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Jaguar V6 SI/HCCI Dual Mode Engine: Real-time Model-based Control

Instrumentation

The Jaguar V6 engine is a Gasoline Direct Injection (GDI), Variable Valve Timing (VVT) and 3 litre capacity research HCCI engine, which is able to switch from Spark-Ignition (SI) mode to Homogenous Charge Compression Ignition (HCCI) mode and vice versa.

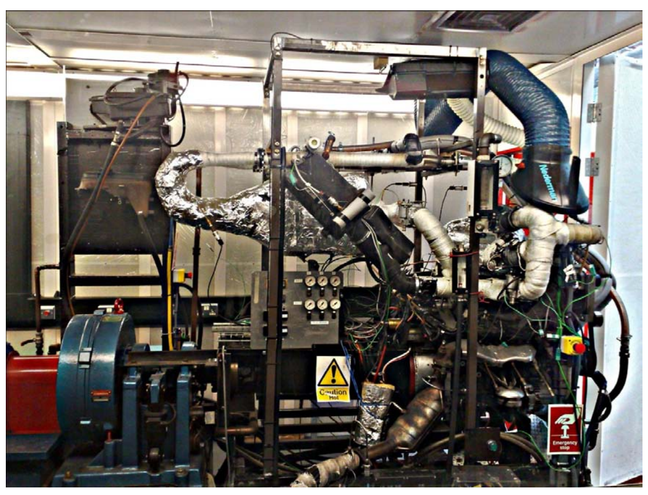

Figure 1. The Jaguar gasoline V6 research engine

Engine type	**Jaguar research V6, 24-V, GDI**	**Compression ratio**	**11.3**
Engine speed	800~ 3500 rpm	**Intake valve timing**	Variable
Bore	89mm	**Exhaust valve timing**	Variable
Stroke	79.5mm	**Intake temperature**	Variable
Fuel	ULG95	**Air/Fuel ratio**	Variable

Table 1. Engine Specification

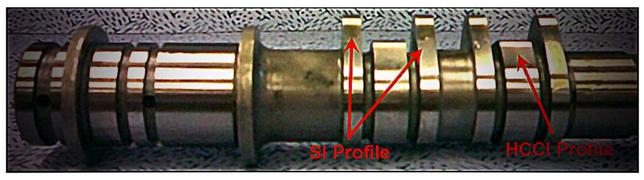

Figure 2. The Cam Profile Switching (CPS) system

The Cam Profile Switching (CPS) system uses the camshaft (Figure 2) to switch between two different cam profiles (9mm/3mm).

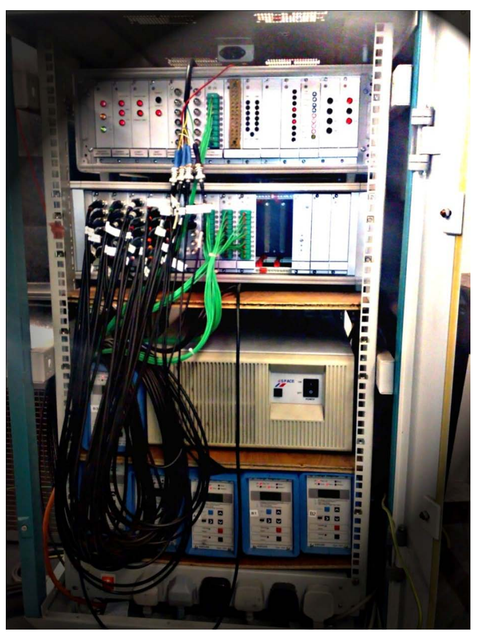

Figure 3. The dSPACE Simulator

The whole engine test bed is controlled by the dSPACE, which is a product able to implement Hardware-in-the-loop (HIL) simulation.

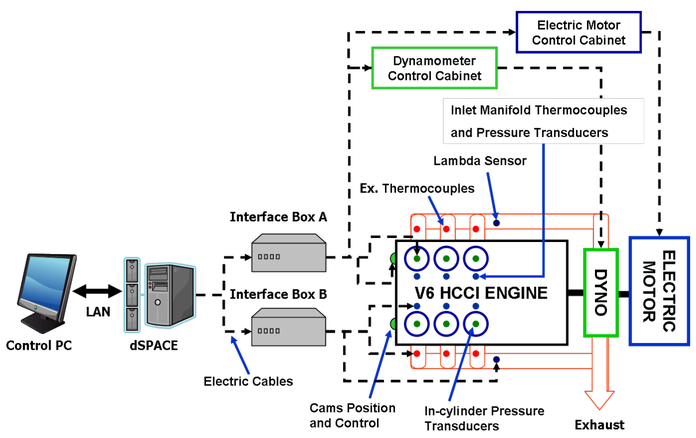

Figure 4. System diagram

The Real-time Control Oriented Model

The real-time control oriented HCCI model is developed by SIMULINK, which is a model for cycle-to-cycle real-time control.

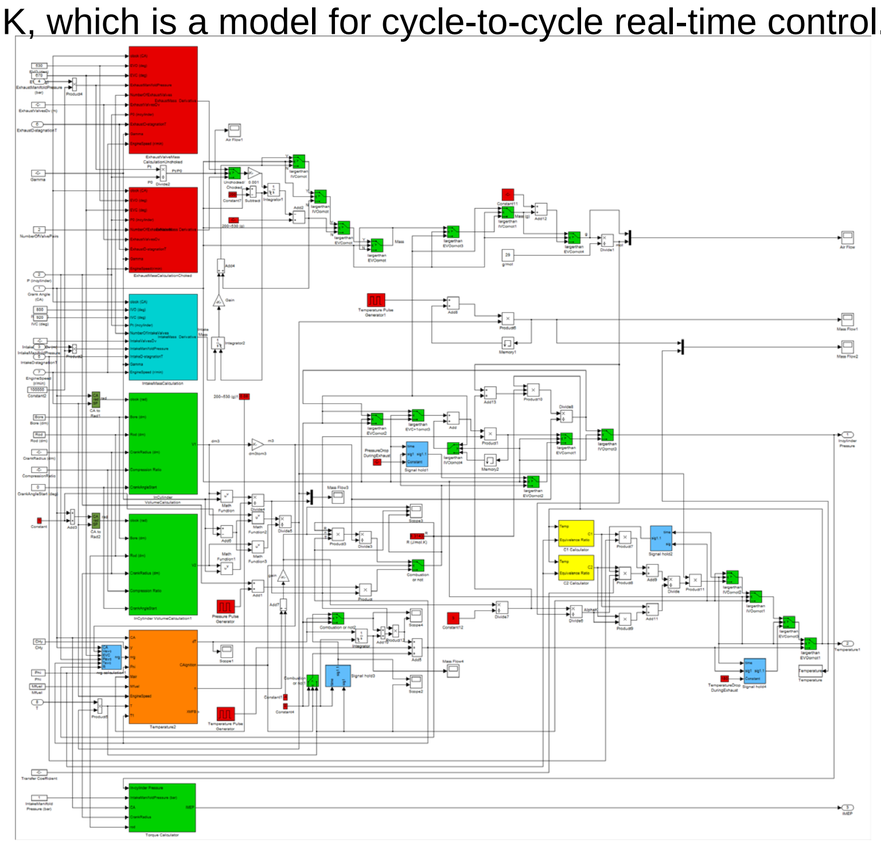

Figure 6. The Real-time Engine model with HCCI combustion

Modelling Results

The model is able to estimate the auto-ignition timing, the mass fraction burned and the heat release rate. The modelling results with different EGR fraction (60%, 58%, 55%, 52% and 50%) are showed as below.

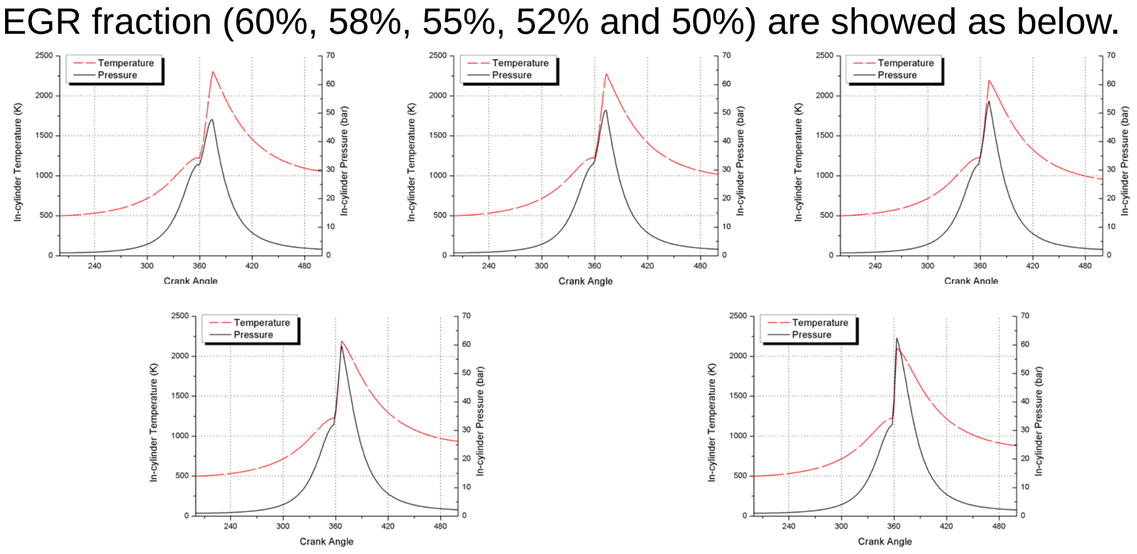

Figure 7. The in-cylinder pressure and temperature simulation results with different EGR fraction.

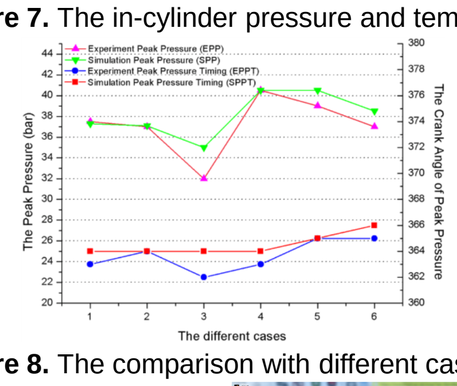

Figure 8. The comparison with different cases.

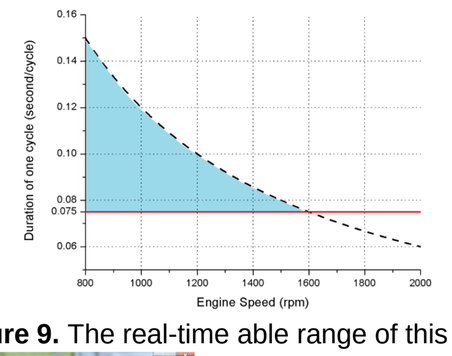

Figure 9. The real-time able range of this model

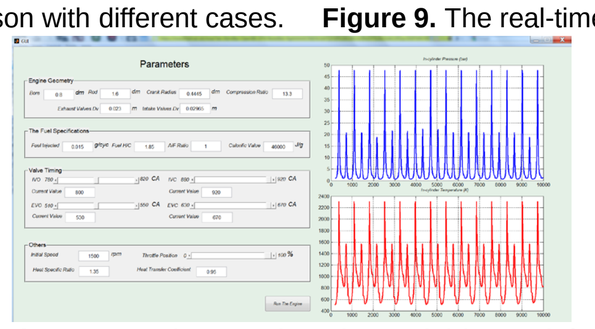

Figure 10. The GUI interface of this model.

The Real-time HCCI Model Description

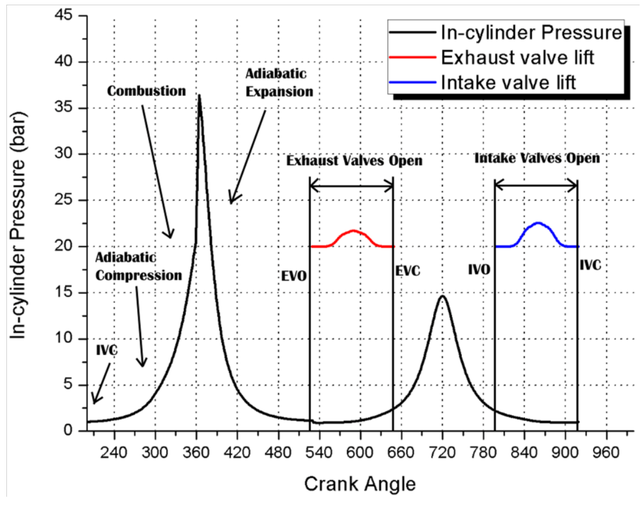

Figure 5. In-cylinder pressure with NVO strategy

For this model, a Negative Valve Overlap (NVO) strategy is used to trap the residual gas, which provides the proper in-cylinder temperature in order to promote HCCI combustion for the coming cycle.

Publication

[1] A. Potrzebowski, J Misztal, H. M. Xu, M. L. Wyszynski, and J. Qiao. —An autoignition combustion model for homogeneous charge compression ignition engine cycle simulations||. *Proc. IMechE Vol.223 Part D*: J. Automobile Engineering, 1207-1221.

[2] J. W. Misztal. —Study of Homogeneous Charge Compression Ignition (HCCI) Combustion and Emission Characteristics in a Multi-cylinder Engine||. Ph.D dissertation. The University of Birmingham, UK, December 2008.