Truck door light weight designs using topology optimization

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To reduce the CO2 emissions and the energy consumption of vehicle, light weight design is the major target for automotive industry in the coming years. A dedicated European Interreg EMR project LightVehicle 2025 (LV2025) has been launched in the cross-border region gathering Belgium, The Netherland and Germany. The project aims at developing four demonstrators revisiting typical vehicle components to highlight lightweight technologies. Each demonstrator has to support all steps of the component redesign from preliminary design to virtual manufacturing and mass production. The present demonstrator investigates the design of a truck door.

To reach out the ambitious target of 20% of mass saving and of 20% reduction of CO2 emissions, the project combines Topology Optimization to generate novel structural designs with material substitution, functionality integration and new production processes. The traditional steel sheet body is hereby replaced with short-fiber reinforced PE shell structure designed for the novel robot molding process and supported by a steel beam structure as an insert in the same production process.

Various structural optimization strategies are applied from the conceptual design up to the detailed design and validation. In the current contribution, the focus is set on the topology optimization of the preliminary design of the door structure. We present here the results of the topology optimization assignment given as an educational design project to engineering students at University of Liege.

At first simplified geometrical models are established to be used in topology optimization, resulting in a nice compromise between a good accuracy of the performance predictions and a modest computer effort in topology optimization loops. The commercial Topology Optimization tool NX-TOPOL is adopted. A quasi 2D model is first used to identify the placement of beam structure supporting the door skin. Three major static load cases are retained, while a specification on natural vibrations is also considered as a restriction. A 3D model is also investigated providing a new insight on the optimized reinforcement concepts. While 2D models lead to classical layouts, 3D models are able to exhibit break-through concepts taking advantage of the new manufacturing capabilities of robot molding and functional integration of the door parts.

Finally, in the detailed design stage, further optimization and simulation runs are performed based on a full and detailed 3D CAD model. The manufacturability constraints such as the weldability of steel are verified, while the CO2 emissions are evaluated using a Life Cycle Analysis.