F2014-EPT-075

OPTIMIZATION OF MOTOR AND GEARBOX FOR AN ULTRA LIGHT ELECTRIC VEHICLE (ULEV)

[1,2]Isabelle Hofman[*], [1,2]Peter Sergeant, and [2]Alex Van den Bossche
[1]Dept. IT&C, Electrical Energy Research Group, Ghent University, Gent, Belgium
[2]Dept. EESA, Electrical Energy Laboratory, Ghent University, Gent, Belgium

Ultra light, Electric vehicle, Optimization, Drivetrain, Integrated design

Research and/or Engineering Questions/Objective

The integrated design (ID) of the drivetrain (DT) of a single person ULEV powered by batteries is optimized towards high efficiency and low mass. The tri-cycle EV has two driven and steering front wheels. The maximum speed of the EV is 70 km/h and a range of 100 km has to be covered. The total curb weight is about 100 kg (batteries included).

Methodology

The highly efficient DT of the ULEV consists of: a gearbox (GB), a brushless DC motor and power electronics (PE). An optimized analytical design of the motor is implemented in combination with an improved GB. The optimized parameters (OP) of the motor are: the outer rotor radius, the number of stator teeth and the number of pole pairs. A single-stage and two-stage GB model is implemented for different gear ratios (GRs). The OP for the GB are: the number of teeth, the module of each gear combination and the total mass of the GB. The analytical models (AMs) of the motor, GB and PE are validated by test setups. The DT is optimized towards a minimal total weight and a maximal efficiency for two driving cycles.

Results

The optimization of the DT over the driving cycles makes it possible to choose the optimal combination of motor and GB for different GRs in order to have high efficiency and low weight. Comparing a single-stage GB with a two-stage GB, a single-stage GB has a higher efficiency, but also a higher weight than a two-stage GB with the same properties. The optimization of the dynamic behavior of the DT over the driving cycles yields a compromise between the total efficiency and the total mass of the DT. The optimum choice will depend on the intended use of the vehicle (drive cycle).

Limitations of this study

The AMs used in the study are useful for designing a good motor in combination with a GB in a fast way, but the models are not accurate enough to predict the efficiency quantitatively.

What does the paper offer that is new in the field including in comparison to other work by the authors?

The ID of the DT increases the integration between the motor, the GB and the PE. This will result in a system that is more compact, lighter and more efficient than a drivetrain with “off-the-shelf components”.

Conclusions

ID of the complete DT will result in an optimal combination of motor and GB for that driving cycle. The optimum choice of motor combined with GB obviously depends on the intended use of the vehicle.