Thermal shock testing for Engines in Dymola

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In this work, we use an acausal multi-domain physical system model to study the interaction between an internal combustion engine operation and a range of cooling scenarios. Although the model can be used for modelling a wide range of scenarios, in this paper we concentrate on the application of "thermal shock".

Many manufacturers carry out thermal shock tests to understand and prevent component failure, as well as to accelerate durability testing of engines and engine components, including cylinder-head gaskets. An internal combustion engine is load-controlled on a dynamometer and coolant temperature transients are imposed on the engine system. Using freely available and commercial Modelica Libraries within the Dymola environment, the whole system integration of the coolant rig and engine dynamometer is achieved. This allows the user to develop and define control strategies for the tests from desktop, prior to engaging in the real tests.

The commercial library used to model the internal combustion engine is the Claytex Engines library [1]. This library is capable of modelling both mean value and crank angle resolved engine models and is fully compatible with the Modelica Standard library. The Modelica Standard library forms the basis for the cooling circuit modelling.

The engine being tested is a 4 cylinder inline Turbo Diesel engine with direct injection. The mean value version model of the engine is installed in a torque controlled dynamometer and coupled to the cooling rig.

The integrated systems including the engine, cooling rig and associated controllers are run within the Dymola environment to predict the engine heat rejection and cooling rig performance in a thermal shock scenario. A good match of experimental data vs. simulation results is achieved for the thermal shock coolant temperatures. The models perform faster than real time with both variable and fixed step solvers. The fixed step solver simulation with inline integration is shown to be capable of meeting and exceeding the required 250Hz sampling for HIL (Hardware In the Loop) simulation.

Keywords: Engine testing, thermal-shock, control system development

References

[1] Dempsey M., and Picarelli A. (2009). Investigating the multibody dynamics of the complete powertrain system. Como, Italy: Proceedings 7th Modelica Conference.