Discontinuous Galerkin Approach to Fire Detection in Cargo Holds

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ABSTRACT

Federal aviation regulations require that all large passenger aircraft have fire detection and suppression systems in every cargo compartment. Several different detection methods are generally used together, such as sensors for temperature, carbon monoxide, smoke particulate, radiation, and optical detection; alarms are required to go off within 60 seconds of fire ignition. Certification of these systems currently requires expensive ground and in-flight tests. Accurate and validated CFD tools could reduce certification costs, and be used to assess the effectiveness of a particular detector placement, as well as optimize their placement in a given cargo hold. Current fire detection research is carried out in empty cargo holds, such as the narrow-body Boeing 707 fuselage located at the Federal Aviation Administration William J. Hughes Technical center in Atlantic City, New Jersey. These types of experiments are expensive, and testing a wide variety of fire sources, positions, and compartment cargo cluttering is not feasible. Moreover, the flow is extremely sensitive to both loading arrangement of the cargo, and ventilation. However, once the fire is started, the bulk flow is entirely driven by buoyancy originating from local heating. We also note that a short distance away from the fire source, the actual chemical combustion process no longer has a significant effect on the dynamics of the flow. Therefore we can accurately model the bulk flow as one that is created by a heat source into non-reactive air, which does not require a detailed computation of the combustion process. The resulting low speed flow exhibits a complex vortical structure and high resolution is required to accurately capture the dynamics. We have recently developed a discontinuous Galerkin flow solver - of arbitrarily-high order of accuracy - for the compressible Navier-Stokes equations with buoyancy, using unstructured meshes. We will discuss the main challenges faced, and share what we have learned in the course of this project.