High Dimensional Fast-Response Particle Number (PN) Surrogate Model Building Methodology for Heavy Duty (HD) Diesel Engine Applications

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India's existing BS-VI emissions standards on sub-23 nm particle number (PN) emission limit applies to the engine testbed level. As heavy-duty (HD) diesel engines are always fitted with Diesel Particulate Filter (DPF), meeting PN emissions legislative limits at the tailpipe level is not difficult. However, future legislation requirements may be similar to European on-road In-service Conformity (ISC), by using Portable Emission Measurement System (PEMS) for vehicle level PN measurements. Therefore, it is an important aspect to understand the physics involved in the generation and evolution of particles, the corresponding sensitive parameters, and therefore to develop a capability to robustly estimate engine-out PN for HD diesel engines. This technical work is focused on estimating the engine-out PN for HD diesel engine by using the MoDS-SRM Engine Suite digital workflow. The purpose is to build detailed physico-chemical engine models and a high dimensional, fast-response surrogate model that is capable of accurately capturing combustion characteristics and engine-out emissions at steady-state operating points. The PN measurement data is collected with AVL APC 489 device, covering various operating conditions with distinct engine speed and load across the entire operating window of a HD compression ignition diesel engine. The physico-chemical models are calibrated (parameter estimation) as part of the MoDS-SRM Engine Suite workflow with 40% of the measured operating points. Subsequently, the calibrated detailed models undergo validation (blind-testing) against the remaining 60% of the measured operating points. The calibrated models are able to simulate the validation points with satisfactory accuracy, capturing the general trend across various operating conditions for gas-phase and particulate emissions. For particulate emissions, 80% and 62% of the validation points are within 50% error in relation to the measurement data for soot mass and PN. Had it been a purely statistical or data-driven model, approximately 85%-95% of the measured operating points would be required for model calibration to reach the level of accuracy that is achieved in this work. In order to reduce computational expense further, a fast-response model is developed to simulate steady-state and transient operating conditions. The surrogate model generated from the MoDS-SRM Engine Suite digital workflow is applied to perform transient cycle simulations in MATLAB. The future scope of the work includes the addition of more measurement data with respect to variations in EGR, injection pressures, high and low ambient temperatures, high altitude, and cold zones to demonstrate the cost-reduction potential of the digital workflow in some of the aforementioned measurements-intensive scenarios.

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[2] Kok Foong Lee, David Ooi, SAE, 2019-26-0062