Contents of Work Package 1-**WP08**: Design Assistance Systems and Calibrated Simulation Processes

1-WP08: Design of Internal Combustion Engine with Design Assistance SYstem (DASY)

Coordinator of the WP

České vysoké učení technické v Praze, zodpov. osoba Ing. Jindřich Hořenín, Ing. Petr Hatschbach, CSc. Prof. Ing. Jan Macek, DrSc.

Main Goal of the WP

- SPEED IN ASSESSMENT, ENGINEERING, ANALYSIS
- Automate prediction of performance, computation of geometry, generation of solid models
- Integrate engineering and analysis phases into the design process for a robust design. Use knowledge-based design rules (including manufacturing)
- Provide consistent design process (product quality, reliability, ..)
- Provide rapid target assessment and tradeoffs of powertrains early in the vehicle program

Content

- Main goal of the WP
- Powertrain development procedure
- Parametric model definition
- Crankshaft mechanism design and optimization
- Camshaft mechanism design and optimization
- Gearbox design and optimization
- Powertrain design and optimization

Main goal of the WP

CREATION OF A QUICK TOOL FOR THE DESIGN OF A VEHICLE POWERTRAIN, WHICH ENABLES

- Quick creation of the basic geometry of the vehicle powertrains (powertrain study)
- Comparison of variant designs and selection of suitable geometry
- Quick definition of masses, moments of inertia and geometry dimensions for detailed calculations

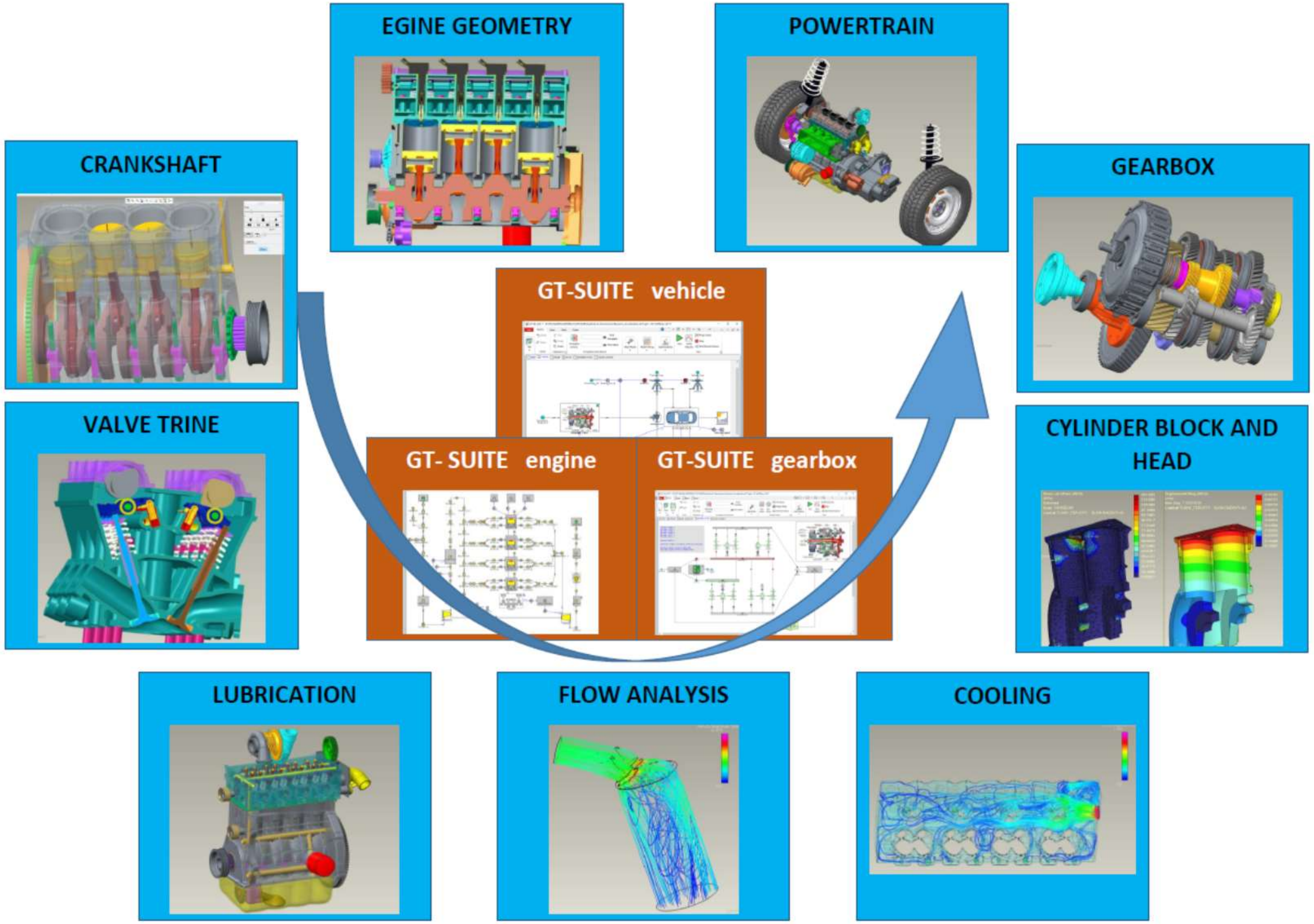
DEVELOPMENT OF THE VEHICLE POWERTRAIN DESIGN METHODOLOGY (STANDARDS)

- Definition of aggregate subdivision
- Definition of the development process
- Consistent design process
- Automation of design steps
- Preservation of knowledge of experts in the methodology of the design process
- Bidirectional connection of 3D models with calculation programs

CREATION OF A PARAMETRIC 3D MODEL OF THE DRIVE UNIT

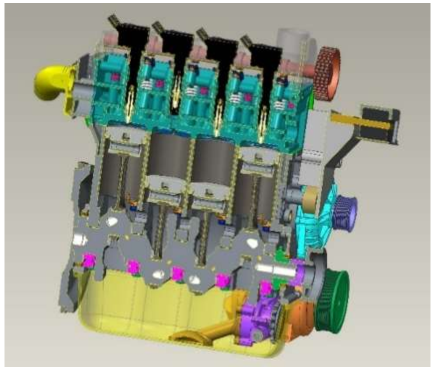
- Definition of parameters of parts and assemblies (dimensions, material, construction, ..) and their mutual relations
- Parameter database (performances, dimensions, materials, etc.)
- Database of design of key parts
- Implementation of design principles in 3D models
- Definition of boundary conditions and computational networks for strength analysis of parts

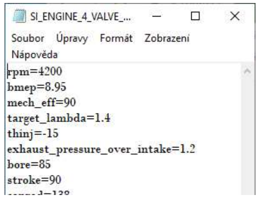
Powertrain development procedure



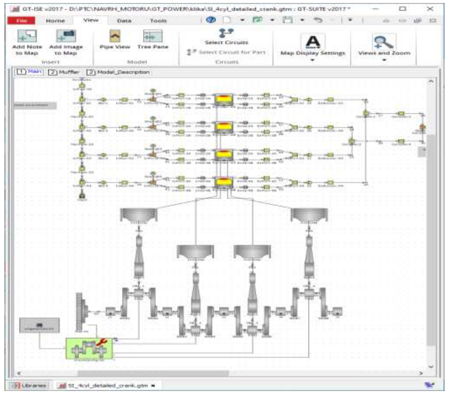
Interaction between DASY GT-SUITE

From DASY **into GT-SUITE**

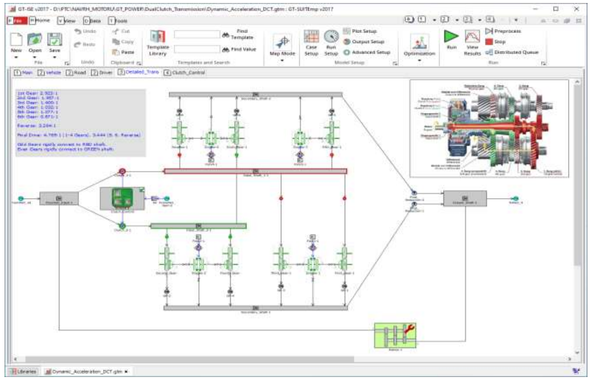


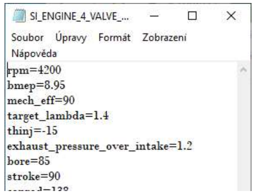


connecting text files



From GT-SUITE **into DASY**





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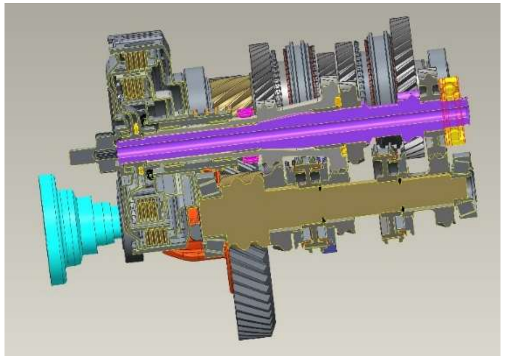
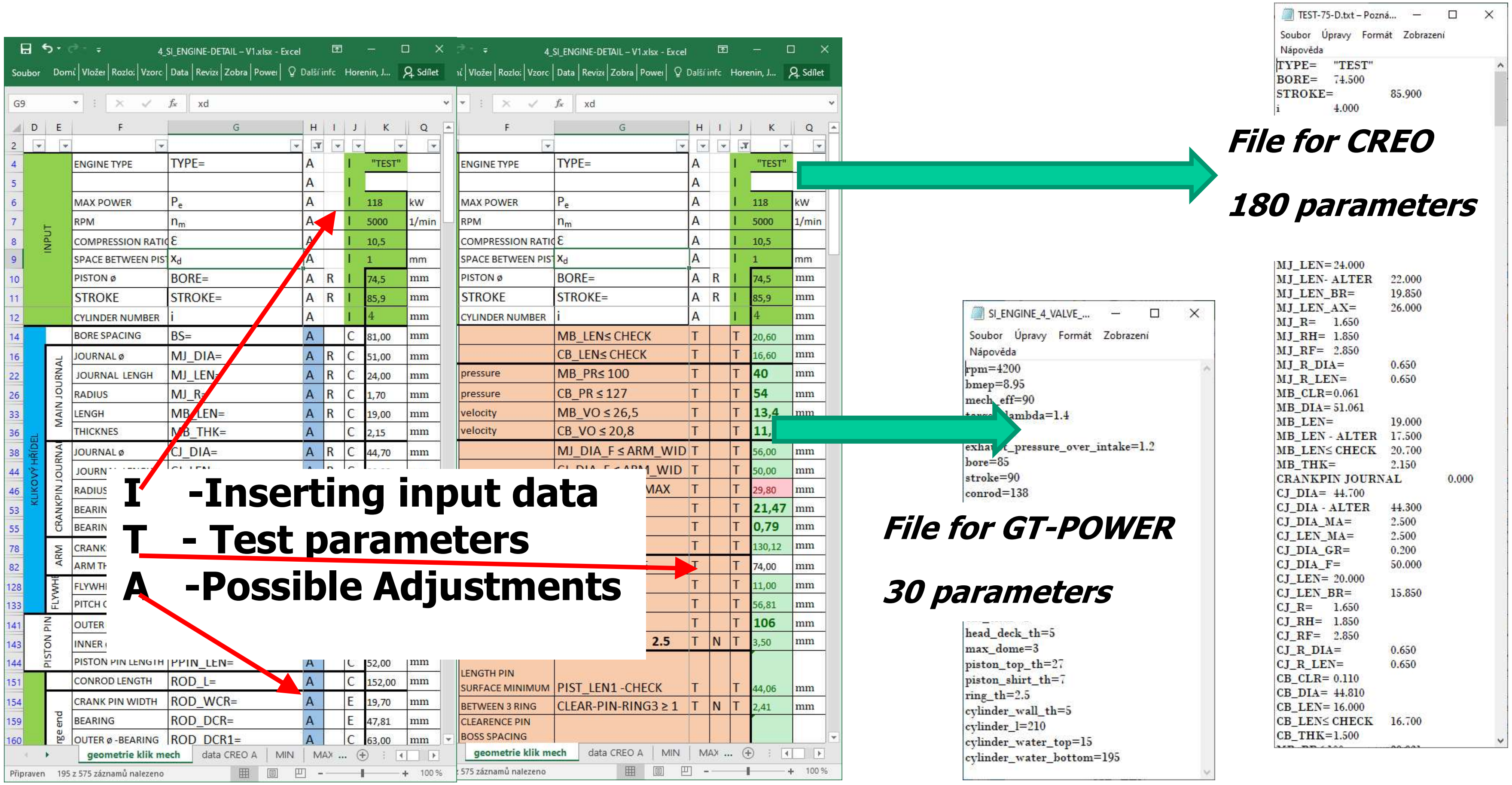
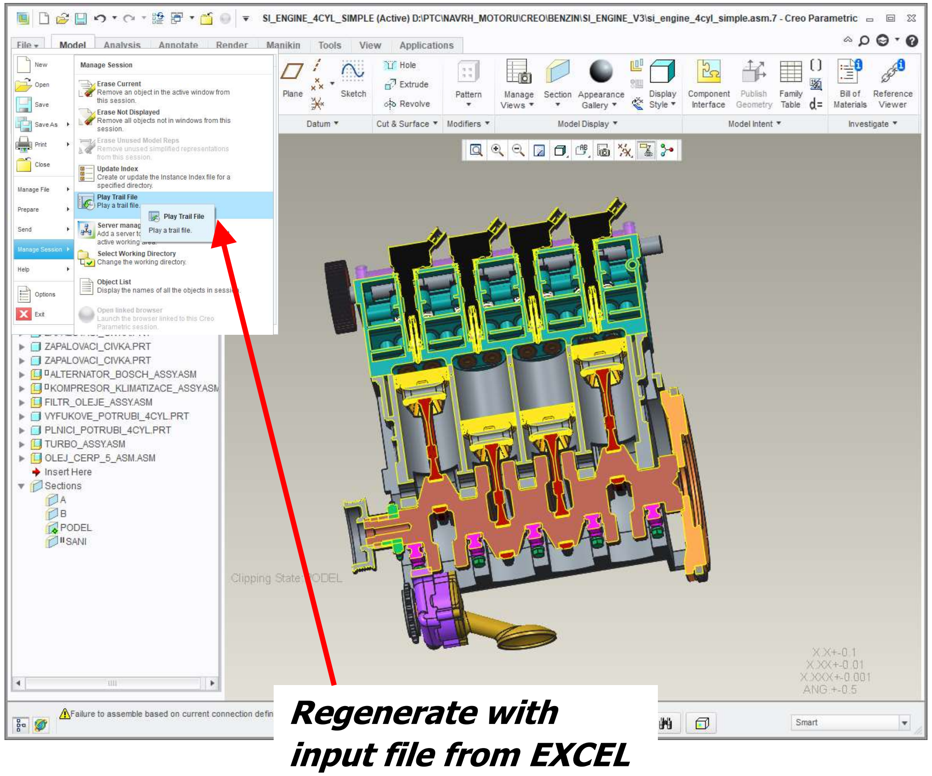


Parameters calculation Files generation

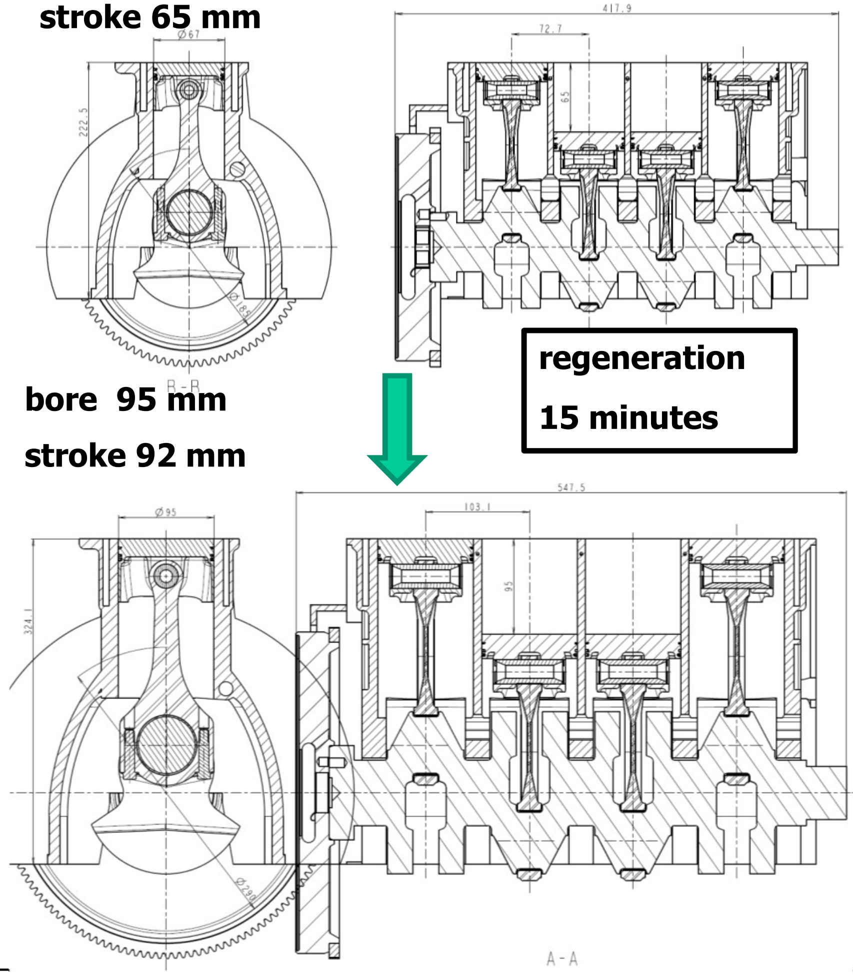


3D model in CREO generation

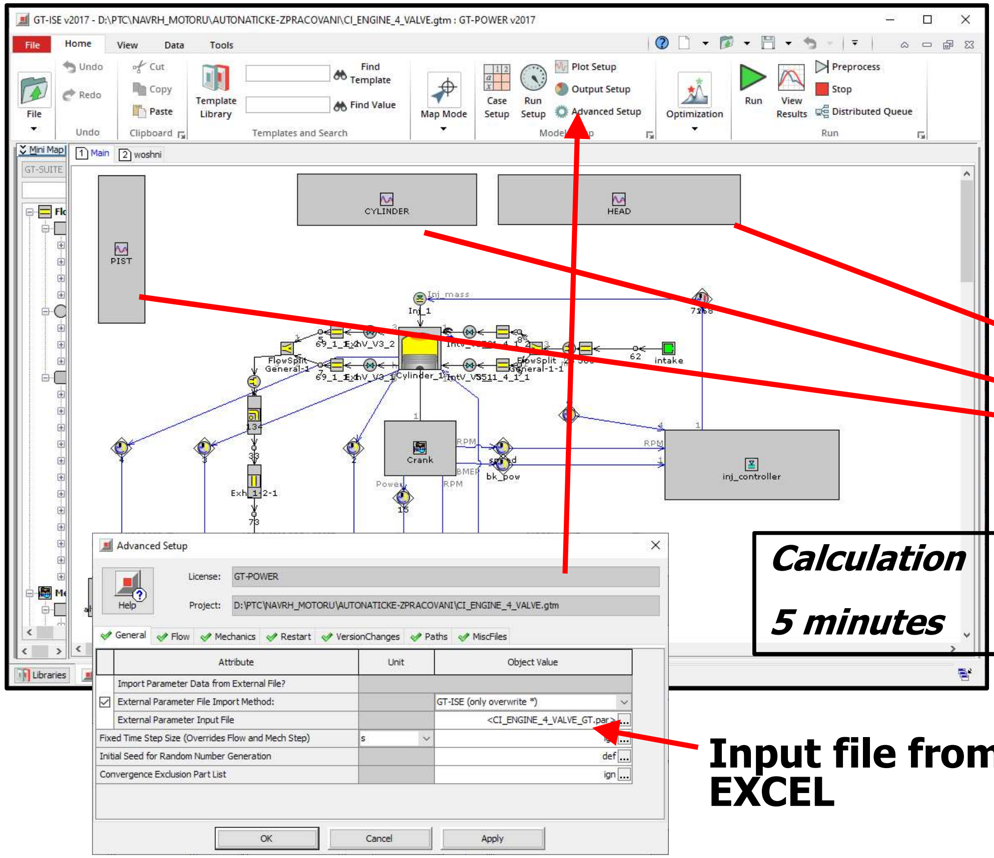


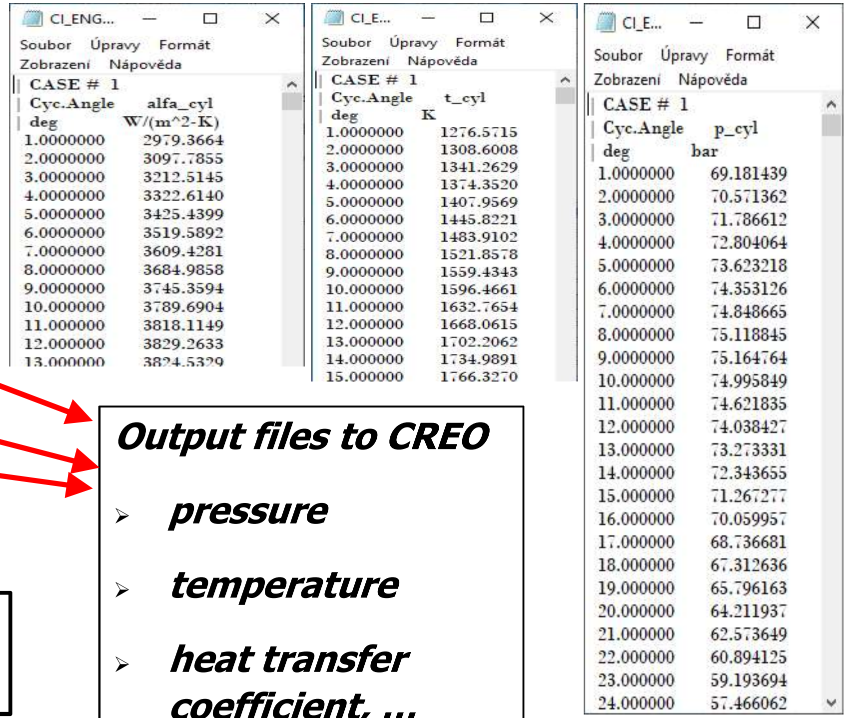
bore 67 mm

stroke 65 mm



GT-POWER calculation





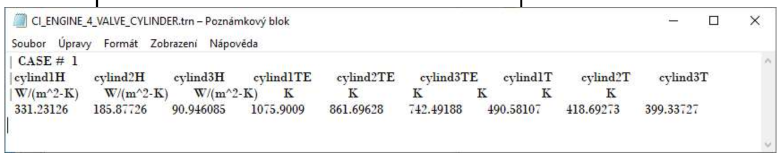
Calculation

5 minutes

Output files to CREO

- **pressure**
- **temperature**
- **heat transfer coefficient, …**

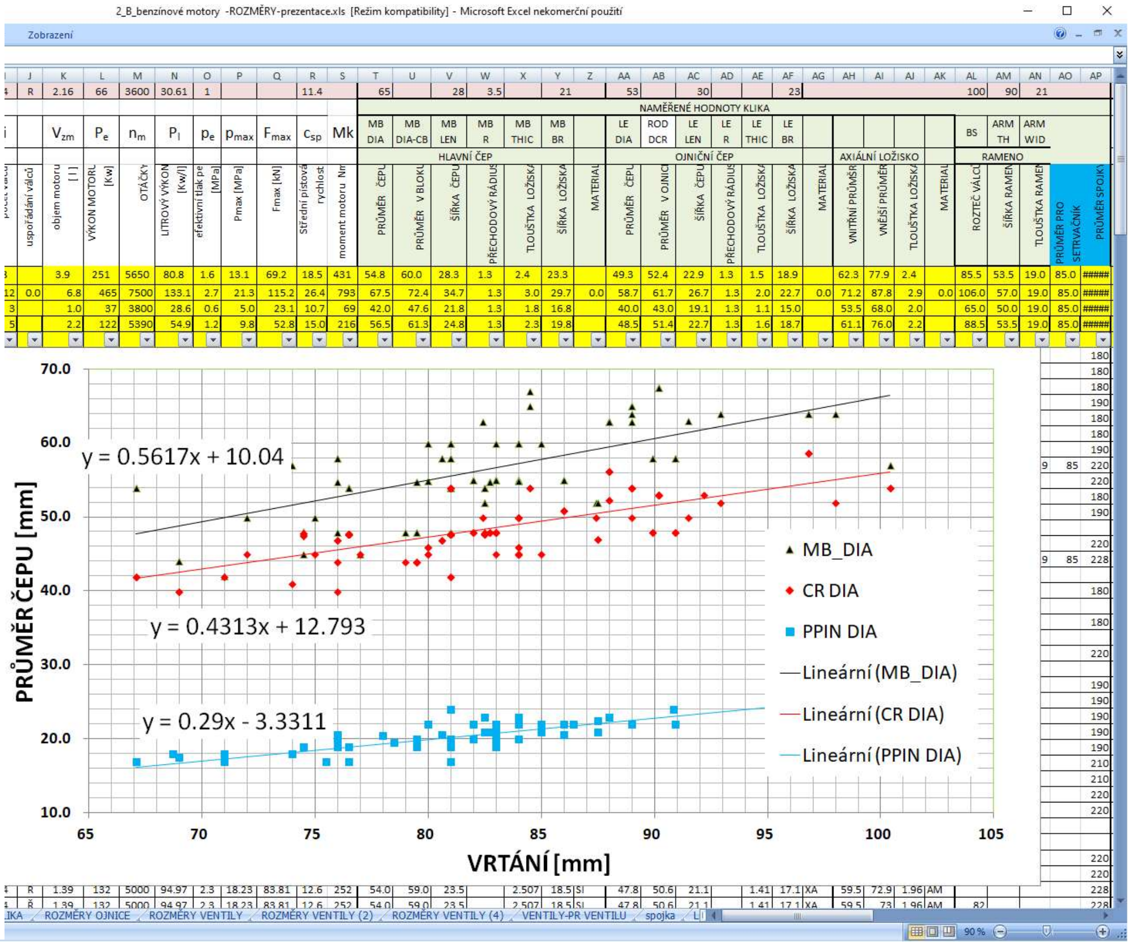
Input file from EXCEL



Parameters definition

Creation of databases of performance parameters and dimensions of parts according to engine groups

- *Spark ignition engines*
  bore from 67mm up to 102mm
  - ❑ *400 engines*
  - ❑ *180 engines with dimensions*
- *Compression ignition engines passenger cars*
  bore from 70mm up to 105 mm
  - ❑ *565 engines*
  - ❑ *120 engines with dimensions*
- *Compression ignition engines for commercial vehicles*
  bore from 100mm up to 170mm
  - ❑ *110 engines*
  - ❑ *10 engines with dimensions*



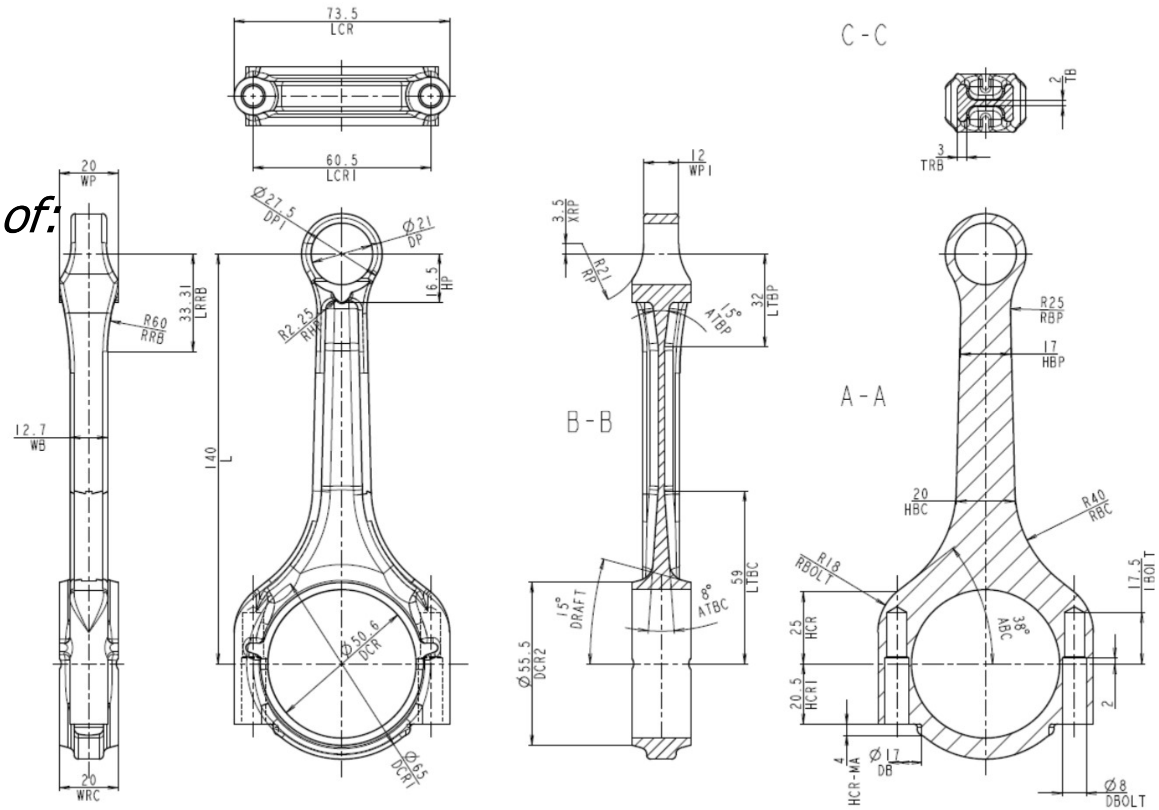
Parameters definition

Parameter types:

- *Dimensions*
- *Material*
- *Design*

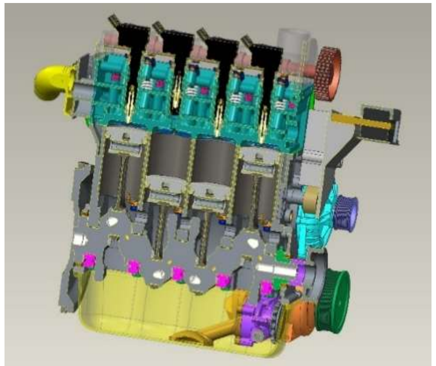
Creating 3D models with definition of:

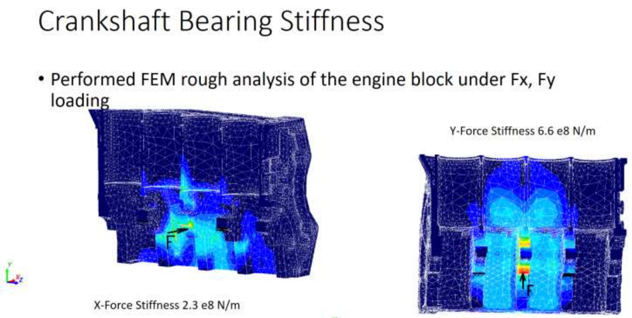
- *parameter relationships*
- *reference dimensions*
- *control parameters*
- *geometry according to design principles*
- *material*
- *finite element mesh*
- *boundary conditions*
- *load*
- *calculation with evaluation*

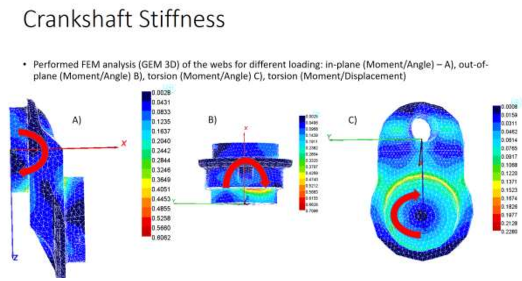


Crankshaft mechanism design and optimization

from 3D geometry

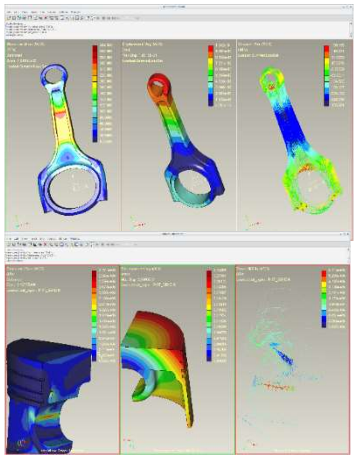


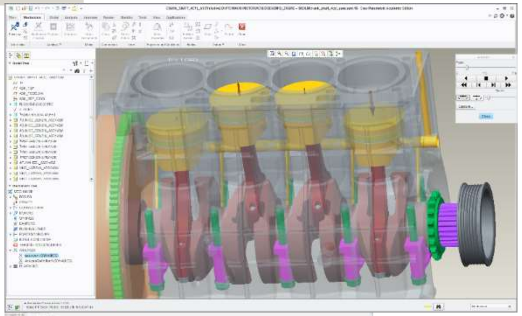


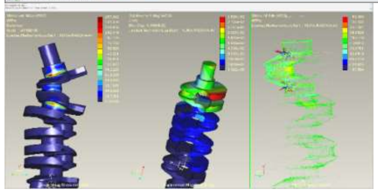


- ***geometry***
- ***weights***
- ***Moments of inertia***
- ***stiffness, ……..***

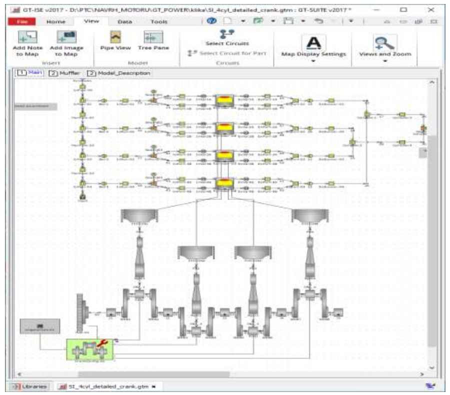
into GT-POWER





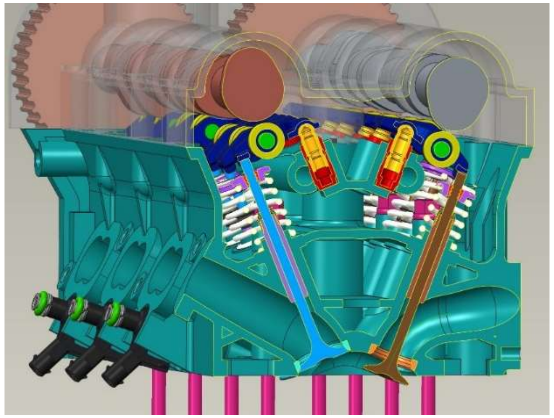


- ***pressures***
- ***temperatures***
- ***heat transfer coefficient, …***

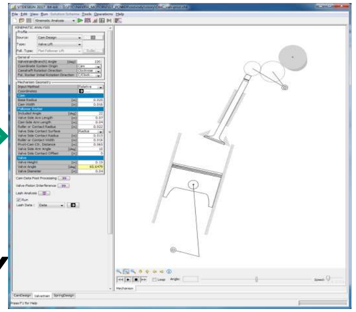


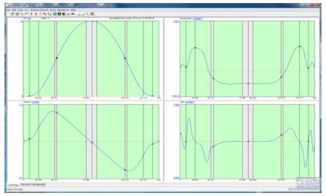
Camshaft mechanism design and optimization

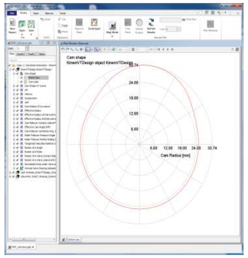
from 3D geometry



into VTDESIGN

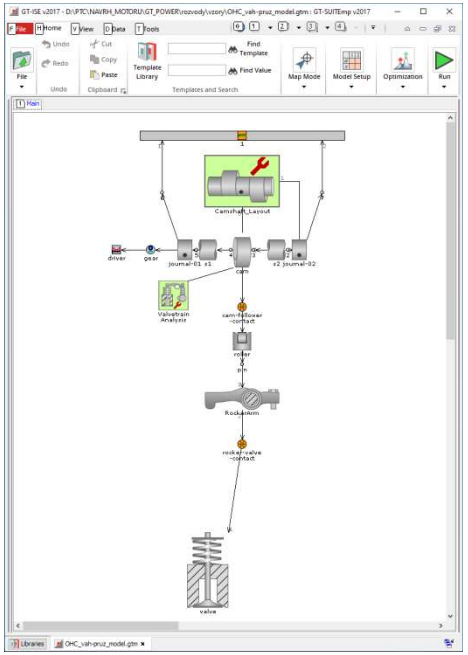


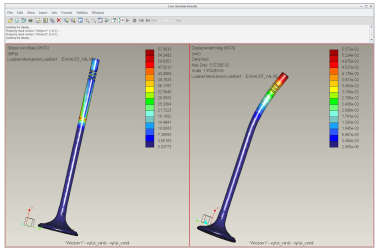


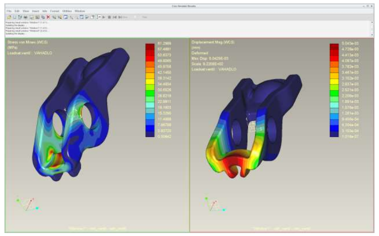


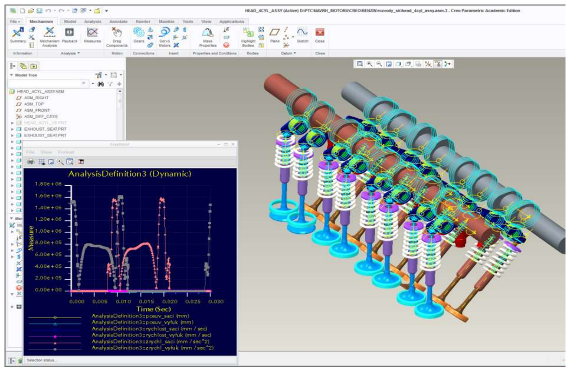
- geometry
- weights
- moment of inertia
- stiffness, ……..

into GT-POWER





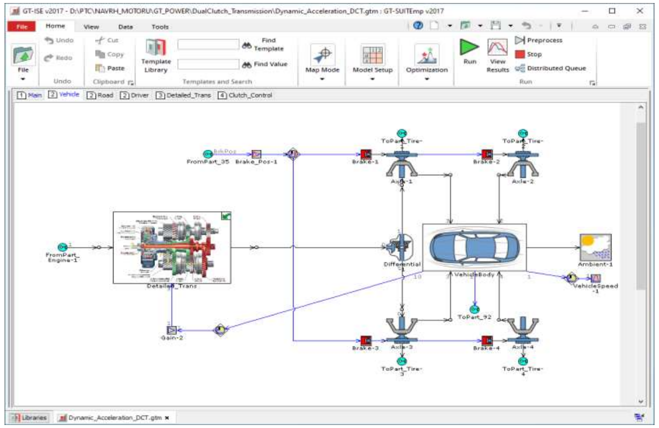




- cam geometry
- springs, …

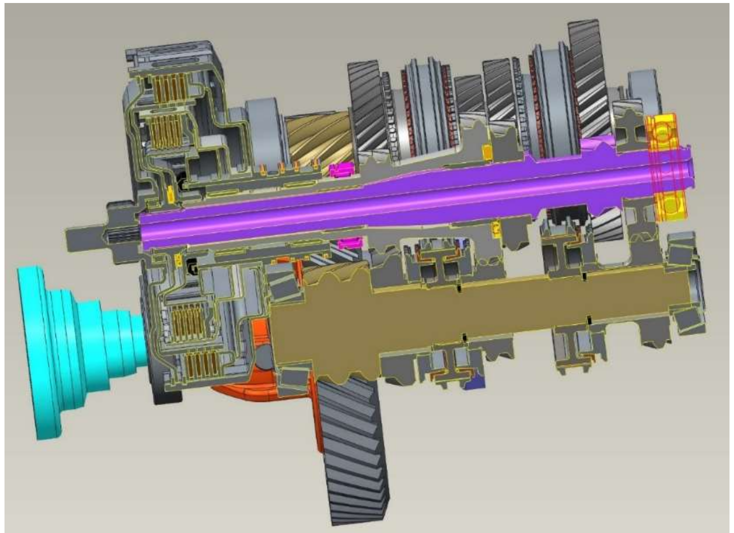
Gearbox design

from GT-SUITE

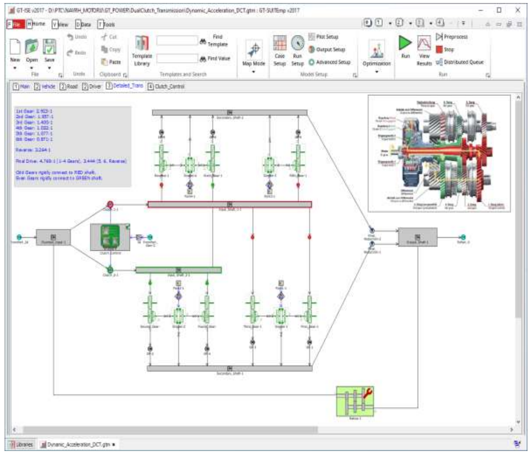


- ***gears***
- ***Number of teeth***
- ***…***

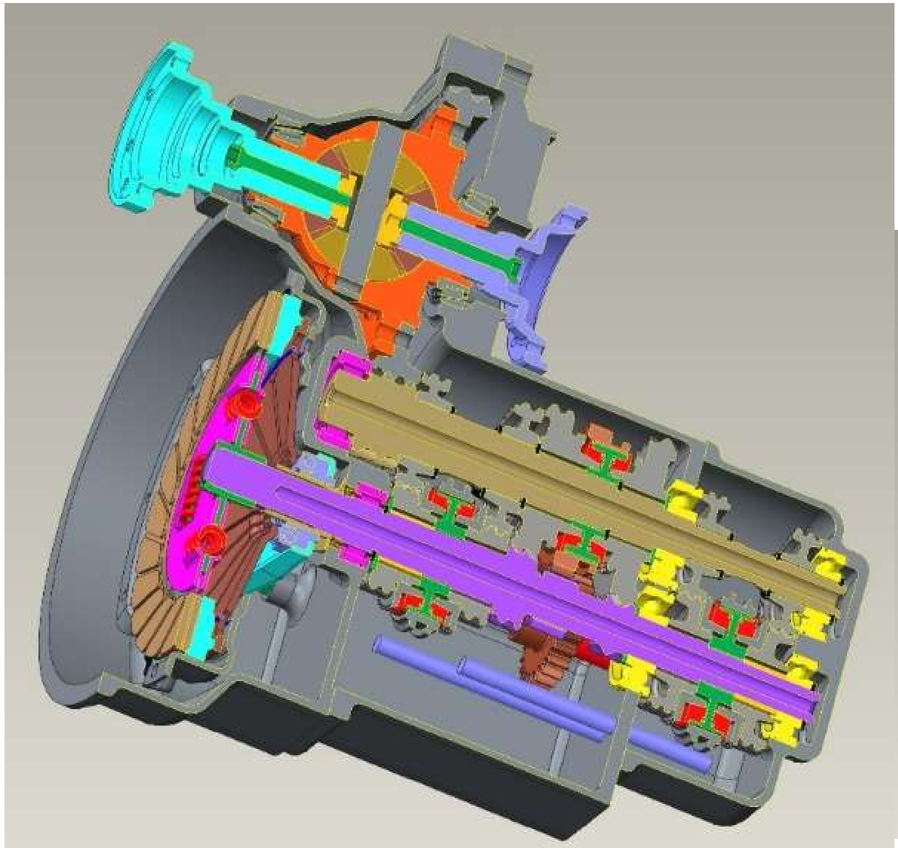
into 3D geometry



- ***geometry***
- ***weight***
- ***moments of inertia***
- ***stiffness, ……..***

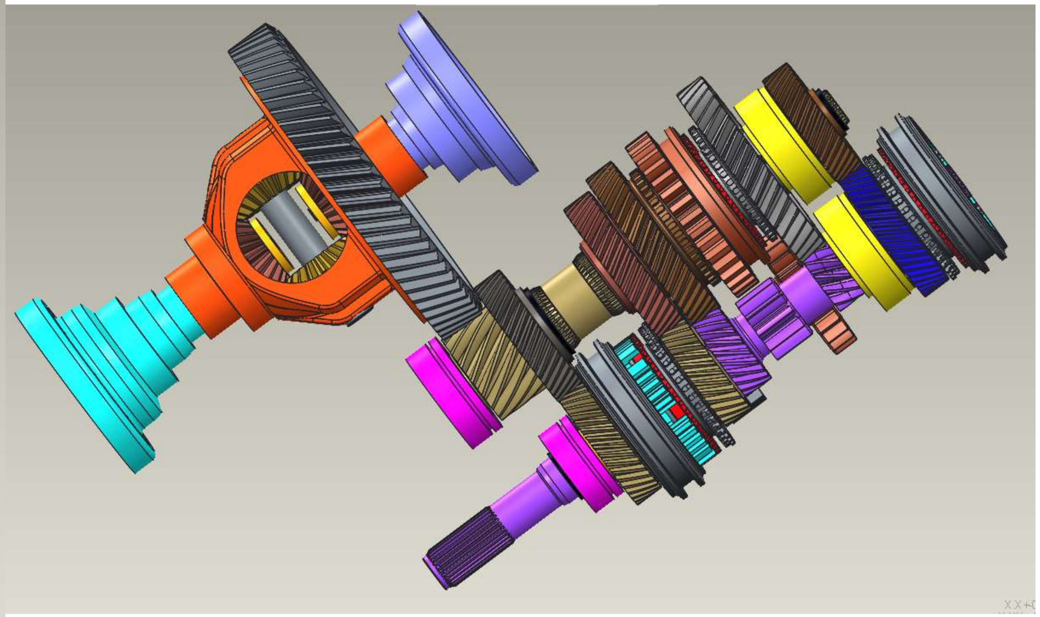


Manual gearbox 5/6 speeds



3D gearbox model controls

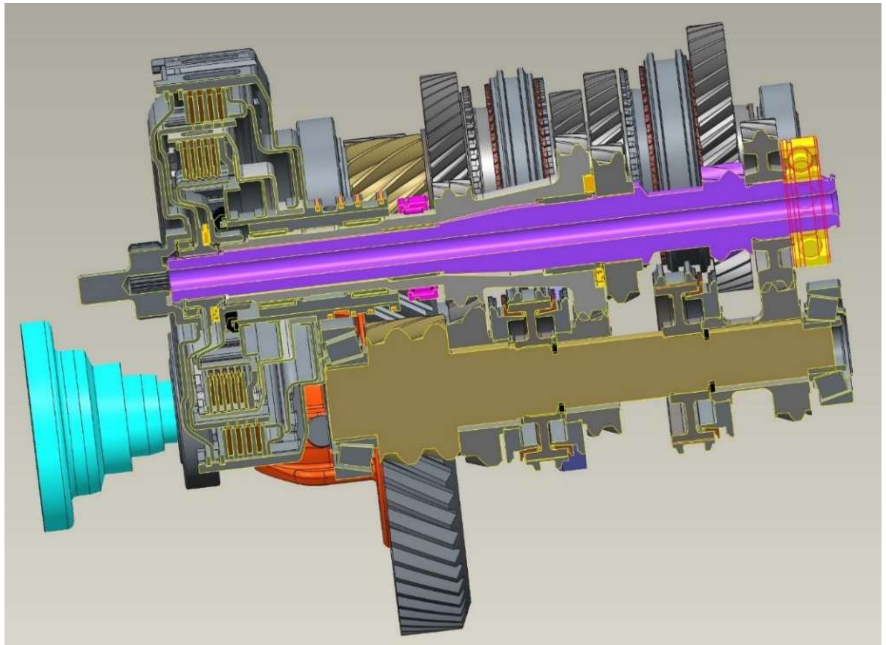
420 parametrs

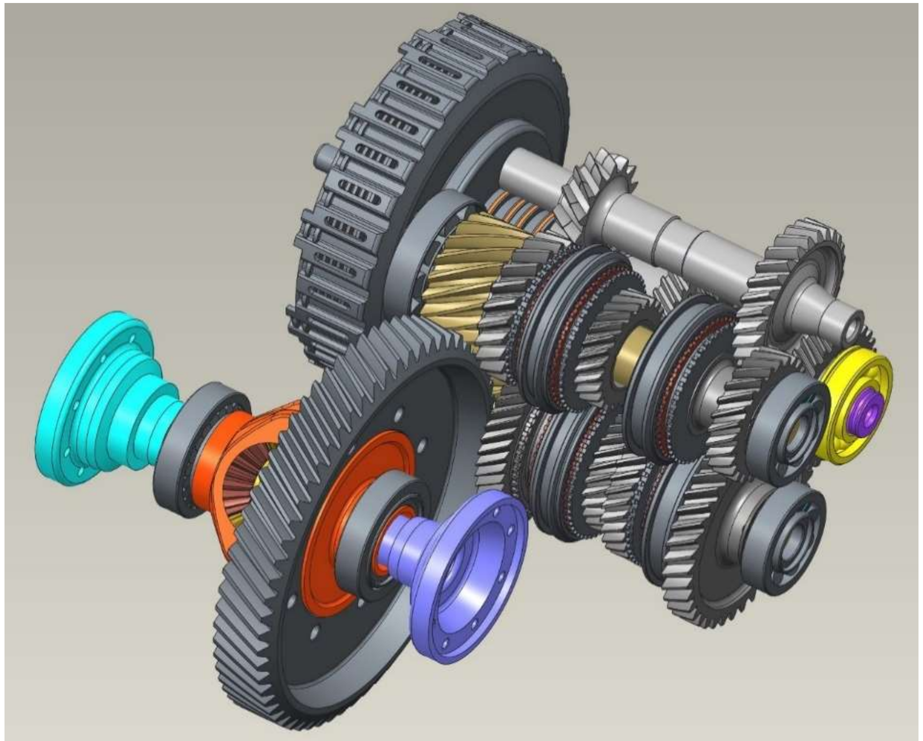


Direct Shift Gearbox DSG 6/7 speeds

3D gearbox model
controls

520 parametrs

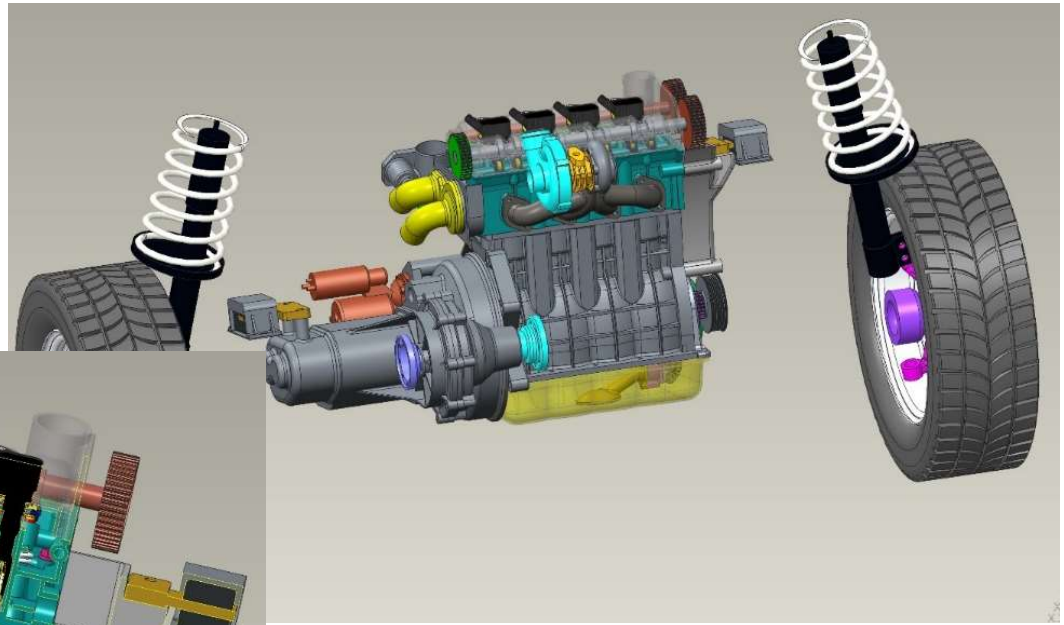


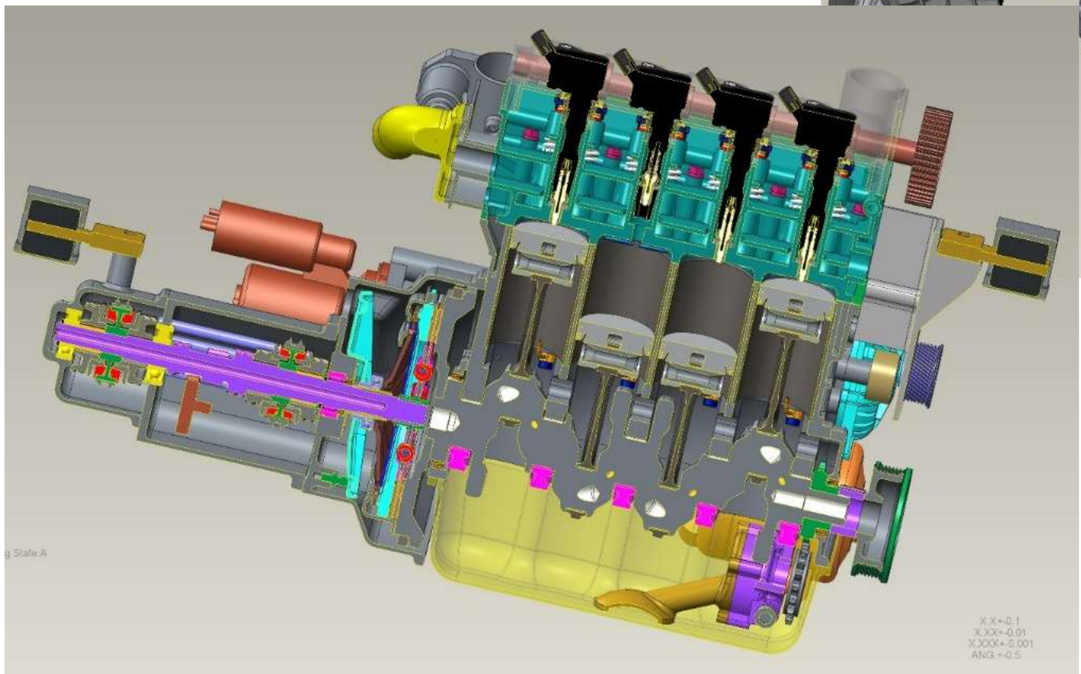


Installation the powertrain to the vehicle

3D parametric model of Installation the powertrain to the vehicle

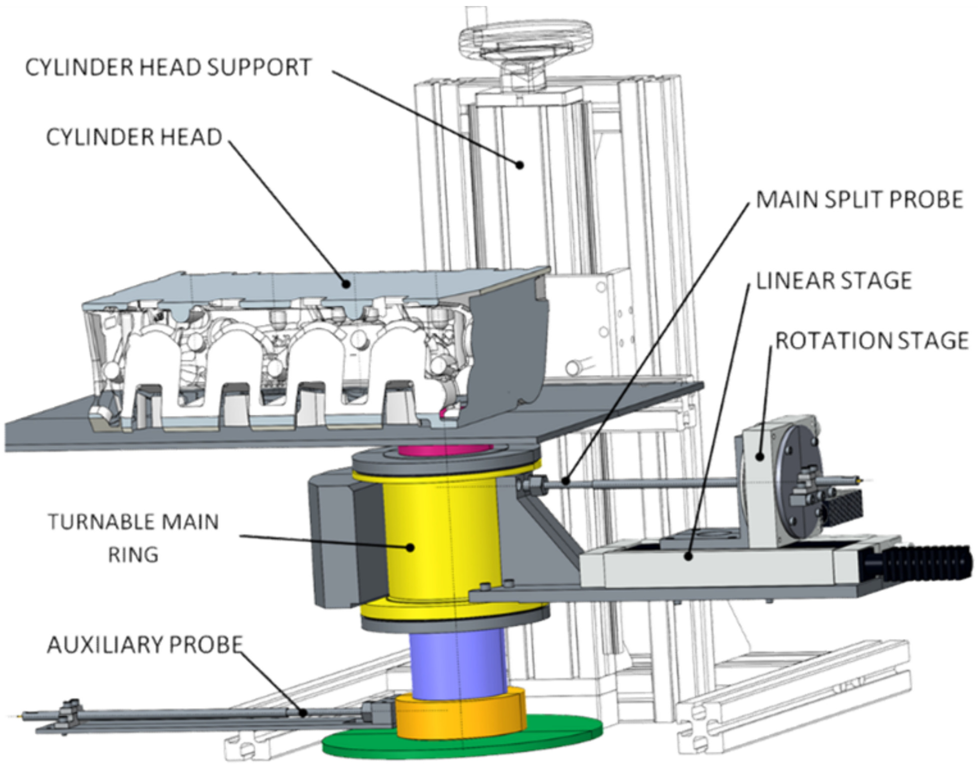
Collision control

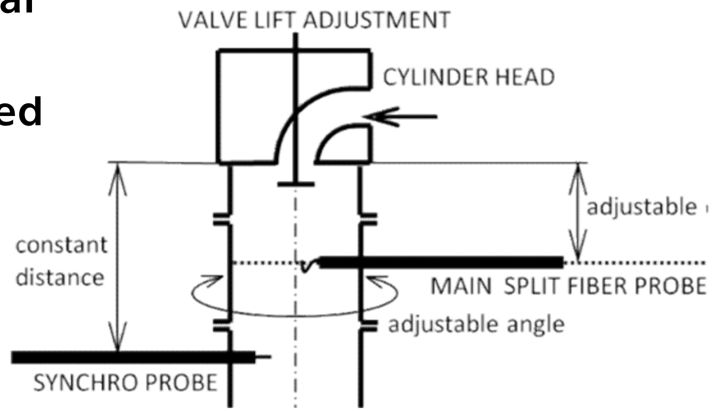


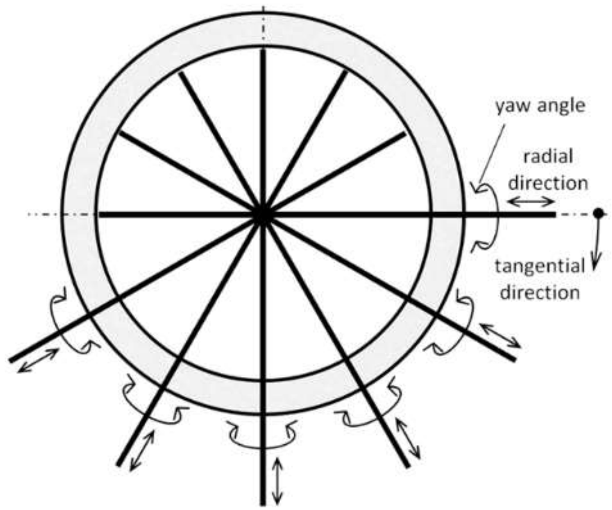


Steady flow rig for in-cylinder flow measurements using HWA

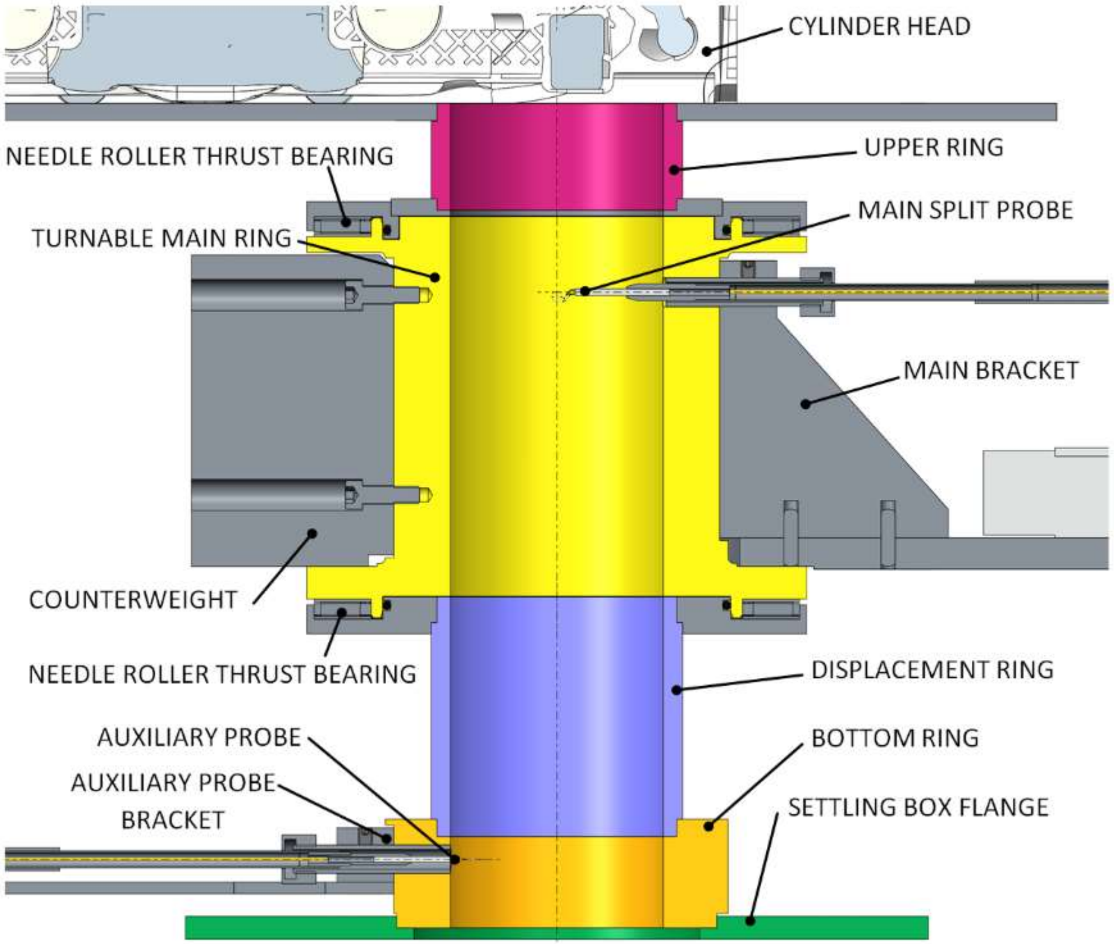
- thermo-anemometric probe can traverse in axial, radial and tangential direction
- axial and tangential velocity components are measured



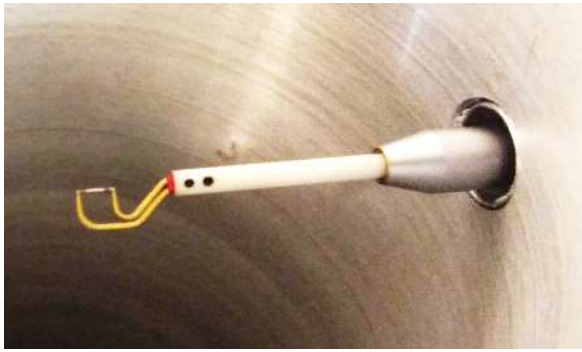




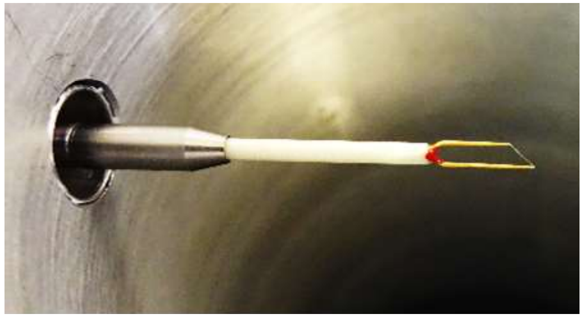
Steady flow rig for in-cylinder flow measurements using HWA



Main split-fiber thermo-anemometric probe Dantec 55R57



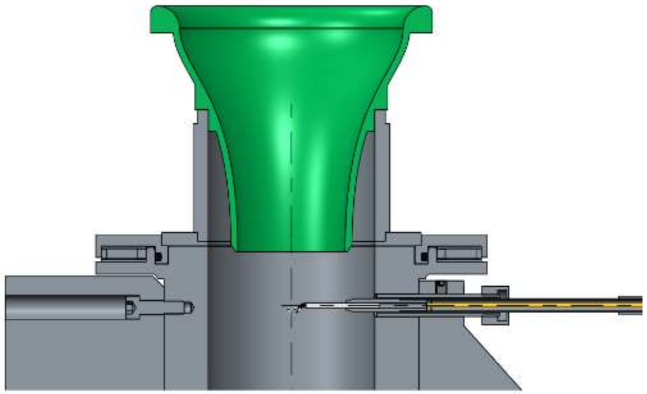
Auxiliary synchro and reference probe Dantec 55R02

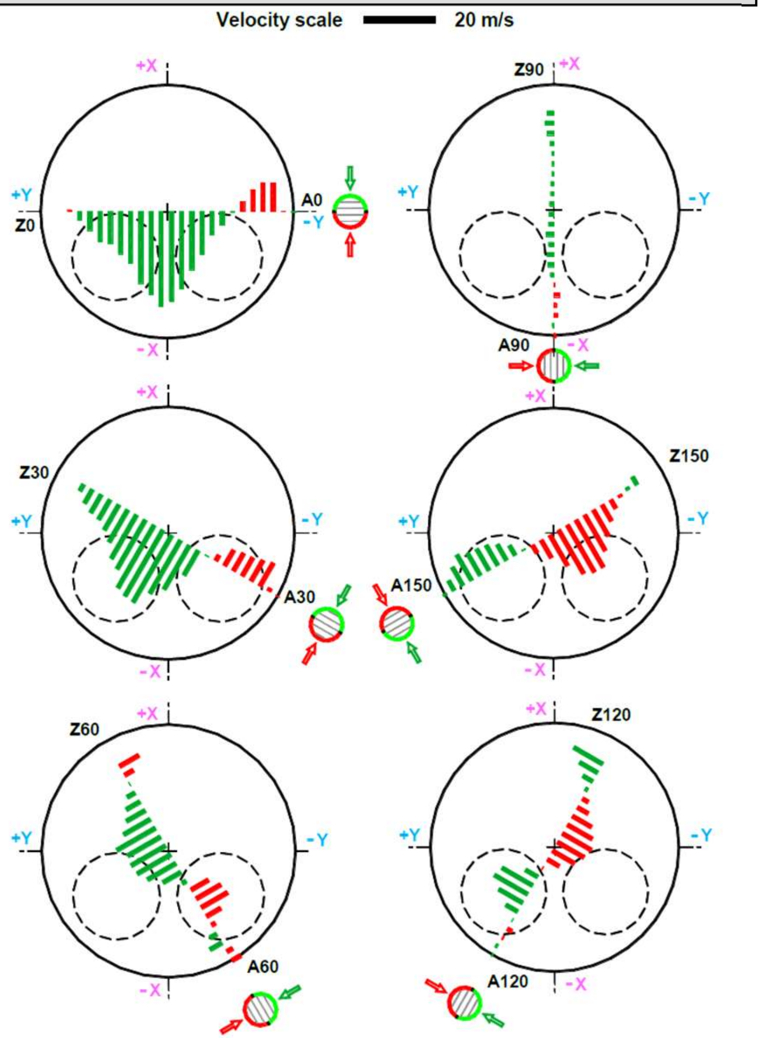


Steady flow rig for in-cylinder flow measurements using HWA

Probe calibration – in situ

velocity range 8 – 135 m/s





Set of experimental data has been acquired:

2 port variants, 2 valve lifts, 2 axial positions

Submitted article „Introductory measurements of in-cylinder flow past intake valve ports with a film split-fiber probe“ to Flow Measurement and Instrumentation Journal

Fulfillment of goals and deliverables of 1-**WP08**: Design Assistance Systems and Calibrated Simulation Processes

Current State of Deliverables, Milestones and Fulfillment of Goals

1-WP08-001 (ZV) | Engine design parametric model | • R - software | Complete parameter model of ICE engine in CREO-Parametric. Parametric models of key engine parts in CREO Parametric, preliminary calculation of their dimensional parameters, collision control, subsequent strength control of key parts and creation of engine assembly. | 10. 12. 2020 | | CTU FME 1 |

1-WP08-002 | In-cylinder flow characteristic measurements | • Gfunk - funkční vzorek | A functional sample of steady flow rig for in-cylinder flow characteristic measurements using hot wire anemometry system. Measured velocity and turbulence can be used for calibration of CFD simulation | 10. 12. 2020 | | CTU FME 1 |

1-WP08-003 | Papers related to advanced design assistance system(s) and detailed port flow measurement. | • O - ostatní výsledky | CTU: 1x paper related to advanced design assistance system.

CTU: 1x paper related to detailed measurement of port flow. | 10. 12. 2020

List of Due Deliverables and Their Added Value

Current contribution of 1-**WP08**: Design Assistance Systems and Calibrated Simulation Processes

Assessment of the Contribution of Deliverables

Parametric model of ICEs for DASY are generally applicable to design of powertrains. 3D models of ICEs are applicable in the design of hydride powertrains.

Steady flow rig for in-cylinder flow measurements is prepared and was tested on a specific measurement, including probe calibration. Submitted article to Flow Measurement and Instrumentation Journal.

Thank you for your attention

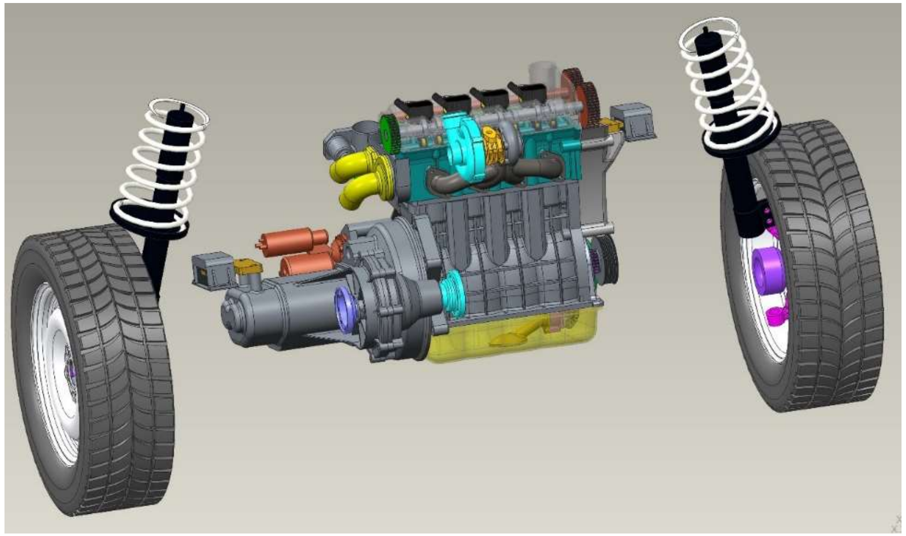
Acknowledgement

This research has been realized using the support of Technological Agency, Czech Republic, programme National Competence Centres, project # TN01000026 Josef Bozek National Center of Competence for Surface Vehicles.

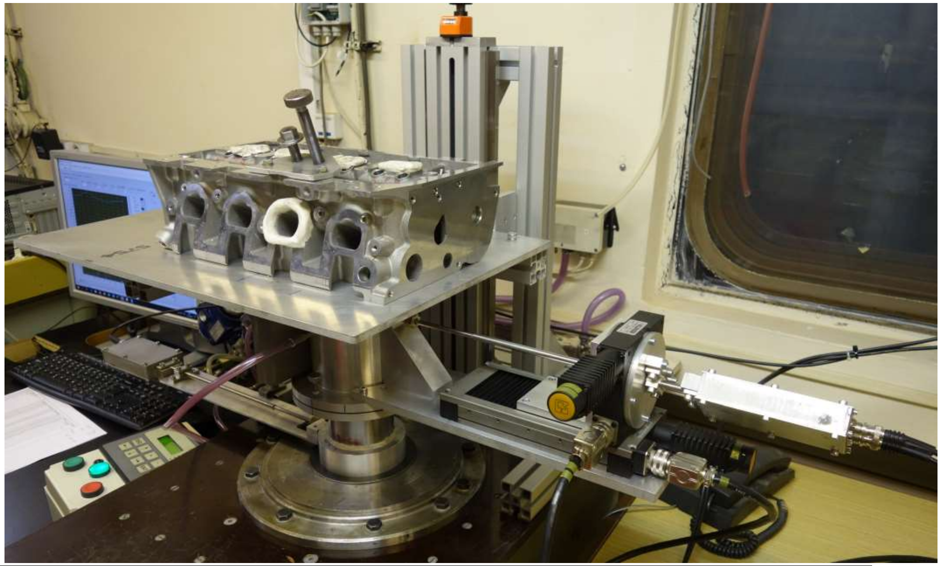
This support is gratefully acknowledged.

Výtah z prací 2019-2020 na 1-**WP08**: Asistenční vývojový systém a Kalibrované simulační procesy

3D parametrický model Instalace hnacího agregátu do vozidla

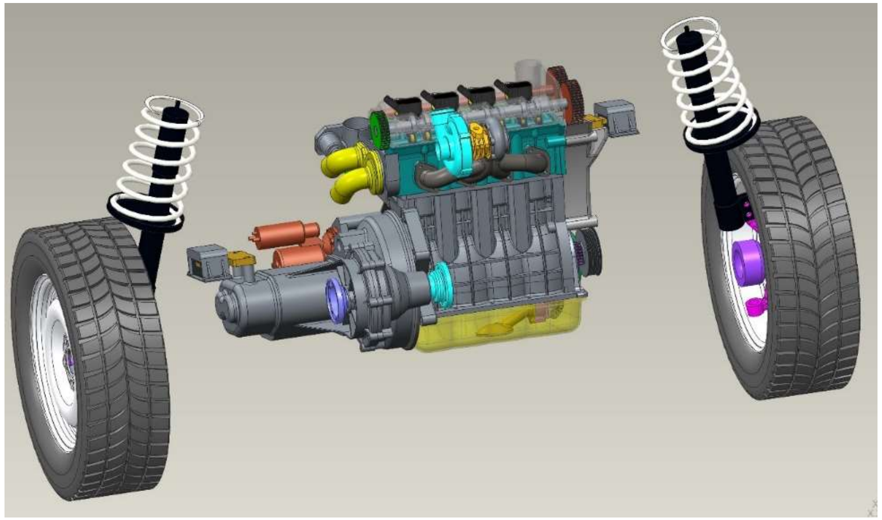


Zařízení pro měření proudového pole ve válci metodou žhaveného elementu



Results of 1-**WP08**: Design Assistance Systems and Calibrated Simulation Processes –Achieved 2019-2020

3D parametric model of Installation the powertrain to the vehicle



In-Cylinder Unsteady Velocity Measurement Using Hot-Wire Anemomemetry