Contents of Work Package 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

4-WP02: Integration of Multiphysics and Digital Twins Technologies into DASY and Operation Reliability

Coordinator of the WP

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Participants of the WP

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University of West Bohemia, Ing. Pavel Žlábek, Ph.D.

Main Goal of the WP

Reduction of the time between the research of the concept and the application of the innovative product on the market.

Creation of parametric 3D models for automation of interconnection of parametric 3D CAD model of the vehicle powertrain with multi-physics solvers (GT-Suite, AVL Fire, ANSYS Motor CAD, etc.)

Research report summarizes the progress of digital twin creation, key activities at the given tractor class, their demands from the point of view of individual tractor components. Based on this knowledge, it is possible to make optimization of a given component during its development and determine the service harmonogram.

Contents of Work Package 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

4-WP02: Integration of Multiphysics and Digital Twins Technologies into DASY and Operation Reliability

Partial Goals for the Current Period

- Creation of parametric 3 D models of charge and exhaust ducts.
- Identification of digital twin creation strategy and key components for evaluation.

Contents of Work Package 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

4-WP02: Integration of Multiphysics and Digital Twins Technologies into DASY and Operation Reliability

Official 4-WP02 Deliverables:

- 4-WP02-001 | **Modules for linking the parametric 3D CAD model of the vehicle powertrain with Multi-physics Simulation Tools**, R-software, XII./2025, CTU 1
- 4-WP02-002 | **Report summarizing the progress of digital twin creation** , O-othe, XII./2025, Zetor 0,3; BUT 0,3; TUO 0,2; UWB RTI 0,2

Activities in 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

4-WP02-001: Modules for linking the parametric 3D CAD model of the vehicle powertrain with Multi-physics Simulation Tools

Planned activities in 2023 -2025

- design and construction of parametric models of charge and exhaust ducts of spark ignition and diesel engines
- design and construction of parametric models of combustion chambers of spark-ignition and diesel engines
- design and construction of parametric models of cooling system of spark ignition and diesel engines
- design and construction of parametric models of the lubrication system of spark-ignition and diesel engines

Activities to be implemented in 2024

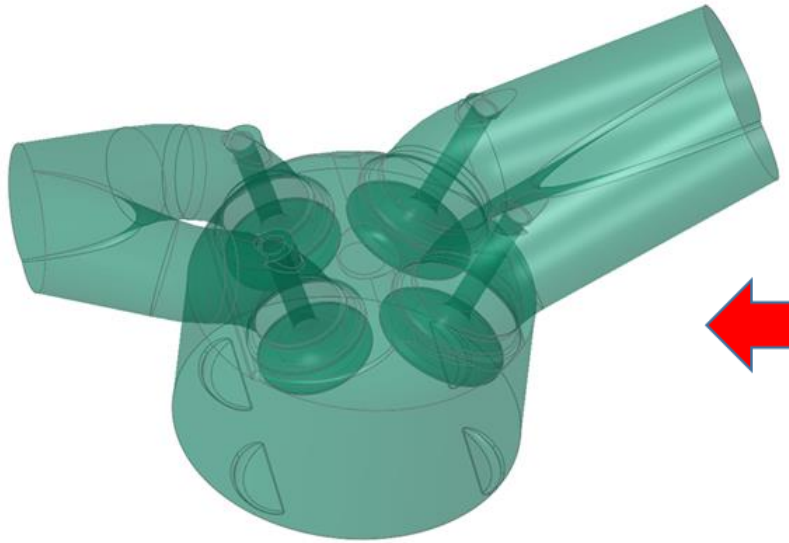
- Analysis of possible types of combustion chambers designs for spark-ignition engines
- Analysis of possible types of combustion chambers designs for diesel engines
- Creation of a parametric model of combustion chambers of spark-ignition and diesel engines
- Analysis of possible types of spark ignition engines cooling spaces designs
- Analysis of possible types of diesel engines cooling spaces designs

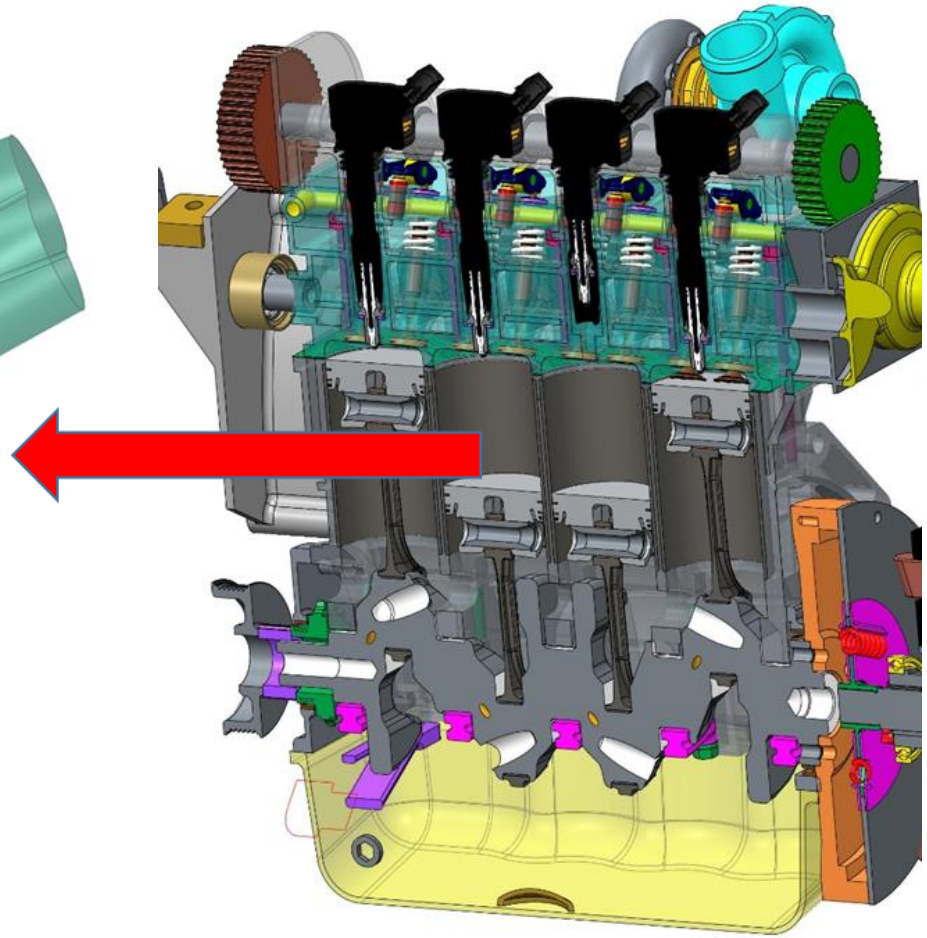
Activities in 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

4-WP02-001: Design and construction of parametric models of combustion chambers designs of spark ignition and diesel engines

Why is it necessary

- Modelling of cylinder content exchange and combustion process in the combustion chamber
- Accelerate geometry transfer between development environments
- Creating virtual twins



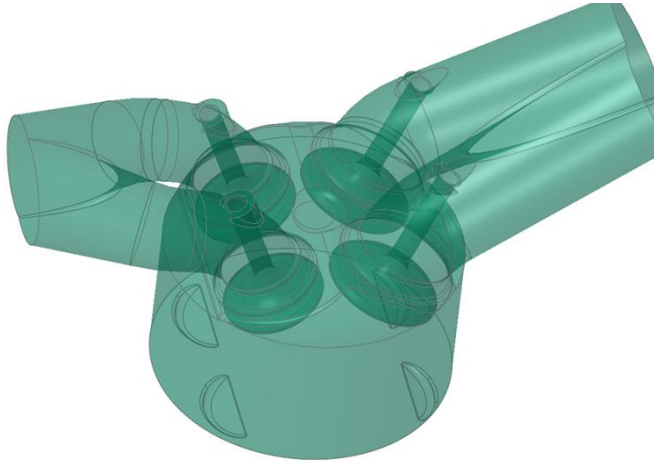


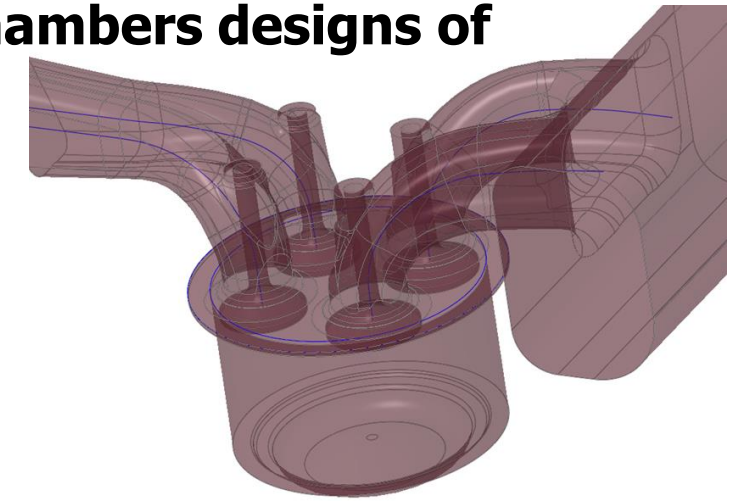
Activities in 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

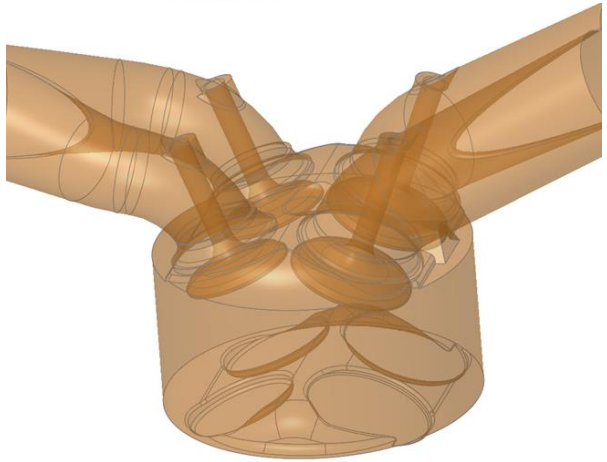
Design and construction of parametric models of combustion chambers designs of spark ignition and diesel engines

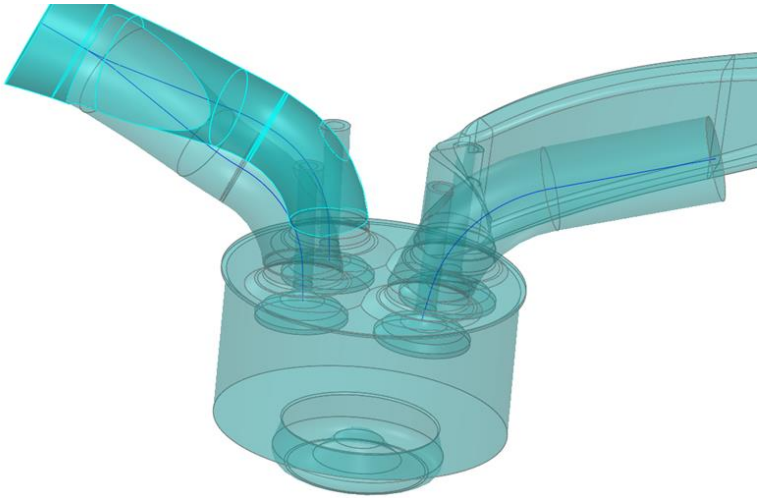
COMBUSTION CHAMBERS ARRANGEMENT

- number of valves
- number of head bolts
- injectors
- glow plugs
- shapes of filling channels
- rotation of valve axes







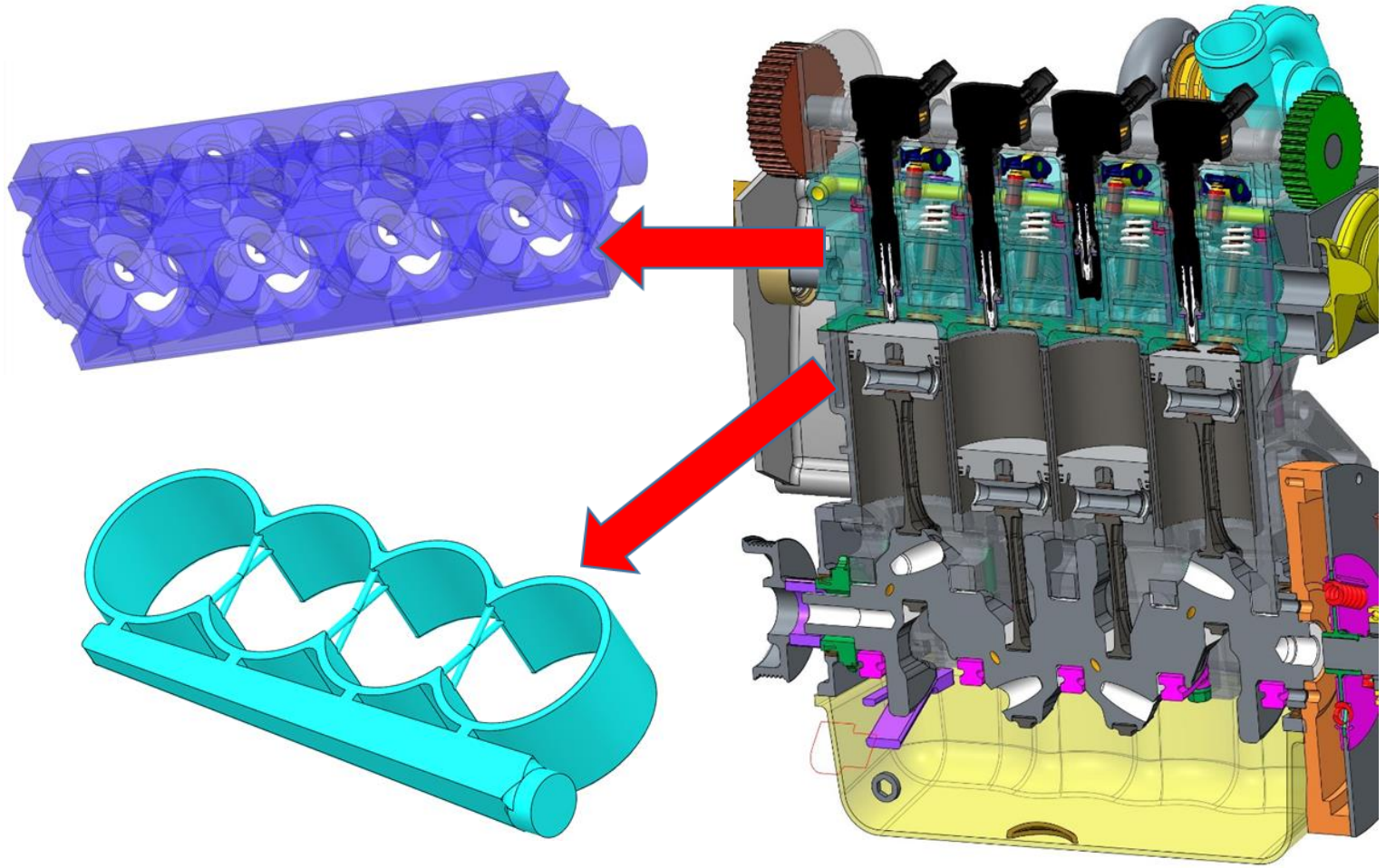


Activities in 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

4-WP02-001: Simulating the flow through the cooling spaces in CREO Flow

Arrangement of engine cooling spaces

- Cylinder block
- Cylinder head



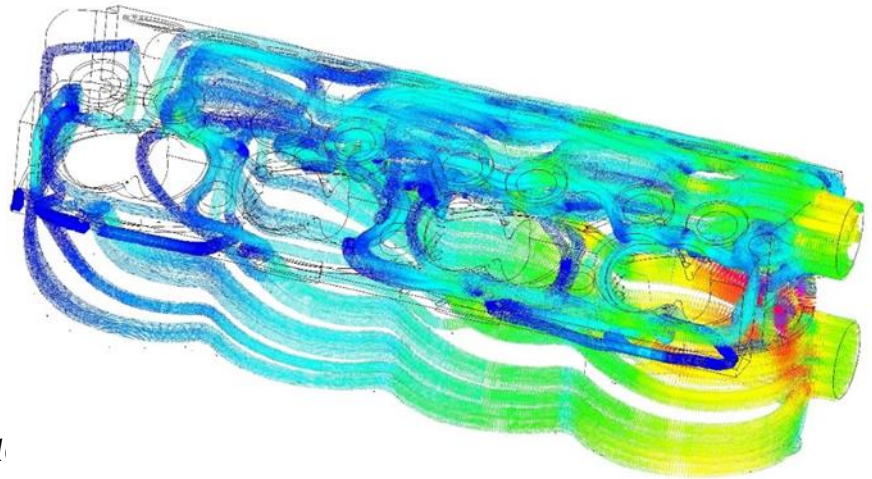
Why is it necessary

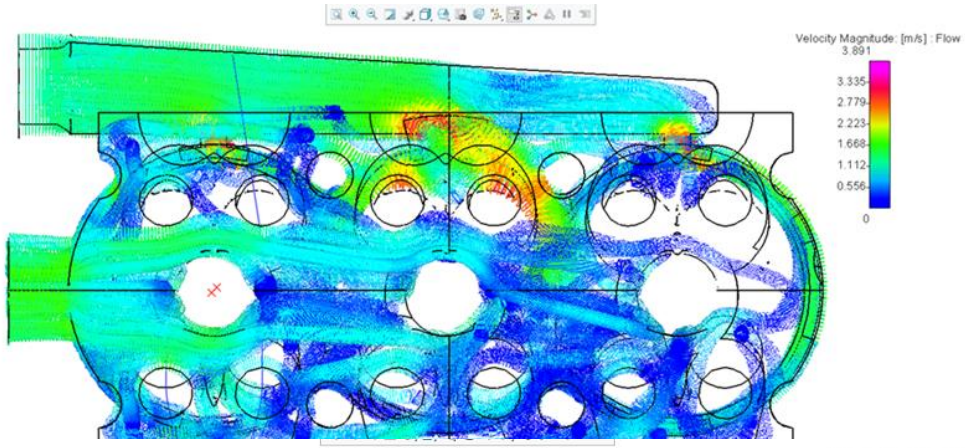
- Velocity modeling in cooling spaces – uniformity of cooling
- Pressure losses in the cooling circuit – water pump design
- Acceleration of geometry transfer between development environments
- Creation of virtual twins

Activities in 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

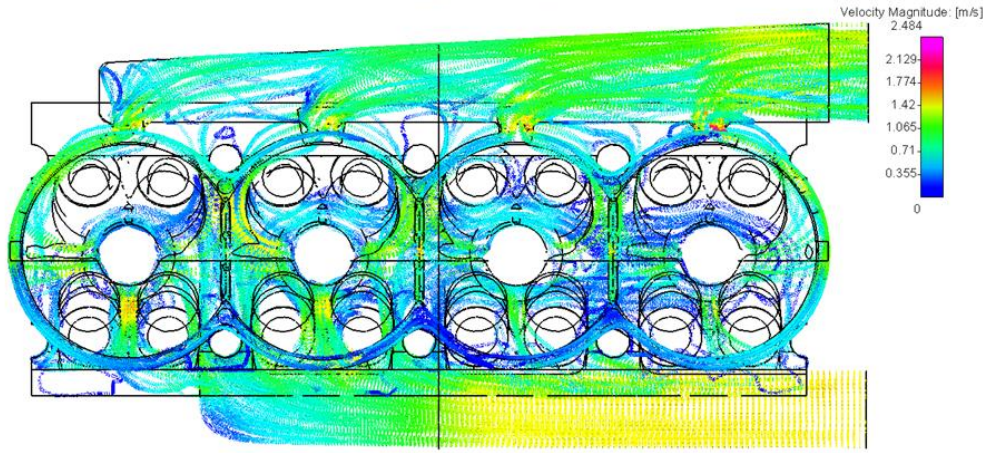
4-WP02-001: Comparison of different cooling arrangement

- *Longitudinal flow*
- *Transverse longitudinal flow*
- *Cross flow*
- *Separate head and cylinder flow control*





- *Input block - output hea*
- *Input head - output block*
- *Input and output - head, block*

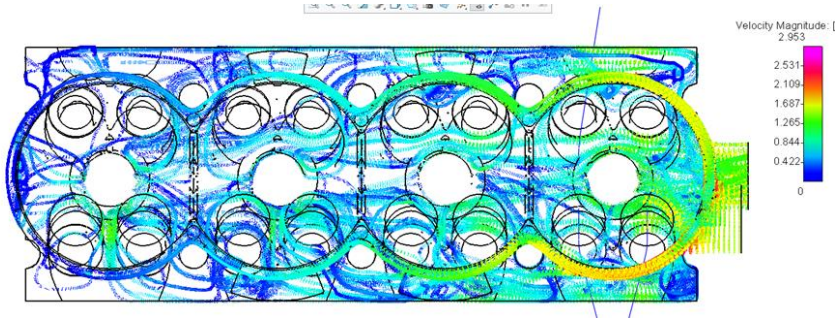


- *Reduction of pressure drop from 8,2 kPa to 4 kPa*

Arrangement of engine cooling spaces

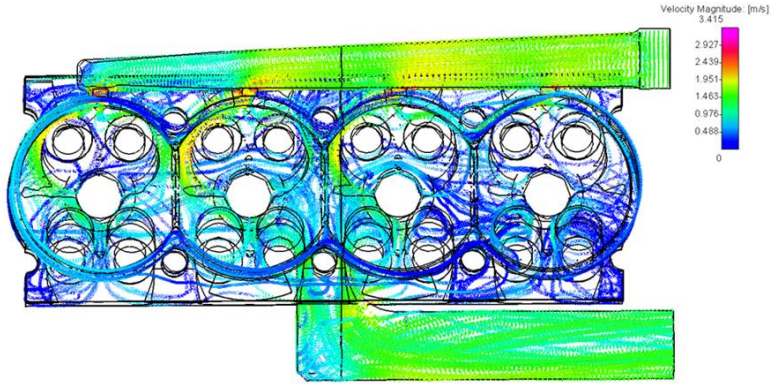
Longitudinal flow

Pressure loss 9,5 kPa



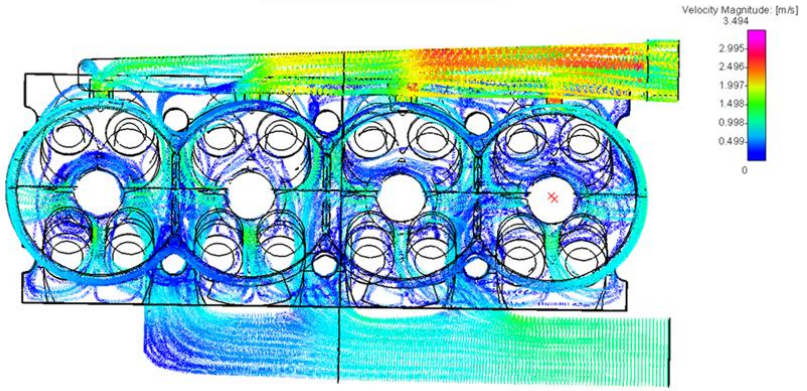
Cross flow

Pressure loss 8,74 kPa



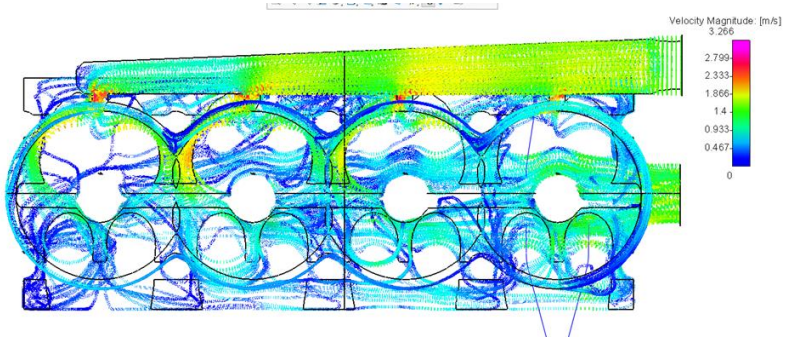
Cross flow

Pressure loss 4,07 kPa



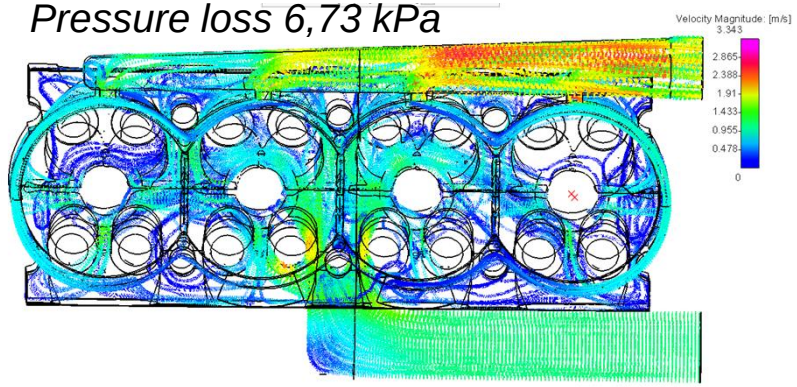
Transverse longitudinal flow

Pressure loss 8,22 kPa



Cross flow reverse inlet

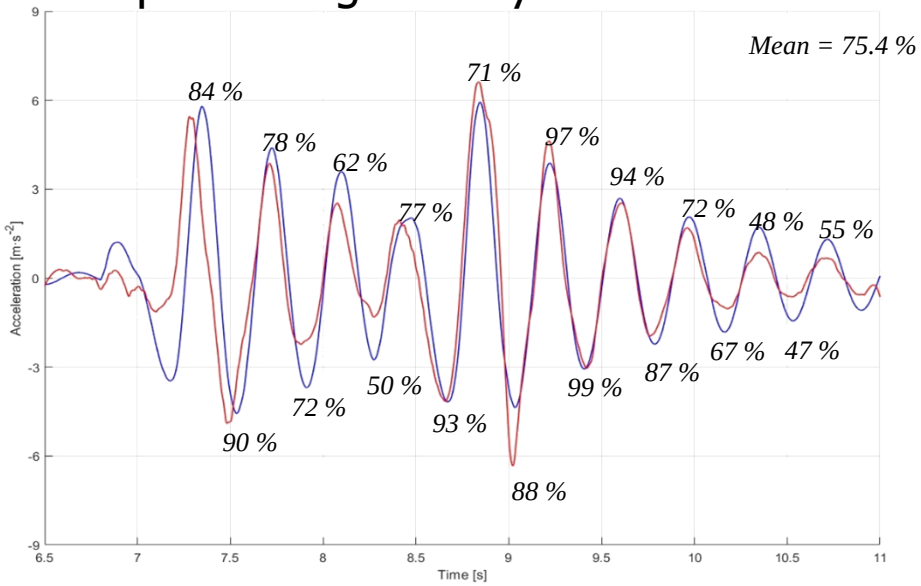
Pressure loss 6,73 kPa

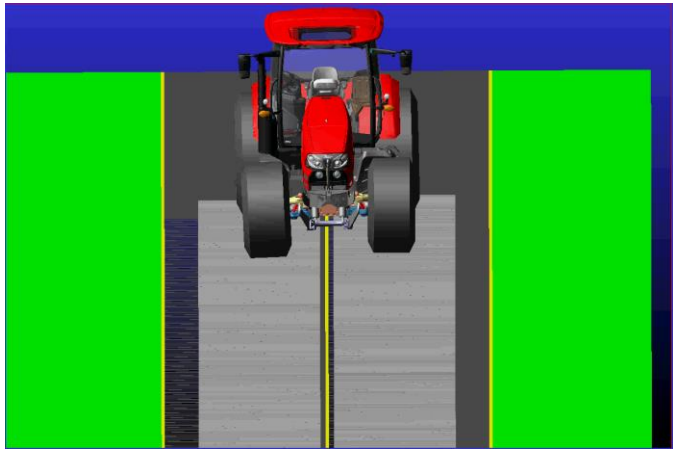


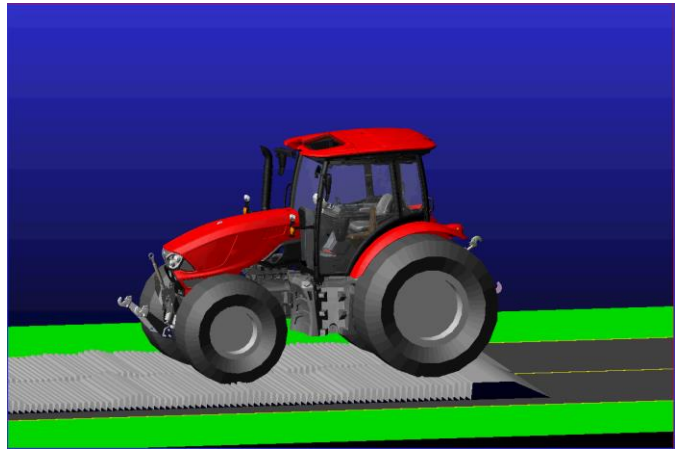
Activities in 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

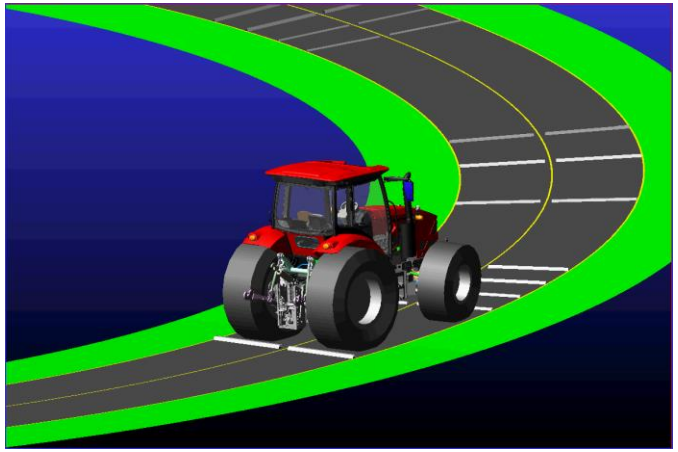
4-WP02-002: Report summarizing the progress of digital twin creation

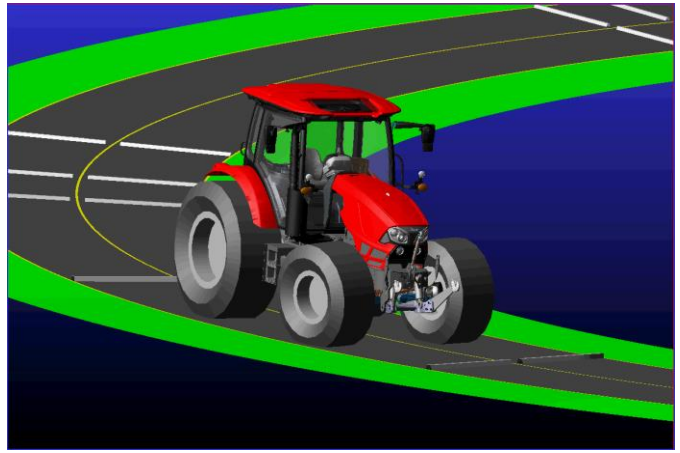
- Perform sensitivity analysis on
  - ISO test rig
  - Lifetime test rig
- Comparison results of numerical and experimental approach
- Data processing – utility creation







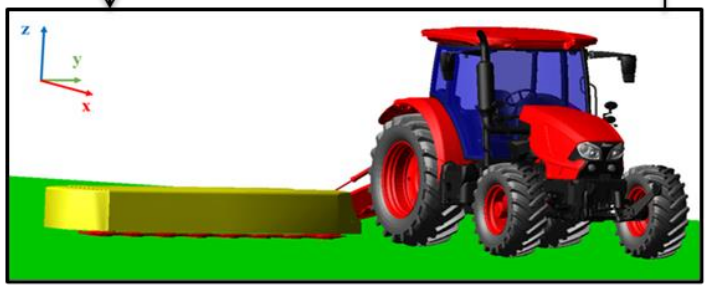


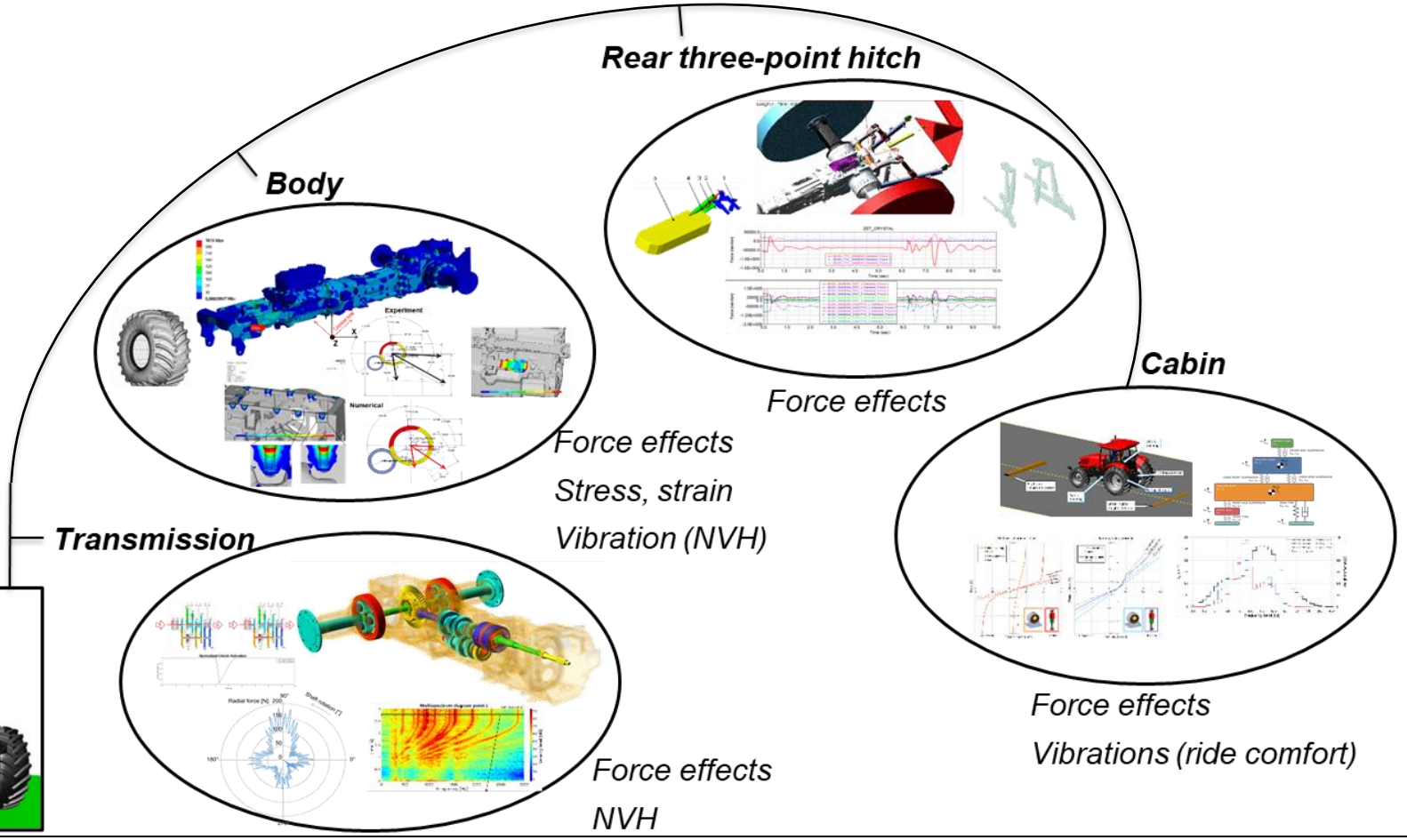


Activities in 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

4-WP02-002: Report summarizing the progress of digital twin creation

- Engine speed
- Gear shift
- Torque
- Steering angle



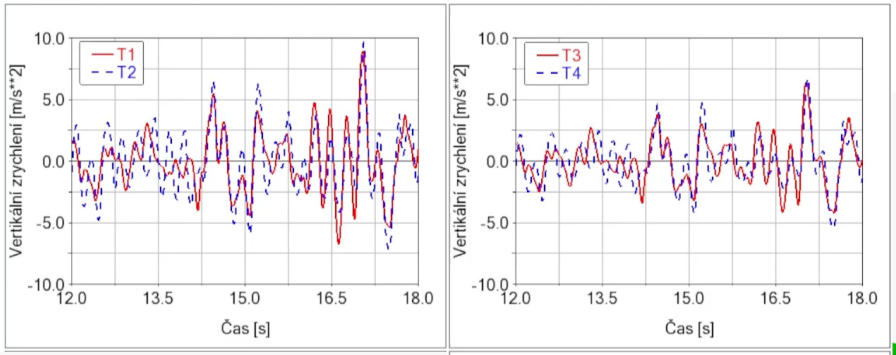


Activities in 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

4-WP02-002: Report summarizing the progress of digital twin creation

Perform sensitivity analysis

- **on ISO test rig**
- **without weight**
- **with weight in front and rear three-point hitch**

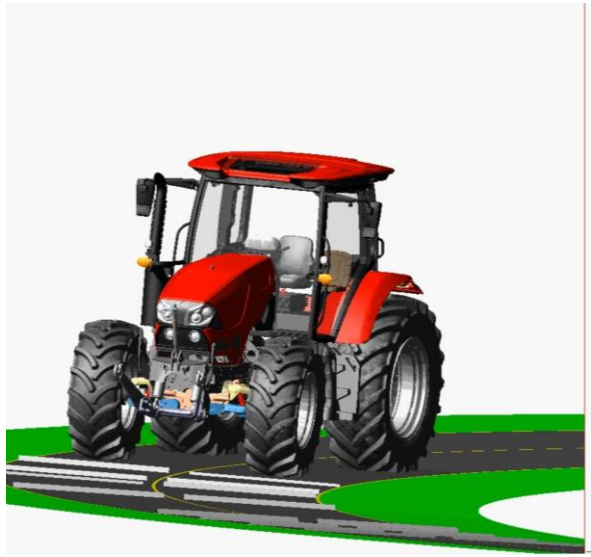


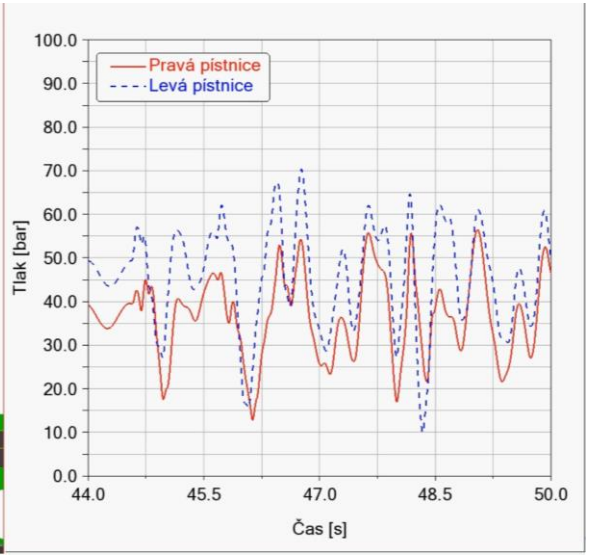
Activities in 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

4-WP02-002: Report summarizing the progress of digital twin creation

Perform sensitivity analysis

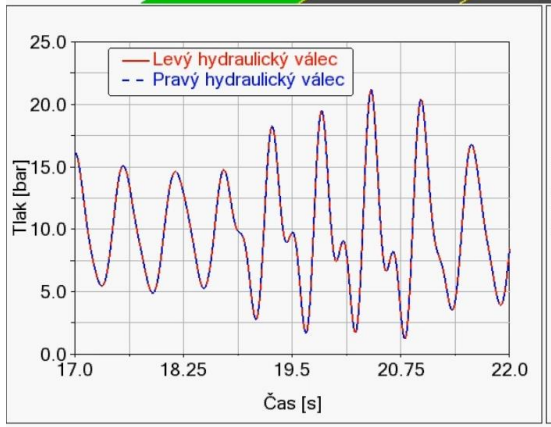
- **on lifetime test rig**
- **without weight**
- **with weight in front and rear three-point hitch**

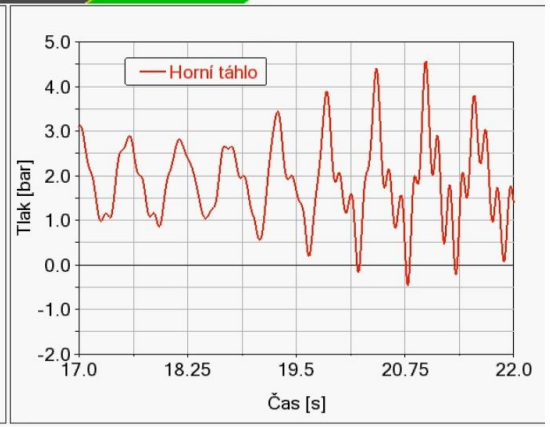


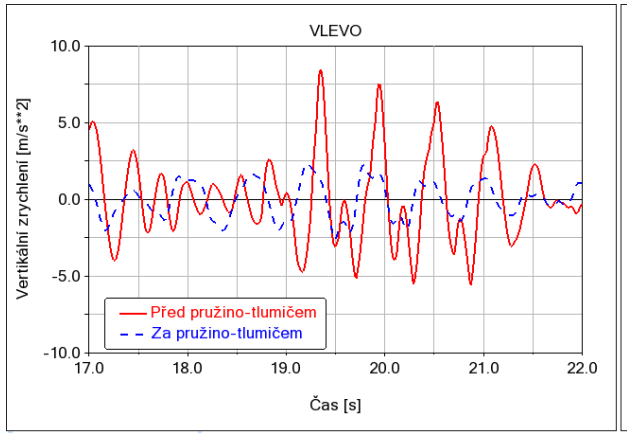


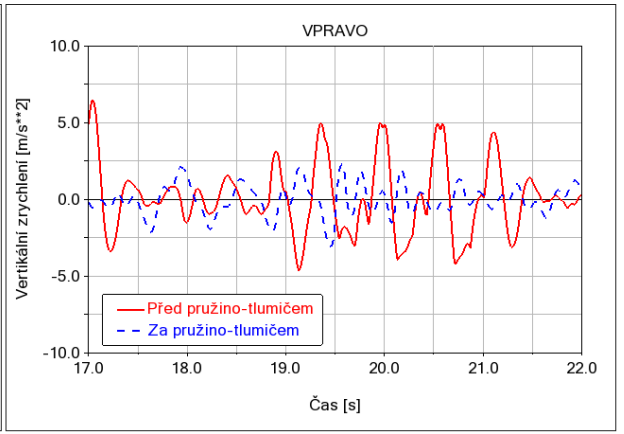
Activities in 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

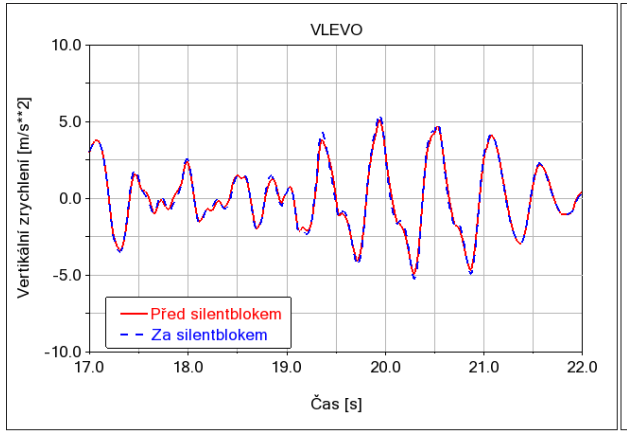
4-WP02-002: Report summarizing the progress of digital twin creation

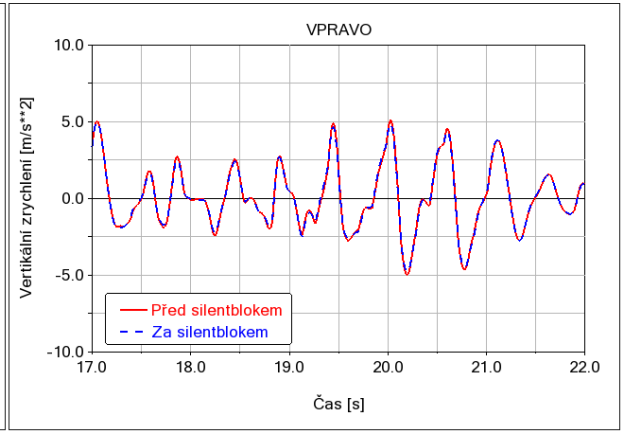








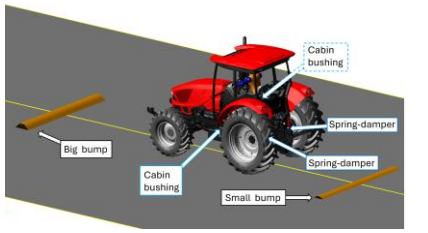


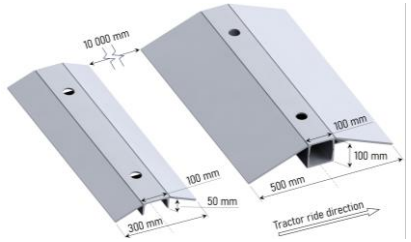


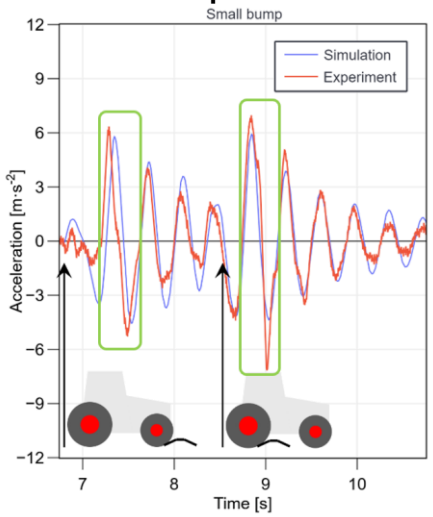
Activities in 4-WP2 Integration of Multiphysics Simulations and Digital Twins Technologies

4-WP02-002: Report summarizing the progress of digital twin creation

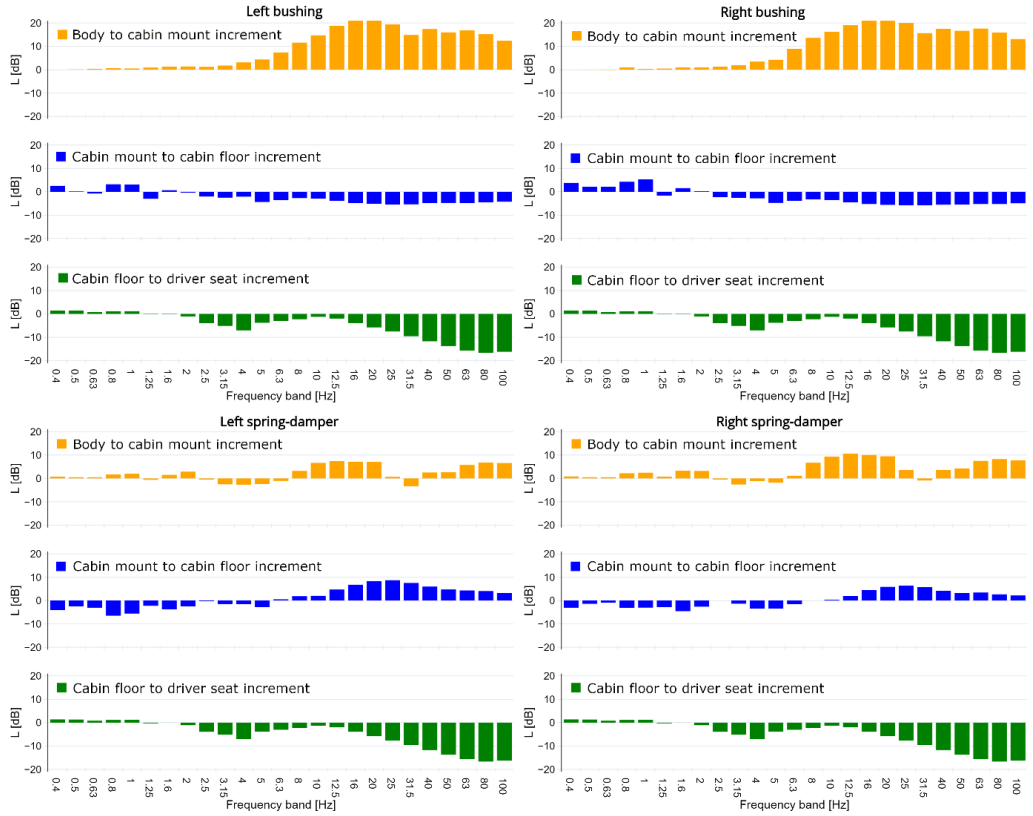
Comparison results of numerical and experimental approach and data processing







	Small bump				Big bump				
	Front axle		Rear axle		Front axle		Rear axle		
	Exp	Sim	Exp	Sim	Exp	Sim	Exp	Sim	
LEFT CABIN BUSHING	2.34	2.66	2.51	2.67	1,97	2,56	2,22	2,49	frequency [Hz]
	86.32		93.63		70.05		87.84		correlation [%]
RIGHT CABIN BUSHING	2.13	2.66	2.44	2.68	1,82	2,55	2,27	2,47	frequency [Hz]
	75.12		90.16		59.89		91.19		correlation [%]
LEFT SPRING-DAMPER	2.86	2.89	2.54	2.92	2,33	2,39	2,35	2,83	frequency [Hz]
	98.95		85.04		97.42		79.57		correlation [%]
RIGHT SPRING-DAMPER	2.86	2.87	2.55	2.91	2,18	2,38	2,32	2,79	frequency [Hz]
	99.65		85.88		90.83		79.74		correlation [%]



Rekem J, Janečková R, Otipka V, Prokop A, Řehák K, Žlábek P. Multi-Body Model of Agricultural Tractor for Vibration Transmission Investigation. *Applied Sciences*. 2024; 14(18):8451. https://doi.org/10.3390/app14188451

Fulfillment of goals and deliverables of 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

Current State of Deliverables and Fulfillment of Goals

- 4-WP02-001 | Modules for linking the parametric 3D CAD model of the vehicle powertrain with Multi-physics Simulation Tools, R-software, XII./2025, CTU 1 – **in progress & no major delays:**
  - Design and construction of parametric models of charge and exhaust ducts of spark ignition and diesel engines.

- 4-WP02-002 | Report summarizing the progress of digital twin creation , O-othe, XII./2025, Zetor 0,3; BUT 0,3; TUO 0,2; UWB RTI 0,2 – **in progress & no major delays**:
  - Increase complexity of multibody model, perform sensitivity study, comparison results of numerical and experimental approach.

Current contribution of 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

Assessment of the Formal/Administrative Goals of the Work Package

	CTU	BUT	Zetor	TUO	UWB RTI
Finances (reporting/spending)	OK	OK	OK	OK	OK
Commercialization (the whole organization)	OK	OK	OK	OK	OK
Deliverables	OK	OK	OK	OK	OK

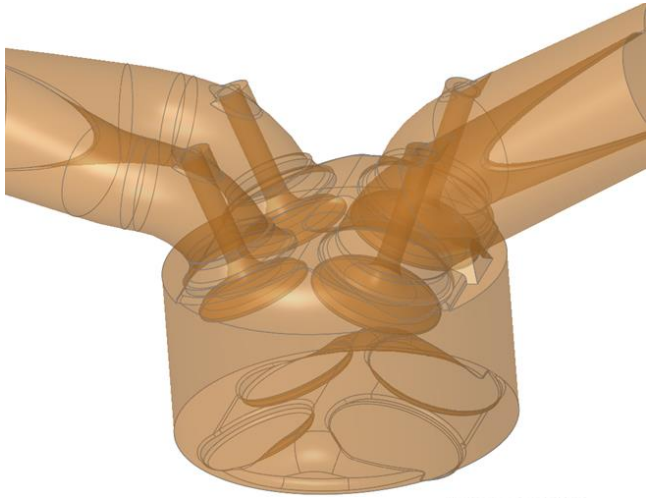
Current contribution of 4-WP02 Advanced Automated Design Tools (DASY) - New Developments

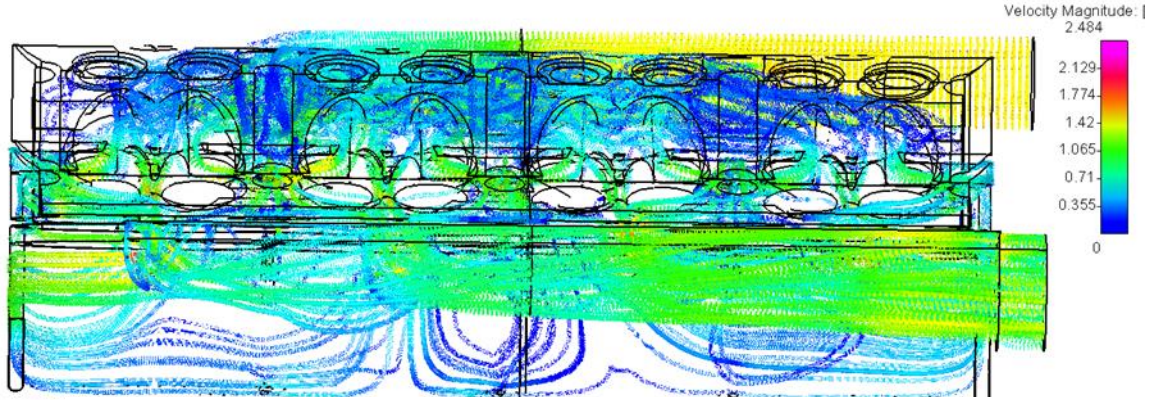
Acknowledgment

This research has been realized using the support of Technological Agency, Czech Republic, programme National Competence Centres II, project # TN02000054 Božek Vehicle Engineering National Center of Competence (BOVENAC).

Výtah z prací 2023-2025 na 4-WP02 Pokročilé automatizované návrhové nástroje (DASY) - nový vývoj

Návrh a konstrukce parametrických modelů spalovacích prostorů zážehových a vznětových motorů chlazení hlavy a bloku





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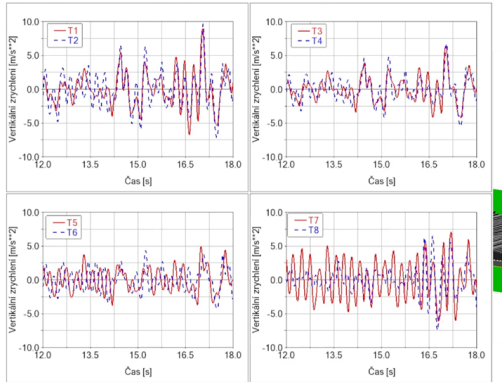
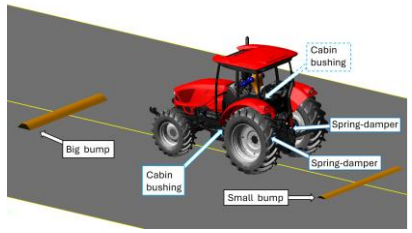
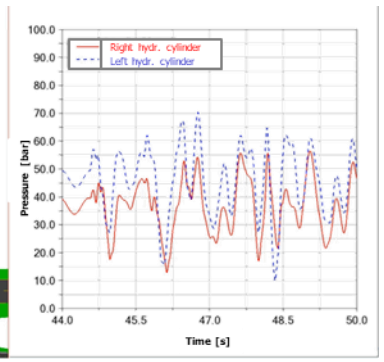
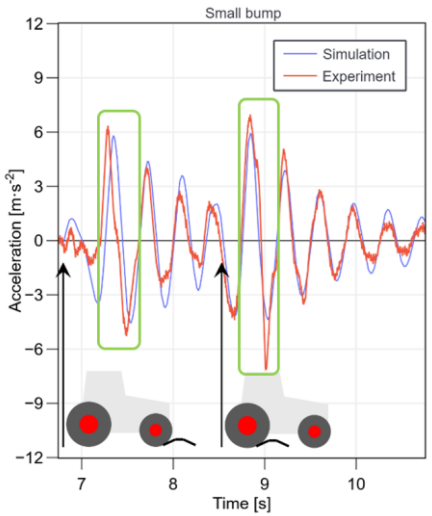
Zvýšení komplexity multibody modelu, realizace citlivostní studie a porovnání dosažených výsledků vůči výsledkům experimentu.







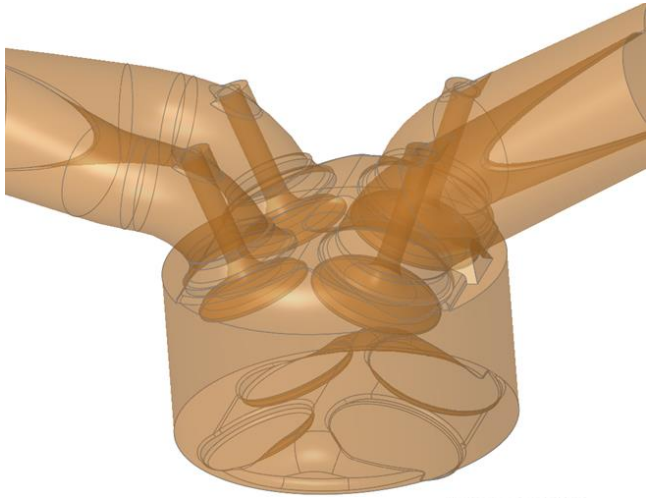


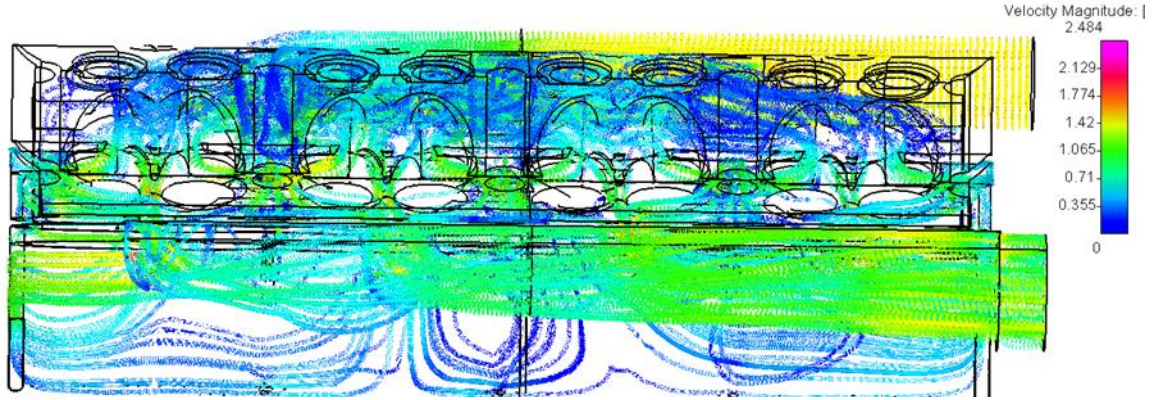
Kamil Řehák kamil.rehak@vutbr.cz.

Results of 4-WP02 Advanced Automated Design Tools (DASY) - New Developments–Achieved 2023-2025

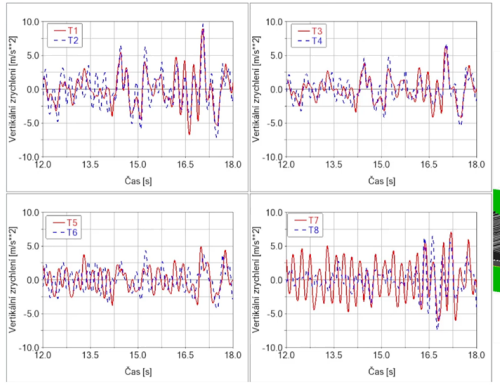
Design and construction of parametric models of combustion chambers of spark ignition and diesel engines

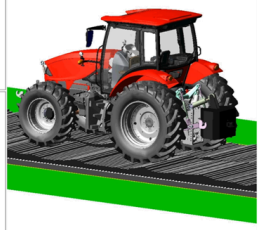
Engine coolig spaces of cylinder head and block

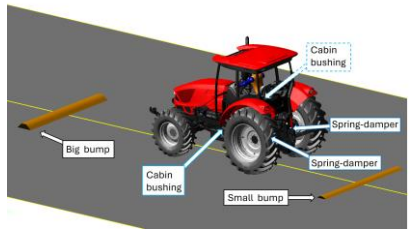


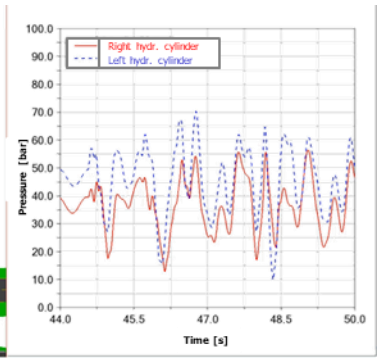


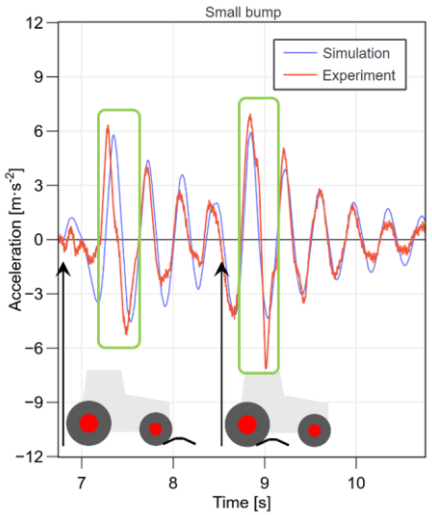
Increase complexity of multibody model, perform sensitivity study, comparison results of numerical and experimental approach.











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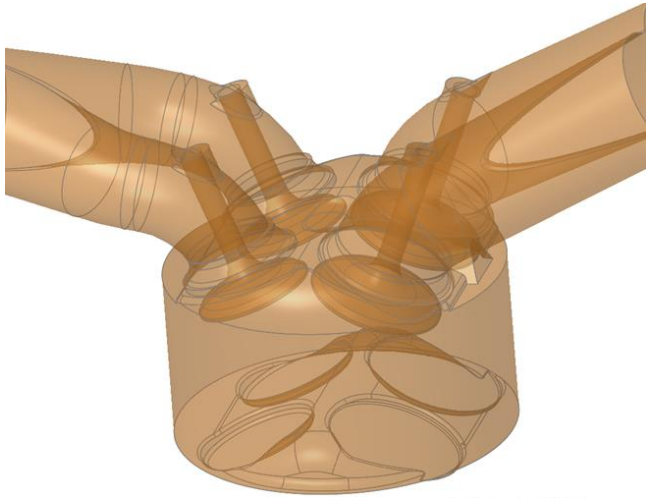
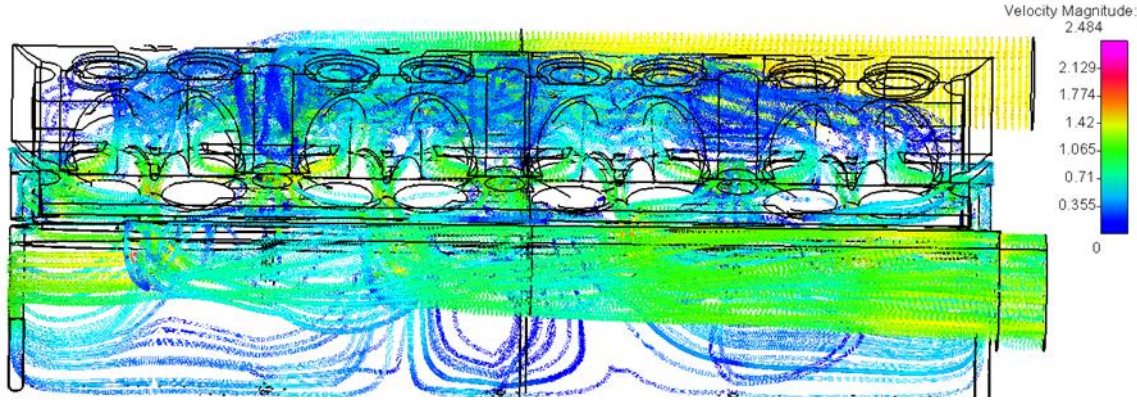
Výtah z prací 2024 na 4-WP02 Pokročilé automatizované návrhové nástroje (DASY) - nový vývoj

Návrh a konstrukce parametrických modelů spalovacích prostorů zážehových a vznětových motorů chlazení hlavy a bloku





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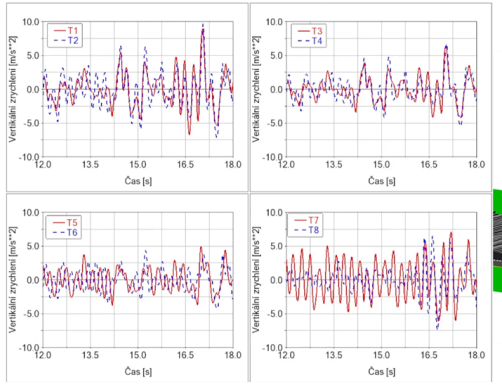
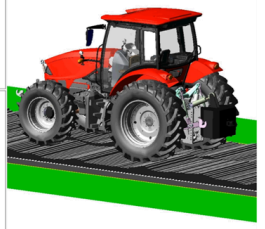
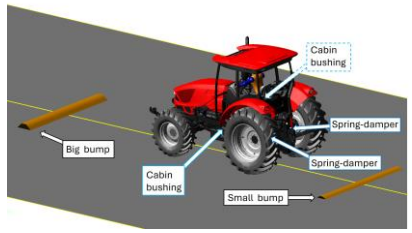
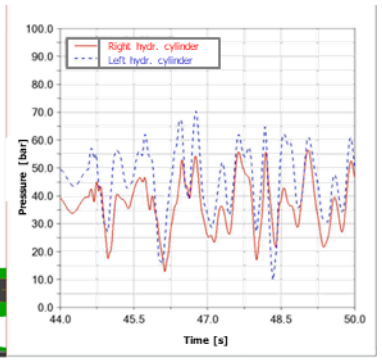
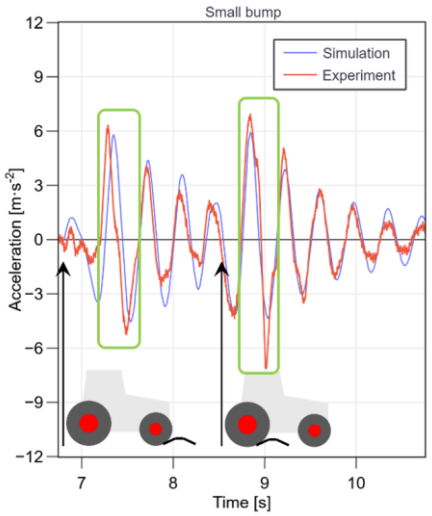
Zvýšení komplexity multibody modelu, realizace citlivostní studie a porovnání dosažených výsledků vůči výsledkům experimentu.











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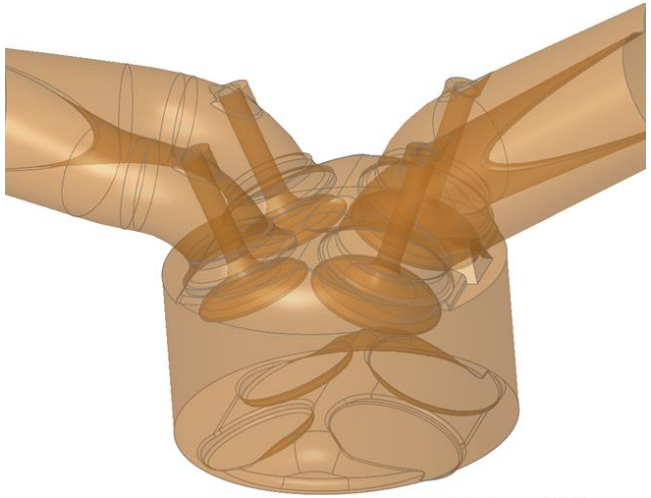
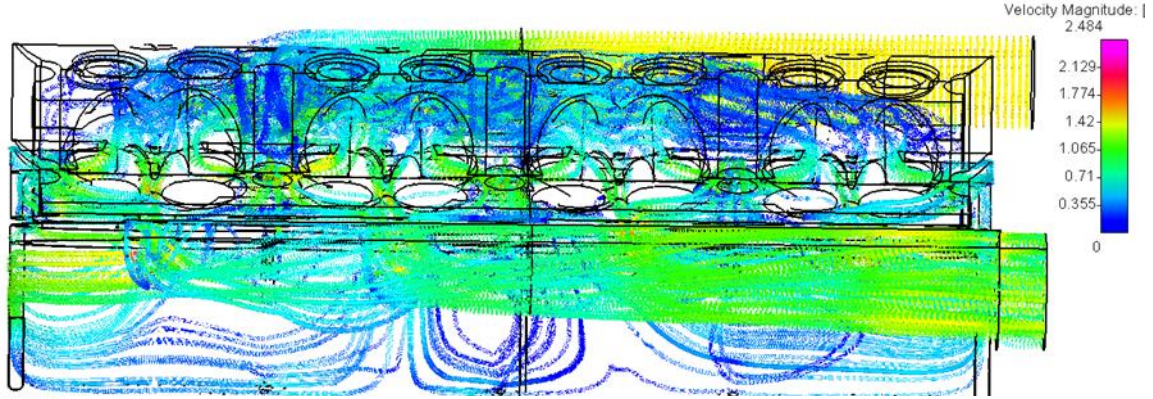
Results of 4-WP02 Advanced Automated Design Tools (DASY) - New Developments–Achieved 2024

Design and construction of parametric models of combustion chambers of spark ignition and diesel engines

Engine coolig spaces of cylinder head and block





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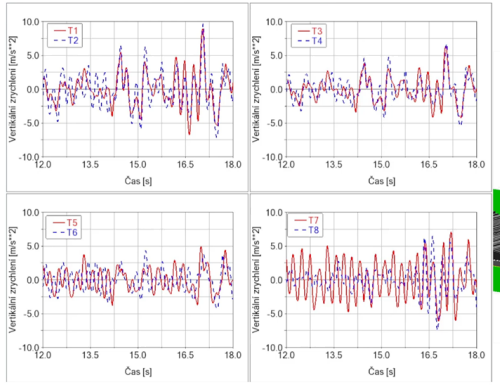

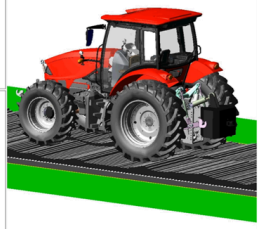

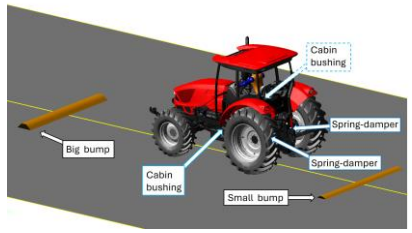

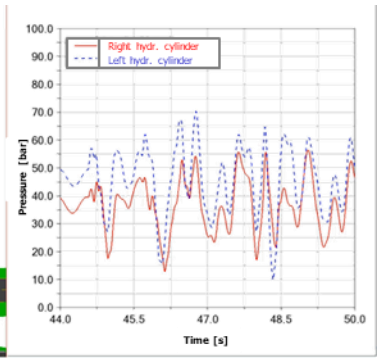

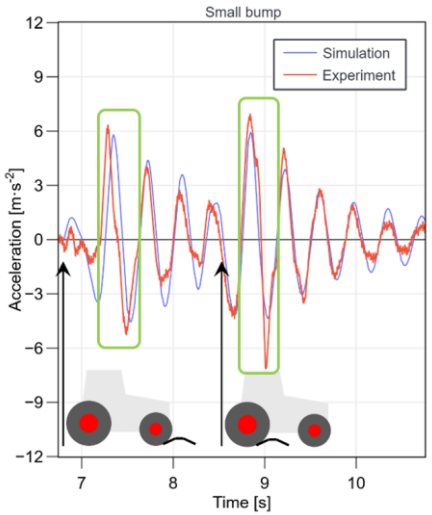

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