TESTING AND VALIDATING OPEN SOURCE CFD FOR THERMAL COMFORT

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ABSTRACT

For more than a decade, ALSTOM Transport has extensively used commercial CFD in its design and development processes to verify and optimise passenger and driver thermal comfort and external aerodynamics for all types of trains and trams. For thermal comfort, the CFD cycle uses commercial software for all aspects, from CAD to analysis and design optimisation. In this cycle, ALSTOM typically simulates the ventilation system coupled with its passenger car but, in the case of trams, the number of cars simulated can increase to five. Such simulations require significant computational resources and commercial software licensing.

The increasing use of open source solutions has lead ALSTOM to investigate this capability with a possible view of replacing some of its commercial CFD capability. The objectives here are to reduce costs whilst simultaneously allowing more complex simulations, e.g. simulating unsteady flow for thermal comfort. Such simulations would enable ALSTOM to better assess its HVAC designs prior to manufacture.

Having worked with ALSTOM Transport since 2005, Renuda was commissioned to undertake an initial study assessing the capability of CAD, meshing, CFD solver and post processing software and testing them on a simplified geometry of a tram driver's cabin. This initial work identified two open source calculation chains that could be used by ALSTOM and indicated that they could be used in an industrial environment. However, more testing and validation work was required.

The objective of a follow on study was therefore to test and validate these two open source chains using a complex geometry and compare the open source CFD results against experimental data and the results of a commercial CFD code. An Amsterdam passenger car was chosen as the test case due to its complex ventilation system involving both ceiling and floor diffusion ducts and grills as well as the size variation of the Amsterdam geometry, varying from 1mm to 13m.

In this second study, an open source CAD software was used to import the Amsterdam geometry in IGES format and complete, where necessary, simple cleaning and closing operations and boundary condition identification. Once finished, the geometry was exported to the open source meshing software.

This meshing software proved to be capable of meshing the Amsterdam car geometry using various cell sizes and local cell refinement in order to retain small geometric details such as the floor and ceiling diffusion grills. This software also proved to be capable of generating an extruded mesh next to the wall surfaces for improved boundary layer modelling. The resulting volume mesh contained some 11 million cells.

Two steady state calculations using different open source solvers were undertaken in parallel for a winter operating condition. The calculations were completed in an acceptable time frame which was comparable to that of the commercial CFD solver. The two sets of predicted results were in good agreement with the experimental data and the commercial CFD code results, although some differences were seen in the air flowing from the floor diffusion ducts. At the floor level, the two open source codes gave virtually identical results which differed to the commercial CFD code results. Comparisons were also made between the parallel speed-up capabilities of the two open source CFD solvers.

Overall, the two open source calculation chains have shown to be capable of being used in an industrial environment, for working with complex geometries and providing viable results. However, it has also been shown that some improvements are required in order to facilitate ease of use and increase robustness.

SUGGESTED THEMES

Simulation Driven Design: Engineering Analysis, Verification and Design:
Simulation Adding Value to Business