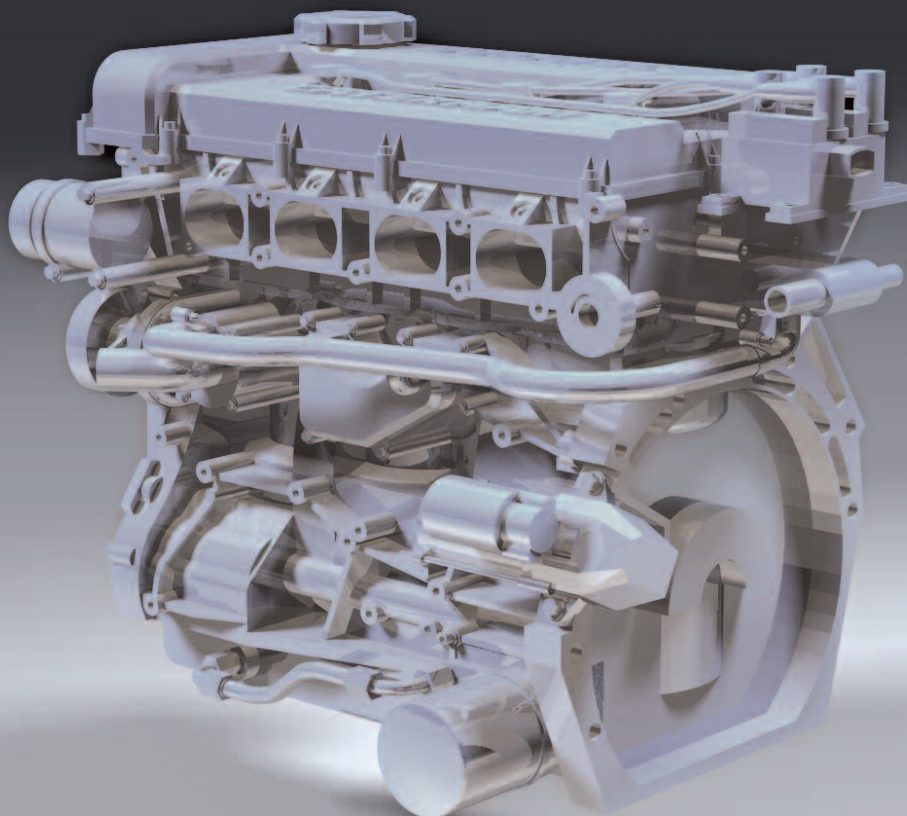


# Engine Design and Development

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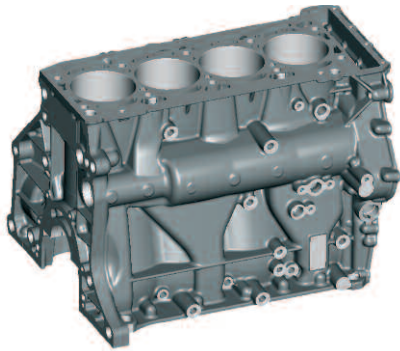
Hardware Design – Calculation / Simulation – Engine Testing – IAV Processes –  
IAV Innovative Concepts



# Design

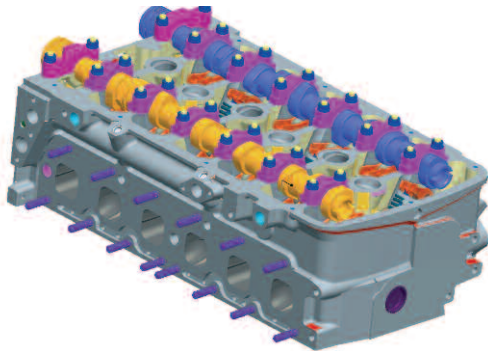
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IAV offers design and development expertise for all engine systems:



## Crankcase / Oil Circuit

- Structure and base concept
- Liner design
- Ventilation / oil aeration
- Oil pump development
- Detail design



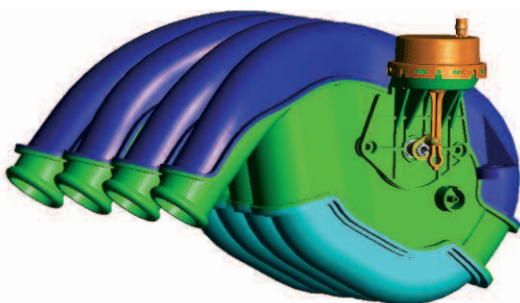
## Cylinder Head

- Cooling optimization
- Combustion chamber
- Charge-exchange ports development
- Mounting / lubrication
- Valvetrain integration
- Oil drain / ventilation
- Design variants



## Engine Mechanics

- Crankshaft, piston, conrod and bearing layout
- Cranktrain concepts
- Timing drive
- Valvetrain, variable valvetrain
- Balance-shaft system



## Charge Exchange

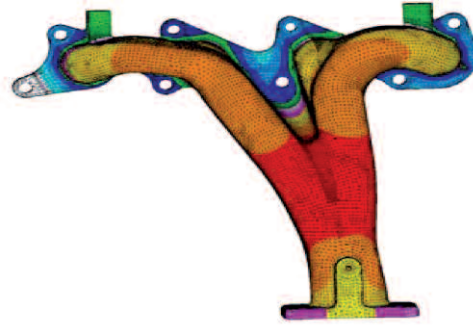
- Charge exchange system layout
- Intake system / exhaust system
- Supercharging

# Calculation / Simulation

IAV provides cutting-edge CAE capabilities in the following disciplines:

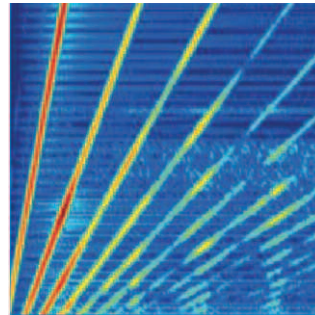
## Structural Mechanics

- Strength / stiffness
- Material behavior
- Durability / fatigue
- Thermomechanics
- Optimization



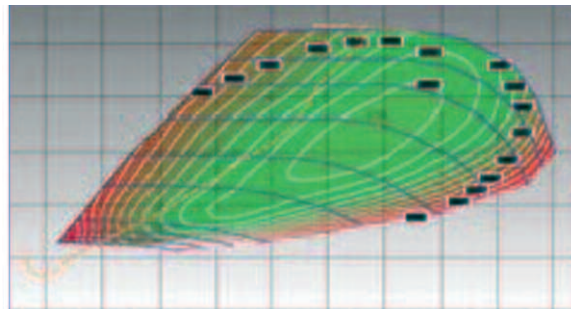
## NVH

- Vibration
- Acoustics
- Elastohydrodynamics
- Friction reduction
- Engine mounting
- Optimization



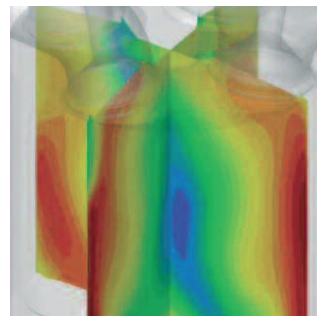
## Fluid Mechanics 1D

- Chargecycle / thermodynamics
- Supercharging
- Cooling system / lubrication system
- Thermal management
- Driving cycle / fuel consumption
- Optimization



## Fluid Mechanics 3D

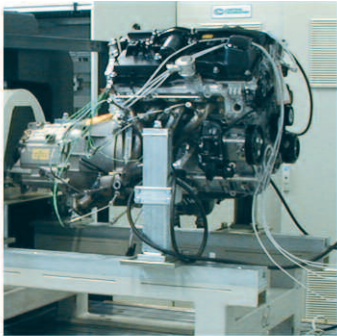
- Intake system / exhaust system
- Cooling system / lubrication system
- Combustion system
- Exhaust-gas aftertreatment / SCR
- Optimization



# Engine Testing – Mechanical Development

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IAV supports development and validation with functional and durability testing, including:



## Mechanics

- Power loss
- Cranktrain
- Timing drive
- Valvetrain



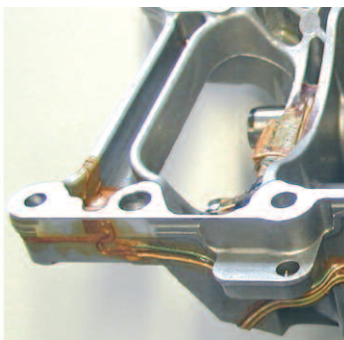
## Lubrication / Cooling System

- Cooling system
- Oil circuit
- Reduction of oil aeration
- Lubricant
- Ventilation system



## Vibration / Acoustics

- Airborne-sound emission
- Sound-source detection
- Structure-borne sound transmission
- Psychoacoustics



## Strength / Durability Testing

- Component strength
- Component deformation
- Durability testing
- Wear analysis

# IAV Engineering Processes

IAV creates methods and processes to support design and development in areas such as:

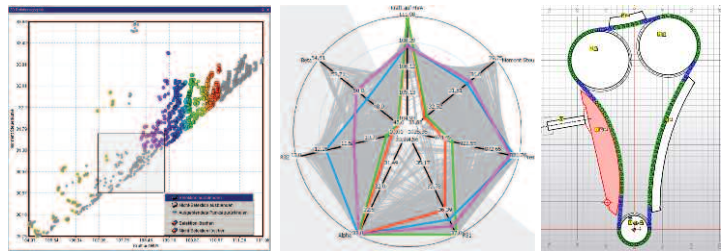
## Virtual Powertrain

- Methodology development
- Digital mock-up
- Data strategy management
- Data integration into customer processes
- Process support / consulting



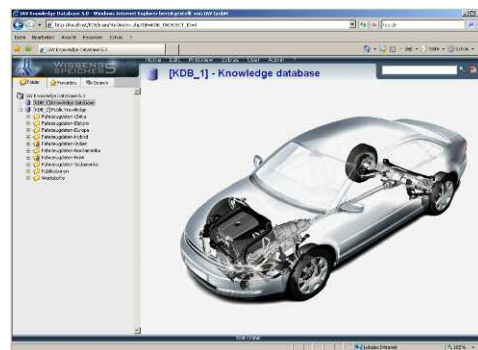
## Dimensioning Tools for Design, Computation and Testing

- Engine mechanics, dimensioning and analysis
- Layout workflows
- Optimization, calculation of variants
- Uniform analysis of calculation results and test results



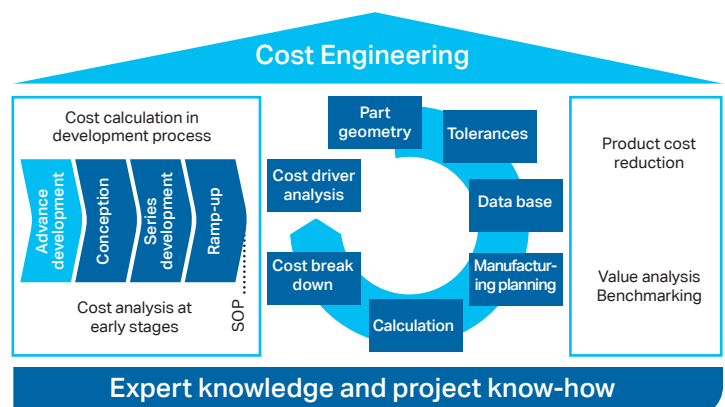
## Knowledge Database

- Central knowledge management
- Technical benchmarking
- Intelligent searches
- Availability of information from Europe, Asia and North America
- Combining public and private knowledge
- Approx. 5500 engines, 7500 vehicles incl. 280 hybrids, 1500 transmissions (as of July 2011)



## Frontloading Methods

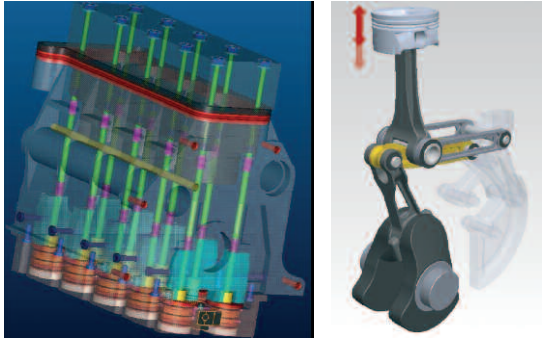
- Development systematics
- 3D tolerance simulation
- Cost engineering
- Benchmark of competition engines
- Casting simulation at early stage
- Fitting simulation and assembly simulation



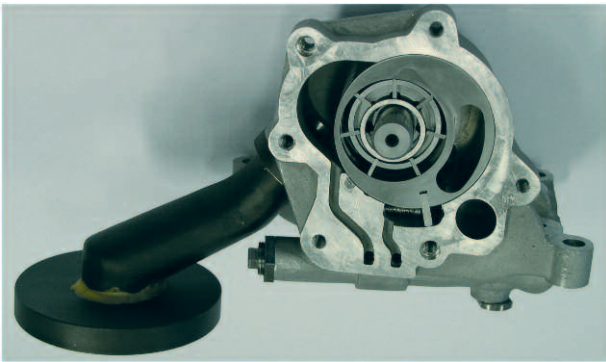
# Innovative Concepts

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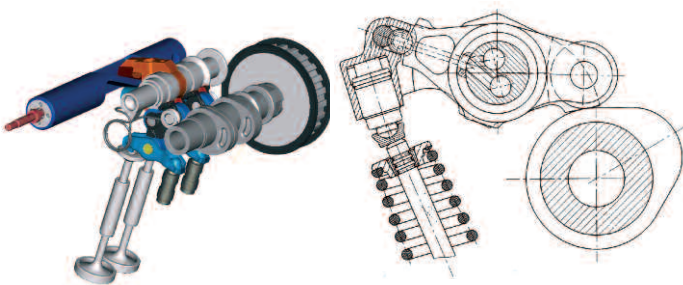
Below are examples of innovative concepts and solutions developed internally by IAV:



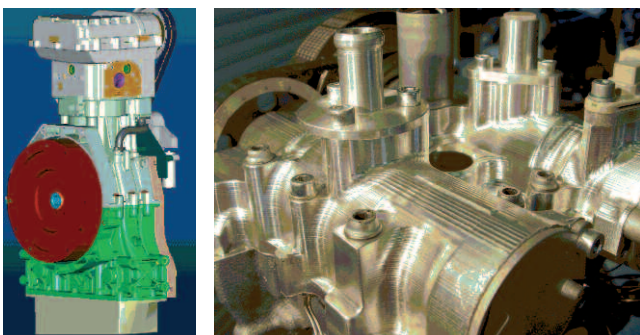
IAV variable-stroke system and variable compression ratio



Oil supply on demand with IAV's controlled vane-type oil pump



VVL system  
IAV-VARIOVALVE® and switchable valvetrain systems



Modular single-cylinder engines for research (combustion, fuel injection)

# Our Services

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IAV provides all aspects of the design and development process of core engine systems:

## Engine Development

- Valvetrain design and optimization (cam optimization and layout optimization, changeover from bucket tappet to roller finger follower)
- Mass-balance system optimization with focus on system development (function, mass, stiffness), manufacturing
- Development of pressurized oil circulation systems, oil return / ventilation systems (oil pump layout and oil pump development, dynamical oil level and gas concentration, oil throwing, disposition to freezing up)
- New design and optimization of highly stressed cylinder head (gasoline, diesel) – thermomechanics, cooling, port development
- New design and optimization of cylinder crankcases (AI, GCI)
- Development of engine-cooling systems (water pump, coolant flow, thermo-management)
- Optimization of auxiliary position and auxiliary function (incl. startergenerator / belt starter generator concepts)
- New design or optimization of intake and exhaust manifolds (with TC Integration)

## Cylinder head

- Port layout and design
- 3D CFD port optimization
- Port measurement and port benchmarking using IAV's DGV (Doppler Global Velocimetry) measurement method
- Water jacket and cooling design and optimization
- Integration of valvetrain and oil system
- Layout and design of oil drain, ventilation and separation
- Entire cylinder head design and structural optimization taking account of manufacturing demands
- Layout and optimization of head block compound considering thermomechanical fatigue and gasket behavior

## Engine Mechanics

- Crankshaft layout, design and optimization using IAV tools and a proven development method including FEM, fatigue analysis and component testing
- Plane-bearing layout and optimization using IAV tools (HD) and EHD calculations
- Conrod design and optimization
- Piston optimization
- Timing-drive layout and optimization (chain drive, gear drive) using IAV tools and other calculation software packages for dynamic simulation
- Valvetrain layout and optimization (all types) utilizing IAV tools and other calculation software packages for dynamic simulation, measurements on test rig
- Balance-shaft system layout and optimization

## Engine systems

- Charging-system layout and optimization (1D, 3D)
- Transient in-cylinder flow investigation including spray analysis, FIE simulation and measurements on test rig, combustion simulation (diesel / gasoline)
- Turbocharger system integration, component development (calculation, testing on hot gas test bench)
- Engine cooling system and water pump layout and optimization (1D / 3D calculation and testing)
- High pressure oil system development, oil pump development incl. simulation and component tests for state-of-the-art pumps and variable displacement pumps
- Engine ventilation, oil drain and oil separation development (calculation and testing)
- Engine freezing behavior (testing)
- Accessory drive layout and tuning

## Crank Case

- Structural layout and design, considering material demands and manufacturing demands
- Liner design and optimization of liner or cylinder distortion (FEM and measurement)
- Bulkhead optimization using FEM and hydro pulse testing
- IAV's variable valvetrains

## Special features

- IAV's variable valve trains for advanced combustion control, exhaust brake etc.
- IAV's map controlled variable oil pump system
- IAV's variable compression and variable displacement concept
- IAV's modular single cylinder research engine

## IAV software packages for engine development

- IAV engine and hybrid database
- IAV VENTIL for valvetrain layout and optimization
- IAV P-CRANK for crankshaft layout and optimization
- IAV V-CD for chain drive layout and optimization
- IAV V. ENGINE for all aspects of laying out and optimizing engine mechanics
- IAV V-SiTE for evaluating simulation and test results
- IAV EngineeringToolbox for integrated engine layout workflow and optimization technology

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