ASSESSING THE IMPACT OF PASSENGER CABIN COMFORT AND OPERATING ENVIRONMENT ON BATTERY ELECTRIC VEHICLE RANGE USING MULTI-DOMAIN COUPLED ANALYSIS

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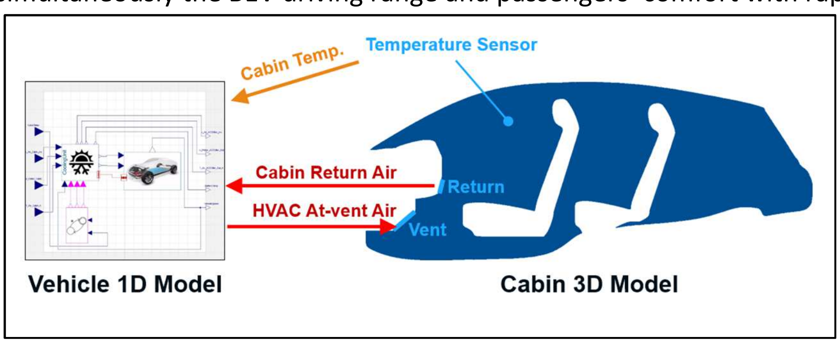
Driving range is a key performance metric for Battery Electric Vehicles (BEVs), but it can be reduced under cold weather conditions, mainly due to energy consumption from the cabin heating system [1]. New technologies for Heating Ventilating and Air Conditioning (HVAC) systems and cabin heating are proposed for BEVs to address such issue. It is essential to accurately assess their effectiveness with quick turn-around simulation methodology. Simulation approaches exist to simulate the full-vehicle systems in 1D model, or to simulate standalone 3D Computational Fluid Dynamic and Conjugate Heat Transfer (CFD/CHT) model. Nonetheless, such approaches either suffer from lack of accurate local surface flow and temperature information needed for human comfort modelling [2], or from longer turn-around time due to the need for physical testing and inability to simulate interactions between systems.

This study proposes a methodology that simultaneously resolves the integrated 1D system and the 3D cabin CFD/CHT models. The interface between them is the HVAC at-vent air and the cabin return air. In cabin air recirculation mode, the HVAC at-vent air leaves the HVAC system and enters the cabin, while the cabin return air leaves the cabin and returns to the HVAC system. At each coupling step, cabin return air properties and the cabin temperature sensor reading is measured from 3D simulation result, and is applied to the HVAC system model as a boundary condition. The HVAC at-vent temperature from HVAC system model is collected, and is applied as boundary condition in the 3D model for the proceeding simulation. Functional Mockup Interface (FMI) standard is utilized during the process.

This study shows the benefit of the integration between 1D vehicle system model and cabin 3D CFD/CHT model, which provides high fidelity result in short turn-around time. Increase in battery range and decrease in time for thermal comfort with the inclusion of local radiant heating panels on specific regions of the cabin, added insulation on cabin parts etc. This can be analyzed with this integrated simulation approach and design changes can be made at the early stage. The methodology helps vehicle manufacturers and suppliers to quickly assess the efficiency of different technologies, and to improve simultaneously the BEV driving range and passengers' comfort with rapid digital design iterations.



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