Abstract

The recent developments in automotive diesel engine subsystems, like injection systems and air management systems, allow for a much greater control and flexibility over the combustion process, thus resulting in significant reductions in emissions and fuel consumption. However, these developments also increase the complexity of the complete system leading to a much higher number of control parameters. This increase in number of control parameters makes the task of diesel engine calibration more complicated, as it requires a solution to an optimization problem of high dimensionality. The traditional optimization methods such as simple gradient method or steepest descent method are not suited for high dimensional optimization problems such as common rail diesel engine since they have a tendency of getting trapped in local optima. To complicate the matter further, the optimized calibration, stored in the form of maps inside the engine control unit, must fulfill stringent requirements in terms of smoothness, ensuring a subtle transition of control parameters between neighbor operating points. This additional requirement of smoothness often means moving away from the optimum calibration, thus resulting in penalties in terms of emissions and fuel consumption. Moreover, traditional calibration methods are often slow and dependent on the experience of the calibration team, which can lead to an increase in the development time and cost for a newly designed engine.

It is therefore necessary to develop a methodology that can reduce this loss of optima and carry out the engine calibration task in a quick and automatic way. With this aim, in this work, a one-click methodology has been developed that uses Genetic Algorithm (GA) to generate multiple optimum calibrations for each engine operating point. These multiple optimum calibrations form a Pareto front, thus providing a solution to classical multi objective optimization problem of diesel engine. Using these multiple optimum calibrations, a large number of calibration

maps are generated. These maps are evaluated on the basis of smoothness and performance over a driving cycle. Following the evaluation, some calibrations are shortlisted automatically based on a tradeoff between the required level of smoothness and minimization of emissions. These shortlisted calibrations can be finally reviewed by the calibration team to select the final calibration.

The multiple optimum calibrations generated using GA were compared with an existing calibration optimized using traditional methods for a C segment vehicle with a curb mass of 1650 kg for a Euro 6d application. Firstly, using the in house developed code for GA optimization, significantly better calibrations were obtained for all the engine operating points. Using these better calibrations and an integrated approach that reduces the loss of optima due to smoothening, a simultaneous reduction of 1% BSFC, 10 % NO_X and 5% Soot was achieved over WLTC in comparison to the existing calibration. These reductions were obtained while achieving the same level of smoothness of the calibration maps of the existing calibration. Most importantly, using the described methodology the time required for calibration can be reduced drastically. The activity that typically takes couple of weeks can be carried out in couple of days. Moreover, using a reduced version of the described methodology an existing calibration was modified within minutes to provide significant reductions in one of the emissions (15% NO_X) without deteriorating any of the other emissions, fuel consumption, combustion noise and exhaust temperature.