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Diesel Injection Rate Shaping

Potential for EURO6 Calibration

Targeted injection rate shaping helps to improve fuel efficiency and exhaust gas emissions in diesel engines. Flexibilities in the rate of injection permit direct control of the mixture preparation and combustion process, even for high-EGR combustion systems.

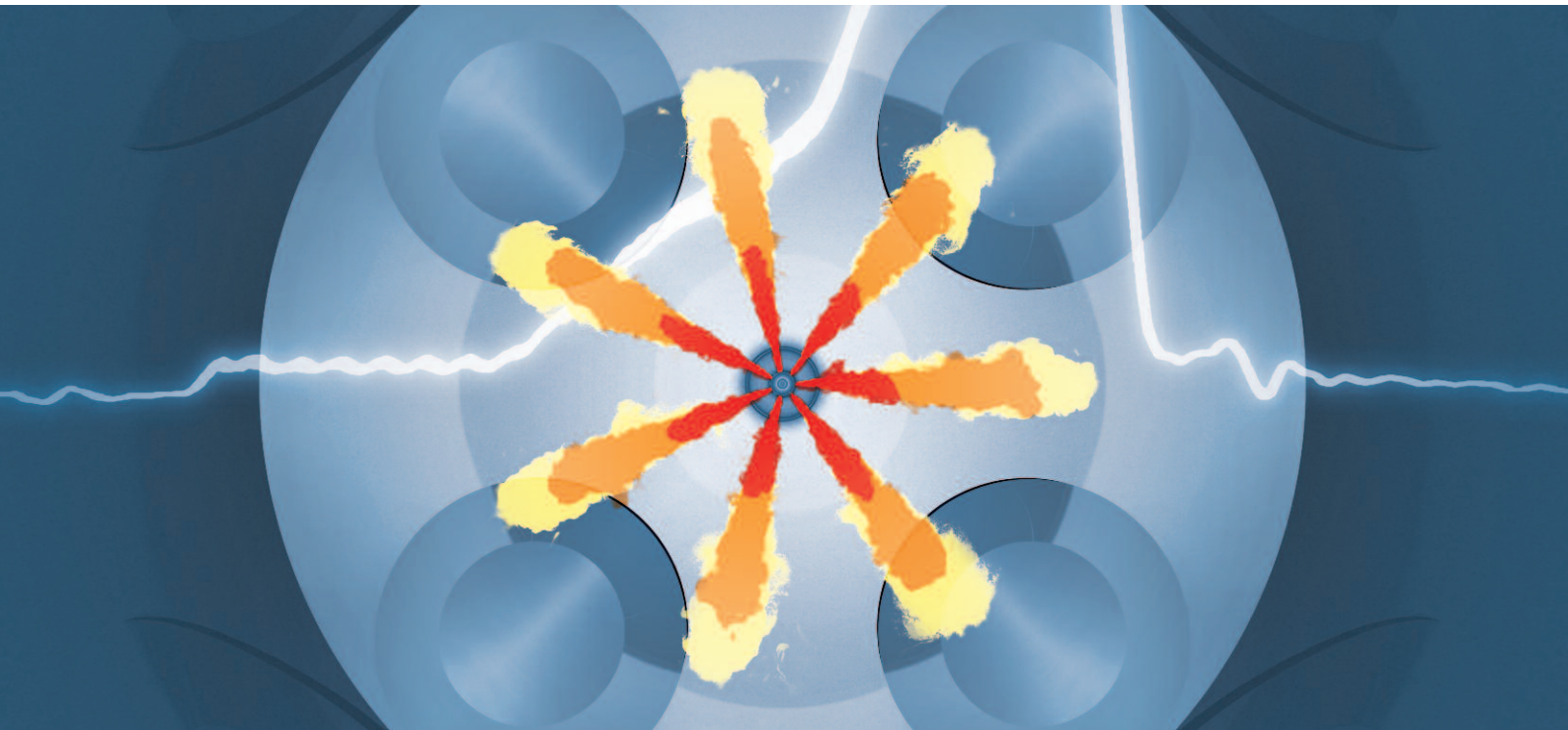
Calibration strategies optimizing thermal efficiency can be realized with very low combustion noise. High injection pressures can be applied at part load while keeping NO_X and soot emissions very low and without affecting combustion noise. CO_2 can be reduced by as much as 3–5% compared to typical EURO5 calibration.

By applying different injection strategies throughout the engine map it is possible to adapt the mixture preparation and the combustion delay and intensity for optimal tradeoff between soot formation and combustion noise.

Different strategies that have shown potential in this regard are:
- Very close pilot injections with zero dwell in low load ranges
- Boot shaped injections in medium load ranges with optional pilot injection
- Mini ramp injection attached to the main injection in full load range

The diesel engine's future is safe in our hands

IAV is a leading service provider for developing passenger-car diesel engines. Generating solutions for the overall system in all of its technical forms, we work on innovative projects ranging from advance development to start of production. Our focal activities cover concept evaluation and simulation, combustion systems, exhaust-gas aftertreatment and powertrain management.



IAV GmbH
Carnotstraße 1 · 10587 Berlin
oliver.predelli@iav.de
+49 5371 805-1508

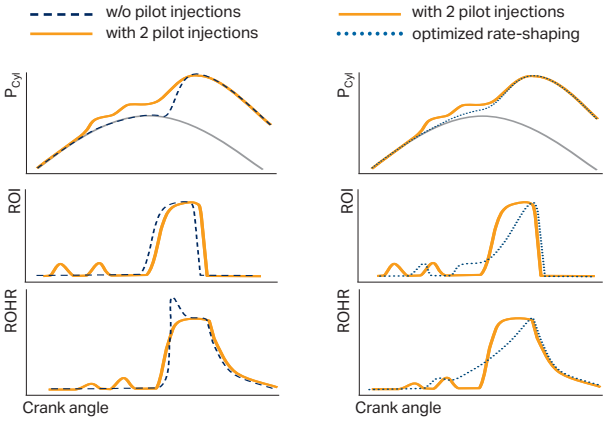


Fig. 1: Interaction between rate of injection and rate of heat release

Mechanisms and Potentials

Fig. 1: As illustrated, the heat-release for diesel combustion is optimized when the rate-of-heat-release curve increases progressively after TDC. This permits compensation of the expansion effect and produces a cylinder pressure trace with a defined linear gradient (dp/dφ = linear). For this, fuel injection must be carefully adjusted over the injection period and also in relation to the operating point. The graphs shown on the left illustrate the principle of shaping the injection rate in this way.

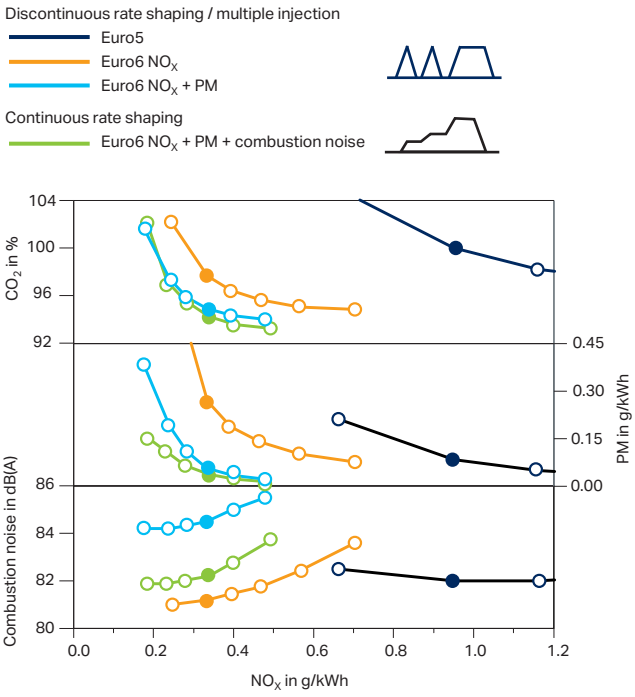


Fig. 2: Variation of combustion phasing

Fig. 2: Proceeding from a EURO5 calibration (black curve), NO_X is reduced to EURO6 levels by increasing both boost pressure and EGR rate (orange curve).

The resultant rise in soot emissions can be counteracted by increasing fuel injection pressure. To enhance the thermal efficiency of the process, combustion phasing is advanced to the optimum setting. With a conventional injection strategy, higher injection pressure and advanced combustion phasing both result in higher combustion noise (blue curve).

Only by employing injection rate shaping is it possible to meet the EURO6 emission standard with a level of combustion noise as low as that for EURO5 calibration (green curve).

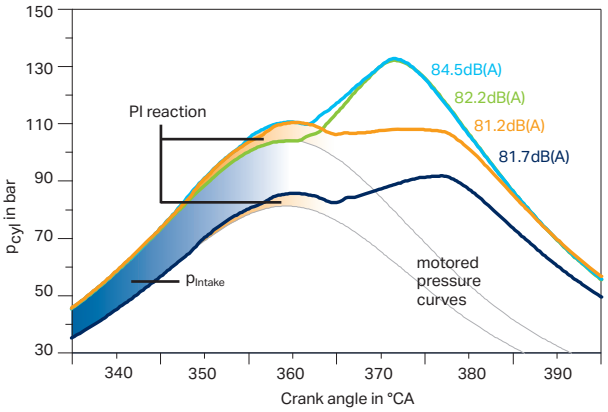


Fig. 3: Cylinder pressure traces

Fig. 3: Continuous injection rate shaping introduces diesel fuel into the combustion chamber at the rate required by the combustion process. It avoids premature heat release before TDC and also permits a compact release of heat with phasing optimized for high thermal efficiency.