MODELING OF SMOKE SPREAD AND GAS TRANSPORT IN AN AIRCRAFT

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The Aviation Research Division of the Federal Aviation Administration′s (FAA) William J. Hughes Technical Center performs research and development work in support of airport and aircraft safety and continued airworthiness. The Aircraft Fire Safety Group under this division studies postcrash and inflight fires with the ultimate goal of minimizing the number of fire accidents and mitigating the hazardous effects of fire. The focus of the current modeling activities within Aircraft Fire Safety Group is *inflight fires*. More specifically, we are interested in improving fire detection capabilities in inaccessible areas during flight, such as cargo compartments and overhead areas with the help of analytical tools.

This presentation summarizes our efforts in which numerical simulations are carried out using Fire Dynamics Simulator (FDS) [1] developed by National Institute of Standards and Technology (NIST). FDS solves governing equations of fluid motion for low Mach number thermally-driven flow, specifically targeting smoke and heat transport from fires. It has been verified and validated for a number of fire scenarios [1].

Numerical simulations are conducted for a small fire with maximum heat release rate of 5 kW in the forward cargo compartment of Boeing 707 (B707) and in the below floor cargo compartment of McDonnell Douglas DC-10 (DC10). For B707 compartment, there were three fire scenarios tested. All three fire scenarios, differed only in the location of the fire source, are modeled. The simulation results are compared with the existing full-scale tests with forty-four thermocouples, six beam detectors and three gas analyzers. For DC10 compartment, only one fire scenario was tested with forty-five thermocouples, four beam detectors and three gas analyzers. The selected metrics for the comparison are the predictions of temperature, light transmission and concentrations of carbon monoxide, CO, and carbon dioxide, CO_2, in the first three minutes of the test initiation.

For the test cases studied, CFD is proven to be a powerful tool producing good agreements with the majority of the available test data. For the concentration fields, model (FDS) predictions are not only within the experimental uncertainty but also, in general, follow the experimental mean very closely. For the temperature field, there is a consistent 2 - 3 K difference between the model estimates and the test data for ceiling thermocouples, and up to 5 K difference for the thermocouples placed on the thermocouple tree. Although these differences are within the reported experimental

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uncertainty [2], improvements in the model, particularly in the implementation of the radiation source term and in the near-wall treatments, may be necessary. However, the aforementioned difference should not be considered entirely due to model limitations and/or experimental uncertainties as there are also uncertainties in the model input. It is suggested that new experimental studies are conducted with which the uncertainties in the model input, such as the radiative fraction of fuel source, the wall heat losses, etc., are minimized.

References

[1] McGrattan, K. B., Hostikka, S., Floyd, J., Baum, H. R., Rehm, R. G., Mell, W., and McDermott, R., "Fire Dynamics Simulator - Technical Reference Guide," NIST Special Publication 1018-5, National Institute of Standards and Technology, Oct. 2010, http://www.fire.nist.gov/fds/.

[2] Suo-Anttila, J., Gill, W., Luketa-Hanlin, A., and Gallegos, C., "Cargo Compartment Smoke Transport Computational Fluid Dynamics Code Validation," DOT/FAA/AR-07/27, Federal Aviation Administration, July 2007.