New concepts of lightweight gearbox rear covers made of aluminum and plastic using multi-material topology optimization.

Ioanna KOUTLA[a] |Pierre DUYSINX[a] | Corentin DESERRANNO[b] | Julie JOSSIEAUX[b] | Michael BRUYNEEL[b] | Philip EYCKENS[c] | Carlos LOPEZ[c]

[a] University of Liège, Department of Aerospace and mechanical engineering, Belgium | [b] GDTech SA, Liège, Belgium| [c] FlandersMake CodesignS core lab, Belgium

Presenting author: A. Ioanna KOUTLA

Lightweight materials and innovative designs have always been an important topic in industrial product development. Among others, constraints on energy consumption and CO2 emissions, efforts to improve resource efficiency as well the continuous search for increasing the range of EVs and their dynamic behavior have greatly stressed the importance of this topic over the last years in automotive. A dedicated Interreg project entitled LightVehicle 2025 (LV2025) has been launched in the Euregio Meuse Rhine (EMR) region since 2018 to develop four demonstrators exhibiting the best technologies mastered in the Region in this field. The project partners have selected four demonstrators revisiting typical vehicle components to highlight lightweight technologies. A consortium of industrial partners has been built around each demonstrator to support all steps of the component redesign from preliminary design, virtual prototyping and simulation, pre series prototyping and testing, virtual manufacturing and mass production.

The present work focuses on the redesign of an electric vehicle gearbox rear cover. Traditionally produced by aluminum and die casting, the gearbox cover offers a good opportunity to showcase the lightweighting potential in powertrain components. A two materials design (aluminum and plastic) is explored to take advantage of the complementary properties of the several materials. A multi-material topology optimization (TO) is used to exhibit innovative designs. Several TO results, with different combinations of volume fractions of each material, with or without stiffeners, give a valuable insight on how the new part should be redesigned. Several alternative layouts are also proposed. The metallic material is used to act as stiffness skeleton while plastic material offers skin functions as oil containment. The plastic material used in this study belongs in the family of styrene maleic anhydride (SMA) copolymers and is glass fiber filled.

In a second step, injection insert molding is chosen to produce the new concepts based on the TO results. Given the fabrication process, a concurrent work between designers and fabrication experts is carried out to adapt the topology optimized layout to cope with the limitations of plastic injection process. Appropriate mechanical interlocks are added to ensure the impeccable connection of the two materials. The injection insert molding is simulated while the filling and warpage behavior is investigated. Subsequently, a final structural analysis on the resulting part is performed as a final assessment stage, taking into consideration the simulation findings such as the real fiber orientations.

Finally, the weight reduction achieved with this new concept is well within the -25% as requested by the target of the project. In addition, a LCA analysis is also performed showing that the new multi material design falls well over the expected 25% reduction of the CO_2 emissions too.