



Final report

T4:7 Hybrid powertrain system design

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Summary

The main technical obstacles for hybrid power trains have step by step been successfully eliminated through a lot of research and development, such that it is possible to design a hybrid powertrain which works well with commercial available parts. However, to implement new technology is not only about getting the technology to work, but to a large extent also about integrating the new technology in the existing products and production process in a cost effective way, and to build a system which use the subsystems in smart ways to maximize the strengths and to compensate for each other's weaknesses. It is also important to find when the new technology should lead to redefining the existing products in some way.

This project has studied, partly developed and described a process to analyse hybrid powertrains from a vehicle and user perspective, in order to be able to better develop suitable subsystems and complete powertrains for different users. The results are not answers about how the powertrains should be, but rather descriptions of how to think when defining requirements, how to analyse the system and how to decrease the cost-benefit ratio.

These results are useful for researchers and engineers working with hybrid power trains as they helps them better understand how to improve the whole powertrain or parts of it. It also increase the effectiveness of their efforts if they understand well what role they should play in the complete development process.

The project was carried out between 2012 and June 2014.

General project description and background

Within this project a group of experts from different powertrain areas, including industrial powertrain experts have jointly defined and described a process to develop and analyse hybrid powertrains.

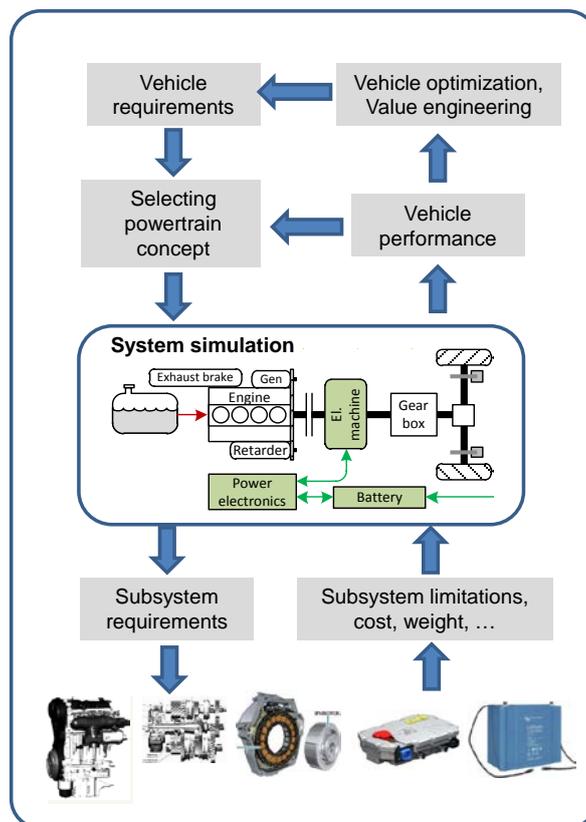
The project aims to describe the design process, design tools and important aspects to understand in order to design good hybrid powertrains. The resulting report is useful for researchers and engineers within the area, especially those who are not themselves working with the overall system design, but still need to understand the process as they contribute with their expertise on a smaller part of the system.

Project scope is to describe the design process, including:

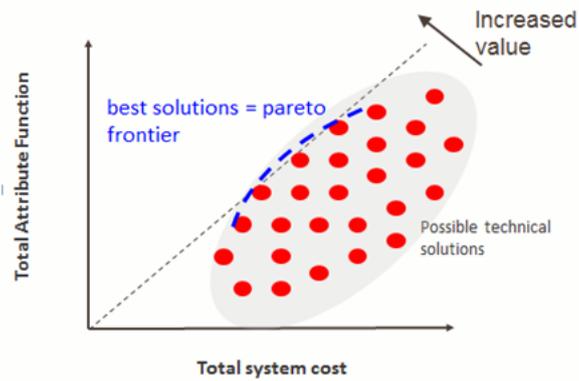
- Customer/User requirements
- Value engineering
- Industrial prerequisites and requirements
- Overview of powertrain concepts
- Sub systems and the requirements on them
- Simulation methods
- Analysis.

Achieved results

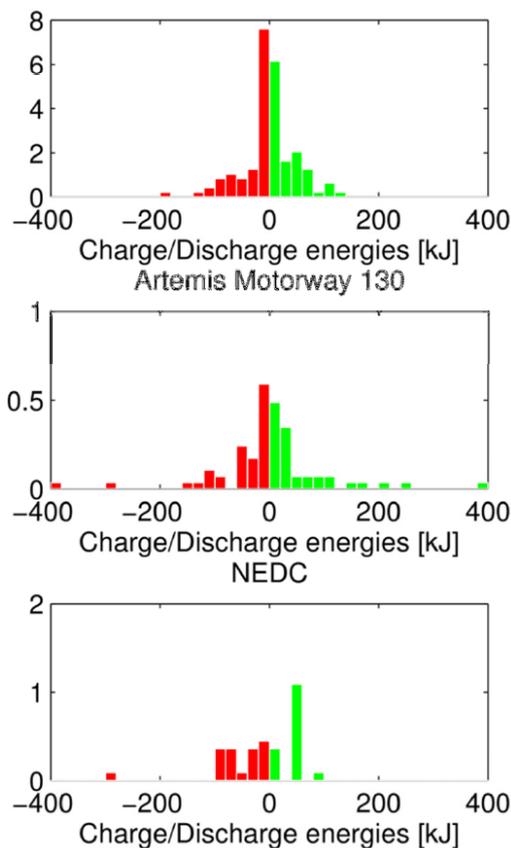
The project covers several different steps and this report only give some examples of the results. One such result is the description of a requirement setting process illustrated in the figure below.



Another result is a discussion of how to evaluate the optimal design using Pareto fronts. This way of analysing a complete powertrain concept is a valuable tool as it provides insights about how many different solutions can all be optimal, for different customers.



Examples of analysis results are shown in the figure below, in which the amount of energy which is used or regenerated at different power levels are shown for three different types of driving. This way of illustrating how the energy is distributed at different power levels is a very good way of quickly comparing how different ways of using the vehicle influence the sizing of some part of the hybrid powertrain.



Timing and finance

2012 - June 2014

The total project budget is SEK 1'200'000, all of which is funded by SHC.

Executors and collaboration

The project has been carried out by a group of experts from different areas. Experts on electric drives, energy storage, system control and analysis as well as industrial powertrain experts. The participants have been:

Mårten Behm, KTH

Mathias Björkman, Scania CV

Sören Eriksson, Volvo Cars

Anders Grauers, SHC/Chalmers (Editor)

Jerker Lennevi, AB Volvo

Johan Lennblad, Volvo Cars

Anders Malmquist, KTH

Per Öberg, LiU

Dissemination of Results

Results have been presented and discussed several times:

- 2012-05-08 Workshop in the doctoral student network
- 2013-03-21 SHC cross-theme workshop
- 2013-11-27 Presented on a SHC battery workshop
- 2014-03-19 The results from the project was one important contribution to a workshop on Hybrids for heavy utility vehicles.
- 2014-06-04 Presented for the SHC international Advisory board.

The results of this project was one important basis for creating the fourth thematic area within SHC, *Vehicle Analysis*, and it influence how problems is being addressed and which methods used in several other projects.

Papers and publications

The project report

Hybrid Vehicles - System design methods

Applied to requirements setting on mild hybrids

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