Modeling Wing Tank Flammability

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An investigation into the flammability of a wing fuel tank is performed to aid in the effort to eliminate or reduce the possibility of a wing fuel tank explosion in commercial aircraft. A computational model is built to predict the generation of flammable mixtures in the ullage of wing fuel tanks. The model predicts the flammability evolution within the tank based on in-flight conditions of a wing fuel tank. The model is validated through supporting experiments performed in an altitude chamber, wind tunnel facility, and full-scale flight tests and the results from the experiments are compared to the computational results. Simulation results from the altitude chamber follow the general trend of the experimental results, but produce them at a different effective fuel flash point. This is due to the replenishment of species with lower flash point at the surface of the fuel causing the effective flash point at the evaporation surface to be lower. Experimental results for the aluminum wing tests from the wind tunnel experiments are in good agreement with the computational results as well.

A simpler model is also developed from a fuel air ratio calculator within the ullage of the fuel tank. This zero-order steady model is then applied to the data sets for the experiments performed in the altitude chamber and wind tunnel. For the tests conducted in the altitude chamber, the correlation estimates the hydrocarbon concentrations extremely well during ascent and descent. An example of the correlation is shown in Figure 1 for an altitude chamber test with ascent to and descent from 34000 ft with 80% mass loading in the wing tank. For the tests conducted in the wind tunnel, the computational values follow the general trend of the experimental values, where the computational values estimates are consistently 10% lower than experimental values.

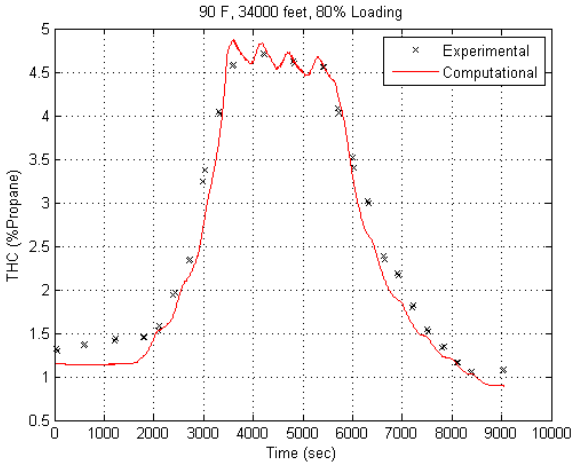

Figure 1 Comparison of wing tank flammability computational model with experimental data from the altitude chamber for a wing tank with 80% mass loading at an initial temperature of 90 ºF. Maximum simulated altitude achieved during test was 34,000 feet.

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