# CMD Process for H$_2$ ICE

FEV propulsion

Charge Motion Design (CMD) process enables effective mixture formation for H$_2$ ICE based on charge motion & turbulence

FEV offers

❯ Determination of port quality and comparison to benchmark

❯ Evaluation of charge motion & turbulence level in pre-development stage

❯ Estimation of burn duration for HRR estimation

❯ Optimization of mixture formation layout via 3D CFD simulations

❯ Comparison of customer layout with FEV benchmark

Why FEV

❯ >30 scatter bands from previous engine developments to identify weak points

❯ More than 80 different premixed engine concepts ranging from pass-car to heavy duty applications (see reference slides)

❯ Optimization of relevant design parameters based on scatter band data
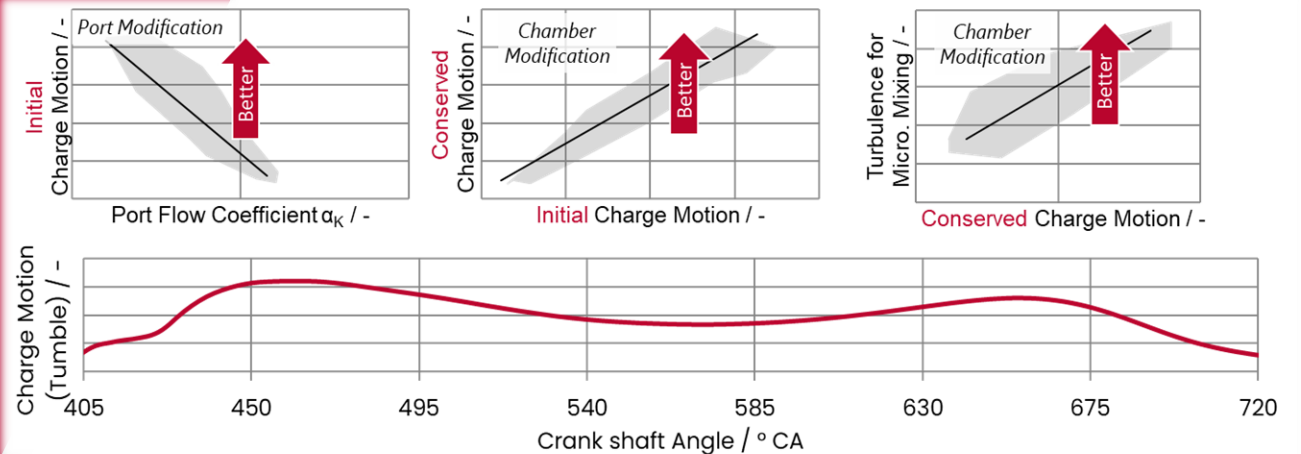
Comprehensive experience with different technologies and applications

SELECTED H2-ICE REFERENCE PROJECTS

Commercial Vehicle
DI H2 engine development

Off-Road Application
PFI H2 **MACHINE** demonstrator

Commercial Vehicle
DI H2 engine development

Commercial Vehicle
DI H2 engine design

» FINISHED

» DEMO MACHINE RUNNING

» ON TEST BENCH

» SIMULATION STAGE

» VEHICLE READY 2022

» VEHICLE READY 2022

» FIRST FIRING 2022

» SOP 2023

Automotive
DI H2 **VEHICLE** demonstrator

Commercial Vehicle
PFI H2 engine development

Commercial Vehicle
DI H2 engine development

Commercial Vehicle
PFI H2 engine development

FEV charge motion design for pre-mixed engines
Optimization of combustion system in engine design layout phase

CMD ANALYSIS IS TRIGGERED AND VERIFIED BY BENCHMARK AND TEST BENCH CORRELATIONS

Concept Phase

➤ Based on FEV's unique scatter band collection

➤ Benchmarking data

➤ Layout of port, valve seat rings, etc.

Development Phase

➤ Based on FEV's combustion prediction tool

➤ Fast post-processing tool

➤ Evaluation based on relevant quantities

Test Bench Validation

➤ Optical test bench

➤ SCE & MCE engine test bench

➤ Validation tools

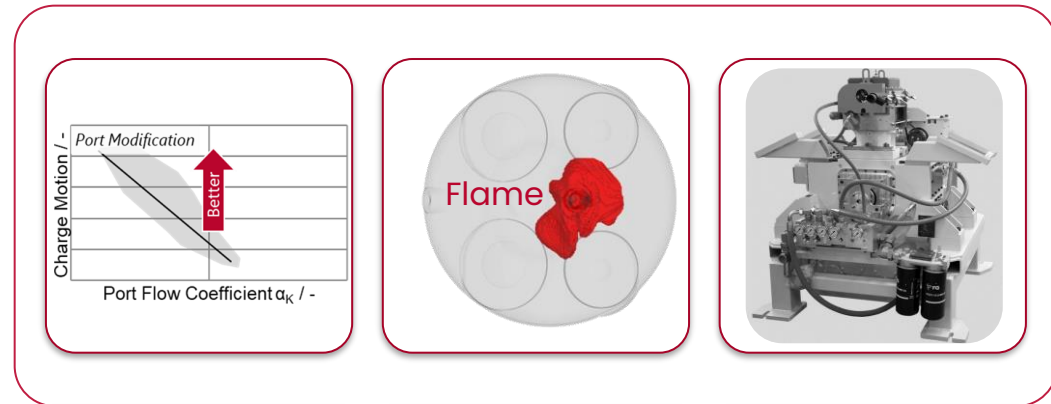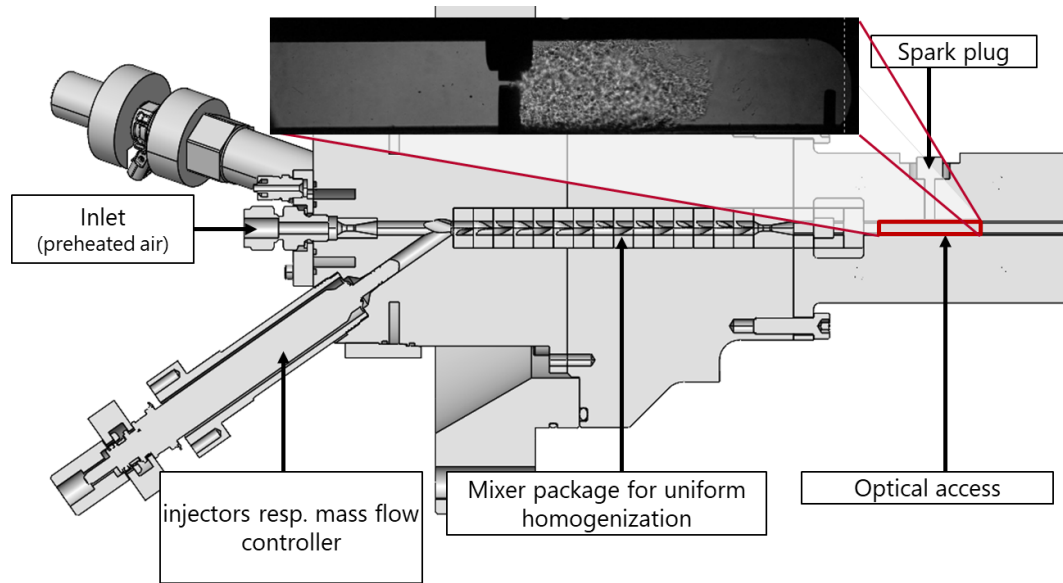|	
Definition of Flow Leading Surfaces	Design of port, valve seat rings & bottom chamfers, etc. and comparison/benchmarking with FEV scatter bands.
Steady State Flow & Charge Motion Generation	3D CFD steady state CFD to calculate flow coefficients & charge motion. Comparison to FEV scatter bands.
Transient Charge Motion & Combustion Quality	Calculation of transient charge motion, turbulence and correlation of CFD results to burn duration (within minutes during post-processing) .
Quality of H_2 Mixture Formation	Calculation of lambda and temperature inhomogeneity with assessment of the effect on combustion.
Test Bench Verification	Verification of performance on test bench. Explanation of test results.

From charge motion to combustion: Extended hydrogen combustion and numerical approach to consider wrinkling effects

MODEL IMPROVEMENT BY PREDICTION OF EARLY FLAME KERNEL GROWTH
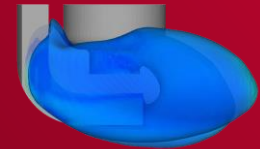(CONSIDERING LEWIS NUMBER & MARKSTEIN LENGTH EFFECTS)

Spark plug

Inlet
(preheated air)

injectors resp. mass flow
controller

Mixer package for uniform
homogenization

Optical access

Flame
speed

Standard models:

FEV model:

Prediction error reduced to < 3%

From fundamentals to industry proven tools

- ❯ Measurements in hydrogen pipe and optical high pressure combustion chamber
- ❯ Allows reproduction of engine-like conditions
- ❯ Yields detailed insights into early flame kernel growth

Get in touch with us for further information

www.fev.com/en/
signature-solutions