Contents of Work Package 2-WP02

2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions

Coordinator of the WP

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Participants of the WP

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Main Goal of the WP

2-WP02-002: Modular semi-active damper for application in railway vehicle bogie.

2-WP02-004: Telescopic shock absorber with variable damping reacting to changes of vehicle load.

Partial Goals for the Current Period

2-WP02-001: Controller for semi-active damper.

2-WP02-003: Simulation verification of the semi-active damping benefits in the bogie of electric locomotive.

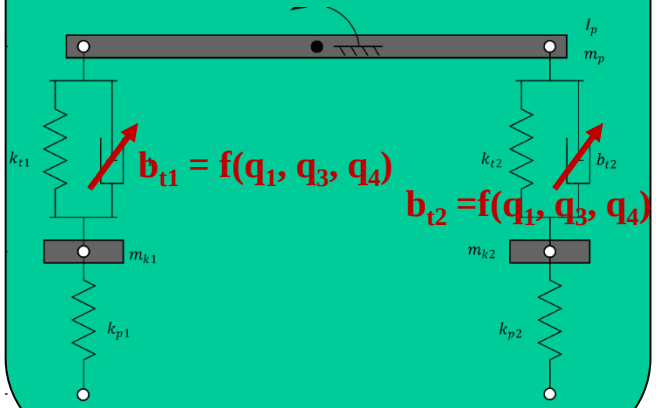
2-WP02-005: Papers/conferences related to semi-active damping.

Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions

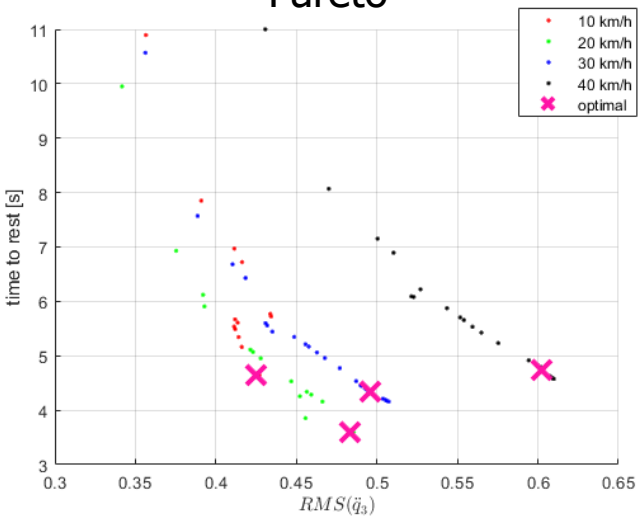
Shock absorber design

Road profile

Phenomenological model

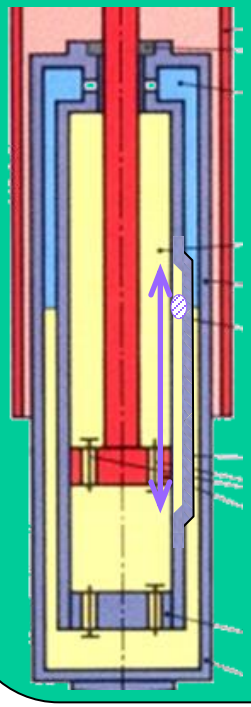


Pareto



Damper parameters optimization

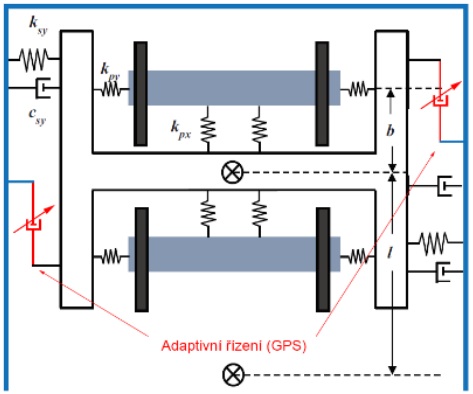
Physical model



Groove parameters

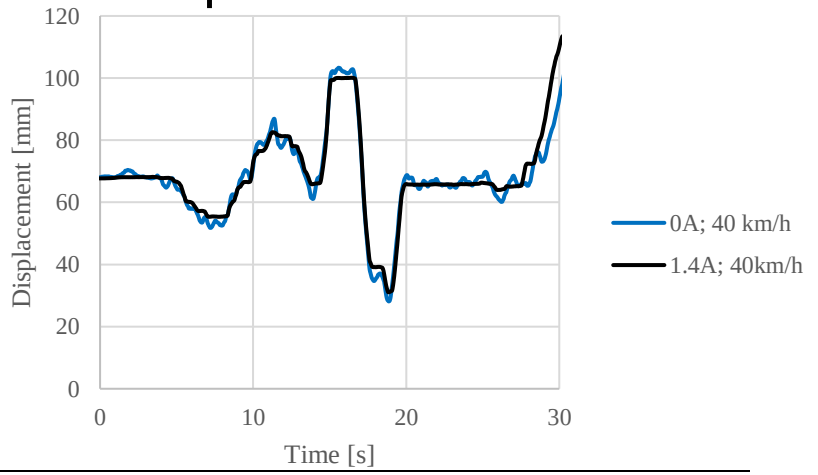
Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions

Rail bogie yaw damper



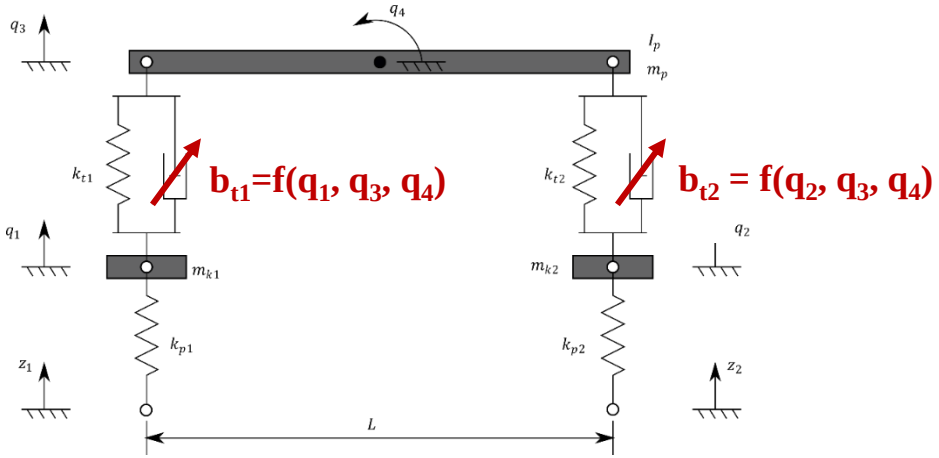
Fast current controller

Damper deformation



Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions: Small truck shock absorber

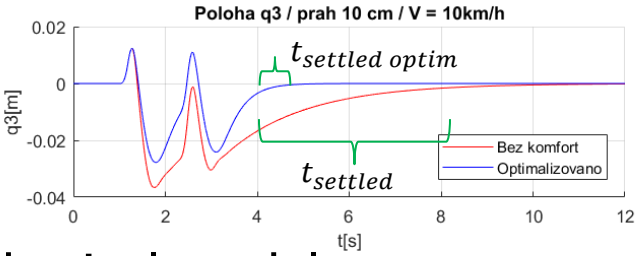
- Telescopic shock absorber with variable damping characteristics
  - Passive variant is selected
  - Shock absorber extended with comfort zone part
  - Comfort zone realization: inner valve has groove with specific characteristics
- Shock absorber: design for particular case, phenomenological model
  - Phenomenological model is tuned to measured behaviour of the existing damper
  - The model is modified to cover the groove influence on the damping forces
  - Dampers are incorporated into the half-car model



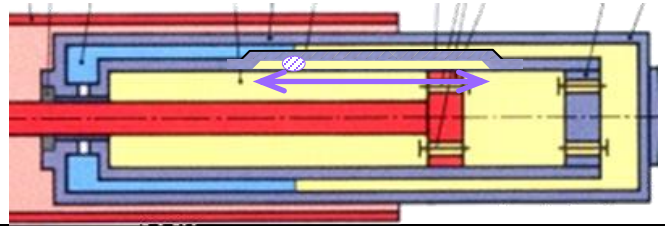
Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions: Small truck shock absorber

- Shock absorber: design for particular case, optimization process
  - Multicriterial optimization process is performed over the half car model: global optimization method based on genetic algorithm
  - Objective function covers the riding comfort (for passangers, cargo,...), responce time (reduction of residual vibrations) and also reflex driving stability

$$OF = \sum_{v} (a_{1v} RMS(\ddot{q}_3) + a_{2v} RMS(\ddot{q}_4) + a_{3v} t_{settled})$$

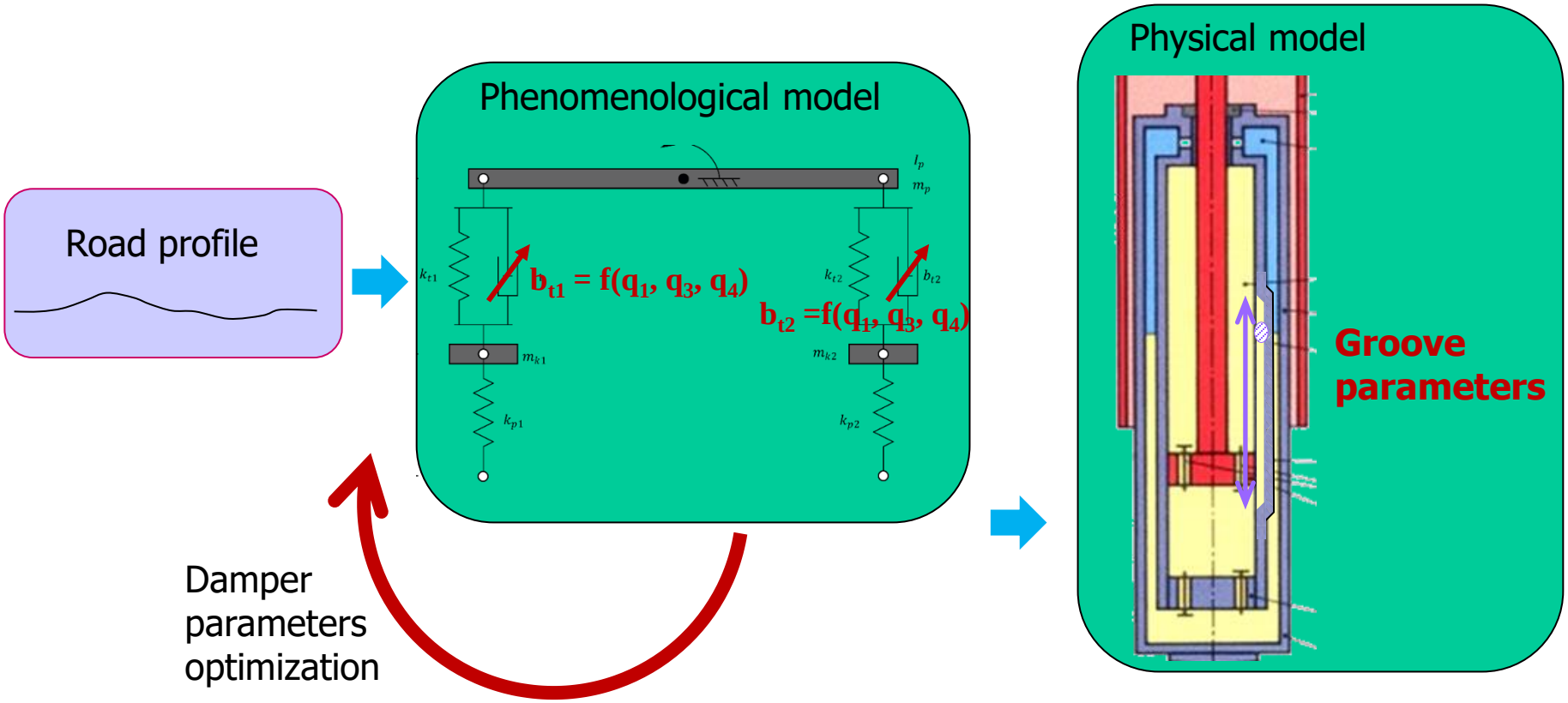


- Shock absorber: design for particular case, physical model
  - Physical model is based on the liquid flux theory to simulate real shock absorber behaviour
  - Model input is optimized damper characteristic from the phenomenological model
  - Groove cross section is obtained after its identification in the physical model



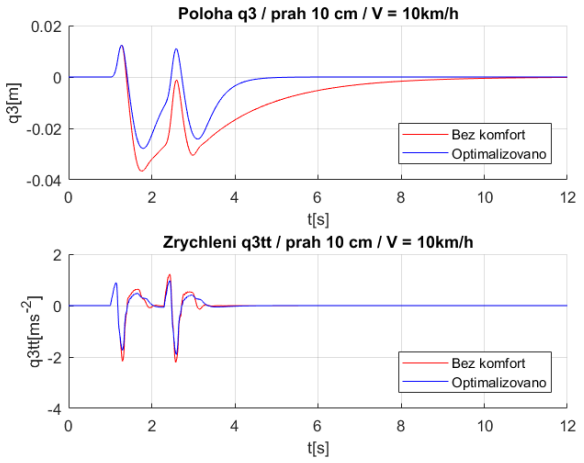
Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions: Small truck shock absorber

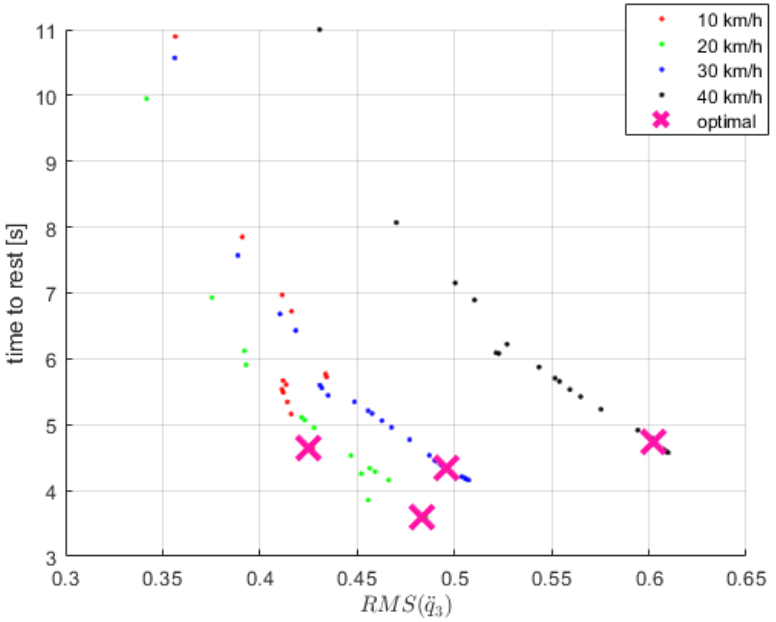
- Shock absorber: design for particular case, design process overview



Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions: Small truck shock absorber

- Shock absorber: design for particular case, design process overview
  - Optimization process is currently running
  - Objective function is still tuned
  - Current best solution, road profile: 10cm bump:

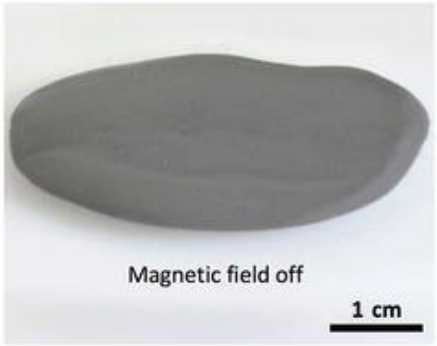




- Technological process development
  - Groove manufacturing process development is running to ensure prescribed parameters

Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions: Magnetorheological (MR) technology

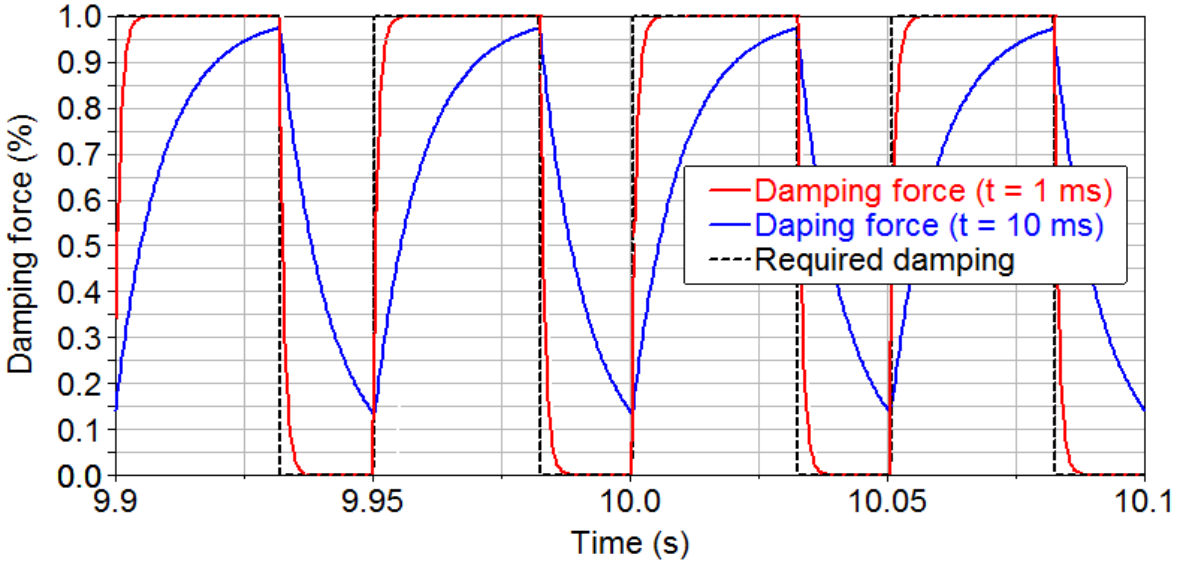
MR fluid

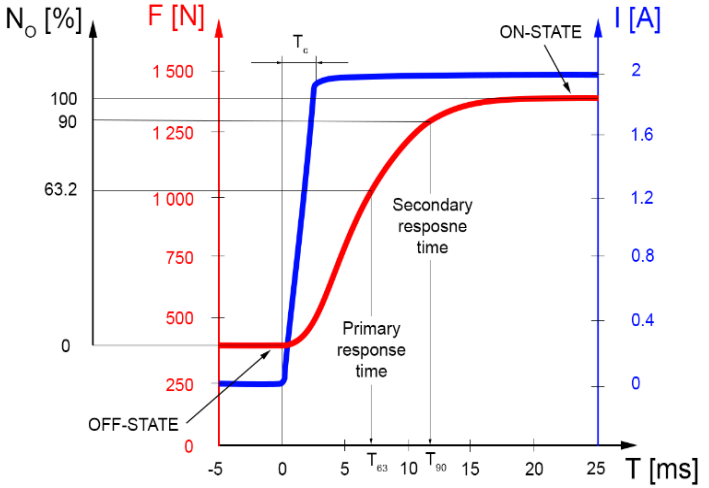


MR damper

Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions : Introduction

Semiactive control of damper

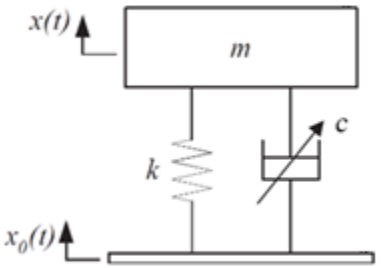




The faster response the better met of requirement

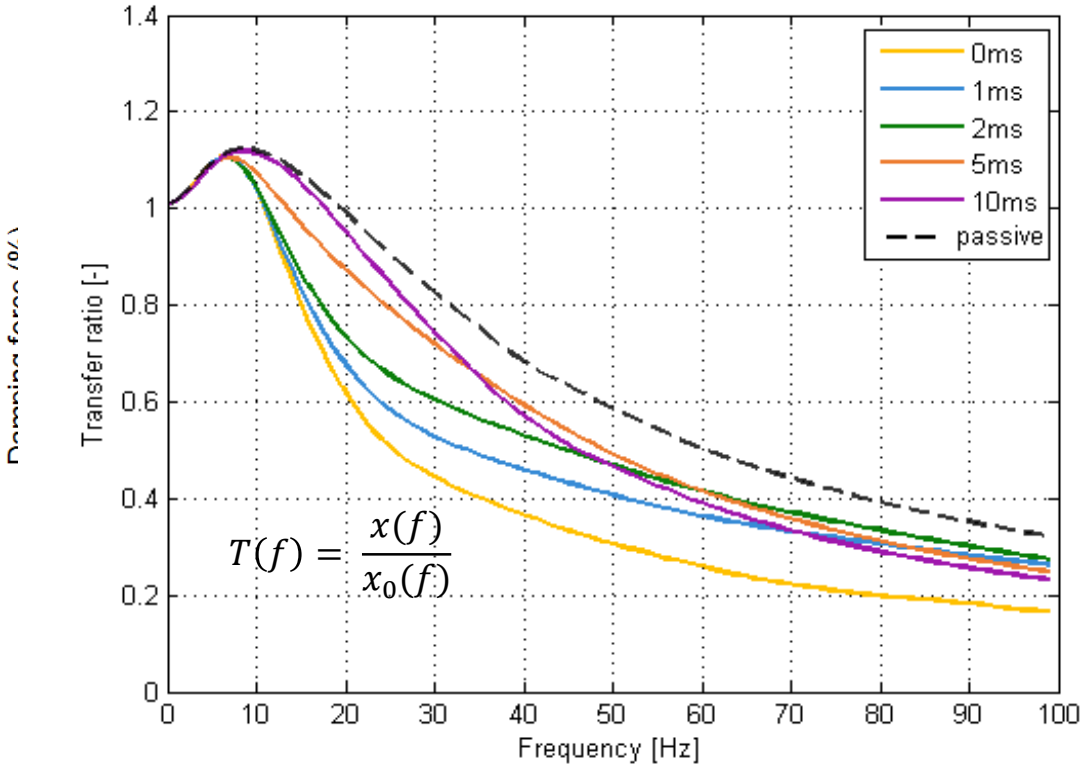
Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions : Introduction

Response time influence on semiactive vibration isolation



ON/OFF Skyhook

$$\dot{x} \cdot (\dot{x} - \dot{x}_0) \geq 0 \rightarrow c = c_{max}$$
$$\dot{x} \cdot (\dot{x} - \dot{x}_0) < 0 \rightarrow c = c_{min}$$



Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions : MR damper with short time response

Response time sources:

- eddy current in coil core

PATENTED

307249

- time response of MR fluid itself

GAČR
GRANTOVÁ AGENTURA ČESKÉ REPUBLIKY
Junior Grant 2020

- current rise (current controler)

PATENTED

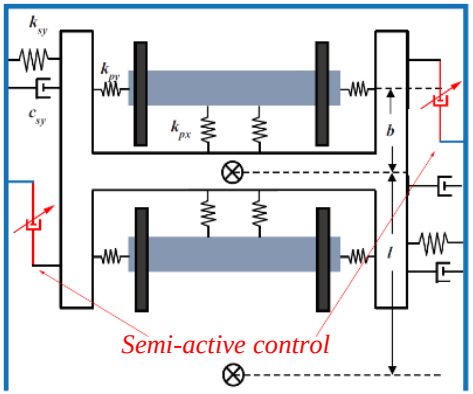
304636

Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions : Railway vehicle application

Yaw damper

Převzato z https://zdopravy.cz/

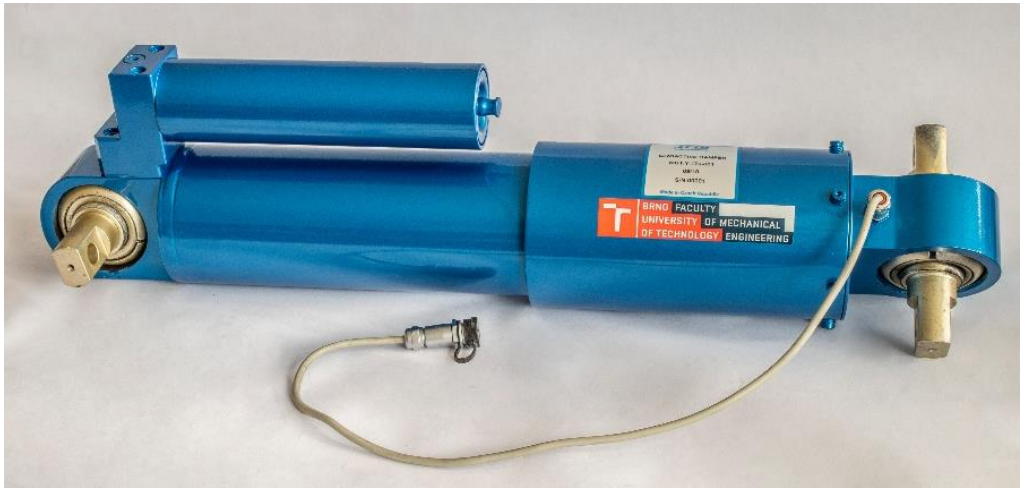
Required trajectory

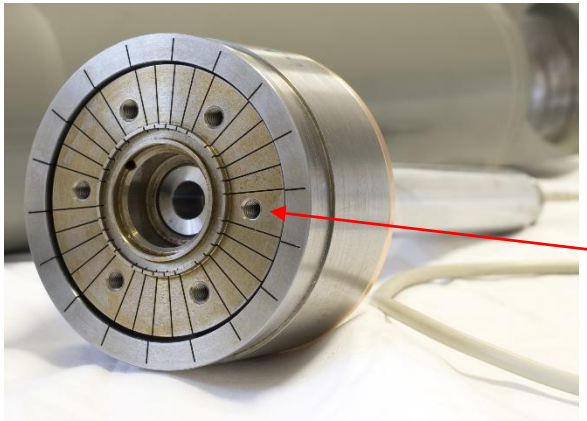


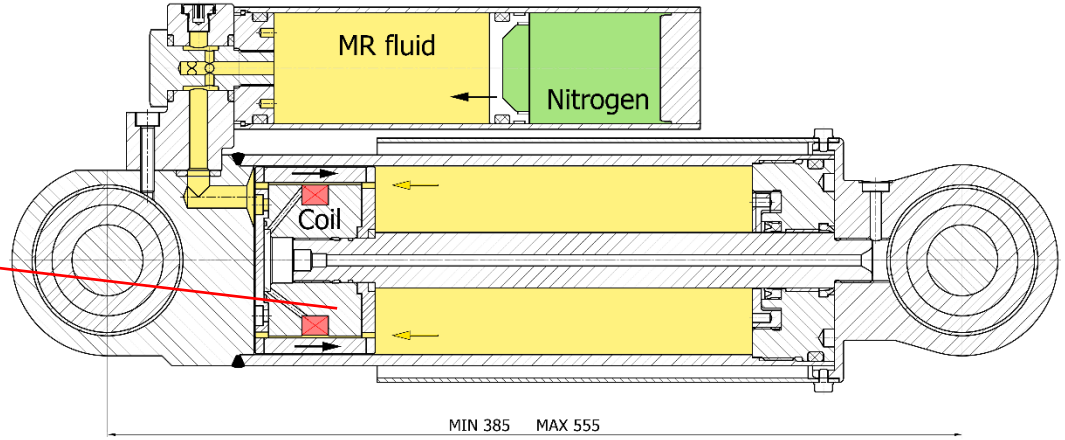
Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions: MR damper for railway application

Yaw damper

Damping force:	0-20 kN
MR fluid volume:	1,05 l
Response time:	8 ms
Power input:	15 W

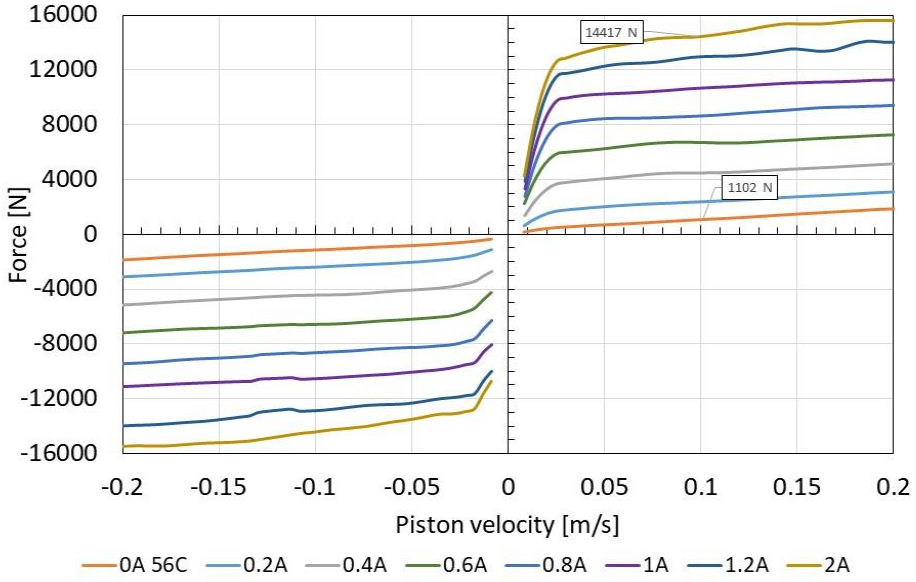




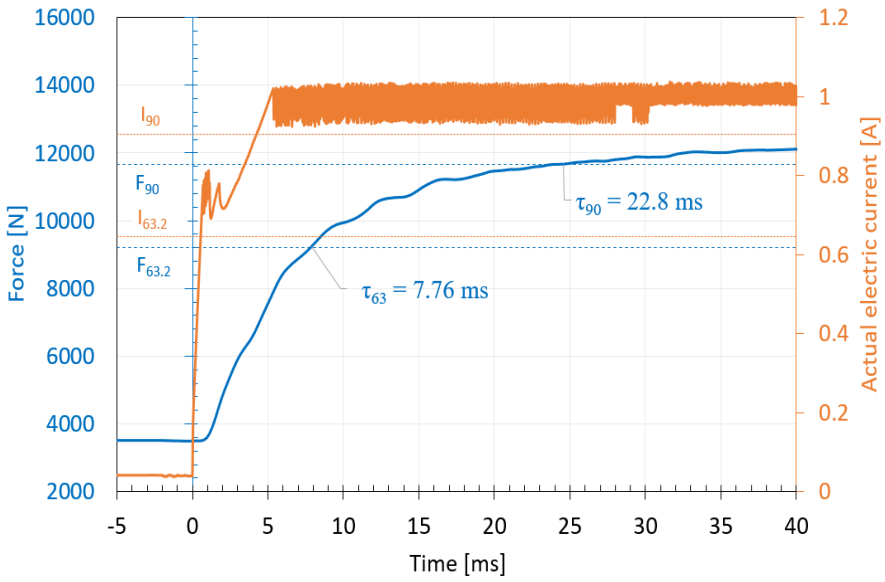


Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions: Measurement of damping force

Force velocity dependency (stroke ± 20 mm)

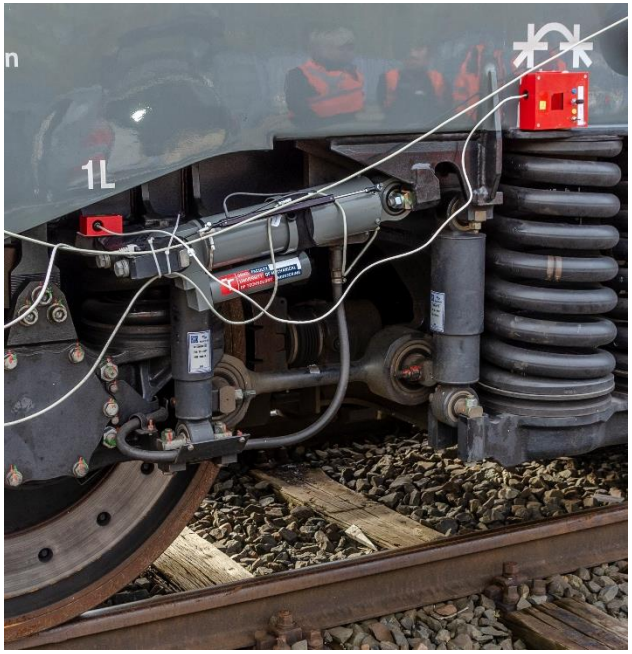


Force response time (piston velocity 0.2 m/s, 1 A)



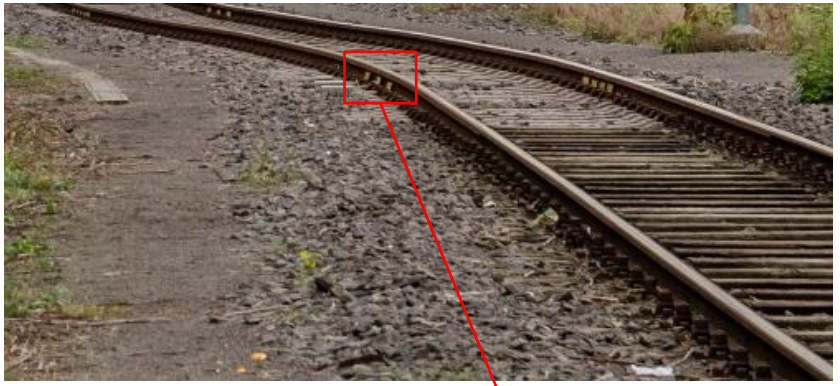
Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions: In-service tests

Vehicle speed: v = 25; 40 km/h



Displacement & acceleration measurement

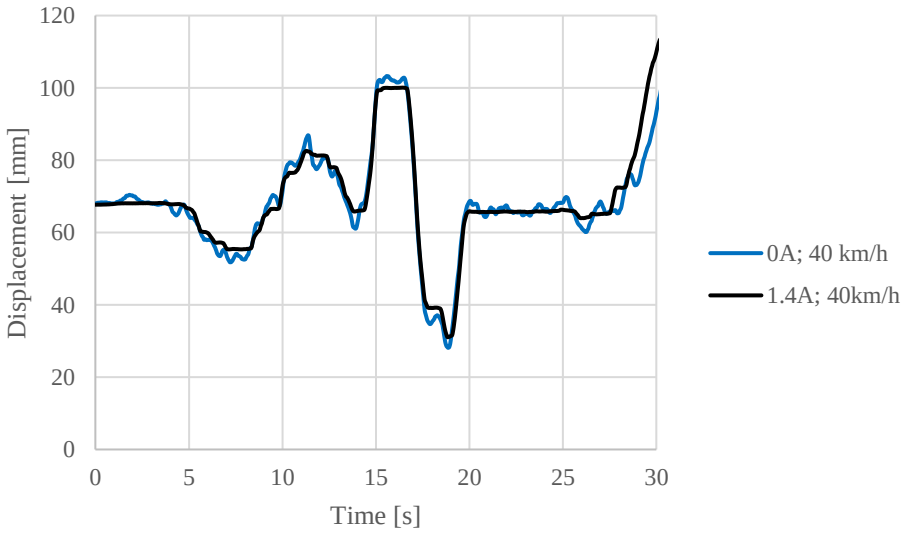
Test track: Minden, Germany
R 190m



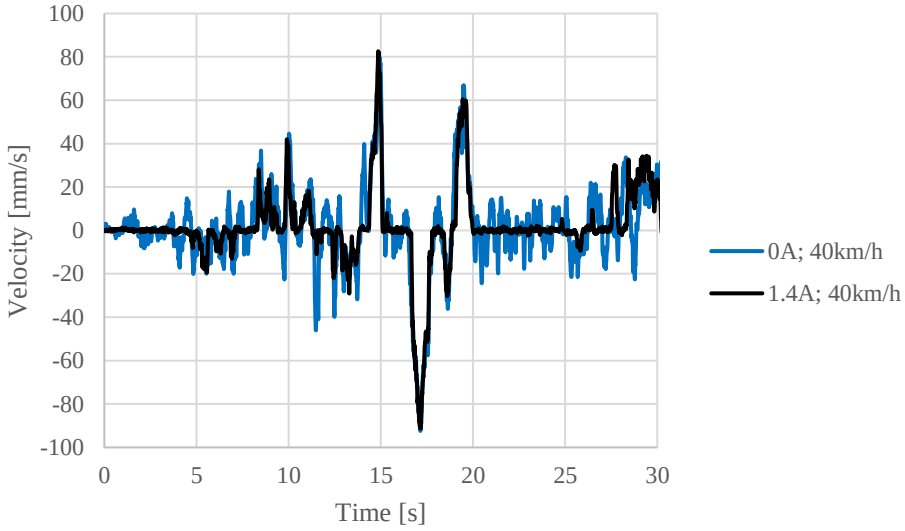
Force measurement

Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions: In-service tests

Deformation of the damper



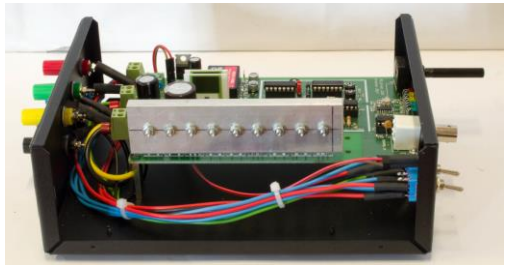
Deformation velocity of the damper



Activities in 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions: Controller for semi-active damper

Fast curent controler

- Enables quick changes of current in inductive loads
- Max current: 4 A
- Rise time 0-2 A: <1 ms (MR damper coil inductance 150 mH)
- Max. Output voltage: 160 V
- Input voltage: 12 V
- Dimensions: 215x160x70 mm



Fulfillment of goals and deliverables of 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions

Current State of Deliverables, Milestones and Fulfillment of Goals

The milestone 2-WP02-002 Modular semi-active damper for application in railway vehicle bogie is finished and functional sample is assembled and tested. The 2-WP02-001 Controller for semi-active damper is finished. Simulations for 2-WP02-003 Simulation verification of the semi-active damping benefits in the bogie of electric locomotive were realized in parallel with hardware development, the software is in the debug and testing phase. Publications in 2-WP02-005 Papers/conferences related to semi-active damping are issued.

The damper 2-WP02-004 Telescopic shock absorber with variable damping reacting to changes of vehicle load development is designed and optimal variant is selected. The technological tests are undertaken for final manufacturing the damper for prepairing the functional sample.

List of Due Deliverables and Their Added Value

2-WP02-002 Modular semi-active damper for application in railway vehicle bogie is finished. 2-WP02-001 Controller for semi-active damper is finishing its development. 2-WP02-003 Simulation verification of the semi-active damping benefits in the bogie of electric locomotive are in the postprocessing phase.2-WP02-005 Papers/conferences related to semi-active damping are issued. 2-WP02-004 Telescopic shock absorber with variable damping reacting to changes of vehicle load development is in the final phase of functional sample delivery.

Current contribution of 2-WP02: Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions

Assessment of the Contribution of Deliverables

Developed dampers are going to be in service railway and car producers participating on the project (e.g. Škoda). It helps to optimize driving properties of the related vehicles. The reduction of the accelerations to the vehicle body and to the road/track decreases their damage and failures during the transport. It increases the road persistence and reduces damage occurrence of the transported goods and increases passenger comfort.

Acknowledgement

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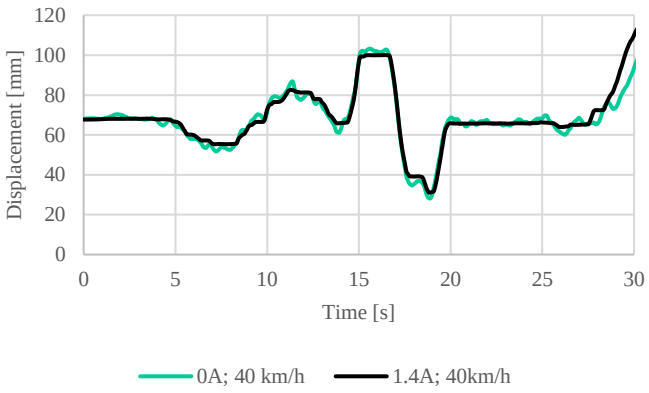
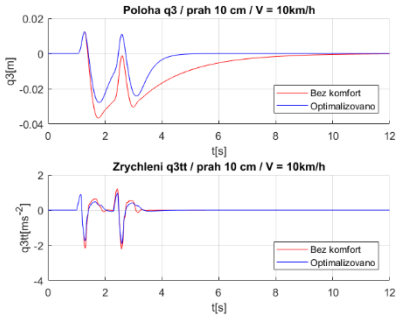
This support is gratefully acknowledged.

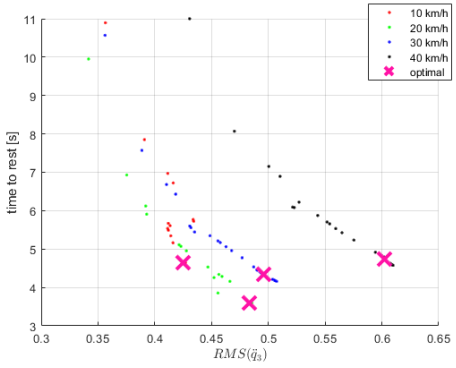
Výtah z prací 2019-2020 na DP2 WP02 Tlumení vertikálních a horizontálních kmitů vozidel

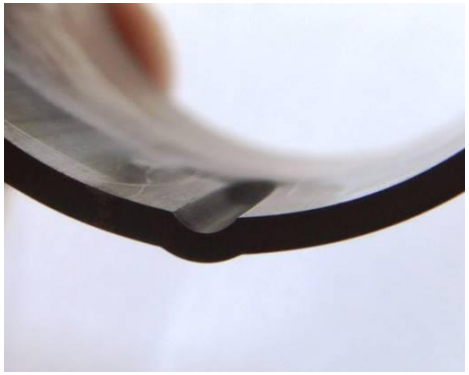
Modulární poloaktivní tlumič s rychlým řízením proudu pro aplikaci na železniční podvozky je vyvinut a otestován. Železniční vozidlo vykazuje snížení vibrací přenášených do kabiny.



Výzkum a vývoj tlumiče pro malé nákladní vozy s proměnnou tlumící charakteristikou reagující na zátěž vozidla. Pasivní řešení. Cílem je lepší pohodlí řidiče a zvýšená bezpečnost nákladu.

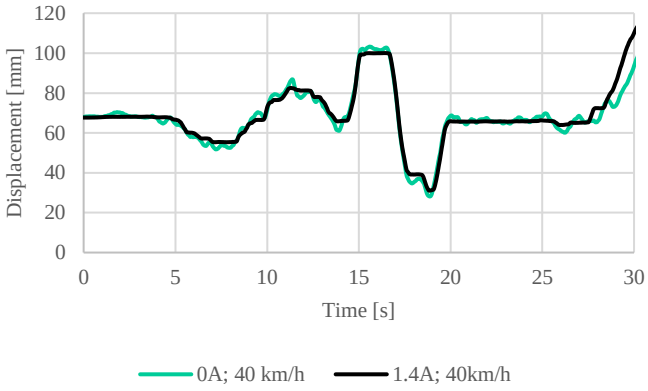






Results–Achieved of DP2 WP02 Damping of Vertical and Horizontal Vibrations in Vehicle Suspensions 2019-2020

Modular semi-active damper with fast current controller for application in railway vehicle bogie is developed and tested at railway test ring. The bogie vibrations are reduced.



Development of telescopic shock absorber for small lorries with variable damping reacting to changes of vehicle load, passive. Target: driving comfort, truckload safety.