Contents of Work Package 4-WP09 Optimized Component Design for Future Rail Vehicles

4-WP09: Optimized Component Design for Future Rail Vehicles

Coordinator of the WP

University of West Bohemia, responsible person: Ing. Pavel Žlábek, Ph.D.

Participants of the WP

DAKO-CZ, a.s.	- Ing. Jan Korejtko, M.Eng., Ing. Michal Štiller
ŠKODA TRANSPORTATION a.s.	- Ing. Petr Špalek, Ing. Lukáš Fara
VUT Brno	- Ing. Kamil Řehák, Ph.D.
VZÚ Plzeň s.r.o.	- Ing. Jan Chvojan, Ph.D.
UWB – FEE	- Ing. Pavel Turjanica, Ph.D., doc. Ing. Vladimír Kindl, Ph.D.
UWB – Regional Technological Institute	- Ing. Pavel Žlábek, Ph.D.

Main Goal of the WP

The main objective is to contribute to the field of different components of transport technology, in this case, in particular railway technology, to improve tools and solutions to find new properties or optimized structures or to evaluate the residual lifetime. It is about gaining key knowledge and tools for industry partners to address their long-term activities.

Partial Goals for the Current Period

This will be described in research reports once functional samples or processes and procedures have been set up.

Contents of Work Package 4-WP09 Tools of Design and Components for Advanced Vehicles

4-WP09 Tools of Design and Components for Advanced Vehicles

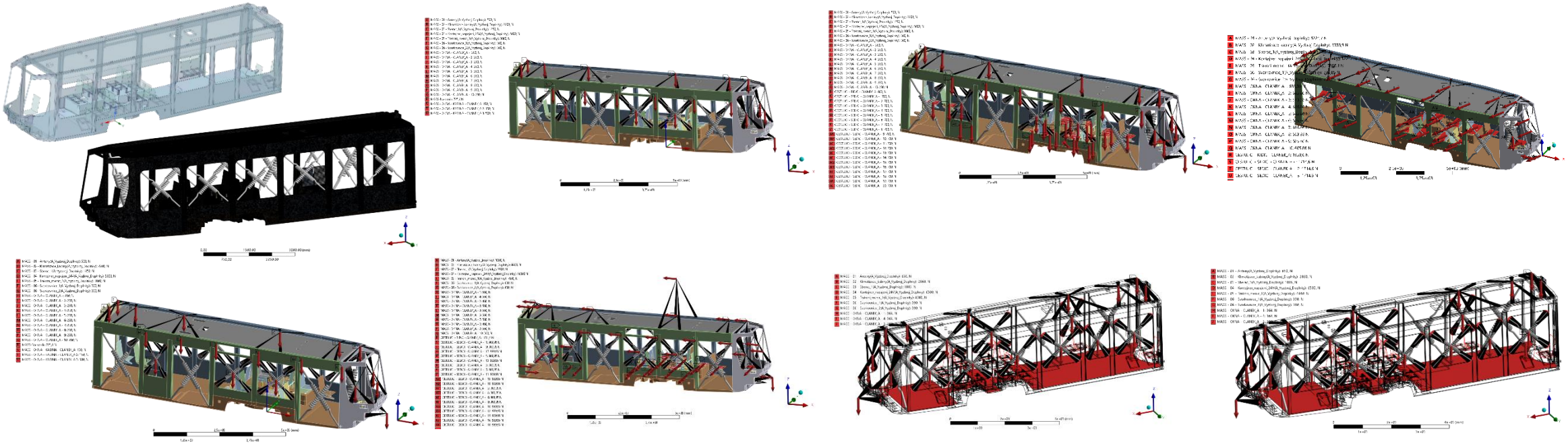
Official 4-WP09 Deliverables:

- 4-WP09-001 | **Design of selected key node of railway/tram body**, Fprum, 8/2025, STRN 0.4; UWB RTI 0.4; VZUP 0.1; BUT 0.1
- 4-WP09-002 | **Technology for the production of selected key structure**, O, 10/2025, STRN 0.4; UWB RTI 0.4; VZUP 0.1; BUT 0.1
- 4-WP09-003 | **Principles of crack detections of composite shaft**, O, 12/2025, STRN 0.4; UWB RTI 0.3; VZUP 0.2; BUT 0.1
- 4-WP09-004 | **The electro mechanical brake actuator for use on rolling stock**, G-funk, 10/2025, DAKO 0.4; UWB FEE 0.3; UWB RTI 0.3
- 4-WP09-005 | **Applicability of electric coils in the field of electro-mechanical brake design**, O, 12/2025, DAKO 0.3; UWB FEE 0.4; UWB RTI 0.3

Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

4-WP09-001: Design of selected key node of railway/tram body

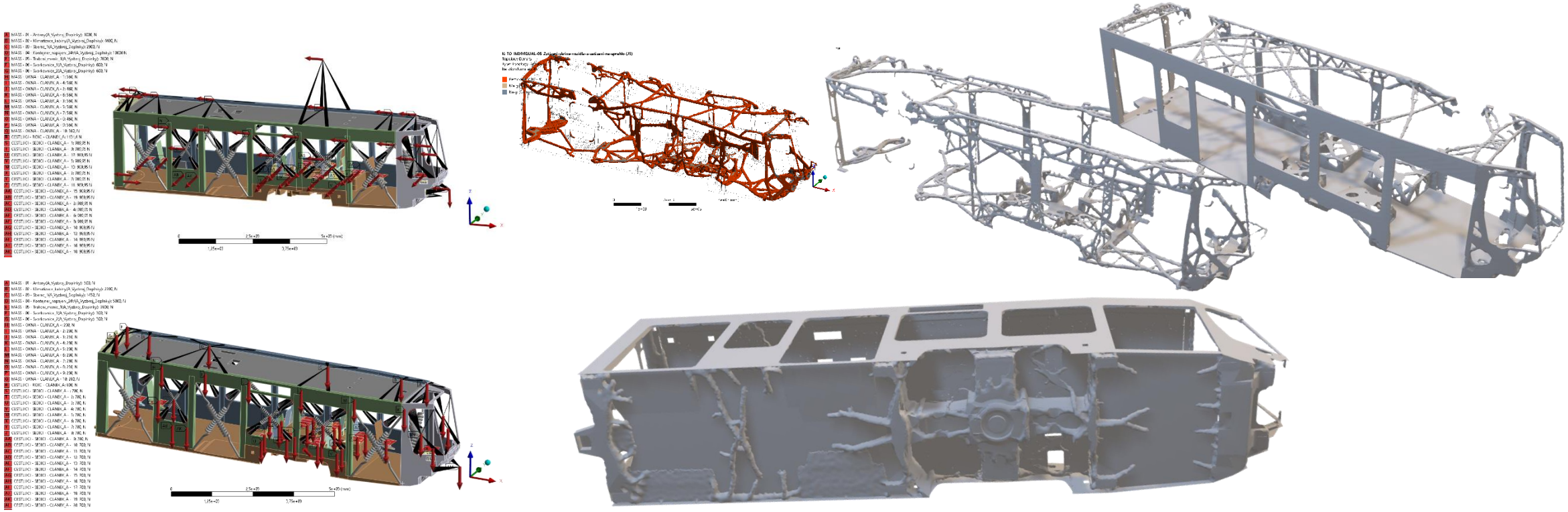
- Definition and design of the input casing for the topological optimization of the chassis of a tram, FEM model, definition of input (critical) loads, implementation of topological optimization for partial load states
- Refinement of the numerical model of topological optimization



Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

4-WP09-001: Design of selected key node of railway/tram body

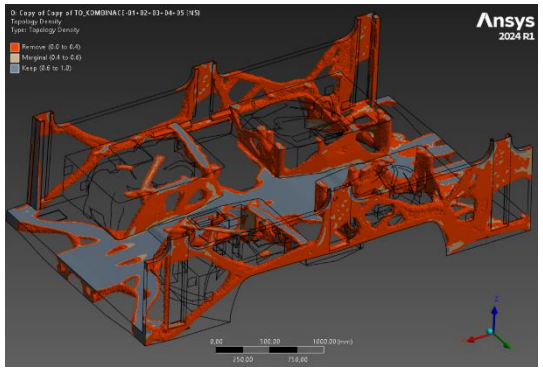
- Completion of critical/input stress states, performing the 2nd, 3rd and 4th refinement iterations of the topological optimization of the tram link

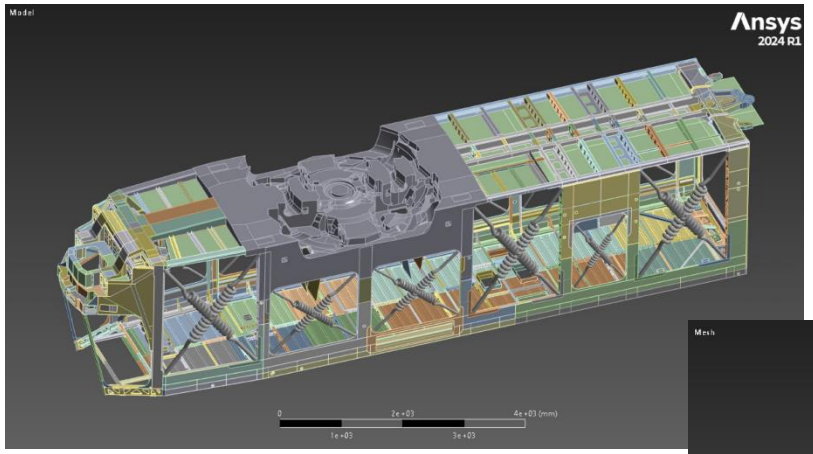


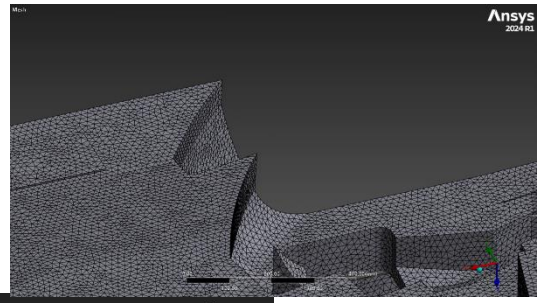
Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

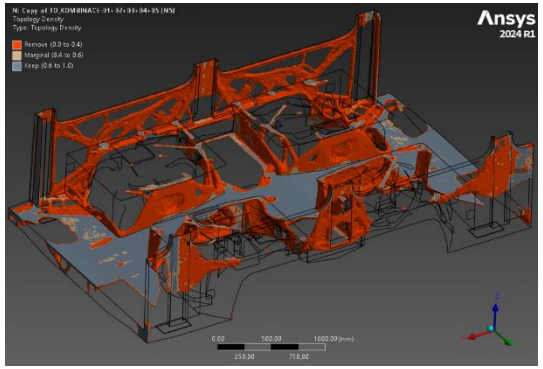
4-WP09-001: Design of selected key node of railway/tram body

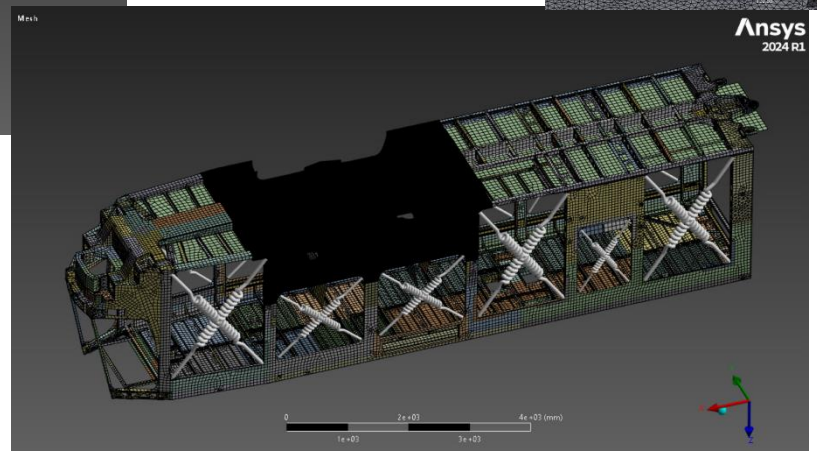
- Creation of a numerical model for the topological optimization of the super carriage nest, the calculation of the topological optimization of the super carriage nest is currently in progress











Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

4-WP09-002: Technology for the production of selected key structure

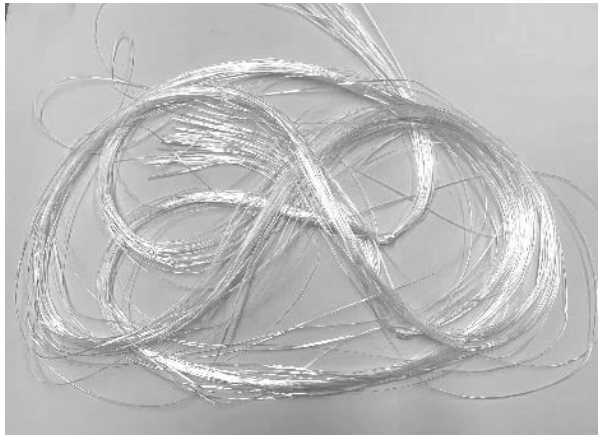
- Realisation of the result is related to the solution of previous activity „Design of selected key node of railway/tram body“. The data for the report is collected during the solution
- Description of the technology used for the production of the selected part, including the rationale for its selection. Describe the improved properties of the key structure that have been achieved

NOTE to optimization process - in the course of solving the topological optimization of the entire structure of the tram link, the possibility of using topographic optimization will be also addressed.

Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

4-WP09-003: Principles of crack detections of composite shaft

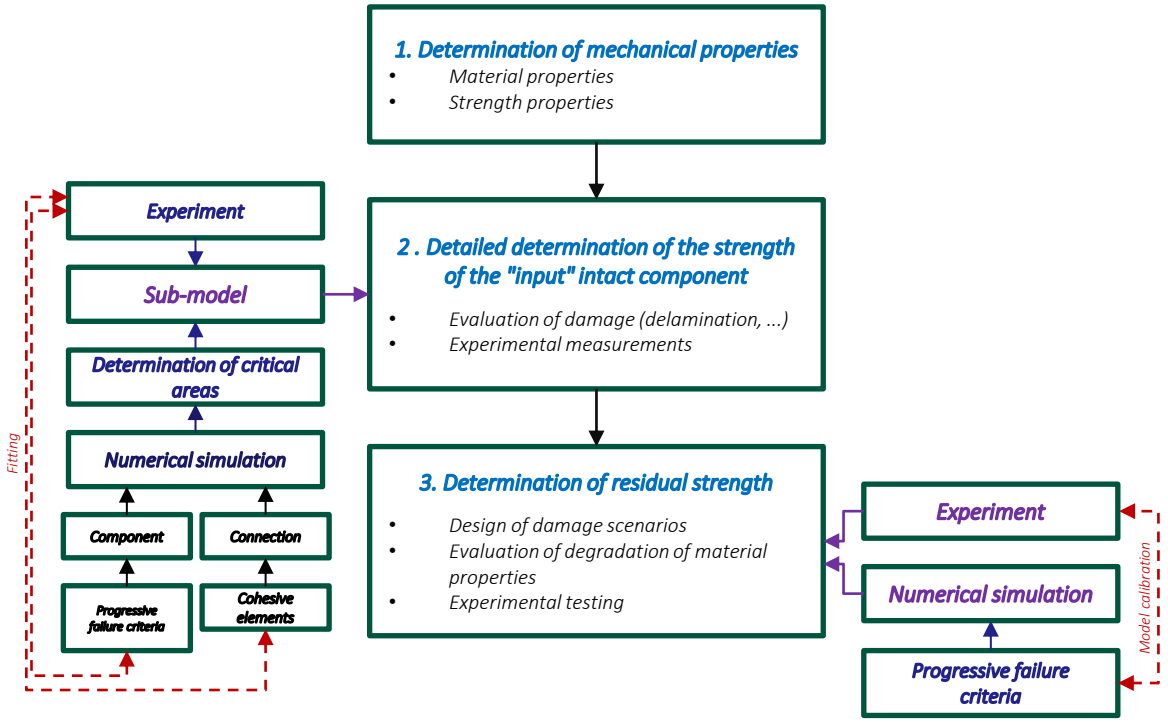
- Proposal of the initial methodology for evaluating the residual strength of composite shafts with local failure, creation of associated numerical submodels based on the FEM principle, selection and study of mechanical failure criteria for the prediction of residual strength of composite shafts with local failure, design of test samples and functional samples of submodels
- Proposal of a basic methodology for identification of parameters of progressive violation criteria enabling prediction of the problem addressed
- Production of test samples and functional samples of submodels (R-310 - S-2 Glass ®Roving and UD CFRP T700 12k (carbon roving)

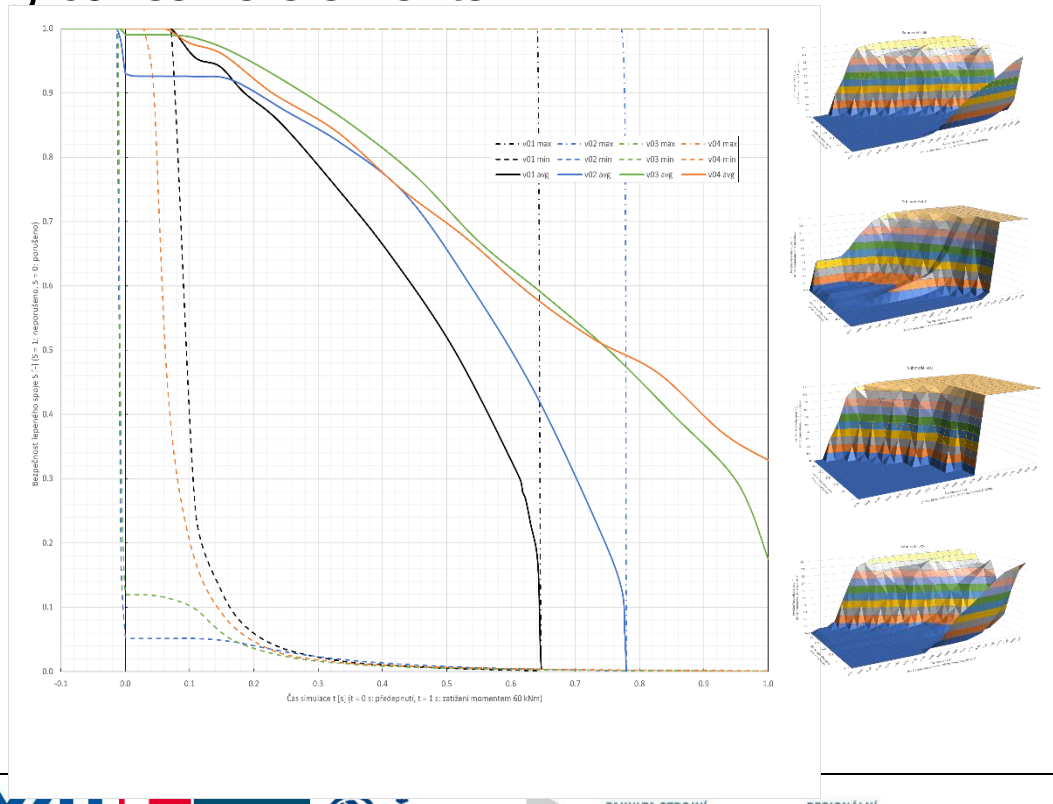


Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

4-WP09-003: Principles of crack detections of composite shaft

- Proposal of a basic methodology for identification of parameters of progressive violation criteria enabling prediction of the problem addressed - analysis of the behaviour of the bonded joint at the shaft-flange interface using cohesive elements

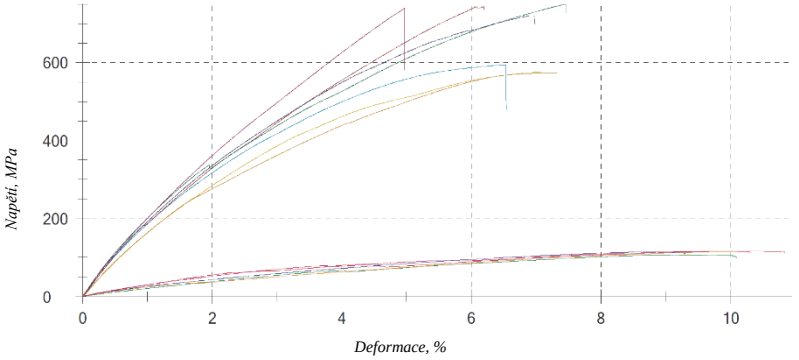


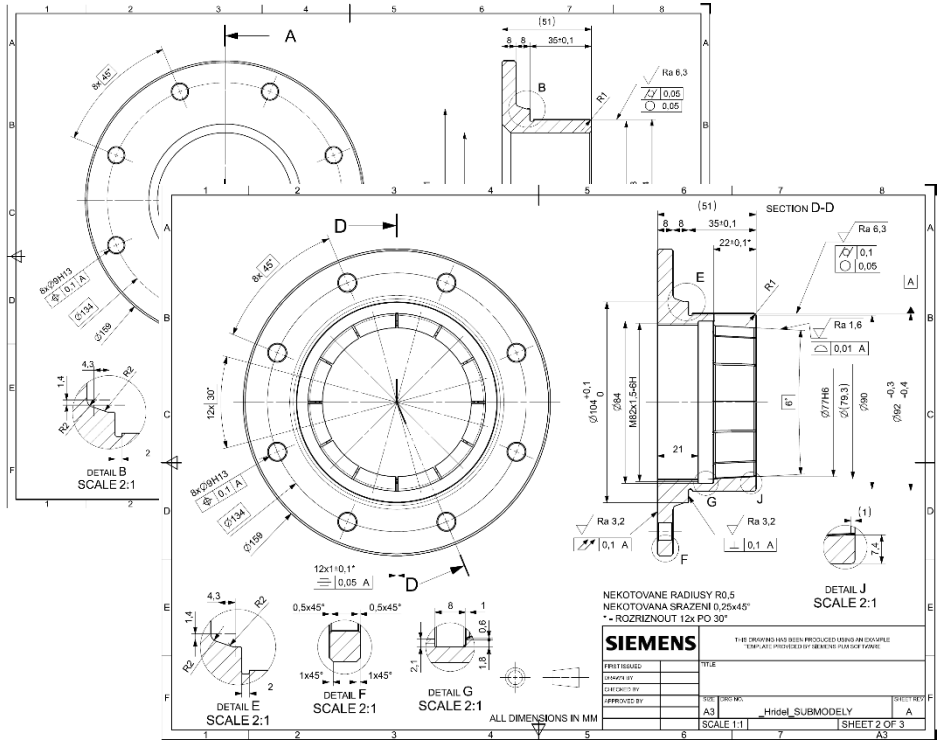


Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

4-WP09-003: Principles of crack detections of composite shaft

- Production of test samples and functional samples of submodels (R-310 - S-2 Glass ®Roving and UD CFRP T700 12k (carbon roving)

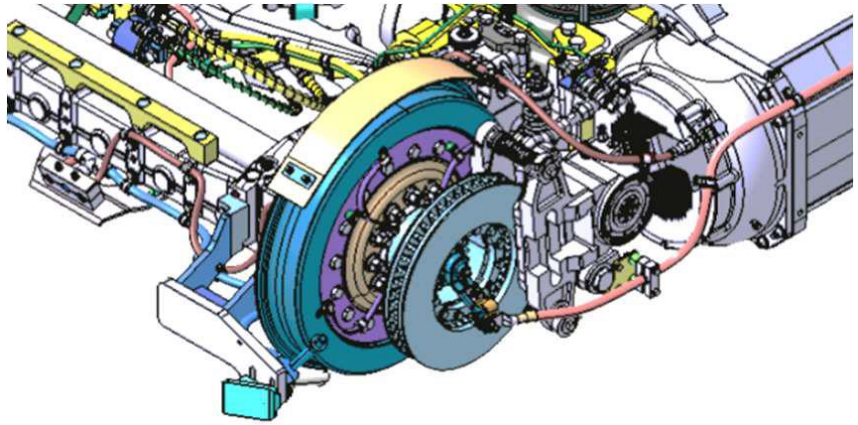


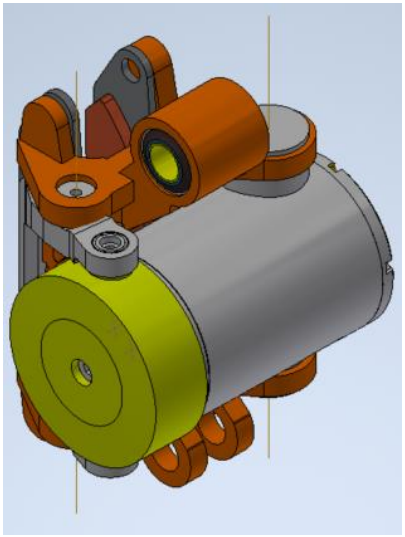


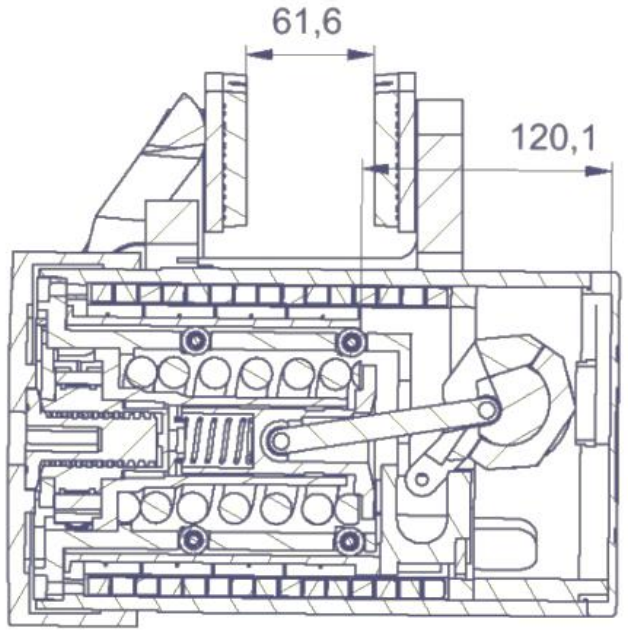
Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

4-WP09-004: The electro mechanical brake actuator for use on rolling stock

- Refinement of the design solution in terms of minimum building space
- Creation of technical documentation for the first parts
- Preparation of production and search for suppliers





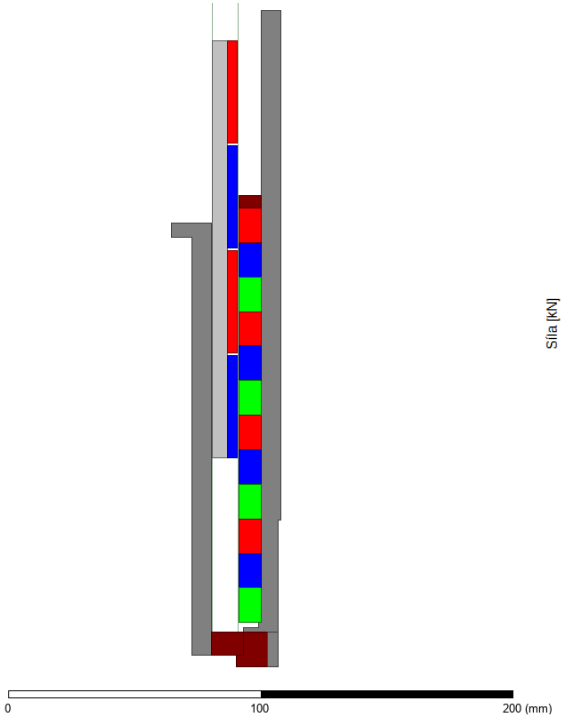


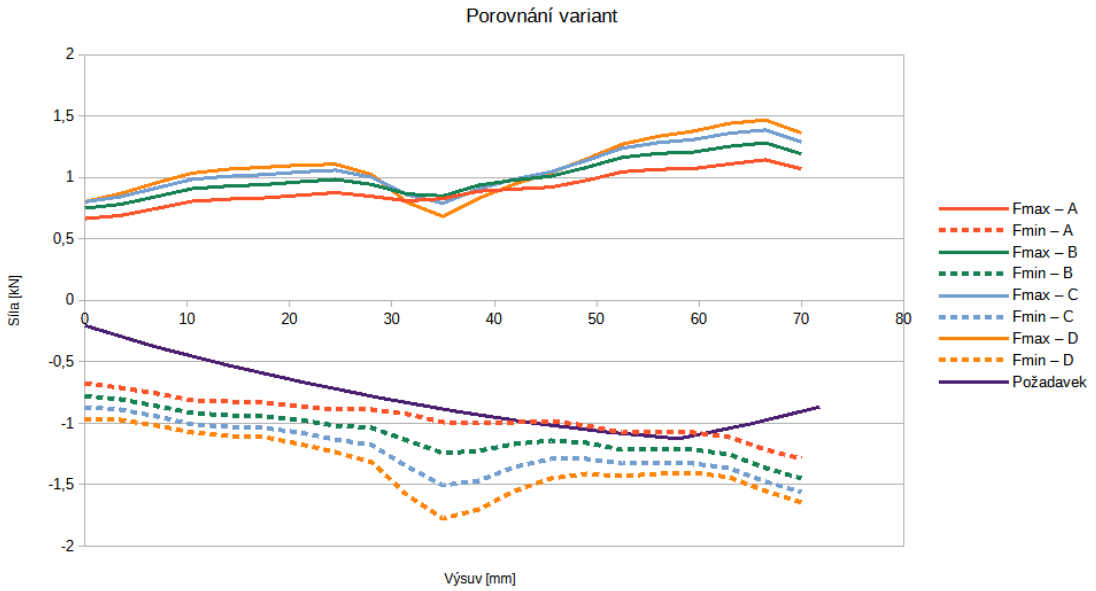
An overview of the brake mounting

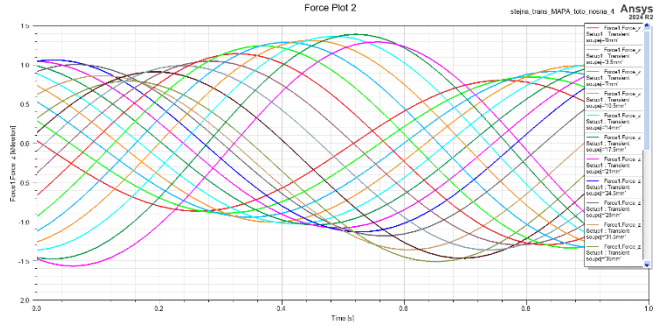
Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

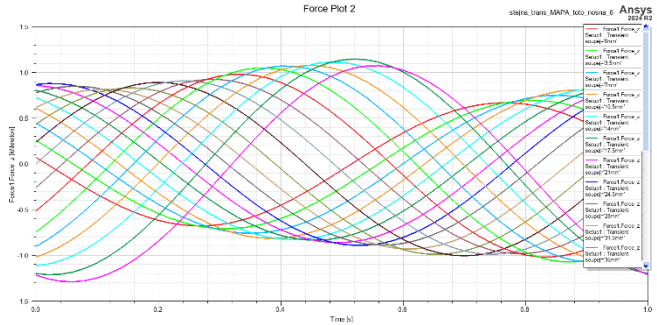
4-WP09-004: The electro mechanical brake actuator for use on rolling stock

- Modifications of electro-magnetic and mechanical model of the brake force source
- Simulation of magnetic forces









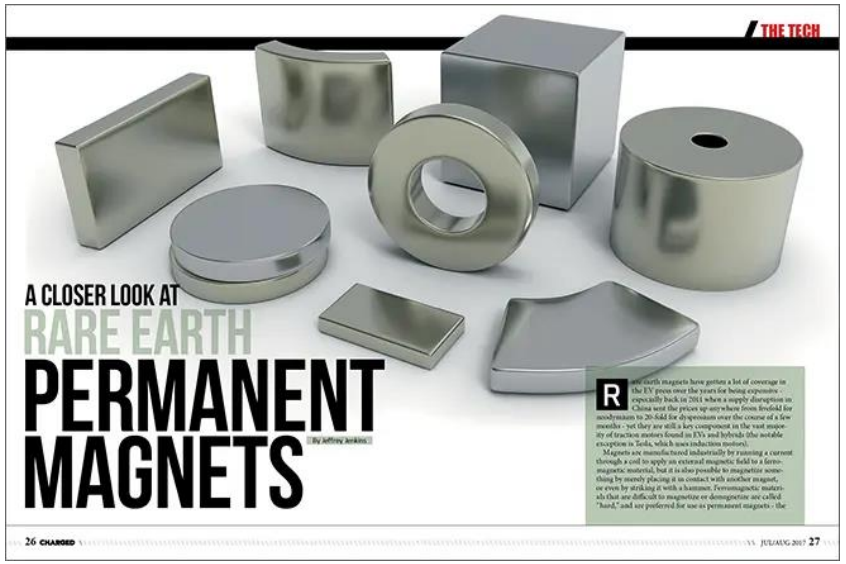
Comparison of variants to requirements

Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

4-WP09-004: The electro mechanical brake actuator for use on rolling stock

- Production preparation and supplier search

Angle sensor



Permanent magnets

Activities in 4-WP09 Tools of Design and Components for Advanced Vehicles

4-WP09-005: Applicability of electric coils in the field of electro-mechanical brake design

- Realisation of the result is related to the solution of previous activity „The electro mechanical brake actuator for use on rolling stock". The data for the report is collected during the solution.
- The research report will contain both a detailed description of the individual phases of the construction/design, as well as results from measurements of sub-components, simulations and proposals for construction solutions.

Fulfillment of goals and deliverables of 4-WP09 Tools of Design and Components for Advanced Vehicles

Current State of Deliverables and Fulfillment of Goals

- 4-WP09-001 | **Design of selected key node of railway/tram body – in progress & no delays:**
  - The final optimization calculations are in progress.

- 4-WP09-002 | **Technology for the production of selected key structure – in progress & no significant delays:**
  - The research report will continue after the final decision on the design of the selected part (and structure, material,...)

- 4-WP09-003 | **Principles of crack detections of composite shaft – in progress & no significant delays:**
  - Testing of material properties and behaviour of the bonded joint at the shaft-flange interface using cohesive elements.

Fulfillment of goals and deliverables of 4-WP09 Tools of Design and Components for Advanced Vehicles

Current State of Deliverables and Fulfillment of Goals

- 4-WP09-004 | **The electro mechanical brake actuator for use on rolling stock – in progress & no delays:**
  - The selection of the brake type (passive/active) and its characteristics has been made, and the coil (actuator) design phase is in progress.

- 4-WP09-005 | **Applicability of electric coils in the field of electro-mechanical brake design – in progress & no significant delays:**
  - Will be done after a design of the electric coil.

Fulfillment of goals and deliverables of 4-WP09 Tools of Design and Components for Advanced Vehicles

List of Due Deliverables and Their Added Value

- 4-WP09-001 | **Design of selected key node of railway/tram body**
  - The economic benefits primarily arise from the lighter weight of the vehicle. Lower energy consumption for vehicle operation (The level of energy savings depends on the selected optimization node, but according to the study, savings of up to 50% could be achieved with a comprehensive solution of the entire rough construction) and lower dynamic impacts in the wheel-rail system. This can extend the maintenance intervals for both the track and the vehicle. With the help of structural optimizations, it is also possible to create a very attractive and futuristic design that could attract more passengers to the railway.

- 4-WP09-002 | **Technology for the production of selected key structure**
  - The report will outline the benefits and drawbacks of the developed optimization technique and evaluate its potential for widespread application in the industry. It will also include a plan for disseminating the acquired knowledge. This activity will expand the competence of the ROs and IOs involved.

Fulfillment of goals and deliverables of 4-WP09 Tools of Design and Components for Advanced Vehicles

List of Due Deliverables and Their Added Value

- 4-WP09-003 | **Principles of crack detections of composite shaft**
  - The report shall clearly identify the benefits and drawbacks of the developed crack detection principles and evaluate and formulate requisites to be applied widely in the industry. Moreover, knowledge dissemination will occur as a part of this activity. As this activity results, the competence of the ROs and IOs will be expanded.

- 4-WP09-004 | **The electro mechanical brake actuator for use on rolling stock**
  - The main goal of the proposed subproject is to support the competitiveness of the Czech railway industry by innovative components. Tram car operators are the final customers of this result.

- 4-WP09-005 | **Applicability of electric coils in the field of electro-mechanical brake design**
  - The report will describe the workflow of the development of the design of actuator for electro mechanical brakes. This report will be used for disseminating the acquired knowledge and it will be used to expand the competence of the ROs and IOs involved in.

Current contribution of 4-WP09 Tools of Design and Components for Advanced Vehicles

Assessment of the Contribution of Deliverables

- The structural optimization addressed in this activity is generally a powerful tool for optimizing parameters and properties of structures and has implications for future cooperation not only with ŠTRN. – also linked to 4-WP10
- The residual life of composites is one of the poorly known properties not only for shafts and the knowledge gained can be applied subsequently to similar composite parts, not only shafts. – also linked to 3-WP09
- The requirements for braking systems are complex and specific to rolling stock and the application of electro-magnetic actuators will help to significantly advance the possibilities of replacing hydraulic or engine driven brakes.

Current contribution of 4-WP09 Tools of Design and Components for Advanced Vehicles

Assessment of the Formal/Administrative Goals of the Work Package

	UWB (RTI FEE)	BUT	VZUP	STRN	DAKO
Administrative	According to plan	According to plan	According to plan	According to plan	According to plan
Commercialization	OK	OK	OK	OK	OK
Deliverables	According to plan	According to plan	According to plan	According to plan	According to plan

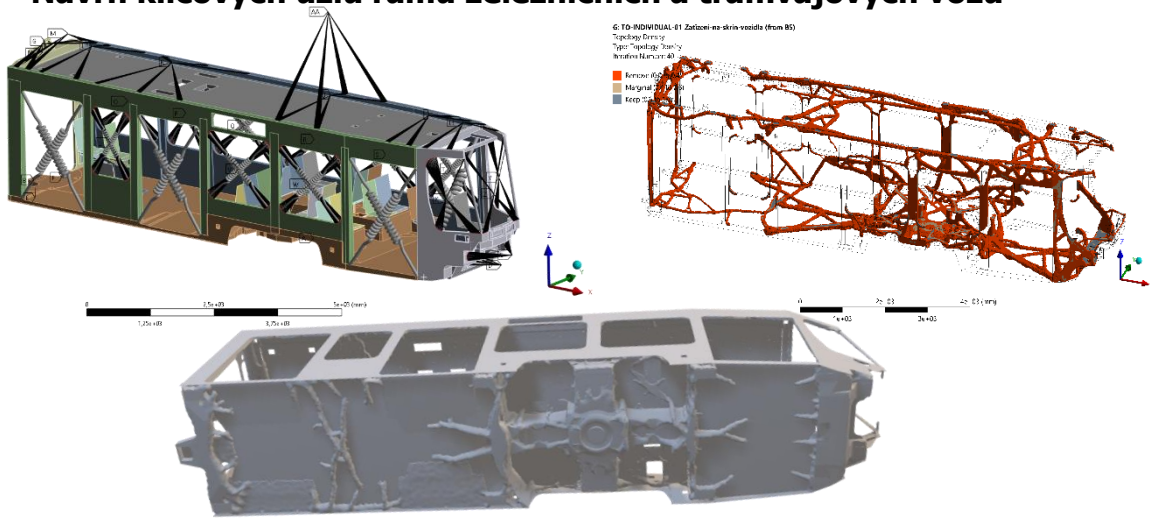
Current contribution of 4-WP09 Tools of Design and Components for Advanced Vehicles

Acknowledgment

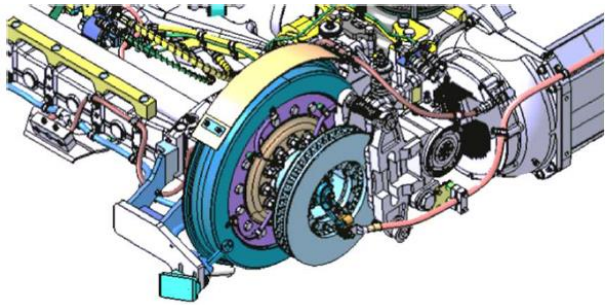
This research has been realized using the support of Technological Agency, Czech Republic, programme National Competence Centres II, project # TN02000054 Božek Vehicle Engineering National Center of Competence (BOVENAC).

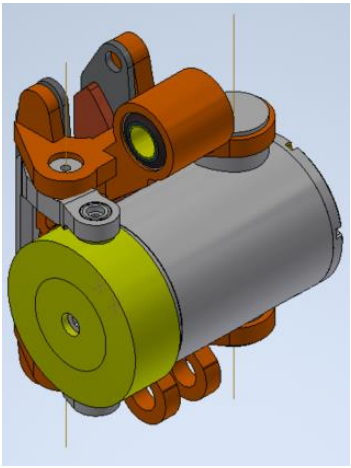
Výtah z prací 2023-2025 na 4-WP09 Konstrukční nástroje a součásti pro pokročilá vozidla

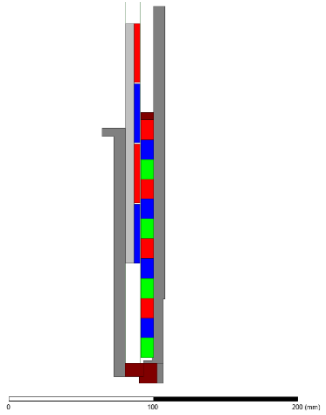
Návrh klíčových uzlů rámů železničních a tramvajových vozů

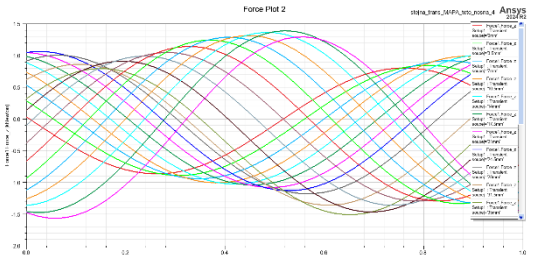


Elektro-mechanický aktuátor brzdy

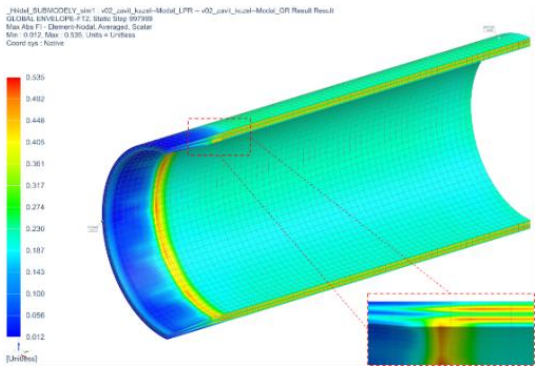


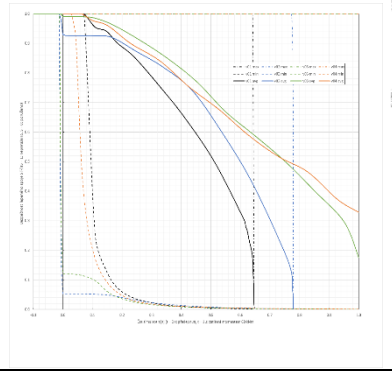


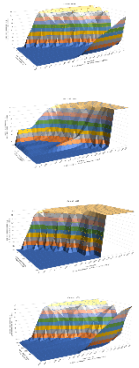




Principy pro detekci trhlin kompozitního hřídele

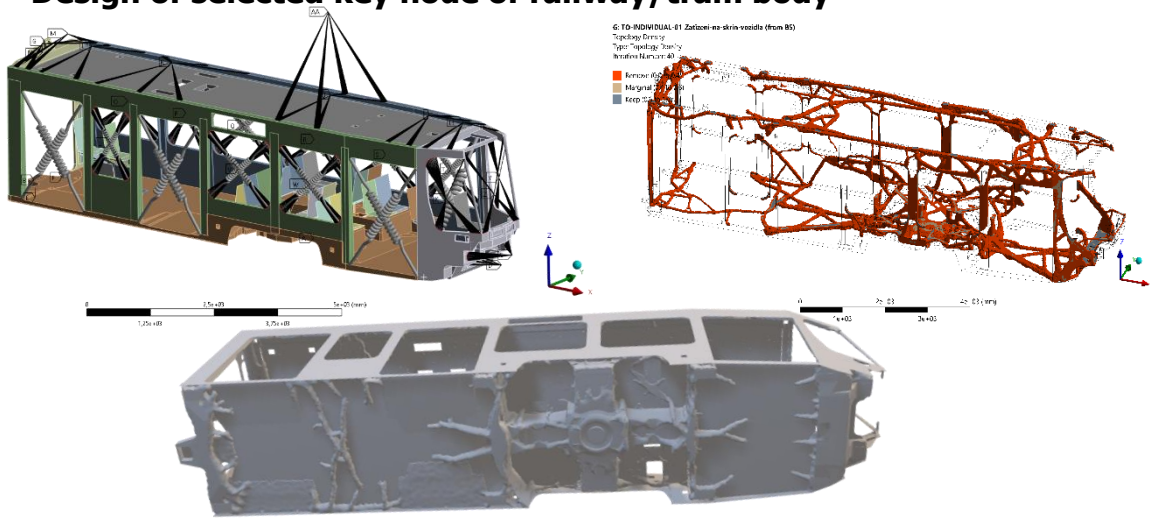




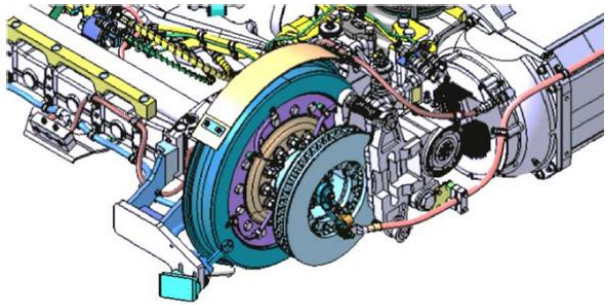


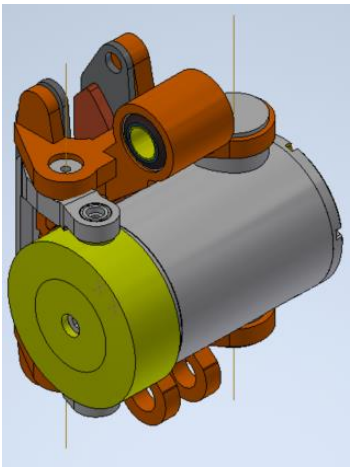
Results of 4-WP09 Optimized Component Design for Future Rail Vehicles–Achieved 2023-2025

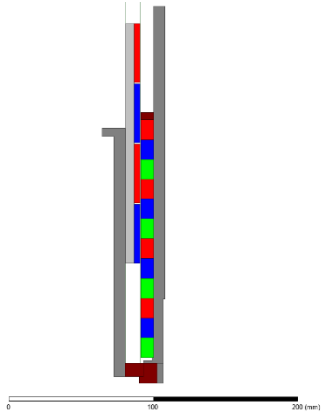
Design of selected key node of railway/tram body

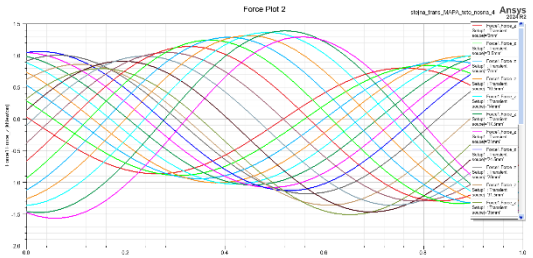


The electro mechanical brake actuator

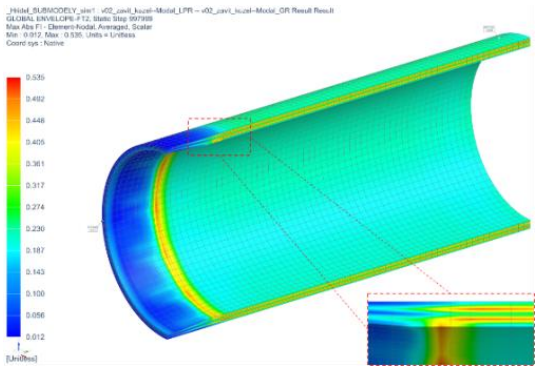


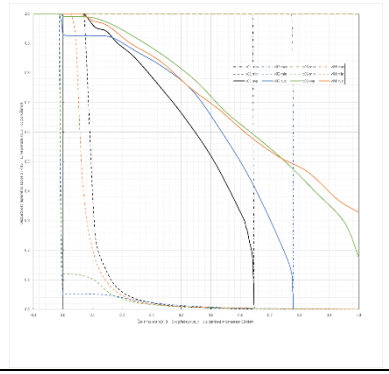


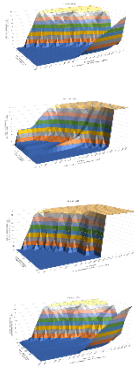




Principles of crack detections of composite shaft

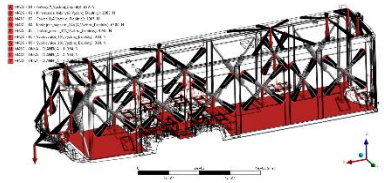


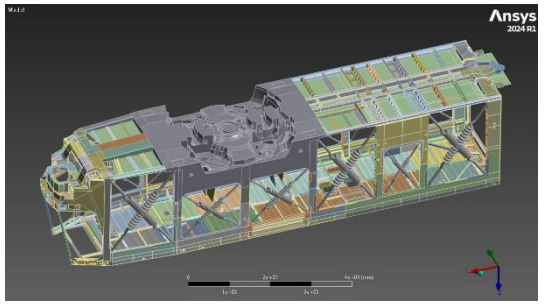


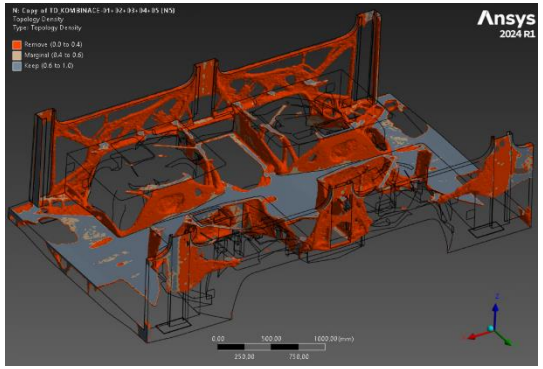


Výtah z prací 2024 na 4-WP09 Konstrukční nástroje a součásti pro pokročilá vozidla

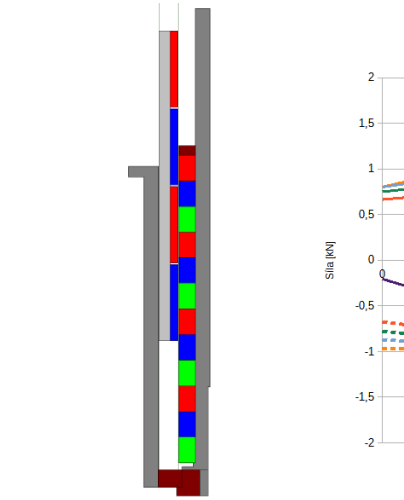
Návrh klíčových uzlů rámů železničních a tramvajových vozů

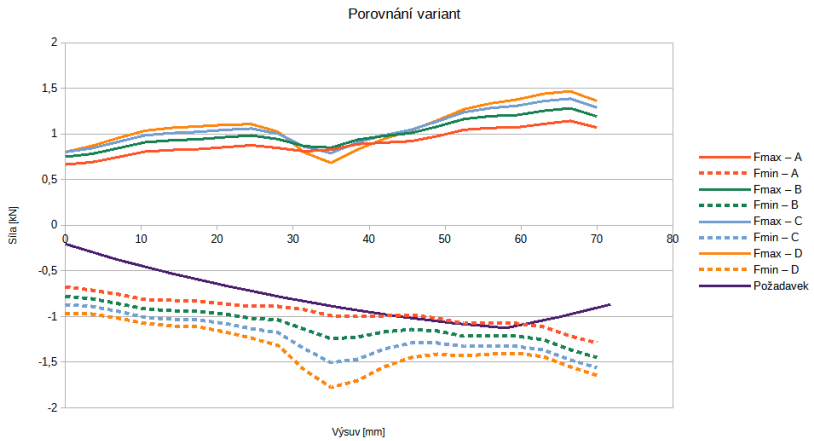




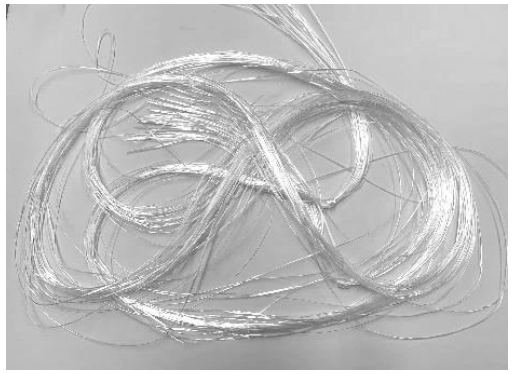


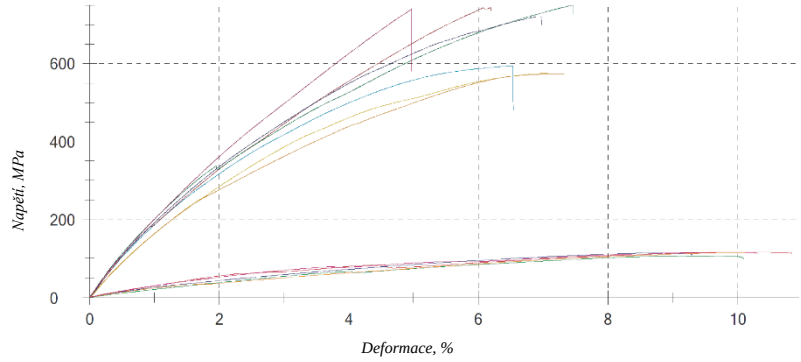
Elektro-mechanický aktuátor brzdy





Principy pro detekci trhlin kompozitního hřídele

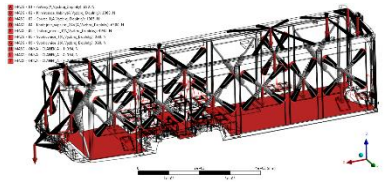


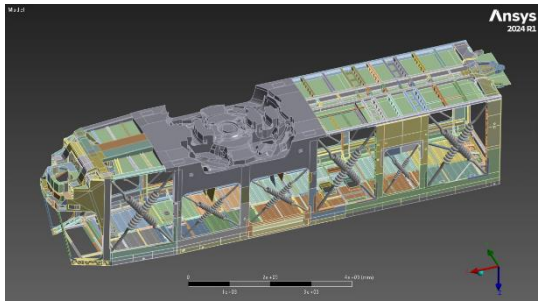


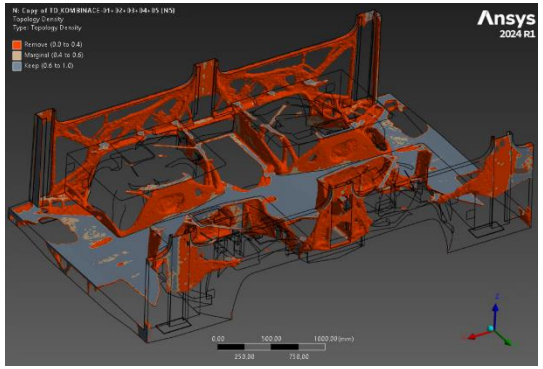
Pavel Žlábek

Results of 4-WP09 Optimized Component Design for Future Rail Vehicles–Achieved 2024

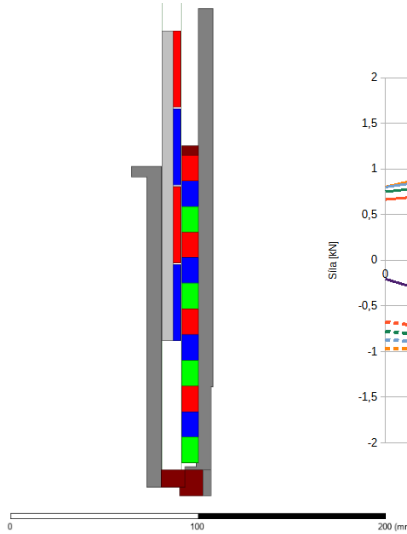
Design of selected key node of railway/tram body

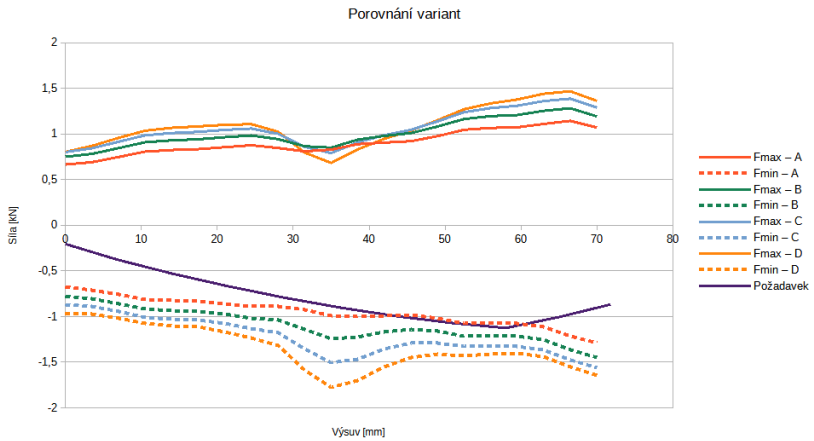






The electro mechanical brake actuator





Principles of crack detections of composite shaft