Engine Calibration & Tuning

5 days **MAPCAL-EN-A**

Overview

LEVEL

Expert

PURPOSE

This course provides a better understanding engine tuning and calibration. It gives an overview of the tuning process to specialists (project, architecture, system design, software development, component development, software integration, functional validation, calibration, …).

LEARNING OBJECTIVES

Upon completion of the course, participants will be able to:

understand the relationship between engines physical functionalities and customer requirements,

manage the requirements compromise,

understand how EMS affects engine performances,

understand the relationship between design and customer requirements,

understand EMS tuning process and development,

know tuning procedures and calibration tools,

master the theory and the interest of DoE,

practice develop and DoE,

understand numerical optimization tools,

understand the use of numerical models for tuning,

practice calibration tools and synthesize engine control tuning.

WAYS AND MEANS

The last two days are based on concrete and practical exercises:

teaching design of experiment is enhanced by the use of computer tools (Matlab),

teaching optimization settings is facilitated by the use of industrial computer tools.

Agenda

INTRODUCTION — 0.25 d

Engine management system fundamentals. Tuning process and calibration in a V development cycle.
Customer requirements, relationships between engine technical definition and customer requirements.

FUNDAMENTALS OF ENGINE PERFORMANCE TUNING — 1 d

Torque and power concepts. Vehicle acceleration and speed concepts, gear impact.
Engine constraints and components constraints.
Engine performance related to injection and fuel control strategies, to air loading, supercharching and air control strategies. Tuning tests and calibrations to ensure engine development performance.
Measurements, benches, tools and test analysis. Calibration compromises. Inter-compromise performance.
Validation plan.

FUNDAMENTALS OF ENGINE CONSUMPTION - POLLUTION & OBD TUNING — 1 d

Emissions regulations, nature of pollutants, cycles and global levels. Engine out emissions fundamentals.
Fuel properties impact on emissions. Engine and components constraints.
Engine emissions related to injection and fuel control strategies. Engine emissions related to air loading and air control strategies. Diagnostics and OBD calibration and development.
Tuning tests and calibrations to ensure engine emissions development. Measurements, benches, tools and test analysis. Calibration compromises. Inter-compromise performance. Validation plan.
CO_2 regulation, CO_2 emissions and tax incentives.
Engine consumption fundamentals: performance.
Engine and components constraints.
Engine consumption calibration related to injection and fuel control strategies, air system and air control strategies, combustion control (phasing injections and ignition).
Measurements, benches, tools and test analysis. Calibration compromises. Inter-compromise performance. Validation plan.

FUNDAMENTALS OF ENGINE CONSUMPTION TUNING

0.75 d

CO_2 regulation, CO_2 emissions and tax incentives.
Engine consumption fundamentals: performance.
Engine and components constraints.
Engine consumption calibration related to injection and fuel control strategies, air system and air control strategies, combustion control (phasing injections and ignition).
Measurements, benches, tools and test analysis. Calibration compromises. Inter-compromise performance. Validation plan.

DESIGN OF EXPERIMENTS

1 d

Customer and cycle driving operating points.
Design of experiments (DoE) theory.
Impact of engine operating parameters on tuning.
Practice of the design of experiments with Matlab.
Numerical models and optimized operating variables. Model quality and predictability validation. Impact on the DoE nature.
Local or global DoE. Calibration methodologies associated with the DoE.

FUNDAMENTALS OF ENGINE DRIVABILITY

0.75 d

Definition of the driving pleasure. Drivability objectification.
Physics fundamentals of powertrain drivability.
Engine and components constraints.
Torque structure fundamentals: target, set point and raw torque.
Drivability strategies: pedal progressivity, anti jerk, dynamic engine speed control, vehicle dynamic control.
Power train phases of life and related calibration: engine off, on-road driving, highway driving, docking, acceleration, idle speed.
Measurements, benches, tools and test analysis. Calibration compromises. Inter-compromise performance. Validation plan.

SYNTHESIS & OPTIMIZATION OF THE ENGINES CALIBRATION

1 d

Digital calibration tools suitable for control strategies.
Commercial generic digital tools for calibration (type AVL CAMEO).
Industrialization and integration of calibration methodologies in a development process.
Minimizing the total number of trials. Creating databases of test data.
Taking into account the drift and dispersion, environmental measurement conditions in tuning numerical models.
Exploitation of DoE. Numerical optimization methodologies.
Autopilot benches. Bench measurements with low dynamics (BFD).
Optimization of multi calibrations. Synthesis and management of the inter-compromise requirements.
Smoothing calibrations.
Practice of a computer optimization and calibration tool.