Study of a Loudspeaker in a Vehicle Door

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Introduction: COMSOL was used to evaluate the performance of a speaker coupled to an automotive door. The Structural Mechanics solver was used to perform the simulation of the speaker membrane displacement for a rigid and a non-rigid door structure. The Pressure Acoustic module was used to simulate the sound pressure in the vehicle.

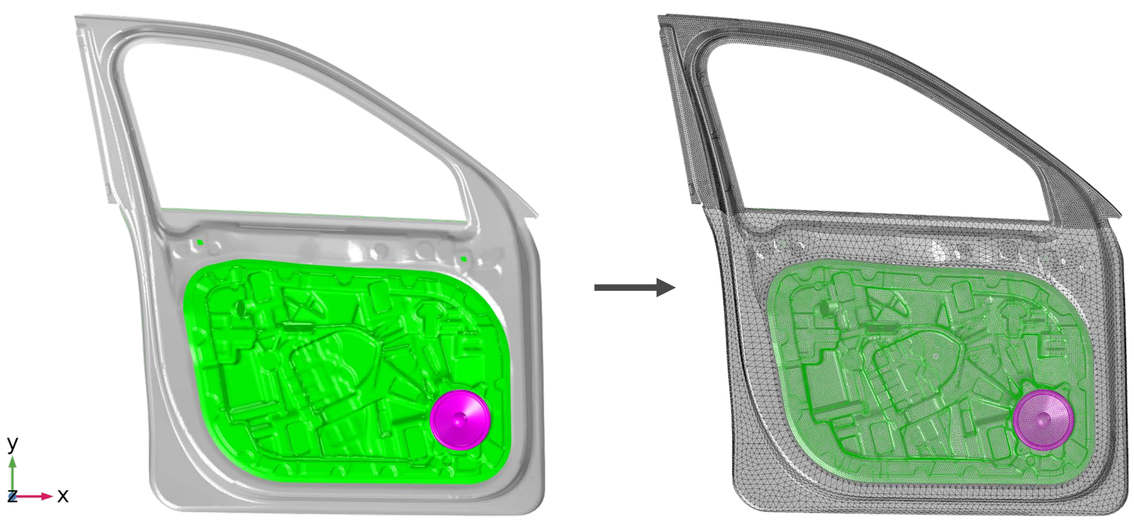

Figure 1. CAD model and corresponding mesh

Computational Methods: A 3D model of a door structure was created and investigated under two conditions. Firstly, a structure was assumed to be fully rigid and the speaker was represented as a rigid piston[1]. Secondly, material properties were applied to the door components, as well as to the speaker geometry (non-rigid case).

Simulated cone displacements were then used to calculate sound pressure in the cabin. Cabin itself was described with frequency dependent absorption coefficients[2].

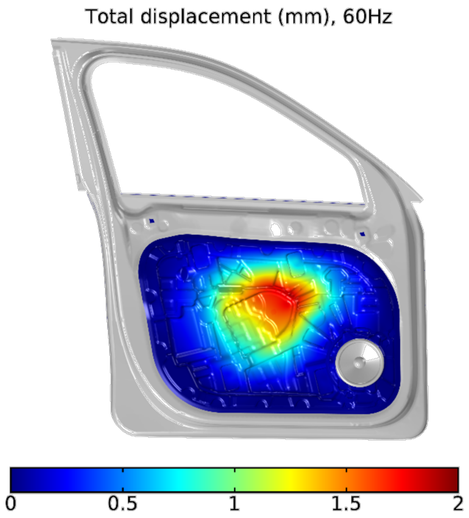

Figure 2.
Panel displacement at 60 Hz

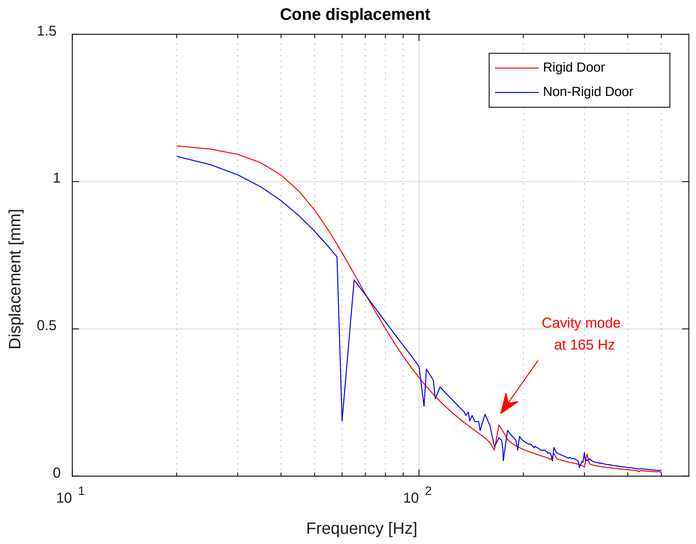

Figure 3.
Cone displacement

Results: The comparison between the *in situ* measurement and the simulation data shows that the non-rigid boundary condition allows to reach good simulation accuracy below 500 Hz. Differences at around 30 Hz come from panorama roof, not included in the simulation model.

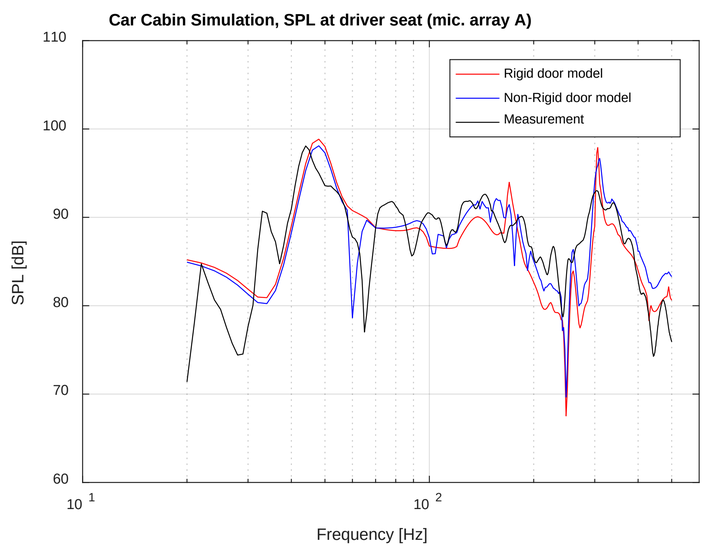

Figure 4. Sound pressure level on the driver's seat

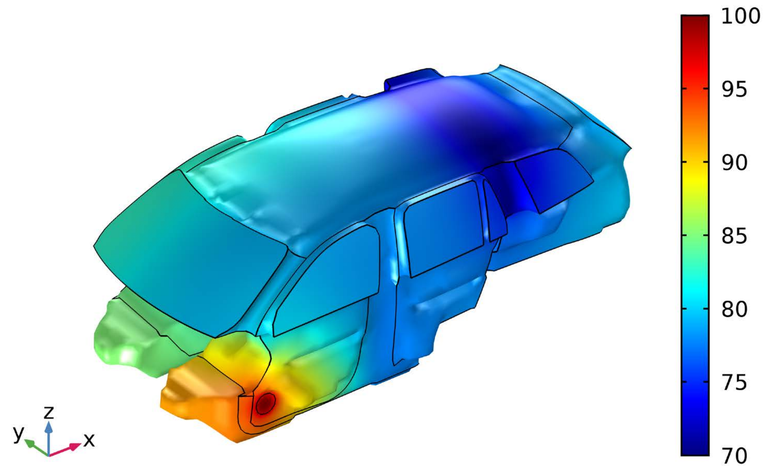

Figure 5. Simulated sound pressure in a vehicle

Conclusions: It has been shown that interaction between the speaker and the vehicle door can be successfully modelled using COMSOL Multiphysics®. This type of simulation can help to optimize a sound system at the early stage of the design.

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References:

1. V. Dickason, 'The Loudspeaker Design Cookbook", 6th Edition, Audio Amateur Press, Peterborough, NH (2000)
2. F. Malbos, M. K. Bogdanski, M. Strauss, 'Loudspeaker Simulations in a Car Cabin ', EU Comsol Conference, Grenoble, France (2015)