HYDROCARBON FUEL BASED ON BALL-MILLED ALUMINIUM AND DODECANE

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Abstract

Nano-fluids are more and more studied in numerous industry areas (medical, energetic, nuclear…). They have particular flow properties and many corresponding models are available. Particularly, use of nano-fuels (liquid fuels with particles of less than 100 nanometers typically) is going more and more from laboratory to advanced studies for automotive (a few percent of nanoparticles) and aerospace (several dozen percent of nanoparticles) applications.

The ramjet propulsion team of MBDA identified in 2015 the possible interest of nanotechnologies and associated possible game-changers or at least techno-enablers, and carried out a free survey in connection with several of its research partners like ENSTA, CNRS, CEA, and ONERA. The interest of nanoparticles to fuel is not new and had been investigated in the past, especially with the "slurry fuels" studied extensively at the end of the last century.

The current trend is to use a smaller amount of quite smaller particles, and estimate the possible operational benefit for future systems as well as the associated showstoppers or risk mitigation actions.

For example, a theoretical work was awarded by MBDA at ENSTA lab in Paris in order to assess by detailed kinetic modelling what could be the benefit (or the lack of performance) of small particles add-on, for combustion range (ignition, blow-off…). This work does not take into account the liquid state of the fuel as well as the size and geometry of metallic particles, but it allowed to state how the fuel ignition delay is modified, for instance by aluminium.

Existing (and scattered) models were used to predict what could be the combustion heating value (MJ/kg), the density (kg/m3) and, with less accuracy, the expected viscosity and thermal conductivity evolutions with temperature.

Propulsion but also cooling performance could be increased by 20 to 40% compared to base fuel without nanoparticles, but many limitation factors have to be taken into account. Risk for safety, security and handling have been assessed. The Research & Technology activity reported here is then dealing with the use of nanofuels for aerospace applications, especially for future airbreathing systems, including in a "drop-in" option.

Current aviation fuels like kerosene are formed of hundreds or thousands of chemical species, and then they are not easy to manage computationally in an R&T study like in the current prospective activity conducted by MBDA and CEA on 'nanofuels'.

N-dodecane ($n\text{-}C_{12}H_{26}$) has been chosen as a basis generic fuel since this alkane hydrocarbon could have a quite similar overall behaviour in engines as regular kerosene. Laboratory tests of dodecane mixed with aluminium nano-sized particles were conducted and analysed, some results will be discussed here, and compared to theoretical or system computations.