopropellant burner.

References

1. Chang, Y.P., and Kuo, K. K., "Assessment of Combustion Characteristics and Mechanism of Hydroxylammonium Nitrate-Based Liquid Monopropellant," *Journal of Propulsion and Power*, Vol. 18, No. 5, pp. 1076-1085, Sep.-Oct., 2002.

2. Chang, Y. P., Boyer, J. E., and Kuo, K. K., "Combustion Behavior and Flame Structure of XM46 Liquid Propellant," 38th AIAA Aerospace Sciences Meeting, Reno, NV, January 10-13, 2000.

3. Boyer, J. E., and Kuo, K. K., "High-Pressure Combustion Behavior of Nitromethane," AIAA 99-2358, 35th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Los Angeles, CA, June 20-24, 1999.