Final report

T4:10 Tekniköversikter inom fordonsanalystemat

Anders Grauers
Chalmers University of Technology

Swedish Hybrid Vehicle Centre
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Summary

As the benefit of a hybrid powertrain, in terms of fuel use, depends strongly on how the vehicle is used, there is a need to have methods which can calculate the fuel use for a given usage pattern. Typically this is done by simulating the powertrain in a long series of driving cycles which shall represent the total use of the vehicle. However, as the simulation model for a powertrain is complicated and the driving cycles are very long it is difficult to make simple and rough estimates of fuel consumption based on this type of analysis. An easy way to estimate the potential of different solutions is vital for being able to understand which powertrain type is suitable for which vehicle.

A method which can estimate the potential fuel saving for different types of hybrid powertrains has been created. This method allow an effective way to determine what types of hybrid powertrains are potentially interesting, and then enable the engineer to quickly pick only a few candidates for a more thorough, and more accurate, analysis using traditional simulation of the whole system.

The project has been carried out between Dec 2014 and June 2015.

General project description and background

When deciding which type of powertrain should be used on which vehicle it is not sufficient to only study the performance requirements of the vehicle, but it will also be very important to study how variations in how the vehicles are driven influence the fuel consumption. This is very important as the willingness to pay extra for a more or less sophisticated hybrid powertrain depends strongly on how much fuel it can save. The fuel savings is then an important part in a cost-benefit analysis made for different users and powertrains. However, since different users of a vehicle model can use it very differently, there is a need to analyse the cost-benefit ratio for large number of users and for several different types of power trains. With methods built on simulation of the powertrains in each driving cycle the time required for this analysis is prohibitively long.

In this project a method to quickly estimate the savings from only a few statistical measures of a driving cycle is developed and tested on one powertrain. The method translates the driving cycle into a power-duration plot from which it can be calculated how much energy the powertrain use in different operating modes and how long it operates in them. This can be easily calculated, without needing a model of the powertrain. These measures are then used in a very simple fuel consumption model, to estimate the fuel consumption of a specific vehicle driven according to the analysed driving cycle.

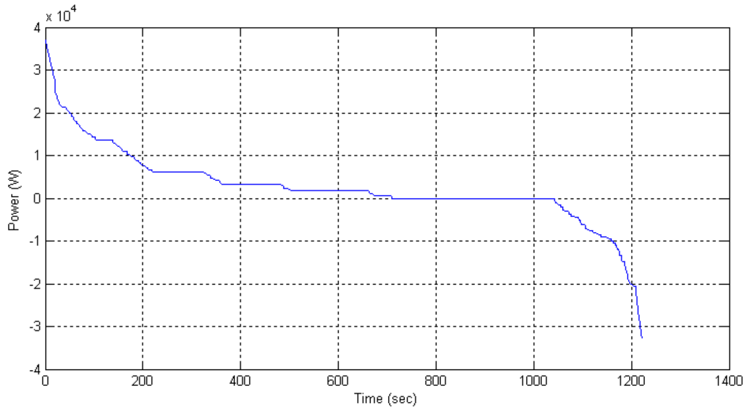
For each driving cycle it will be very easy to test powertrains with different degree of hybridization, and thus a suitable powertrain can be found quickly.

The method is excluding some phenomena which can increase the fuel consumption, and is therefore mainly capable of estimating a lower bound on the fuel consumption. This means that it should mainly be used to find interesting candidates, and to eliminate solutions which are definitely not cost effective, before doing a detailed analysis of a small number of candidates using the traditional detailed models.

Due to its simplicity and the possibility to analyse a driving cycle from only a few measures this method is a tool which can help powertrain engineers to better understand how the potential to hybridized vehicles change for different driving cycles. This will be an important for making better and quicker decisions about which powertrain to develop or which versions of powertrains to offer to different customers.

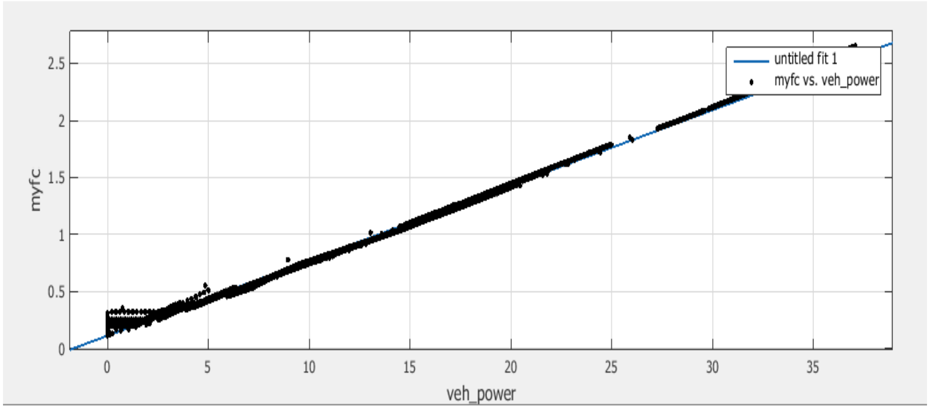
Achieved results

The basis for the method is to calculate the power-duration plot for a certain way of driving the vehicle, this is done using a simple vehicle model, and it look like in the figure below.

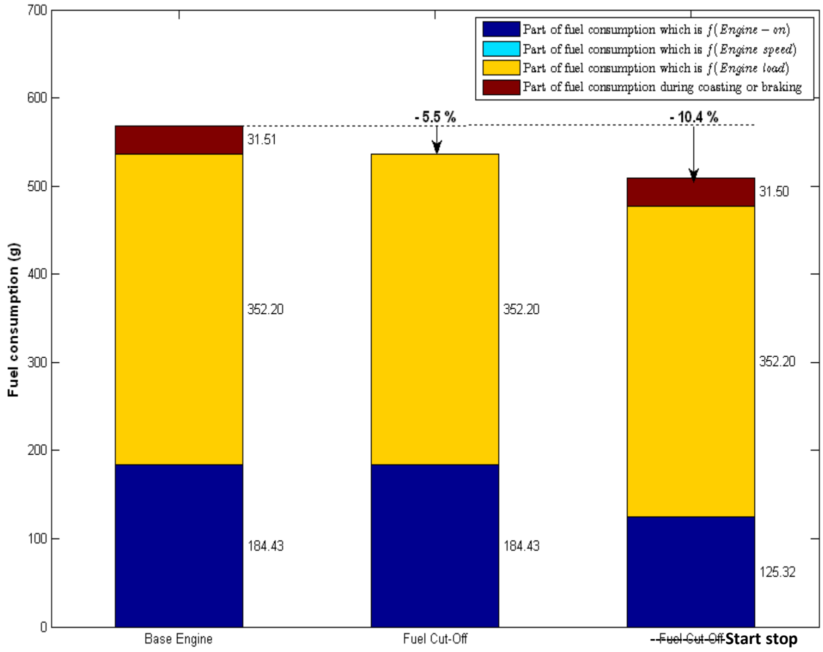


The possibility to also simplify the fuel consumption to be a function of only the demanded power has been analysed. It turned out that it was not possible to do that for the general case, but for a powertrain which use fuel-optimal gear shifting the fuel consumption could in the interesting power range be approximated as an affine function, as can be seen in the figure below.

Modelling the fuel consumption fairly accurately for the whole operating region of the engine, and thus for an arbitrary gear shifting, was possible. However, the model then needed so many different parameters that it did not serve its purpose in this kind of simplified analysis.



By calculating how long time the engine will run in different modes, for different types of power trains, and how much energy it will need to produce in these different modes, it is possible to calculate the fuel used in these different modes. In the figure below an example is showed of how the fuel consumption is reduced when using fuel cut-off or using a start/stop system.



A very important property of this method is that he time required for the analysis does not depend on the length of the driving cycle, except for generating the power-duration plot which is a small part of the total analysis.

The model still need more testing on different engines and different driving cycles before we can say anything certain about the accuracy. However, the results we have so far suggest that it will be capable of roughly estimating the fuel savings potential, with sufficient accuracy to determine which powertrains are interesting to analyse further. Note, that a very high accuracy is not necessarily very useful as the other input to the cost-benefit analysis, like the driving cycles and cost models, are also very uncertain and also have a very big influence on the total cost-benefit ratio.

Timing and finance

The project was run Dec 2014 - June 2015

The total project budget is SEK 450´000 of which all is funded by SHC.

Executors and collaboration

The modelling and simulations in this project has been carried out by Karthik Upendra, and the analysis has been done by Karthik and Anders Grauers.

Dissemination of Results

The results from this project are just being summarized, and there has not yet been time to present them for a bigger audience. They will be presented in SHC seminars, and may also be the subject of a workshop.

The results and the method will also be integrated into the SHC PhD course on Design of hybrid powertrains.

Swedish Electric & Hybrid Vehicle Centre
Chalmers University of Technology
Hörsalsvägen 11, level 5
SE-412 96 Göteborg

Phone: +46 (0) 31 772 10 00
www.hybridfordonscentrum.se