This course can be adapted to virtual classroom mode

3D Powertrain Modeling

5 days **MS3D-EN-A**

Overview

LEVEL

Expert

PURPOSE

This course provides an overview of 3D modeling applied to the engine: fluids modeling, combustion modeling, thermal and mechanical modeling.

It is also a prerequisite for powertrain and vehicle investigations.

LEARNING OBJECTIVES

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

understand the principles of 3D modeling,

master the basics of 3D modeling in the area of compressible and incompressible fluids, combustion, mechanics and thermals,

know the components of a 3D powertrain model: modeling agencies, components, circuits and fluid systems,

design and develop a 3D model of an engine,

implement and configure the components of a 3D model,

learn the principles of different 3D simulation tools, such as Star CD, Star CCM +, KIVA, FLUENT, AVL FIRE, Open Foam, …,

use 3D models and 3D simulations to develop powertrains: large choices of architectures (displacement, compression ratio, bore, volumes and lengths of pipes, …), parts dimensioning and design impacts on powertrain performance.

WAYS AND MEANS

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

Design of complete 3D models of parts or engine parts on an “Open-FOAM”.

Concrete case studies of 3D simulation.

Simulation and exploitation of 3D models for system designs: air system, combustion chamber, cooling system, fuel system, mechanical engine parts.

Agenda

3D FLUID MODELING & SIMULATION — 1.5 d

Basics of 3D modeling and numerical simulation. 3D simulation compared to 0D and 1D simulation in the design process of a powertrain system.

Fundamentals of fluid modeling: Eulerian approach, Lagrangian, Navier-Stokes equations, conservation of mass, momentum and energy, nature of the flow, boundary layer concept, the notion of compressibility, definition of viscosity, equation Barré Saint-Venant, flow coefficients, pressure wave propagation. Average flow and instantaneous flow turbulence.

Spatial discretization, mesh, digital resolution scheme, solvers and comparison software (Star CD, Star CCM +, Fluent, AVL-Fire, Converge,Open Foam, open source software), operating principles and properties of the software.

Modeling components of compressible fluids: modeling pipes and volumes, modeling valves, modeling boosts components.
Modeling components of incompressible fluids: modeling of hydraulic circuits, modeling pumps, taking into account the deformation of the flexible.
Determination of calibration models and components.
Application of modeling with “Open Foam” simulation tool: introduction to Open Foam, principles and operation of the software; computers skills upgrade (using the Shell Linux, Linux basic commands); construction of an air circuit model, modeling of the air circuit, building skin mesh, parametric study; construction of a hydraulic model, modeling of a fuel hose, parametric study.

3D COMBUSTION & EMISSIONS MODELING & SIMULATION

1.5 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, …
1 zone model, 2-zone model, 3-zone and multi-zone model. 3D combustion model, influential parameters modeling.
3D Diesel combustion model, influential parameters modeling.
Predictive modeling of emissions (NOx, particles, HC, CO and CO_2), statistical modeling programs: mapping and neural networks.
3D modeling combustion CFD models, model heat transfer, aerodynamics, combustion model, chemical models.
Spatial discretization, mesh, digital resolution scheme, solvers and comparison software (Star CD, Star CCM +, KIVA, AVL-Fire, Converge, Open-Foam), operating principles and properties of the software.
Modeling components: modeling of jet fuel, rate of introduction of the cylinder, geometry of the combustion chamber, piston, spark and dynamic mesh of the combustion chamber.
Calibration of 3D models.
Generic application of “Open Foam”: creating an engine model and dynamic mesh.
Diesel application of “Open Foam”: creating a diesel combustion model.
Gasoline application of “Open Foam”: calculation based on a 3D model gasoline combustion.

3D MODELING & THERMAL SIMULATION

0.75 d

Fundamentals of thermal modeling, conduction, natural and forced convection, radiation, thermal inertia, heat balance equations, dimensionless numbers in heat: Prandtl, Nusselt.
Modeling components: fluid and combustion components incorporating thermal models (lines and volumes, heat roller), heat exchangers, thermostats, loss models for walls.
Characterization of components, building materials, masses, specific heat, thickness, …
Open foam applications: construction of an exchanger model, parametric study on the heat exchanger model.

3D MECHANICAL MODELING & SIMULATION

0.75 d

Fundamentals of mechanical modeling: inertia, stiffness and damping torsional deformations.
Modeling components: masses, springs, dampers, motion conversion, reducers, trees, strength, speed, time.
Examples of 3D modeling engine design, part modeling and studies of mechanical systems: piston shafts, engine block, manifolds, cylinder heads.
Applications: modeling and parametric study of a mechanical system.

3D MATCHING & BOUNDARY CONDITIONS

0.5 d

Good use of 3D modeling. Boundary conditions.
3D models reduction in 1D or 0D models.
Coupling a 3D model to a 1D or 0D models.
Application: GT-Power and Open-FOAM coupling.