Some comments on the SHC analysis of F1 hybrid power trains

By: Anders Grauers

The main reason for SHC to study F1 hybrids is to see what we can learn from them which are also relevant for conventional light and heavy duty vehicles. The F1 hybrids and their technology have been studied by Karthik Upendra, with Anders Grauers as a supervisor, and the results are reported in the report: *Analysis of 2014 Formula one hybrid powertrain - A Preliminary study with focus on its applicability to road cars.*

This document aims to present a few general insights about the 2014 F1 hybrid power train. The document only includes the insights we have drawn during the analysis, and they have not yet been widely discussed. Experts with other background are expected to find other insights, so do not expect this analysis to be complete.

What we have seen, which may become interesting in conventional vehicles is for example the electrified turbocharger. I.e. the turbo is equipped with an electric machine (EM) on its shaft.

- The EM on the turbo charger has not been used much in passenger cars, but may perhaps be a good idea for premium HEV (Hybrid electric vehicle) passenger cars (and perhaps later also on more standard). It may be a cheaper way to reach quicker response than to boost with an electric machine on the engine crankshaft. Still it requires rather high power of several kW, so it most likely requires a 48V electric system or higher.
  (Audi has presented concept cars with 48V electric compressors)
- Not only can the electric turbo act as a boost, but it can also recuperate some energy from the exhaust pressure (at least in a diesel engine) which is otherwise wasted through the waste gate. This is already done in another way in some heavy duty diesels, with turbo compounding. For engines which often run at high load turbo compounding can reduce the fuel consumption by several percent's. But they need to be controlled so that the back pressure does not increase to a great extent which may induce knock in gasoline engine. On the other hand, for diesel engine with short route EGR, a slight increase in back pressure is favourable for the EGR path.

The possibility to use the electric turbo to both reduce the turbo lag and recover energy from the exhaust pressure is of course two reasons why it may become used in heavy or light duty diesel engines. It recovers less energy than some other technologies recovering energy from exhaust gases, but it is a very compact solution which builds on components already existing in most vehicles. One thing to learn from the F1 teams is that the heat from the exhaust turbine may affect the EM much, and therefore it is critical how the EM is cooled and where it is mounted.

A very important general conclusion is that one should be careful to assume that a technology successfully used in F1 will end up in conventional vehicles. The reason for this is that the F1 cars are developed to meet completely different objectives than conventional vehicles. For example:

- In a conventional vehicle fuel savings almost always is seen as a benefit which the customer can be prepared to pay a little extra for. The purpose of the F1 hybrid is only to stay below the limit of 100 kg of fuel per race. I.e. it does not pay-off much to reduce fuel consumption to a much lower level.

- The F1 rules put many constraints which are not valid when designing conventional vehicles, for example, there is a limit on how much energy can be regenerated and limit on the engine displacement.
- The F1 powertrain has priority on power and quick response, while hardware cost is of minor importance.
- The F1 car can be optimized for a very specific way of driving, while a passenger car or a truck must be a compromise for many types of driving.

We can also see some hardware differences, which will not necessarily be carried over to conventional vehicles.

- In F1 there are very few situations when the propulsion power demand is low for any longer time, and therefore the electric machine is directly connected to the crank shaft of the engine without any clutch. It is then typically connected to the non-drive end of the crankshaft. A passenger car would typically use a clutch between the engine and the Electric machine, to allow for pure EV mode and Engine stop to reduce engine idle losses when only little propulsion power is required. Therefore the EM in a conventional vehicle is more likely to be mounted on the transmission side of the engine and with a clutch to be able to disconnect and stop the engine when desired.