

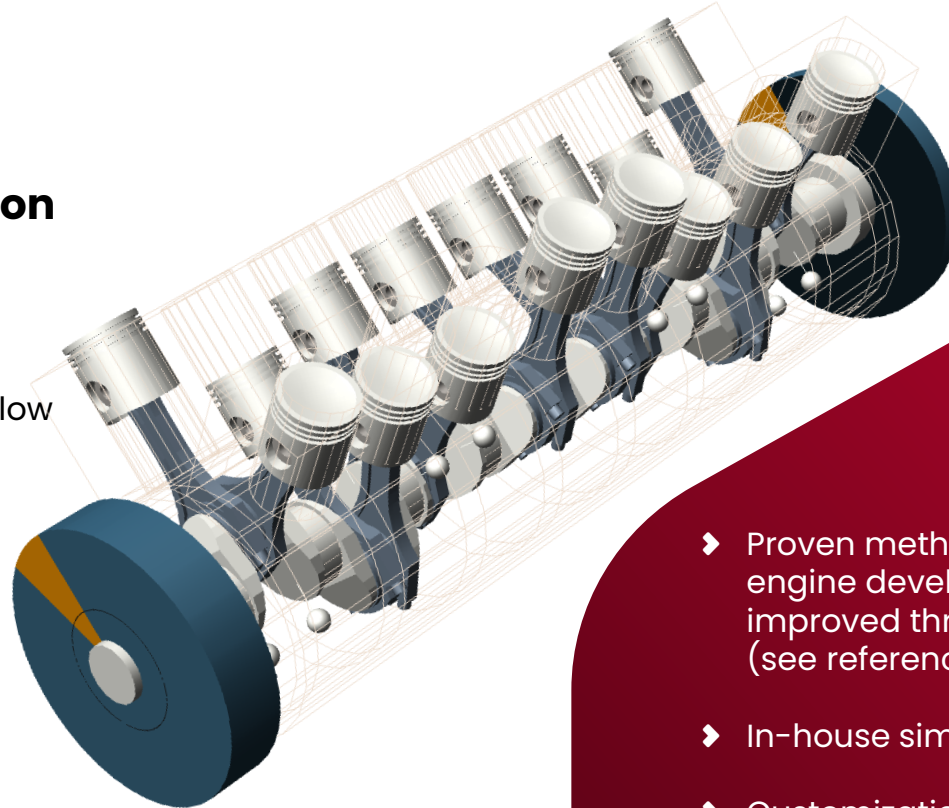
Firing Order Optimization for Multi-Cylinder ICEs

FEV SIGNATURE SOLUTIONS

Our unique solution provides you with optimized ICE for any fuel and application

FEV offers

- ▶ Optimization of firing order to achieve high power, low fuel consumption and emission, required engine durability and NVH
- ▶ Applicable for new engine developments, prototypes or for engines in production including adaptations to new low carbon fuels and new engine applications
- ▶ Possibility to include crankshaft design changes (crank star and counterweight layout) with detailed engine balancing study
- ▶ Possibility to consider various torsional vibration damper tunings and driveline layouts
- ▶ Best suited for V-engines with more than 10 cylinders



Why FEV

- ▶ Proven methodology applied to various engine developments and continuously improved throughout the last > 10 years (see reference slide)
- ▶ In-house simulation tool chain
- ▶ Customization to exactly address customers' needs

Reference projects

FEV FIRING ORDER OPTIMIZATION
EXPERIENCE



**V20, V16, V12 and
V8 high speed
engines**

(Engine family
development)



**V16 medium speed
engine**

(Engine family extension)



**V20 medium speed
engine**

(Engine family
development)



**V16 high speed
engine**

(Engine family
development)



**V20 medium speed
engine**

(Engine upgrade)



**V20, V16 and V12
high speed
engines**

(Engine family
development)



Patents

**Crankshaft, combustion
engine and control device**

KONRAD BUCZEK et al.
DE102020007330B4 (granted),
CN114576001A (pending)

■ European OEM

■ Asian OEM



**V20, V16 and V12
high speed
engines**

(Engine family
development)



**V20 high speed
engine**

(Engine family
development)

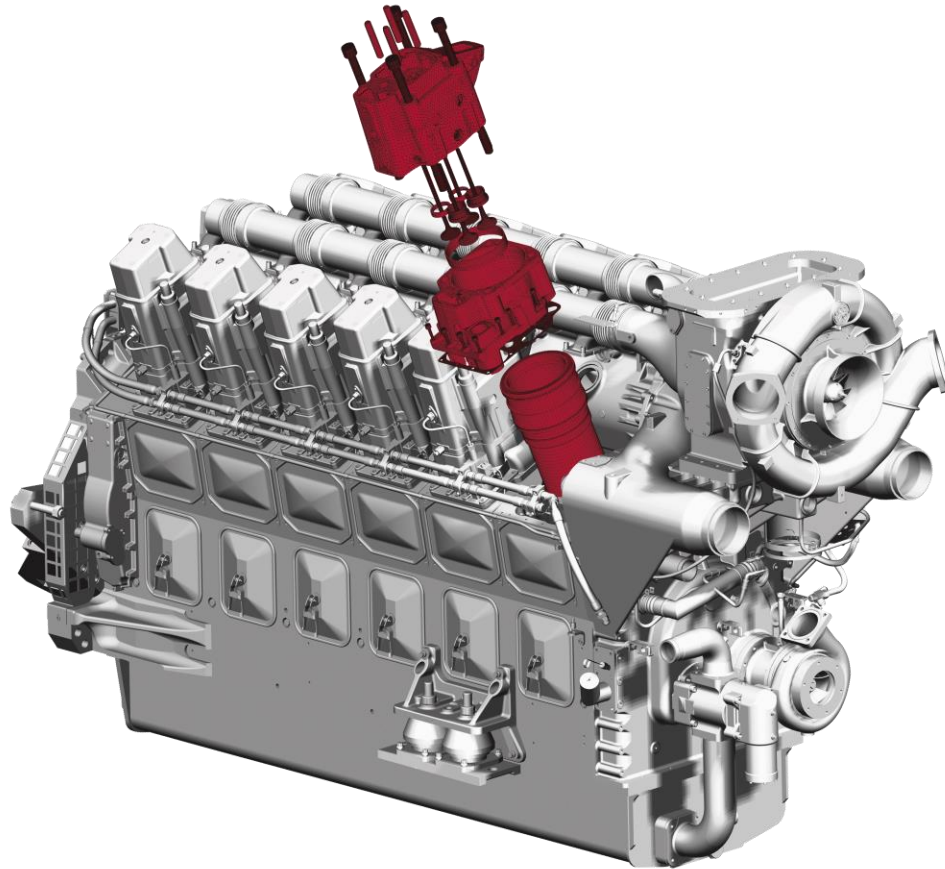


**V16 high speed
engine**

(Engine family extension)

FEV's firing order optimization for multi-cylinder ICEs

FIRING ORDER AS A KEY PARAMETER FOR AN OPTIMIZED ENGINE



Crankshaft / cranktrain

Control of the crankshaft vibration excitation (torsional, axial) and bending load of crankthrows to achieve low cranktrain dynamics and required durability of its components.

Torsional vibration damper

Determination of TVD load, influence on TVD type (cost), size and tuning.

Hydrodynamic main bearings

Determination of loads, influence on oil film thickness, pressure and friction in hydrodynamic main bearings.

Gas exchange dynamics / power and emission

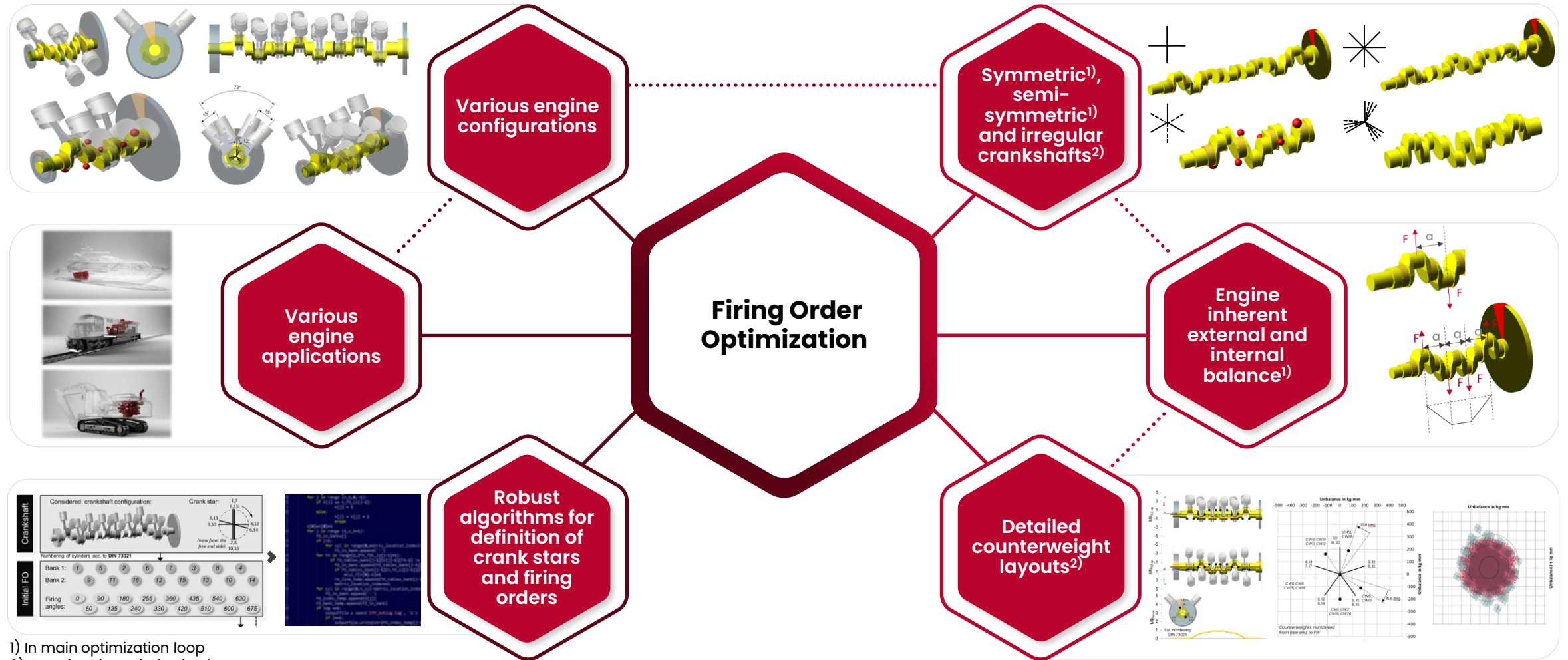
Minimization of variations in trapped air and residual gases between cylinders, to achieve high power and low emission.

Engine structure and accessories

Determination of engine external balance (by crank star change), control of rigid body and structural vibration excitation of engine and accessories to achieve required vibration targets and optimize NVH.

FEV's firing order optimization for multi-cylinder ICEs

HIGHLIGHTED FEATURES



- 1) In main optimization loop
- 2) Out of main optimization loop

Get in touch with us for further information



[www.fev.com/en/
signature-solutions](http://www.fev.com/en/signature-solutions)