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1 Introduction

Most of the research related to powertrain design focuses on finding the optimal design under given conditions. However, only limited research is focused on the design space around this optimum, which would be interesting in order to determine the robustness of the optimum found. This creates insight into the sensitivity of the optimal performance to variations in the design and/or conditions of the vehicle. This is crucial for research into the design of 'modular' powertrain components, components designed for multiple vehicle segments.

2 Sensitivity studies

Multiple types of sensitivity studies are available, ranging from one-factor-at-a-time (OAT) to variance based methods. Since the purpose of the use of sensitivity studies here is in the first phase of vehicle design, high computational expenses should be avoided. Therefore, computational inexpensive, but still accurate enough, sensitivity studies are preferred. In this work, discussed in more detail in [1], a sensitivity study based on a two-level factorial design is performed on a hybrid electric heavy-duty truck.

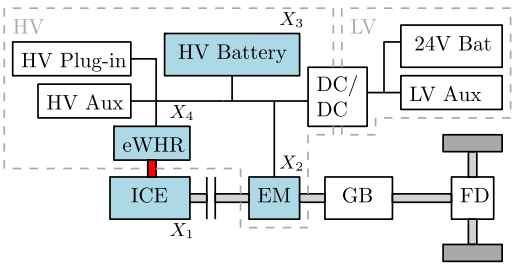

Figure 1: Topology of the vehicle studied [1].

3 Two-level factorial design

The vehicle studied is a parallel hybrid plug-in heavy-duty truck. The vehicles topology is shown in Figure 1. The factors studied are indicated in blue, which are: sizing of the internal combustion engine (X_1), electric machine (X_2), and battery (X_3), and the presence of a WHR system (X_4). The objectives studied are: (f_1) the fuel savings, (f_2) powertrain efficiency, (f_3) energy generated by the WHR system, (f_4) reduction in total cost of ownership, and (f_5) the average torque split.

The research leading to these results has received funding from the European Community's Horizon 2020 Programme under grant agreement No. 653468 (ECOCHAMPS).

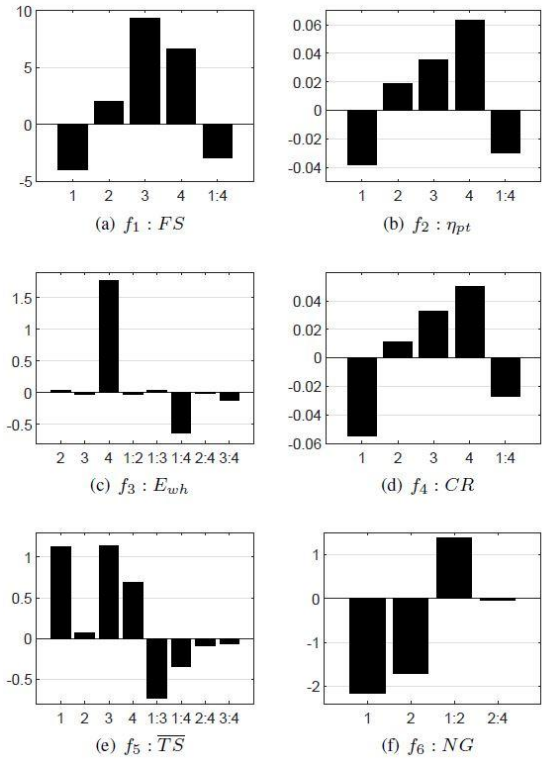

Figure 2: Plots of significant regression model parameters for each of the six objectives studied [1].

The method is based on a two-level factorial design, where for each factor studied two levels are simulated. For each of the objectives a linear regression model is fitted w.r.t to the four factors. A more detailed description of the method can be found in [1]. The significant regression model parameters are plotted in Figure 2.

4 Conclusions

The main conclusions that could be drawn for the vehicle studied using this method, and visible in Figure 2, are:

- Non-optimal vehicle design w.r.t. cost and fuel
- Cost effective WHR system
- Significant coupling between ICE and WHR

References

[1] F.J.R. Verbruggen and T. Hofman, "Design sensitivity analysis for heavy-duty hybrid electric trucks with a waste heat recovery system," in Proceedings of *Vehicle Propulsion and Powertrain Conference*, Belfort, France, 2017