World Academy of Science, Engineering and Technology
International Journal of Civil and Architectural Engineering
Vol:18, No:03, 2024

Reducing the Computational Cost of a Two-way Coupling CFD-FEA Model via a Multi-scale Approach for Fire Determination

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

Abstract : Structural integrity for cladding products is a key performance parameter, especially concerning fire performance. Cladding products such as PIR-based sandwich panels are tested rigorously, in line with industrial standards. Physical fire tests are necessary to ensure the customer's safety but can give little information about critical behaviours that can help develop new materials. Numerical modelling is a tool that can help investigate a fire's behaviour further by replicating the fire test. However, fire is an interdisciplinary problem as it is a chemical reaction that behaves fluidly and impacts structural integrity. An analysis using Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA) is needed to capture all aspects of a fire performance test. One method is a two-way coupling analysis that imports the updated changes in thermal data, due to the fire's behaviour, to the FEA solver in a series of iterations. In light of our recent work with Tata Steel U.K using a two-way coupling methodology to determine the fire performance, it has been shown that a program called FDS-2-Abaqus can make predictions of a BS 476 -22 furnace test with a degree of accuracy. The test demonstrated the fire performance of Tata Steel U.K Trisomet product, a Polyisocyanurate (PIR) based sandwich panel used for cladding. Previous works demonstrated the limitations of the current version of the program, the main limitation being the computational cost of modelling three Trisomet panels, totalling an area of 9 . The computational cost increases substantially, with the intention to scale up to an LPS 1181-1 test, which includes a total panel surface area of 200 .The FDS-2-Abaqus program is developed further within this paper to overcome this obstacle and better accommodate Tata Steel U.K PIR sandwich panels. The new developments aim to reduce the computational cost and error margin compared to experimental data. One avenue explored is a multi-scale approach in the form of Reduced Order Modeling (ROM). The approach allows the user to include refined details of the sandwich panels, such as the overlapping joints, without a computationally costly mesh size.Comparative studies will be made between the new implementations and the previous study completed using the original FDS-2-ABAQUS program. Validation of the study will come from physical experiments in line with governing body standards such as BS 476 -22 and LPS 1181-1. The physical experimental data includes the panels' gas and surface temperatures and mechanical deformation. Conclusions are drawn, noting the new implementations' impact factors and discussing the reasonability for scaling up further to a whole warehouse.

Keywords : fire testing, numerical coupling, sandwich panels, thermo fluids
Conference Title : ICSFDSFE 2024 : International Conference on Fire Safety Design and Structural Fire Engineering
Conference Location : Sydney, Australia
Conference Dates : March 25-26, 2024