Development of an integrated experimental and numerical methodology for the performance analysis of multiple hybrid electric architectures over different driving cycles

Abstract

In response to rising concerns about road transportation and its climate impacts, the electrification of modern powertrains plays a crucial role as a key measure to reduce pollutant and greenhouse gas emissions. Worldwide governments are conveying their efforts in the run for a sustainable transportation system that is required to be as much as clean and efficient as possible under various driving conditions. Hence, the so-called real-world emissions are under the microscope, since they are measured outside of a controlled testing environment. In this scenario, the fast pace of innovation along with the increasing complexity represents a new challenge for OEMs. Therefore, development and validation of these new powertrain concepts is receiving more and more importance.

In this regard, a research activity has been carried out in collaboration between Politecnico di Torino and FEV Italia, within their facilities in Piedmont, Italy. The aim of this collaboration is to provide a "virtual test rig" capable to evaluate the performance of various electrified powertrains over a wide range of different real driving scenarios. The proposed integrated and standardized methodology wants to bridge the gap between testing and modelling of hybrid electric vehicles (HEVs), reducing the testing effort in terms of time and cost. The experimental campaign relies on a limited set of dedicated tests: standstill starts, accelerations, constant speed driving and different type of decelerations; carried out to collect data for the reverse engineering of the powertrain and for vehicle simulation. Most important, components characterization is based on a customized and non-invasive powertrain instrumentation.

On the simulation side, a comprehensive 0D map-based model was developed and calibrated according to the aforementioned test campaign, with particular focus on the Energy Management System (EMS) reverse engineering. The simulation platform is able to simulate several hybrid architectures with high flexibility, also in real driving scenarios. The methodology was applied to 3 different electrified vehicles available on the market, with increasing complexity order, such as a 48V mild-hybrid (MHEV) Diesel P0 architecture, a P0-P2 gasoline Plug-in hybrid (PHEV) architecture and a P2 Diesel PHEV architecture.

As a result, the virtual test rig is used to evaluate the energy split, CO_2 emissions and fuel consumption on different driving cycles and Real Driving Emissions (RDE) tests, allowing the universal vehicle model to be adopted in the predevelopment phase of new powertrains.