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Evaluation of Coupled CFD-FEA Simulation for Fire Determination

Authors : Daniel Martin Fellows, Sean P. Walton, Jennifer Thompson, Oubay Hassan, Ella Quigley, Kevin Tinkham

Abstract : Fire performance is a crucial aspect to consider when designing cladding products, and testing this performance is extremely expensive. Appropriate use of numerical simulation of fire performance has the potential to reduce the total number of fire tests required when designing a product by eliminating poor-performing design ideas early in the design phase. Due to the complexity of fire and the large spectrum of failures it can cause, multi-disciplinary models are needed to capture the complex fire behavior and its structural effects on its surroundings. Working alongside Tata Steel U.K., the authors have focused on completing a coupled CFD-FEA simulation model suited to test Polyisocyanurate (PIR) based sandwich panel products to gain confidence before costly experimental standards testing. The sandwich panels are part of a thermally insulating façade system primarily for large non-domestic buildings. The work presented in this paper compares two coupling methodologies of a replicated physical experimental standards test LPS 1181-1, carried out by Tata Steel U.K. The two coupling methodologies that are considered within this research are; one-way and two-way. A one-way coupled analysis consists of importing thermal data from the CFD solver into the FEA solver. A two-way coupling analysis consists of continuously importing the updated changes in thermal data, due to the fire's behavior, to the FEA solver throughout the simulation. Likewise, the mechanical changes will also be updated back to the CFD solver to include geometric changes within the solution. For CFD calculations, a solver called Fire Dynamic Simulator (FDS) has been chosen due to its adapted numerical scheme to focus solely on fire problems. Validation of FDS applicability has been achieved in past benchmark cases. In addition, an FEA solver called ABAQUS has been chosen to model the structural response to the fire due to its crushable foam plasticity model, which can accurately model the compressibility of PIR foam. An open-source code called FDS-2-ABAQUS is used to couple the two solvers together, using several python modules to complete the process, including failure checks. The coupling methodologies and experimental data acquired from Tata Steel U.K are compared using several variables. The comparison data includes; gas temperatures, surface temperatures, and mechanical deformation of the panels. Conclusions are drawn, noting improvements to be made on the current coupling open-source code FDS-2-ABAQUS to make it more applicable to Tata Steel U.K sandwich panel products. Future directions for reducing the computational cost of the simulation are also considered.

Keywords : fire engineering, numerical coupling, sandwich panels, thermo fluids
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