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Abstract

"Modeling and control of advanced powertrain systems and Waste Heat Recovery technologies for the reduction of CO_2 emissions in light-duty vehicles"

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Abstract

Transportation is the major sector in the EU where greenhouse gas emissions are still rising. Therefore, in the recent years, the OEMs research and development has focused on the reduction of carbon dioxide (CO2) and pollutants emissions. On the other hand, the European Commission proposed targets for the further reduction of CO2 emissions from new cars by 2020. In this scenario, concepts such as the engines downsizing and other advanced technologies as well as more costly hybrid solutions and, more recently, waste heat recovery (WHR) systems have been proposed.
A model based computational framework capable to simulate different vehicles with several powertrain configurations has been developed. To this purpose, modularity has been achieved by exploiting approaches and models with enhanced composability and scalability properties. The vehicle-powertrain model simulates the dynamics of vehicle, engine, driveline, transmissions and electrical components. It allows evaluating the benefits achievable in terms of fuel economy and CO2 reduction depending on powertrain configuration (vehicle, engine, transmission, etc.), selected scenario (standard NEDC, WLTC or arbitrary driving cycles), Hybrid or WHR technology, components sizing and management.
A list of ten technologies for the improvement of the overall ICE energy conversion efficiency has been considered and their impact on the emission of CO2 has been investigated by means of the Willans line method. In the thesis, different hybrid electric configurations are studied in order to give an overview on the energy conversion and management strategies to support the design of propulsion systems and the selection of relevant components. More innovative WHR technologies include Electric Turbo-Compound (ETC), Thermo-Electric Generator (TEG) and Organic Rankine Cycle (ORC). The performed investigation explores from a broader perspective these systems to better understand the opportunities and their limits for implementation on conventional vehicles. In general, some WHR may be considered as a secondary component for the powertrain that could successfully innovate the powertrain towards fuel saving objectives. The results presented prove that hybrid vehicles are the most viable alternative solution to reduce the greenhouse gas emissions. On the other hand, although technologically feasible, ETC, TEG and ORC are not yet mature for a large-scale production and implementation. As evidenced by the simulations, they offer significant improvements on fuel economy and CO2 reduction. The analyses performed provide a comprehensive framework to evaluate those technologies that can promote the development of more efficient propulsion systems.