Advances in Liquid Fuel Research: Properties of Real Fuels for Aviation, Aerospace and Vehicular Transportation

NIST has a major effort underway to experimentally characterize representative fluids, and to model them with an accurate equation of state. The design and specification of liquid fuels includes engine operability, environmental and supply considerations. All reformulations to increase efficiency or reduce environmental impact change the properties of these fuels, and as such the fluids cannot be used without an understanding of how the physical and chemical properties are affected.

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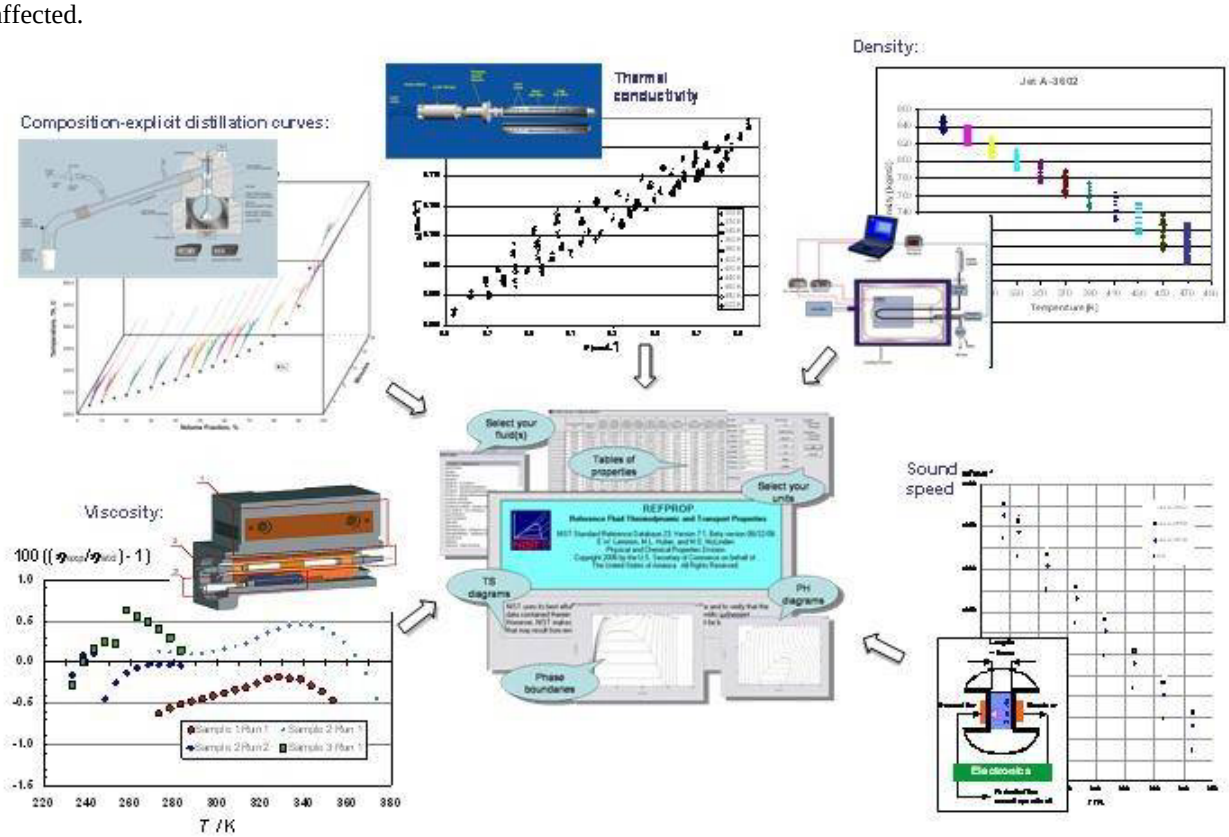
Liquid fuels have long been the most convenient on-board fuel source for all sectors of transportation. This includes aircraft, rockets, and land based vehicles (such as cars, trucks, locomotives and military vehicles). The design and specification of such fuels includes engine operability, environmental and supply considerations. For example, in recent years, oxygenates have been added to diesel fuel (to reduce particulates released into the environment), and aviation fuels have been formulated from coal and natural gas (to avoid supply problems). All of these reformulations change the properties of these fuels, and as such these fluids cannot be used without an understanding of how the physical and chemical properties are affected.

A cooperative effort of experimental measurements and modeling is applied to the study of fuels. Typically, the measurements include density, viscosity and thermal conductivity (as a function of temperature and pressure), and the advanced distillation curve and speed of sound (at ambient pressure). The density is measured with several vibrating tube instruments that can measure at ambient pressure and in the compressed liquid region. We also have a dual sinker densimeter for reference quality measurements. The viscosity is measured with a Stabinger viscometer at ambient pressure, while the compressed liquid viscosities are measured with a torsional crystal viscometer. For the speed of sound a pulse-echo device is used at ambient pressure. The thermal conductivity is measured with a transient hot wire instrument. The distillation curves are measured with a new approach that provides a composition-explicit data channel in addition to the usual temperature and volume channels.

The figure is a schematic depiction of how experimental inputs are used to obtain a mathematical model that describes the properties of a fluid, accessible with a user-friendly standard reference database.



NIST has completed comprehensive measurements on high priority fuels:

- Missile fuel, JP-10, and
- Aviation fuels mixture Jet-A and S-8 (made from natural gas by the Fischer Tropsch process).

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Publications:

Bruno, T.J., Huber, M.L., Laesecke, A, Lemmon, E.W., Perkins, R.A., ***Thermochemical and thermophysical properties of JP-10,*** *NIST-IR 6640, National Institute of Standards and Technology (U.S.),*. 2006.

Bruno, T.J., Arno Laesecke, Stephanie L. Outcalt, Hans-Dieter Seelig, Beverly L. Smith, ***Properties of a 50/50 Mixture of Jet-A + S-8,*** *NIST-IR 6647, National Institute of Standards and Technology (U.S.),* 2007.