POWERTRAIN ENGINEERING

APPLIED GRADUATE STUDIES

Content

IFP SCHOOL

TU1 – INTRODUCTION TO THE POWERTRAIN

Objectives

- Understand the basic concepts related to the operation of the internal combustion engines and the main parameters which characterize their performance, fuel consumption and emissions;
- Understand the operation of the main components of the automotive powertrain including terminology and functionality;
- Be familiar with the industrial constraints of engine production (casting, machining, assembly, fitting out of vehicle).

Content

- Introduction to the Internal Combustion Engine
- Integration field trip: visits to automotive industrial sites in Turin, Italy
- Practical introduction to the automotive powertrain technology

PWT2 – COMBUSTION IN THE ENGINE

Objectives

- Master the physical-chemical foundations of combustion phenomena;
- Apply the knowledge of these phenomena to analyze and explain engine test results, and optimize the engine calibrations;
- Know the latest trend of gasoline and diesel combustion, such as HCCI and CAI.

Content

- Fundamentals of combustion in the gaseous phase, including a class work
- Combustion in gasoline and diesel engines
- New combustion processes: HCCI and CAI

PWT3 – THERMODYNAMICS AND ENERGY CONVERSION

Objectives

- Understand and apply the principles of thermodynamics to the calculation of engine cycles;
- Establish the mathematical equations that govern certain physical phenomena inherent in the energy conversion process in a piston engine;
- Develop a 0-D numerical model of an engine cycle including gas exchange, heat transfer, combustion and expansion;
- Have an overall knowledge about advanced optical techniques for combustion analysis.

Content

- Class work: Thermodynamics of engines
- Project: 0-D Simulation of an engine cycle
- Advanced experimental techniques for engines

PWT4 – ENGINE TECHNOLOGY

Objectives

- Be familiar with the function of the main engine components;
- Understand the advantages and disadvantages, challenges and technological trends of their design;
- Apply mechanical theory to kinematics and dynamics problems concerning the moving parts of the internal combustion engine;
- Be able to constructively discuss with equipment suppliers in order to determine the optimum components for a given engine.

Content

- Technology of fixed components (engine block, cylinder head etc.)
- Technology of the piston and conrod
- Basics of the valve train
- Mechanics, balancing and bearings of reciprocating engines
- Technology of crankshaft
- Technology of 2-stroke engines

PWT5 – FUEL AND AIR SUPPLY

Objectives

- Know the main characteristics of the fuel injection systems (diesel, gasoline, LPG and NGV), and be able to optimize the injection parameters to improve engine management;
- Understand the influence of different design parameters on an intake and exhaust system in order to optimize engine air charging efficiency;
- Comprehend the influence of turbocharger characteristics on engine performances, and carry out the turbo matching process;
- Have a general understanding of the modeling techniques applied on the design of the intake and exhaust system.

Content

- Gasoline and diesel fuel injection systems
- Fuel injection systems for LPG and NGV engines
- Gas exchange processes, including a 1-D modeling class work
- Turbocharger technology for engines
- EGR systems
- Modeling of Fluid Flow
- Product process of the intake and exhaust system

PWT6 – ENVIRONMENTAL ISSUES AND EMISSIONS REDUCTION

Objectives

- Know the main automotive emissions sources, and the emission regulations worldwide;
- Understand the life cycle and well-to-wheels analysis in the automotive sector;
- Be familiar with all the current available technologies for the after treatment of exhaust gas;
- Understand the various trade-offs and engineering tools required to engineer exhaust after-treatment systems.

Content

- Pollutant formation in engines and emissions legislation worldwide
- Atmospheric pollution and its impact - Life Cycle and Well-to-Wheels analysis in the automotive sector
- Aftertreatment systems, usage and performance evaluation
- Diesel Particulate Filters: catalyzed systems and systems with additives
- Ceramic and Metallic substrates in automotive aftertreatment
- Thermal management requirements
- Catalyst recycling and supply considerations for platinum group metals

PWT7 – FUELS AND LUBRICANTS

Objectives

- Analyze the effects of modifications to various fuel characteristics on engine performances;
- Understand the use of alternative liquid fuels (biofuels, XtL etc.) in current and future engines;
- Identify the lubrication requirements of various powertrain components;
- Choose an oil according to the lubrication constraints of an engine and of a transmission;
- Know the different mechanisms of filtration and separation for engine fluids.

Content

- Refining and Fuels
- Lubrication circuits and lubrication requirements
- Functions, composition and grading of motor oils
- Filtration of fluids in engines

PWT8 – TRANSMISSIONS AND ALTERNATIVE DRIVE TRAINS

Objectives

- Understand the action and performance of various types of transmission technologies (both conventional and advanced) in terms of vehicle performance, fuel consumption and emissions;
- Know the basic functionality requirements of a transmission system and be capable of making decisions regarding engine-transmission matching;
- Be familiar with the technologies of the electric machines and batteries for the electric propulsion;
- Be able to dimension a full hybrid drive train.

Content

- Manual and Automatic transmissions technologies
- Hybrid drive train
- Energy storage systems, electric traction and generation machines
- Batteries for electric and hybrid vehicles
- Micro to mild hybrid components
- Exhaust waste energy recovery

PWT9 – POWERTRAIN TESTING

Objectives

- Be familiar with experimental equipment specifications and limitations in order to avoid measurement errors (sensors, signal conditioning and processing, measurement devices position and calibration, gas analysis etc.);
- Operate conventional testing equipments and post process the measured data;
- Characterize the operation of some engine components (i.e. ignition, injection, turbocharger, cylinder head permeability, etc.) by carrying out specific tests;
- Analyze and understand test bench results, in order to suggest improvements and/or complementary tests;
- Be able to turn a technical question into an engine testing program;
- Apply Design of Experiment methods to an engine test campaign.

Content

- Introduction to internal combustion engine testing and to endurance testing
- Analysis of engine test results
- Practical exercises on: Gasoline and Diesel engine test benches, chassis dynamometer
- Practical exercises on: aerodynamic test bench, injection test bench, ignition test bench
- Design of experiment and data analysis concepts, including a class work

PWT10 – POWERTRAIN CONTROL AND MECHATRONICS

Objectives

- Have a basic knowledge of the operation of a powertrain control system;
- Describe the main functions managed by a powertrain control system (i.e. for diesel and gasoline engines);
- Describe the main physical phenomena inherent in engine control using equations and deduce model-based control laws:
- Propose an approach to the development of a control function or sub-system with allowance for its interactions in the control system as a whole;
- Prototype a controller from control laws to final validation
- Understand the operation of electronic control systems and know how to detect possible malfunctions.

Content

- Control prerequisites
- Basics of gasoline and diesel engine control, including a class work
- Advanced engine control for the air path
- Advanced after-treatment control
- Hybrid stop-and-start control, energy management
- Class work on the dynamic calibration of an hybrid powertrain
- Advanced powertrain control
- Electronics in the powertrain
- On-board diagnostics

PWT11 – VEHICLE INTEGRATION (INCLUDING FINAL PROJECT)

Objectives

- Understand the constraints imposed by the integration of the powertrain in the vehicle;
- Evaluate the vehicle performance, drivability and consumption;
- Be familiar with noise, vibrations and harshness (NVH) engendered by the powertrain;
- Know the main vehicle functions interacting with the powertrain (i.e. ABS, ESP, climate control, etc.);
- Have a general overview about conventional and advanced architecture of the external cooling circuit;
- Know the main heavy duty engine characteristics and vehicle requirements.

Content

- Longitudinal dynamics of the vehicle
- Supervised application class work: off-calculation of performance and consumption
- Anti vibrations technologies, automotive acoustics and engine noise
- Practical work on vehicle comfort and safety functions interacting with the powertrain
- External cooling circuits
- Heavy duty vehicle integration and requirements
- Final project: development of a complete chain of powertrain and its energy control management

PWT12 – AUTOMOTIVE MARKET, DEVELOPMENT AND SUPPLY CHAINS

Objectives

- Be aware of the own cultural backgrounds and habits as well as those of other nationalities in order to communicate and work more effectively in multicultural teams;
- Broaden the knowledge and analytical skills thus allowing the development of intercultural management approaches, as a central theme of international business and project development;
- Understand the impact of local and global forces on the automotive and powertrain market;
- Understand the development stages of an automotive technology: delivery on time at targeted quality and cost; the supply chain including the OEM-supplier relationship.

Content

- Developing intercultural skills
- Intercultural management
- The economy of the energy industry
- The international automotive and powertrain markets, with special focus on the Chinese and Indian industry and domestic markets
- Trends in vehicle - transmission - engine - fuel matching considering "global" markets, "local" constraints and customer expectations
- Project management, delivering new products on time at targeted quality and costs
- The R&D and supply chain in the automotive industry: OEMs and suppliers relationships

PWT13 – COMPLEMENTARY TECHNICAL MODULE

Objectives

- Analyze the functioning cycle of a turbomachine and calculate its thermal balance;
- Know the technological characteristics of the different types of the industrial gas turbines;
- Apply the know-how acquired on typical automotive engines to small IC engines (i.e. motorcycle engines), and to marine and industrial engines;
- Be able to perform a 1-D model of a Common Rail solenoid injector, analyze the results and propose design improvements.

Content

- Introduction to turbomachines
- Gas turbines cycle calculation: turbojet, turbofan
- Combustion in continuous-flow engines
- Small engines for marine outboard application (2 and 4 stroke)
- Modeling of fuel injection system class work