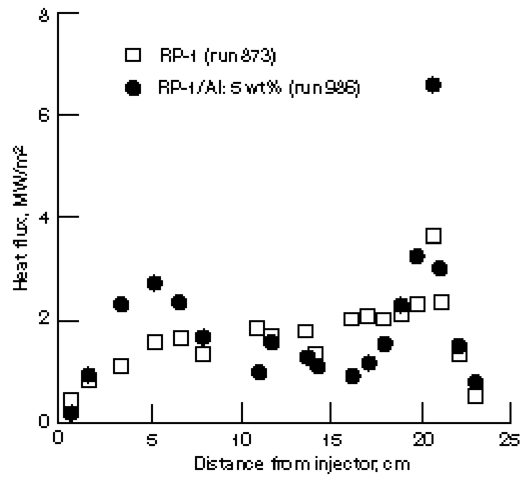
Metallized Gelled Propellant Heat Transfer Tests Analyzed

A series of rocket engine heat transfer experiments using metallized gelled liquid propellants was conducted at the NASA Lewis Research Center. These experiments used a small 20- to 40-lbf thrust engine composed of a modular injector, an igniter, a chamber, and a nozzle. The fuels used were traditional liquid RP-1 and gelled RP-1 with 0-, 5-, and 55-wt % loadings of aluminum particles. Gaseous oxygen was used as the oxidizer. Heat transfer measurements were made with a rocket engine calorimeter chamber and nozzle with a total of 31 cooling channels. Each channel used water flow to carry heat away from the chamber and the attached thermocouples; flow meters allowed heat flux estimates at each of the 31 stations.

Comparisons of the heat flux and temperature profiles of the RP-1 with those of the metallized gelled RP-1/Al fuels show that, with the metallized gelled O_2/RP-1/Al propellants, the peak nozzle heat fluxes are substantially higher (up to 2 times higher) than they are for the baseline O_2/RP-1. Analyses showed that for the RP-1/Al at 55 wt % the heat transfer to the wall differed significantly from its value for the RP-1 fuel. Also, a gellant and an aluminum combustion delay were inferred in the 0- and 5-wt % RP-1/Al cases because of the decrease in heat flux in the first part of the chamber. A large decrease in heat flux in the last half of the chamber was caused by fuel deposition in the chamber and nozzle. According to heat flux estimates from the temperature measurements, engine combustion occurred well downstream of the injector face.

Metallized gelled liquid fuels have the potential to increase the specific impulse, density, and safety of rocket propulsion systems. Although the benefits and military applications of Earth-storable (IRFNA/MMH) gelled and metallized gelled fuels and oxidizers are well established, some questions still exist regarding their application to NASA missions. Oxygen/RP-1/Al and cryogenic metallized gelled propellants show promise in design studies for NASA missions that have an engine efficiency comparable to that for traditional liquid fuels. Analysis of this work and planning for the future is ongoing at NASA Lewis.



Metallized gelled propellant heat fluxes.

The figure depicts the RP-1 and 5-wt % RP-1/Al heat flux profiles. The flux was slightly lower than the baseline RP-1 value near the injector face, reached a peak in the chamber at 5 cm from the face, dropped below the RP-1 flux in the last part of the chamber, and reached a final highest peak just before the nozzle throat. The peak flux in the nozzle was 6.5 MW/m^2. We can infer that the coating of partially consumed gel in the chamber reduced the heat flux in the second half of the chamber.

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