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MULTIMATERIAL TOPOLOGY OPTIMIZATION OF A RAVIGNEAUX PLANETARY GEAR

Pierre Duysinx[(1)], Pablo Alarcón Soto[(1)], Simon Bauduin[(1)], Eduardo Fernández Sánchez[(1)], Julie JOSSIEAUX[(2)], Sebastien GOHY[(2)], Michael BRUYNEEL[(3)], Jean-Marc VAASSEN[(4)], Pascal DEVINCENZO[(4)]

[(1)]University of Liège, Belgium
p.duysinx@uliege.be; palarcon@uliege.be, s.bauduin@uliege.be, efsanchez@uliege.be

[(2)]GDTECH, Belgium
julie.jossieaux@gdtech.eu, sebastien.gohy@gdtech.eu

[(3)]GDTECH / ULiege, Belgium
michael.bruyneel@gdtech.eu

[(4)]Open Engineering, Belgium
jm.vaassen@open-engineering.com, p.devincenzo@open-engineering.com

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Abstract: To reduce fuel consumption of automobiles, one can reduce the vehicle mass and increase the transmission efficiency of drivetrain components. To this end, topology optimization is a potential great design tool to help engineers in finding new designs exhibiting higher performance for a smaller weight. This research explores the ability of topology optimization to propose new designs of high efficient transmission components. The redesign of a Ravigneaux gear train has been selected to serve as a benchmark to investigate the possible weight savings in a typical transmission component while preserving or improving the energy efficiency. In gear trains, the transmission efficiency is related to the misalignment of gears because it is a source of mechanical losses during operations. While most of topology optimization studies consider compliance minimization, it is interesting to investigate if considering specific performance objective functions can bring an added value compared to the general statement of topology optimization based on compliance design. In addition, to save some further weight, there is also a great interest in considering multimaterial solutions to see if these solutions could bring sufficient improvement compared to the increase of cost and manufacturing complexity that results from these designs. It was observed that design can be blurred so that the convergence procedure can greatly benefit from the introduction non-discreteness indicator as design constraints. The multimaterial optimization is formulated using the Shape Function with Penalization by Bruyneel (2011), a similar approach to the Discrete Material Approach proposed by Stegman and Lund (2005). Non discreteness measure, initially proposed by Sigmund (2007), is introduced here as a design constraint. This constraints is very useful to ensure a stabilization of the convergence process as shown in our numerical experiments. Following the work by Bauduin (2018, this conference), gear misalignement is estimated using the modulus of the cross product of the gear unit vectors. The new formulations and developments have been implemented in the OOFELIE by Open Engineering, which has been used to conduct the numerical experiments. The work is organized as follows: 1/ Presentation of different formulations of the design problem. 2/ Formulation of multimaterial topology optimization using Design Material Optimization and Generalized Shape Function. 3/ Formulation of misalignment constraint and non-discreteness measures. Sensitivity analysis. 4/ Solution scheme. Numerical applications and discussion of the results. 5/ Conclusions and future developments.