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MECA0063- Vehicle architecture and components

COMPUTER PROJECT OF VEHICLE ARCHITECTURE AND COMPONENTS

PROJECT DESCRIPTION

The homework consists in the design study of an electric vehicle gear box casing using topology optimization and CAD design tools.

The problem is inspired by the design of new gear box casing taking advantage of multi-material design. In particular, a remarkable proof of concept was published by ARRK combining composite materials and aluminium (see Fig 1 and Ref. [1]).

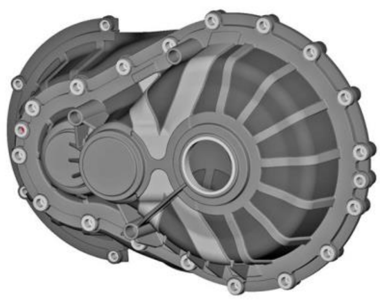

Figure 1 : First Thermoplastic Composite Gearbox Housing: 30% Lighter Than Aluminum by ARRK Engineering Division (www.materialsforengineering.co.uk)

A similar design case has been addressed in the framework of the project Light Vehicle 2025 supported by the Interreg 5a Euregio Meuse-Rhine in which University of Liège was involved as a partner [2].

The project concerns the design of a generic multi-material gear box, whose geometry has been provided as free source in GrabCAD (see Fig. 2).

Figure 2: Generic multi-material gear box rear cover from GRABCAD

The rear cover is supposed to be supported along its flange with the main body of the gear box casing. One can assume in a first step that this boundary is clamped (see Fig 3).

The loading comes from the contact forces applied by the transmission shaft at the two bearings supported by the main part of the cover as sketched in Figure 4.

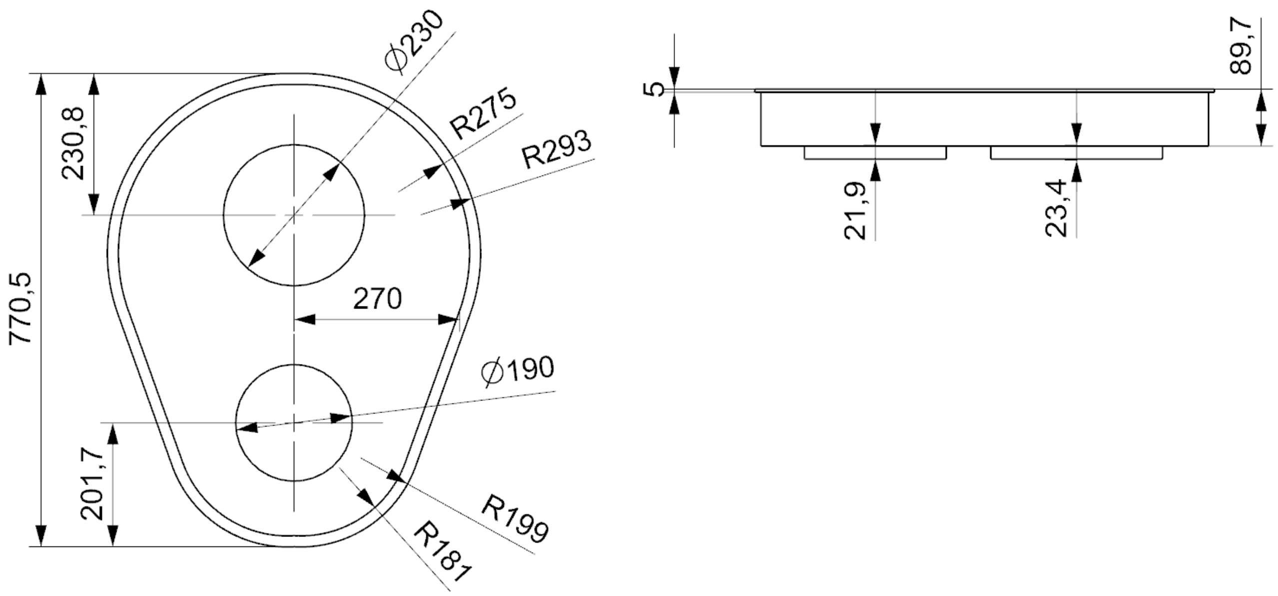

Figure 3: Geometry of the generic gearbox casing test case

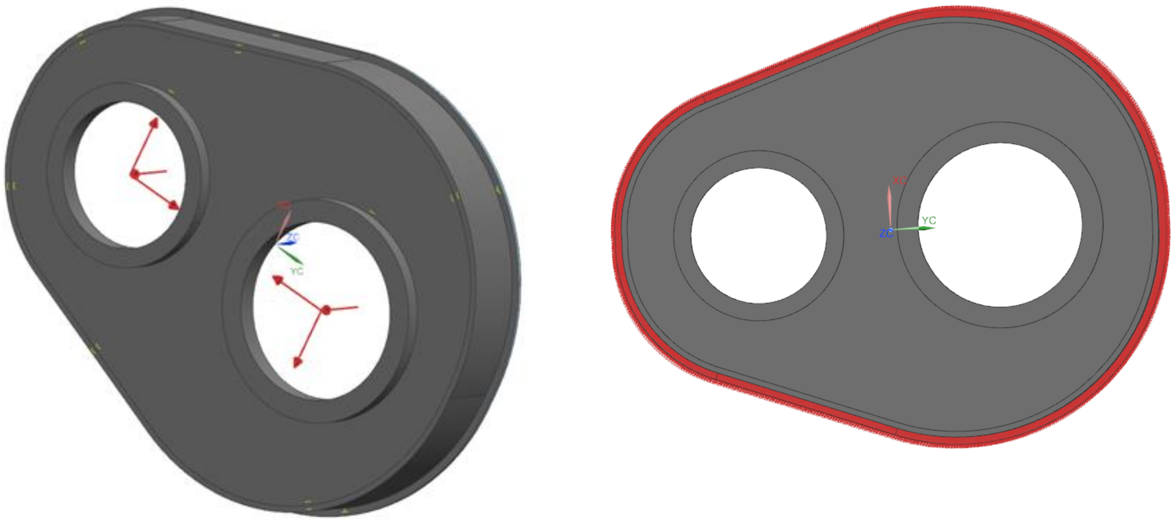

Figure 4: Boundary conditions and load cases of the gearbox rear cover

The load case applied to the gear box is given in non-dimensional form in Table 1

LOAD	Point 1	Point 2	Ratio
Along x	0.46 F	0.17 F	2.7
Along y	1.00 F	0.29 F	3.4
Along z	0.86 F	0.06 F	14.3

Table 1: Load case definition

The project consists in designing a new concept of the gear box casing that is at least 25% lighter than the original design made of full aluminium, while exhibiting the same (or better) performance. In addition, the students are challenged to define a manufacturing process that emits 25% less CO_2 on the basis of a life cycle analysis.

The main service specifications of the gear box casing are:

- Overall stiffness: compliance and maximum displacements should not increase compared to the reference design.
- Stress concentrations must remain below admissible limits of the material (please consider an appropriate fatigue scenario).
- Natural eigenfrequencies should not be reduced. They should also remain within an interval of 10% with respect to the initial vibration spectrum to avoid resonance with rotating elements in the surrounding areas.
- Oil leakage at the sealing with the gear box main body should be prohibited.
- Thermal deformations should be under control and not lead to oil leakage and modification of the misalignment of the gears.

MAIN STEPS OF THE STUDY:

At first the student will make a review of the relevant topics for the project: gear box design, light weight design, topology optimization for automotive components, multi material solutions.

The project will be performed in the Siemens-NX CAD environment.

The gear box concept will be revisited using topology optimization 1/ assuming a single material design (aluminium with stiffeners) and 2/ assuming a multi-material solution is allowed.

The students will get a training in using topology optimization using NX-TOPOL. Some exercises will help the students to discover the main functions of TOPOL.

Based on the topology optimized results, the students will propose a new CAD model taking advantage of the optimal material distributions. The new model will be elaborated in Siemens NX.

Then, the actual performance of the new NX design will be assessed using Finite Element simulations, checking for static responses (displacement, deformations, and stresses) and natural vibrations.

Other specification criteria will also be discussed (using simulation or other techniques).

The fabrication drawing will be provided and a reduced scale of the innovative design will be prototyped using FDM additive manufacturing (fused deposition modelling) in our FABLAB.

Intermediate and final reports will be delivered at milestone and at the final deadline.

Discussion and defence will be organized during exam session.

TERMS OF DUTY:

The work will be in a group of two students. The group will work together and contribute equally to the project.

Each group will submit a final report of 30 pages maximum. Reports are preferably submitted under pdf format. The report will include a description of the hypotheses and boundary conditions made, the equations used, the complete results (possibly in appendix) and a critical analysis of the results.

The final report will be submitted by email to p.duysinx@uliege.be and palarcon@uliege.be by Sunday, May 22, 2022 at 23:59 (Brussels time).

The work will be discussed during the oral exam in June.

MILESTONES AND DELIVERABLES:

- Milestone 1: March 4, 2022: Solution of the training exercises in TOPOL.
- Milestone 2: April 1, 2022: Pitch of the work and preliminary results. New concepts generated using topology optimization.
- Deliverable: May 22: Report on new gear box design.
- June: Oral presentation during the exam session (15 minutes presentation + 15 minutes discussion).

REFERENCES

[1] T. Schneider. Reinforced Plastics. Volume 63, Issue 1, January–February 2019, Pages 40-45
[2] Lightvehicle 2025. https://www.lightvehicle2025.eu/