Hot Surface Ignition Temperature of Aircraft Fluids

by
N. A. Moussa, Kulu Joshi , Kevin Vien, Tenzin Nanchung
BlazeTech Corp., 29B Montvale Ave., Woburn, MA
Presented at FAA 9th Triennial International
Aircraft Fire and Cabin Safety Research Conference
Atlantic City, NJ
Oct. 28-31 , 2019

The risk of aircraft engine fires is due to the potential leaks of fuel and engine oil in proximity to hot engine surfaces and compressor bleed air ducts. To minimize such occurrences, designers ventilate the nacelle and insulate the hot surfaces which requires a good knowledge of the Hot Surface Ignition Temperatures (HSIT) for each fluid, release and environmental conditions.

When fluid impacts the surface, the surface temperature drops making it difficult to define or measure the temperature at which ignition occurs. It has been known that as the quantity of fluid is increased, the initial surface temperature that produces ignition must be higher to compensate for the quenching effect. We performed tests where we minimized this quenching effect by using a surface of very high thermal diffusivity and thermal inertia and by injecting very fast, small liquid streams. The surface was 1 ft in diameter, flat and horizontal plate producing a well know natural convection plume around it. Jet A and n-decane were injected onto the plate center in about 0.2 to 0.3 s, producing a splash zone at the surface, followed by droplet breakup, droplet heating and evaporation in a Leidenfrost mode as they traverse the plate, and ignition (or not) before leaving the plate. We measured HSITs that are much lower than what has been reported in the past, consistent with a reduced quenching effect in our setup. However, we found that as the injection volume decreased from 300 to 20 microliters, the HSIT increased, and no ignition occurred below 20 microliters, results that are opposite to what is expected in a quenching regime. It appears that we are operating in a vapor dissipation regime – where vapors produced by the fast moving droplets dissipate in the buoyant air plume resulting in vapor lean concentrations which necessitate higher temperature for ignition as the injection volume is decreased, and no ignition below 20 microliters. These results will be presented along with a model that relates them to the key parameters of hot plate, fluid and flow field so as to enable extrapolation beyond our test conditions. Our results show that the old safety rule of assuming that the minimum HSIT is about 200 C higher than the autoignition temperature needs to be revised to better serve the designers and improve safety.