IFP Training

Internal Combustion Engines: Theory & Practice

10 days **ICE-EN-A**

Overview

LEVEL

Knowledge

PURPOSE

This course provides a deeper knowledge on mechanical operations and behavior and challenges of air induction, combustion, thermodynamics, performance improvements…

LEARNING OBJECTIVES

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

calculate effective sections of a cylinder head or EGR circuit,

understand and apply the equations used on the engine test bench,

analyze the causes of engine component damage or failure,

understand the vocabulary and tools used in the vibration analysis field,

calculate and select a turbocharger to match a performance curve (turbo matching).

WAYS AND MEANS

All the training below includes many practical exercises to illustrate the concepts presented.

Agenda

THERMODYNAMICS APPLIED TO ENGINES — 1.5 d

Engine history: evolution till the 4-stroke engine.
Thermodynamics first and second principles: calculation of an exhaust temperature. Why compressing before combustion?
Engine efficiencies: calculation of the engine best possible efficiency.
Calculation of cylinder pressure at compression end. Internal energy, enthalpy, entropy. Ideal gas equation. Laplace equation.
Different thermodynamic cycles (Beau de Rochas, Diesel, Atkinson, Miller, Stirling).
Turbocharger isentropic efficiency.

PERFORMANCE & EFFICIENCY — 2 d

MEP: analysis of energy per cycle by mean pressure: BMEP (Brake Mean Effective pressure), IMEP (Indicated Mean Effective Pressure), FMEP (Friction Mean Effective Pressure).
Global efficiency: analysis of the 4 main efficiencies of a reciprocating engine, fuel consumption (BSFC), impact of different settings (load, A/F ratio, ignition timing, …) on the efficiencies. Differences between the ideal cycle (Beau de Rochas) and the real cycle (thermal loss, pumping loss, …).
Volumetric efficiency.
Engine-vehicle adaptation: Willans diagram, fuel consumption, gear staging.

ENGINE MECHANICS — 1.5 d

Engine acyclism: reasons why an engine does not work regularly: forces due to gas pressure and inertia of moving parts. Consequences of acyclism (belt resistance, damper pulley, double flywheel clutch - DFC).
Balancing: use of a balancer shaft or a counterweight on a crankshaft. Inertia load due to rotary and alternative forces. Inertia load of first and second order (H1, H2) on a 4-cylinder engine.

Valve timing: how the different valve drives work.
Lubrication: the different lubrication modes. Viscosity. Stribeck curve.

INLET/EXHAUST PROCESSES - PERFORMANCES & FORCED INDUCTION

1.5 d

Fluid dynamics: Bernoulli equation, Saint Venant equation, sound velocity.
Gas exchange and flow processes: use of pressure waves in inlet and exhaust pipes to increase the volumetric efficiency.
Exhaust Gas recirculation (EGR): uses of EGR, low pressure EGR, high pressure EGR.
Turbocharging: how it works, technology, turbo adaptation.

MATERIALS - MECHANICAL ENDURANCE

1.5 d

Characteristics of metal alloy steels used in engines: grey iron, ductile iron, steel, aluminum.
Manufacturing processes (foundry and forge). Surface treatment.
Mechanical properties: Young’s modulus, minimum yield, shear rating. Analysis of the engine major parts whose material and manufacturing process must be chosen.

ENGINE PARTS DAMAGE MODES

1 d

Due to thermal problems: carbonization, loss of mechanical characteristics, intercrystalline corrosion, creep, melting.
Due to mechanical problems: plastic deformation, fracture, fatigue failure, Goodman diagram, impact of vibrations.
Due to thermo-mechanical problems.
Due to tribologic problems: lubrication, Stribeck curve, pitting, fretting, abrasive wear, adhesive wear, erosive wear, cavitation, scuffing, stick-slip.

VIBRATIONS

1 d

Transverse vibration, Eigen mode, resonance, damping.
Acceleration, velocity, displacement parameters. Vibration levels: amplitudes, frequencies. Spectrum decibels, harmonic number.
Vibration measurement, sonogram, tracking.
The above training includes many practical exercises.