

Use of modern application methods in the development of turbo charged direct injection engines

M. Bross, BMW Group, München

Only by continuous innovation the BMW Group successfully meets the conflicting requirements of different interest groups. On the one hand development faces emission laws in various markets that become ever more stringent, on the other hand the customer requests agility and dynamic response in longitudinal and lateral direction and low fuel consumption at the same time. In particular the latter requirement was recognized early by BMW and has been implemented consistently by the EfficientDynamics™ strategy. An important factor of this strategy was, and still is, the development of efficient drive concepts, resulting in the presently available engines with DI- and TC-technology. In this sense, innovations allow to reconcile conflicting requirements and boundary conditions that become more and more demanding.

As a consequence of above requirements the complexity of the engine hardware and of the engine control increases, which is reflected for example in the continuous increase of the labels to be populated with data. Simultaneously the number of variants to be processed increases since, on the one hand, the required sales growth can only be achieved by a more extensive segmentation of the market (“niche formation”) and, on the other hand, the heterogeneity of the world-wide available fuels (lead, sulphur, ethanol) also requires suitable adaptations for example.

As regards the application this means, in summary, that the complexity and the quantity of tasks increases significantly while the available resources remain constant. This conflict can only be solved by the implementation of modern application methods.

The application methods developed by BMW using software Matlab can each be assigned to a specific hardware platform. This results in four fields of one family of application tools:

All application methods used in operational vehicles belong to **CarApp**. Although the application in the vehicle is a rather traditional process, a methodical approach can open up new possibilities here as well. In this regard we have for example developed a tool that allows for the simulation of driving cycles via the Matlab-Inca interface. Legal cycles can be driven on a test track in a reproducible manner without a roller dynamometer or arbitrary, critical driving manoeuvres can be driven.

The wide group of **AutomApp** applications covers all approaches performed on function test rigs. These serve as component test rigs for the system “engine” and allow for the data population of the stationary behaviour. Among other tasks this involves solving model generation tasks and optimization tasks, performed by an algorithm referred to as „mbMinimize“ within BMW Group. This algorithm allows to find optimal parameter sets even in the highly dimensional search spaces that are typical for complex engines and hence ensures minimal fuel consumption with simultaneous consideration of side conditions like emissions or engine knocking.

If the capabilities of a function test rig are extended by a real-time simulation of the drive train and of the vehicle itself a highly dynamical test rig is achieved that can simulate the vehicle behaviour via a highly dynamical electric motor that functions as torque interface. The **DynApp** methods allow e.g. to drive legal driving cycles and to obtain emission and consumption data.

A further and last abstraction method is the real-time simulation on HILs or offline on PCs. These methods are referred to as **VirtApp** methods and also cover a process that models the fresh air volume fed that flows into the engine. This task can be performed however completely on the function test rig. Due to the low availability of engines in particular during the early development phases it is more efficient to parameterize a physical model with just a low number of measuring points and then simulate the full volume of operating points.

As shown above, it is the use of modern application methods that allows to tap the potentials of today’s innovative and complex engines and to meet economic constraints at the same time.