This course can be adapted to virtual classroom mode

0D Powertrain Modeling

5 days **MS0D-EN-A**

Overview

LEVEL

Expert

PURPOSE

This course provides an overview of 0D modeling applied to the engine: fluids modeling, combustion modeling, thermal and mechanical modeling. It is also a prerequisite for powertrain and vehicle investigations and powertrain management.

The models developed in this course are operational and directly applicable to real design applications.

LEARNING OBJECTIVES

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

master the principles of 0D modeling,

know the basics of 0D modeling in the area of compressible and incompressible fluids, combustion, mechanics and thermals,

know the components of a 0D powertrain model: modeling agencies, components, circuits and fluid systems,

design and develop a 0D model of an engine,

design and develop powertrain control strategies,

implement and configure the components of a 0D model,

learn the principles of different 0D simulation tools, such as Matlab-Simulink, GT-Power or AMESIM,

use 0D models and 0D simulations to develop powertrain systems and powertrain controls.

WAYS AND MEANS

This course presents the state of the art of 0D computer simulation tools.

This training course is based on continuous balancing between theory and practice, knowledge and expertise.

Design of complete 0D models of engine parts or engines on Matlab Simulink.

Concrete case studies of 0D simulation.

Simulation and exploitation of 0D models for system and control designs: air system, combustion chamber, cooling system, fuel system, mechanical engine parts.

Agenda

INTRODUCTION TO 0D MODELING — 0.25 d

Basics of 0D modeling and numerical simulation. 0D simulation compared to 1D and 3D simulation in the design process of a powertrain system. Notions of model reduction 3D/1D to 0D. When can we use 0D models in a powertrain design, for what kind of studies?
Mathematical models, statistical and physical. Fundamentals of numerical simulation, numerical schemes of resolution, operating solvers, numerical errors and waste.
Presentation and technical comparison of the main tools for the simulation 0D simulation Matlab-Simulink, GT-Power and Amesim.

0D FLUID MODELING & SIMULATION — 1.5 d

Fundamentals of fluid modeling: conservation of mass, momentum and energy, nature of the flow, the notion of compressibility, definition of viscosity, equations “Barré Saint-Venant” and Bernouilli, flow coefficients. Problem of the propagation of pressure waves in 0D solvers and comparison software (Matlab-Simulink, GT-Power and AMESIM), operating principles and properties of the software.
Modeling components of compressible fluids: modeling pipes and volumes (air filter, plenum, headers …); modeling valves (throttle body, shutters, EGR valves); modeling turbochargers and mechanical compressors.
Modeling components of incompressible fluids: modeling of hydraulic circuits, modeling pumps.
Determination of calibration models and components.
Application to the modeling of hydraulic components: modeling of the injection system, water system and oil system of an engine, calculation of pressure, pressure drop and flow.
Application of modeling tools based on Matlab-Simulink simulation: construction of a supercharged engine with EGR model, parametric study.

0D COMBUSTION & EMISSIONS MODELING & SIMULATION

1.25 d

Introduction to the modeling of combustion, heat, burning rate, creation of chemical species, chemical kinetics, the concept of self-ignition delay, knocking engine, premixed flame and diffusion flame, laminar velocity and turbulent aerodynamic, coupling combustion cycle to cycle variation, statistical aspects related to combustion models, …
Combustion models: 1 zone 2 zones Eddy burn-up and barba and multi-zones, physical models and combustion rate imposed models.
Influence of combustion parameters: wealth, rates of RBG, EGR rate, the injection timing, the ignition, aerodynamic phenomena, … Modeling knock.
Phenomenological modeling emissions and statistical modeling of emissions (mapping and neural networks):
Modeling components: heat transfer model, aerodynamics (turbulence), combustion models, kinematic models.
Model calibration, recalibration of combustion models.
Application to diesel: example of Diesel predictive combustion models, example of statistical models emission.
Application to gasoline: analysis and correlation of cylinder pressure, intake and exhaust; parametric study; examples of combustion models.

0D THERMAL MODELING & SIMULATION

0.5 d

Fundamentals of thermal modeling, conduction, natural and forced convection, radiation, thermal inertia, heat balance equations.
Modeling components: fluid components and combustion models incorporating thermal, heat exchangers and thermostats.
Characterization of components, thermal correlation, building materials, masses, specific heat, thickness, …
Application: operation of an exchange model (EGR and CAC impact on engine air loading).

0D MECHANICAL MODELING & SIMULATION

0.5 d

Fundamentals of mechanical modeling: inertia, stiffness and damping, spring mass system complete.
Modeling components: masses, springs, dampers, friction aerodynamics, engine friction, motion conversion.
Applications: examples of a gearbox and a kinematic modeling of a vehicle; operation of the model on a driving cycle.

0D ENGINE MANAGEMENT MODELING & SIMULATION

1 d

Using 0D models for powertrain control. Modeling real time operating system. Numerical modeling of PID controllers.
Modeling and simulation of real-time operation systems: generation of classical synchronous and asynchronous events in motor control.
Modeling and simulation of regulators engine control strategies: example of the PID controller.
Modeling and simulation of control strategies: integration strategies, real-time system and environmental models.
0D modeling used to find the optimum requirement compromise.
Applications: design of the boost pressure regulation; design of an EGR control rate; development and calibration of engine control strategy.