Density and Viscosity of RP-2 Rocket Propellant at Temperatures to 573 K and Pressures to 100 MPa

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A liquid propellant rocket engine converts chemical energy into kinetic energy as the propellant is burned in a combustion chamber to form hot high pressure gas that is expanded through a supersonic nozzle to provide thrust. Because the rocket propellant (RP) is used for regenerative cooling, RP bulk fluid temperatures greater than 473 K can be attained, while near-wall fluid temperatures can exceed 700 K. RP pressure can reach values approaching 100 MPa when exiting the fuel pump. In order to enhance the accuracy and significantly extend the thermodynamic range of fluid property data used in the modeling of rocket engines, we have measured the density and viscosity of two RP-2 samples at temperatures to 573 K and pressures to 100 MPa. A high-temperature, high-pressure (HTHP) variable-volume, windowed densimeter was used to determine density as the ratio of the RP-2 mass to the densimeter working volume. A HTHP variable-volume, windowed, close-clearance, rolling-ball viscometer was used to determine viscosity based on the terminal velocity of the rolling ball and RP-2 density. To enable property evaluation at state points not targeted by these experiments and to facilitate the use of accurate data in computational modeling and analysis, RP-2 density was then modeled with the Tait expression and the HTHP perturbed-chain statistical associating fluid theory (PC-SAFT) model. Viscosity was modeled with surface fitting, a modified version of Vogel-Fulcher-Tamman (MVFT) equation, and a free volume theory (FVT) model.