Announcing the Final Examination of Sergio Arias Quintero for the degree of Master of Science

Time & Location: October 23, 2012 at 9:00 AM in Business BA 216
Title: Thermal Stability Characteristics of Fischer-Tropsch and Hydroprocessed Alternative Aviation Fuels

Growing prices, limited supply, and public concern about greenhouse gases associated with crude-derived jet fuels have led to development of renewable alternatives which must be compatible with the worldwide civilian and military aviation infrastructure, which were designed for operation with Jet-A/JP-8. Any alternative fuel should not have negative effects on the aircraft engines and fuel systems, especially from a thermal stability perspective, since any adverse effect of the physical properties, and chemical composition, including existence of trace elements, of those fuels may only be revealed after extensive operation, resulting in higher life-cycle maintenance and operation costs.

This study considered four types of alternative fuels: two derived by Fischer-Tropsch (FT) process, and two types of Hydro-processing Esters and Fatty acids (HEFA). For each of these types, both raw and 50:50 blends in volume with Jet-A samples have been prepared, thus resulting in eight different fuel blends. Fit-for-purpose ability of these alternative fuels is first investigated by studying the effects of the fuel properties and composition effects on elastomer materials, and micro-turbine performance. When elastomer o-rings, similar to those used in aircraft fuel systems were immersed in renewable fuels, smaller volume change or swelling was detected (lower than 2%), contrary to a 14% swelling observed for baseline Jet-A. Lower swelling may result into leaks during aircraft operation. This trend was reversed when renewable fuels were blended with aromatics containing Jet-A.

Lower energetic content per unit volume of the renewable fuels, resulted in a thrust reduction around 10% when compared to baseline Jet-A at full throttle settings, but other than this, no other significant effect on the engine combustion temperature or other parameters were found for short duration testing. However, longer duration testing and/or frequent fuel switching led to deposit formation in the fuel injectors leading to turbine malfunction. It is this finding that led to the primary focus of this thesis - thermal stability and deposit formation for alternative fuels. A complete investigation on the overall impact of these deposits on turbine operation is left for future studies.

Primary focus of this study is coking behavior of 8 different alternative fuel blends over 4 different metallic surfaces, as compared against baseline Jet-A. A specialized single tube heat exchanger apparatus was used where each fuel sample was allowed to flow through a metal tube placed inside a tube furnace. Thermal stresses caused by the break-down of hydrocarbon molecules and the catalytic effects of the tube surfaces affect thermal stability of the fuel, leading to coking deposits under the auto-oxidation and pyrolysis mechanisms.

In the results reported in this study, physical methods such as gravimetric measurements were used to obtain the deposits, while UV/VIS absorption, and GC/MS were used to study chemical changes in fuel composition and their relation with coking deposits. Thermal depositions between 16 and 46 $\mu$g/cm² were measured at the tubes after 3 hours of testing, finding no significant differences between the baseline Jet-A and the renewable fuels blends, even when sulfur levels, which are linked to deposits formation, were lower for the renewable fuels. Fuel bulk constituents, such as paraffins and cycloalkanes, under thermal stressing and catalytic influence of the tube metals cracked into reactive intermediates leading to surface deposits formation, like aromatic compounds. These compounds were identified by the shift towards longer excitation wavelengths of the UV-Vis absorption measurements on stressed fuels.

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