Mastering engine downsizing

A fun-to-drive DI gasoline vehicle with reduced fuel consumption

Key achievements

- Demonstration of an IFP downsizing approach combining several well-known technologies - direct injection, turbocharging and variable valve timing.
- A downsized (1.8-litre) four-cylinder DI gasoline engine with the performances of a 3-litre V6 engine and significantly lower CO_2 emissions and fuel consumption in a European Driving Cycle (20% reduction).
- Engine performances: 340 N.m at 1,500 RPM, 147 kW at 5,500 RPM, lowest BSFC 238 g/kWh, 195 g/km CO_2 on NEDC.

IFP Vel Satis demonstrator vehicle

IFP expertise

IFP has implemented the different stages of development: definition of vehicle and engine specifications, design and manufacture of prototype parts, engine development tests, development of engine control algorithms, and vehicle calibration.

Technological engine definition

- Turbocharged gasoline engine with direct injection in homogeneous mode (collaboration with HTT Honeywell Turbo Technologies).
  - Twin variable valve timing for intake and exhaust valves.
- Single-scroll turbocharger design.
- Transmission adaptations (after completion of IFP-DRIVE* simulation).
- Redesign of piston head shape.
- Original compact intake plenum specifically for short turbolag.
- Dedicated valve timing and event duration definition for scavenging process optimization.
- Specific 1,000°C-compatible exhaust line (collaborations with HTT Honeywell Turbo Technologies for tubocharger and Faurecia for exhaust manifold).

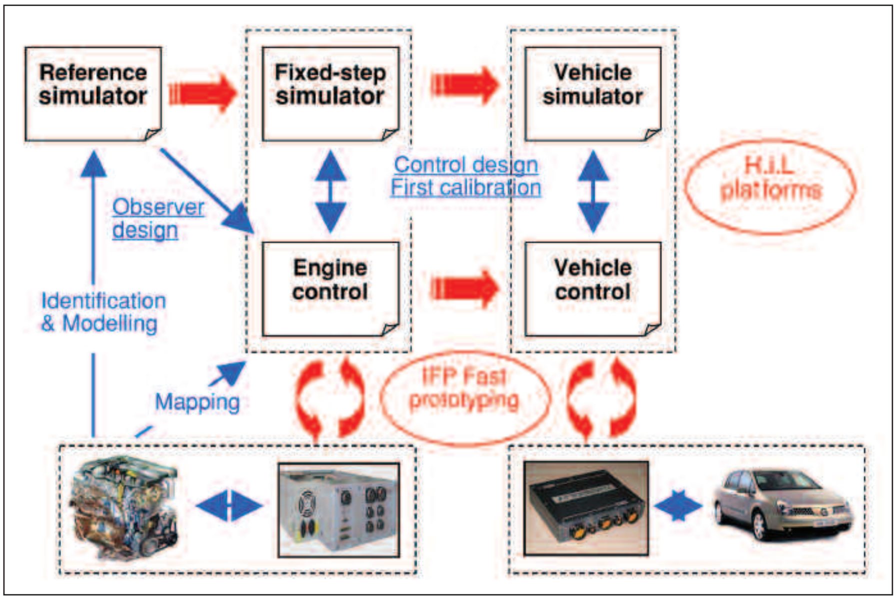
Simulation-based process for engine control design, calibration and validation

- Use of high frequency 0D engine and AMESim vehicle simulators using IFP-ENGINE* and IFP-DRIVE* libraries (real-time compatible).
- Matlab/Simulink/RTW software platform for control development.
- Step-by-step process (co-simulation, real-time HiL) ensuring rapid, robust development.
- In-house IFP full-pass rapid prototyping system in combination with xPC target kernel.

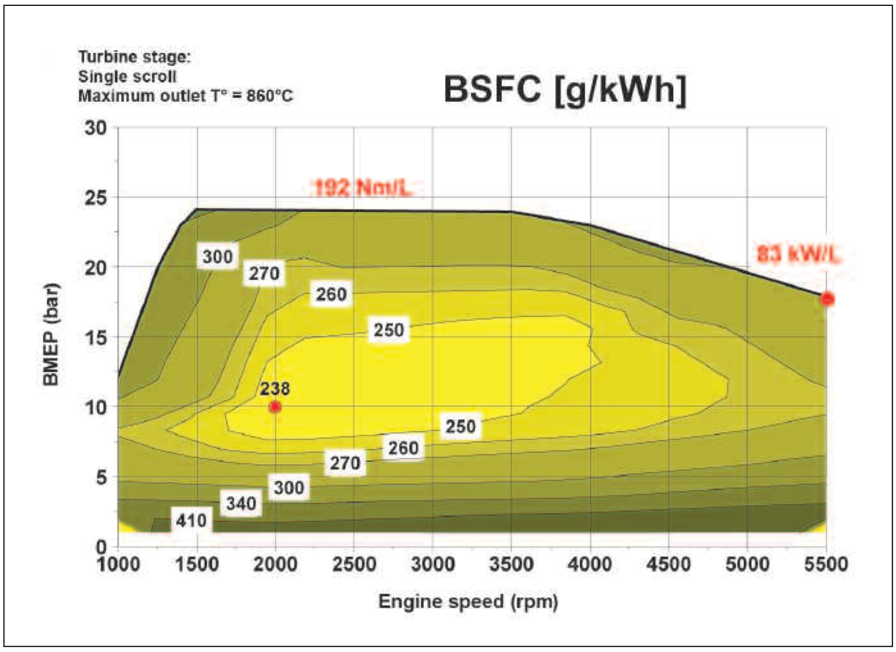
* available in AMESim software marketed by IMAGINE company.

As an international research and training center, IFP is **developing the transport energies** of the 21st century.

Innovation
Energy
Environment



Control development and validation process



Specific fuel consumption map of IFP's 1.8l GDI turbo engine

An advanced torque-based control structure developed entirely by IFP

- Design of observers and non-linear controllers for unmeasured relevant variables: in-cylinder trapped air mass, air scavenging and burned gases.
- Control of trapped air mass to reach the torque corresponding to the driver's command (pedal position).
- Control of residual burned gases at low load to minimize fuel consumption and pollutant emissions.
- Control of scavenging at high load to improve combustion efficiency and reduce turbolag.
- Supervision of quantity of each gas (fresh and BRG) in cylinder to achieve performance while reducing fuel consumption and pollutant emissions and optimize the warm-up phase.
- Dynamic knock strategy to adapt spark advance to in-cylinder conditions in steady-state and transient conditions.
- Fuel/air ratio control for optimal catalytic exhaust conversion.
- Final road calibration for enhanced driveability.

Communications Division -051007 - GraphiDoc

Worldwide:
Corinne Charondière
IFP-Powertrain Engineering - Marketing Manager
1 & 4, avenue de Bois-Préau - 92852 Rueil-Malmaison Cedex - France
Tel.: +33 1 47 52 65 56 - Fax: +33 1 47 52 70 69
powertrain@ifp.fr

IFP (Head office)
1 & 4, avenue de Bois-Préau
92852 Rueil-Malmaison Cedex - France
Tel.: + 33 1 47 52 60 00 - Fax: + 33 1 47 52 70 00

IFP-Lyon
Rond-point de l'échangeur de Solaize
BP 3 - 69360 Solaize - France
Tel.: + 33 4 78 02 20 20 - Fax: + 33 4 78 02 20 15

www.ifp.fr

Innovation Energy Environment