ENERGETICS

Ammin/Siemens - Human-in-the loop platform for assessment of hybrid vehicles fed with biofuels, integrating model-based control strategies and NVH analysis

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Context of the research activity	The objectives of the present research activity are: • Correctly assemble the different descriptive models and the control logics to improve the powertrain calibration and validation process for engines fed with biofuels. • Real-time capable powertrain and vehicle vibro-acoustic modelling approaches for the integration of NVH interactive assessment in a multiphysics digital thread. • Demonstration of the developed multiphysics framework on industrially relevant use cases.
	Significant research efforts to reduce CO2 and pollutant emissions from the transport sector are currently ongoing. To achieve this aim, several technologies are under investigation, among which the electrification of the powertrain and the utilization of biofuels derived from renewable sources will surely play a significant role in the next few decades. While fully electric vehicle architectures are becoming more common in the private transport segment, their limitations in terms of driving range, cost, required infrastructure, and safety make them less suitable for certain applications. As a result, hybrid electric vehicle (HEV) architectures are expected to be widely adopted in the near future for applications that demand long driving ranges and short refueling times, such as light-duty and heavy-duty commercial vehicles. Moreover, the utilization of biofuels instead of conventional fossil fuels can further reduce the impact of greenhouse gas and pollutant emissions. The electrification and hybridization processes are implying an exponential increase of the architectures applicable to the newly developed vehicles, with a need for optimizing the performance in terms of engine combustion, energy flow and NVH. To handle this increased complexity, the OEMs' approach to the design, development and testing of the next generation vehicles should take advantage of preliminary simulations carried out with digital twins in order to assess the multiphysics performance of the vehicle. This also helps

Objectives	minimize the need for physical prototypes. The development of digital twins requires accurate modeling approaches for both the physical systems and the related controllers. In the present PhD proposal, in collaboration and co-funded by Siemens Industry Software NV (SISW), the integration of real-time model-based controllers for engine combustion, NVH and energy flow optimization will be explored, also evaluating the potential of Artificial Intelligence. This procedure allows also to jointly explore and optimize – early in the vehicle development process – conflicting attributes and targets. One of the most salient examples, that will be tackled within this project, is the mutual influence of powertrain energy management strategies and noise and vibration emission targets for HEV architectures. Due to the unconventional operation of the internal combustion engines (ICE), the ICE operating points in HEVs can vary significantly during the vehicle mission, not only because of the vehicle speed, gear selection and driver torque demand, but also based on the power split between the ICE and the electric machine(s), which is determined by the vehicle's energy supervisor. This articulated behavior of the active components could imply undesired noise, vibration, and harshness (NVH) and consequently worsen the perceived product quality. The unconventional engine operation in HEVs determines a larger effort in terms of experimental calibration, needed to identify several maps suitable for the different vehicle operating modes. The alternative way investigated within this research activity, consists in the use of a model-based approach for the real-time optimization of the engine calibration parameters in a digital environment. The digital twin approach requires that all the different vehicle components (ICE engine, EV motor(s), gearbox, etc.) are modeled also from the NVH point of view. To this purpose sub-structuring techniques can be adopted to define NVH attributes that are invariant with respect to the components' operational conditions. The use of component-based approaches in a multi-attribute and real-time context is still underexplored. The involved PhD student will investigate approaches to include NVH in the abovementioned digital thread with the ultimate ambition of defining an interactive environment in which both energy management and NVH levers can be explored online and offline adopting X-in-the-loop (XIL) technologies.

Skills and competencies for the development of the activity	The PhD candidate should demonstrate: • Excellent knowledge of engine thermodynamics and combustion, of engine control, pollutant formation and aftertreatment. • Knowledge of HEV architectures. • Knowledge of 1D/0D-CFD simulation codes (such as GT-SUITE). • Basic knowledge of combustion noise and NHV