

Squeal Noise Generation in the Wheel-Rail Contact with Modified Friction

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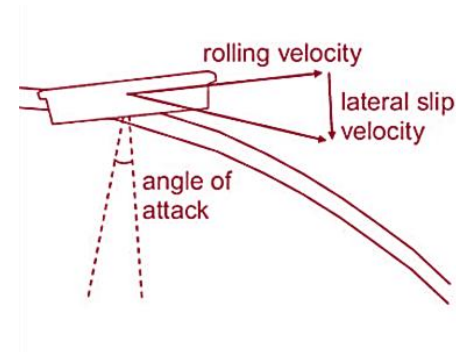
Paper 3

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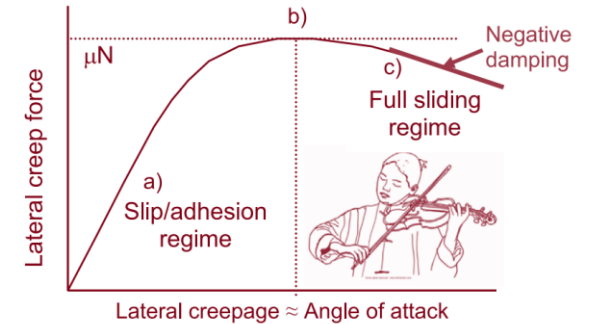
Conclusions

Introduction

Wheel squeal noise



(Thompson, 2009)



(Meehan & Liu, 2019)

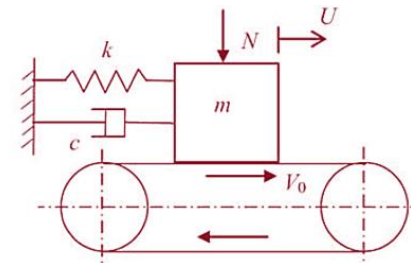
- Angle of attack
- Rolling velocity
- Lateral slip
- Contact pressure
- Rail dynamics,...

Literature review

Mechanism of squeal generation

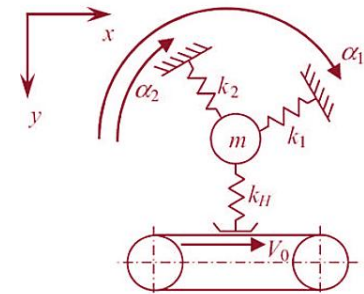


Falling friction
mechanism



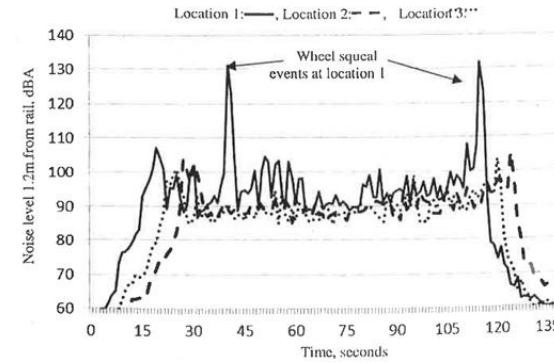
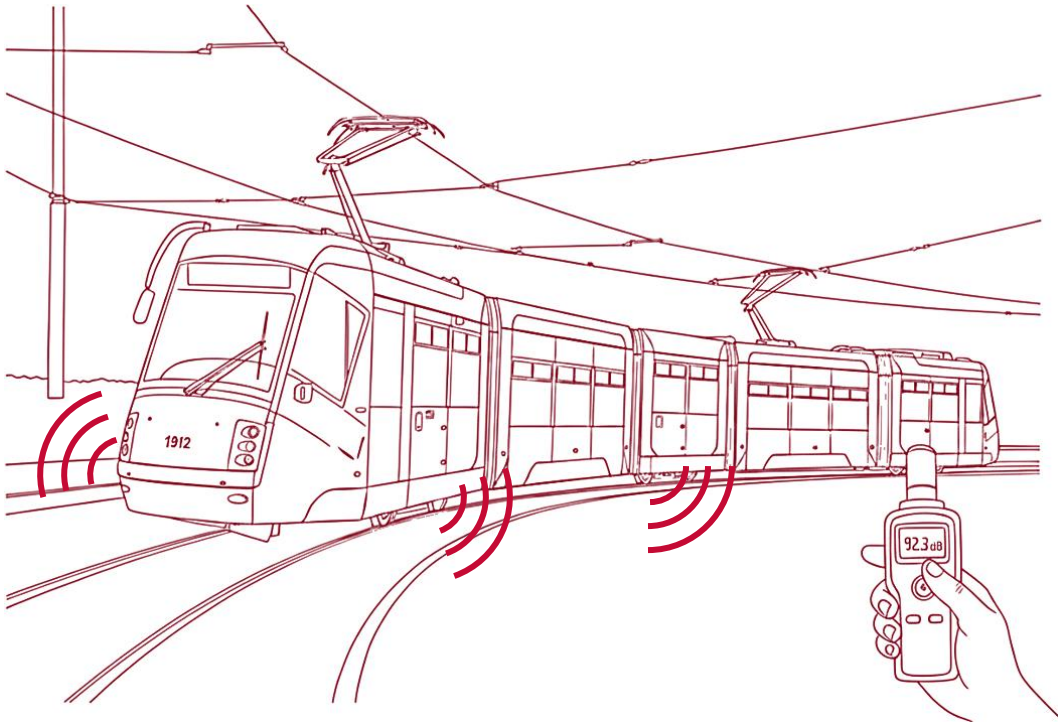
vs.

Mode coupling
mechanism



Literature review

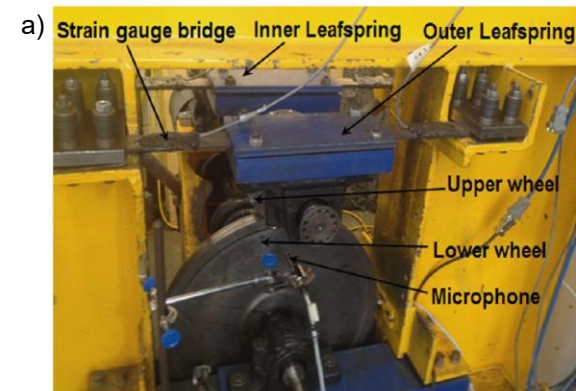
Noise investigation



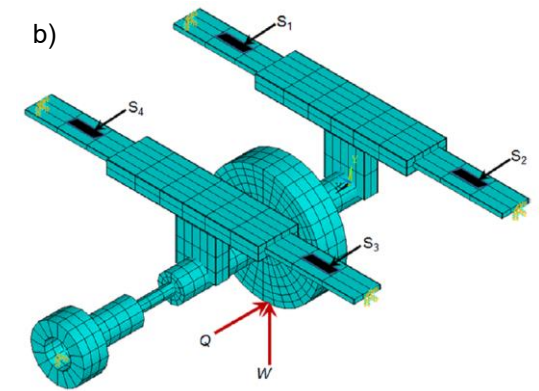
(Curley, 2015)



(Oertli, 2005)

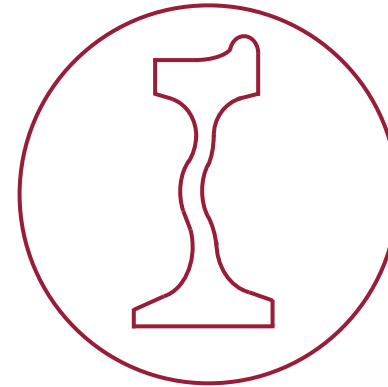
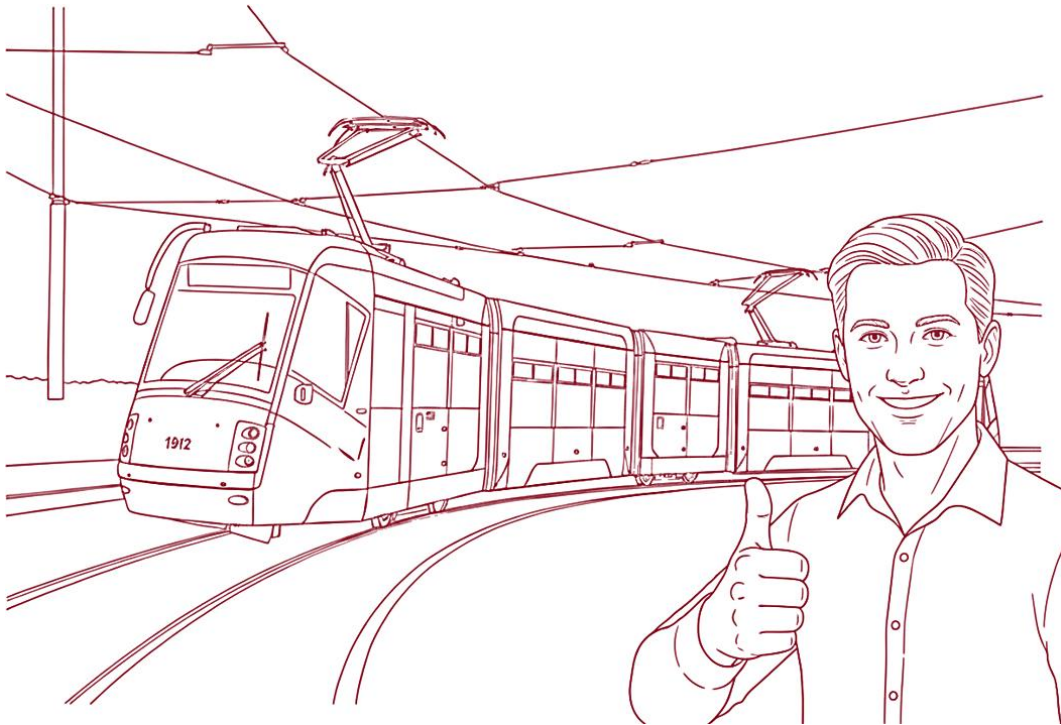


(Liu & Meehan, 2015)

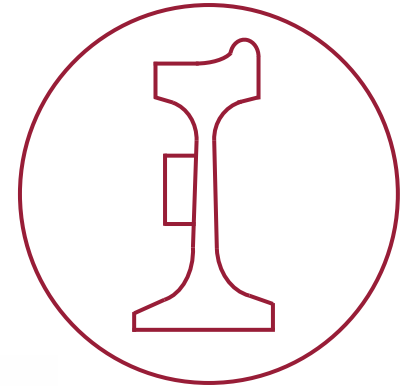


Literature review

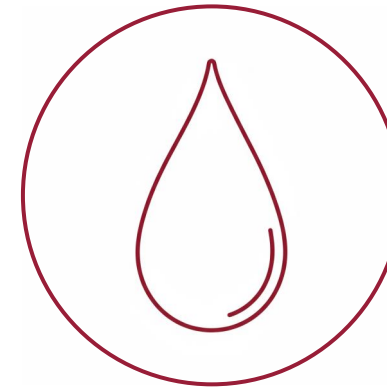
Noise reduction measures



Passive



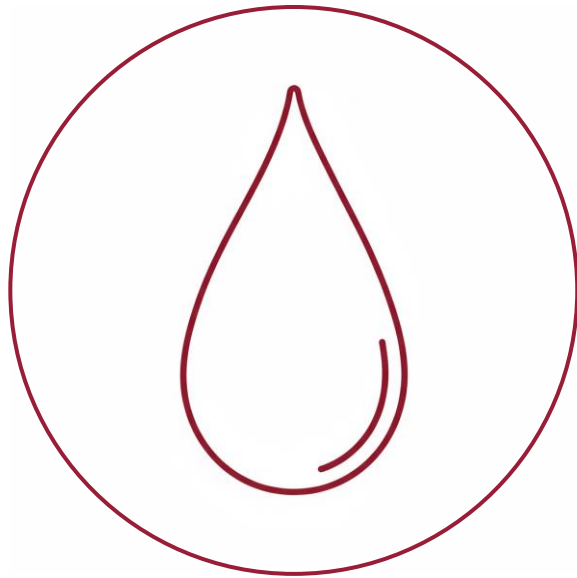
Active



Friction management

Literature review

TOR Products

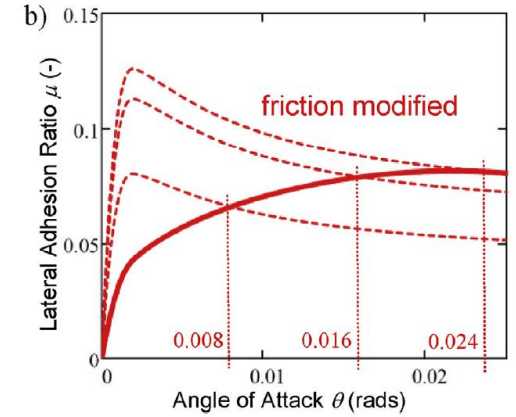
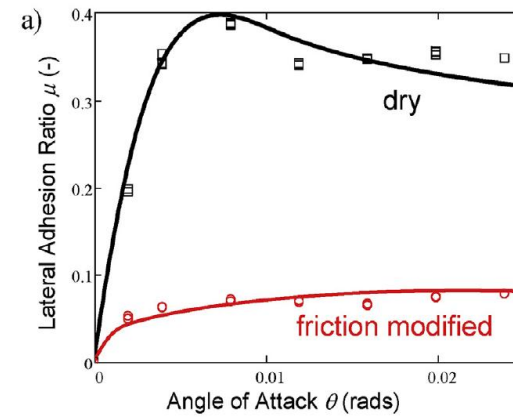


1 Base

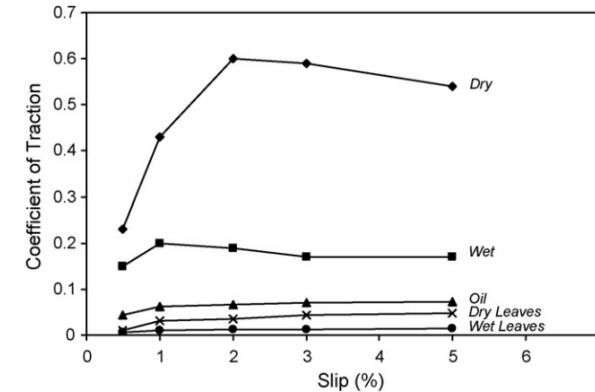
2 Binding agent

3 Particles for FM

4 Solid lubricant



(Meehan & Liu, 2019)



(Gallardo-Hernandez & Lewis, 2008)

Analysis of literature review

What do we know?

- Mechanism of noise origin under dry conditions
- Mathematical models to predict the noise
- Concept of the test rigs
- Ways how to reduce the noise
- The effect of TOR product on noise and adhesion
- Theories about noise generation under modified friction properties

What do we not know?

- Experimental validation of theories about noise generation under modified friction properties
- More environmentally friendly alternatives to TOR products
- The effect of water application on both noise and adhesion
- How to prolong water retentivity

Scientific questions

Q1

To what extent can the addition of typical TOR product components prolong water retentivity at the wheel-rail contact?

Q2

What is the mechanism by which water reduces noise?

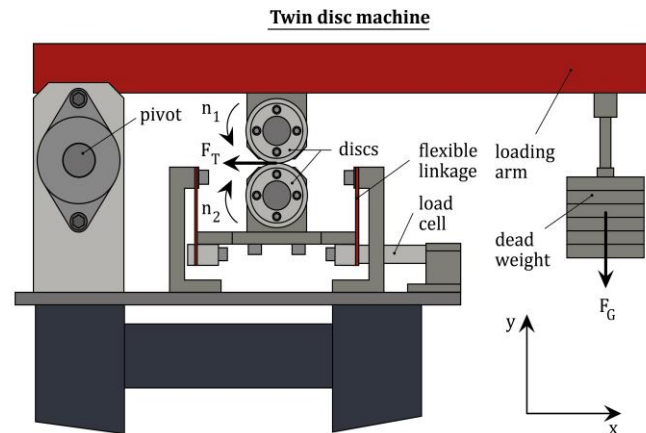
Q3

What is the mechanism by which noise is generated in contact with water-modified frictional properties?

Paper 1

Q1

Set	Applied substance	Test Type	Monitored variables
1	None	Reference test with dry contact	Noise Adhesion
2	Water	Test with water-flooded contact	
3	9 compositions	Tests of "wet" films	
4	9 compositions	Tests of films after base evaporation	



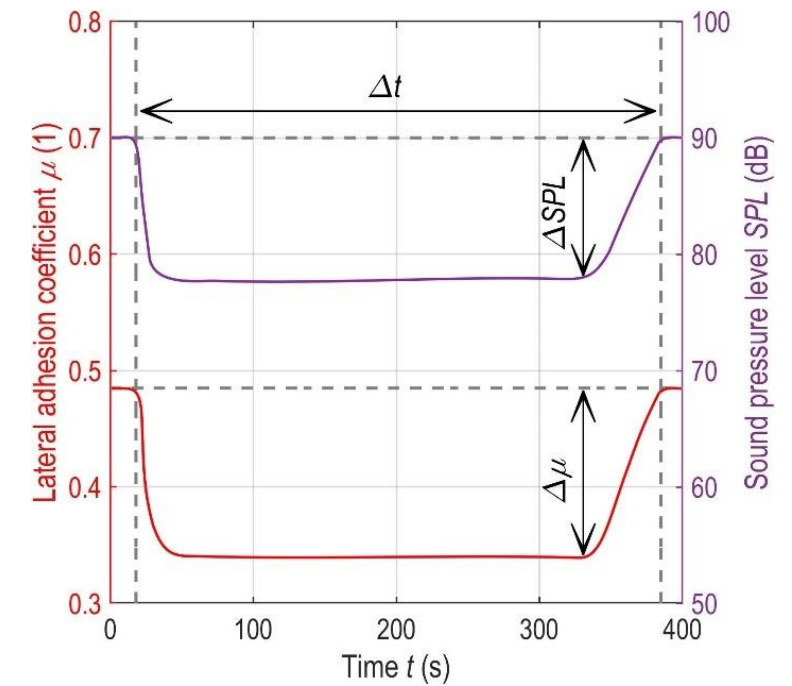
- Rolling speed 1m/s
- Contact pressure 800 MPa
- Angle of attack 4°



Paper 1

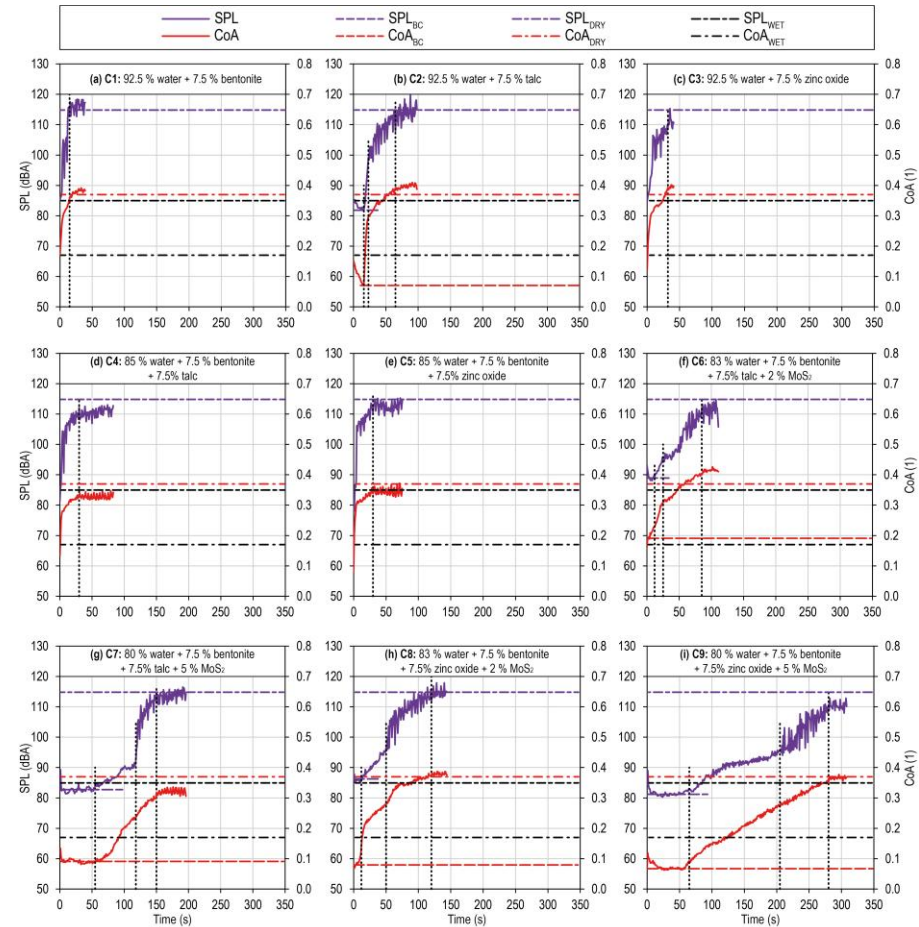
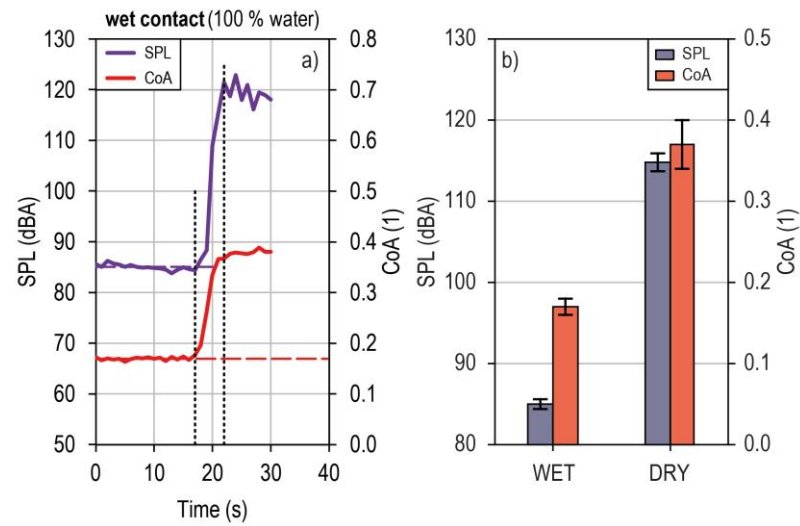
Q1

Composition	Base medium	Binding agent	Friction modifier	Solid lubricant
W	100 wt.% water	/	/	/
C1	92.5 wt.% water	7.5 wt.% bentonite	/	/
C2	92.5 wt.% water	/	7.5 wt. % talc	/
C3	92.5 wt.% water	/	7.5 wt.% zinc oxide	/
C4	85 wt.% water	7.5 wt.% bentonite	7.5 wt.% talc	/
C5	85 wt.% water	7.5 wt.% bentonite	7.5 wt.% zinc oxide	/
C6	83 wt.% water	7.5 wt.% bentonite	7.5 wt.% talc	2 wt.% MoS ₂
C7	80 wt.% water	7.5 wt.% bentonite	7.5 wt.% talc	5 wt.% MoS ₂
C8	83 wt.% water	7.5 wt.% bentonite	7.5 wt.% zinc oxide	2 wt.% MoS ₂
C9	80 wt.% water	7.5 wt.% bentonite	7.5 wt.% zinc oxide	5 wt.% MoS ₂



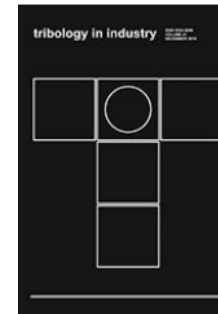
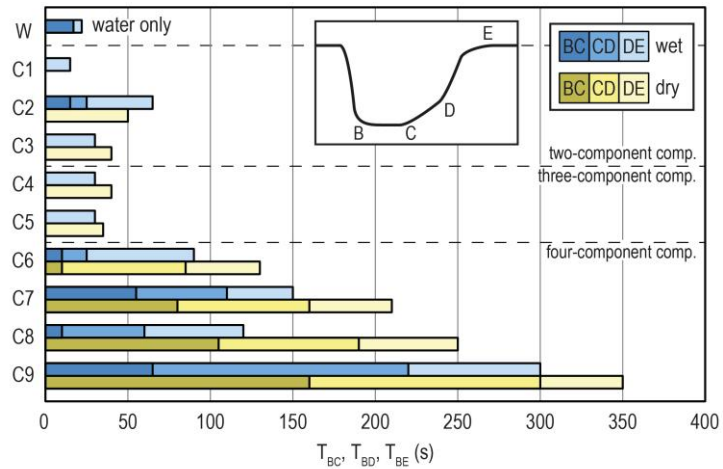
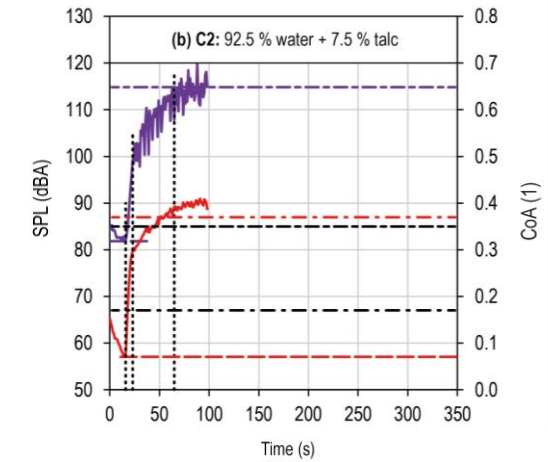
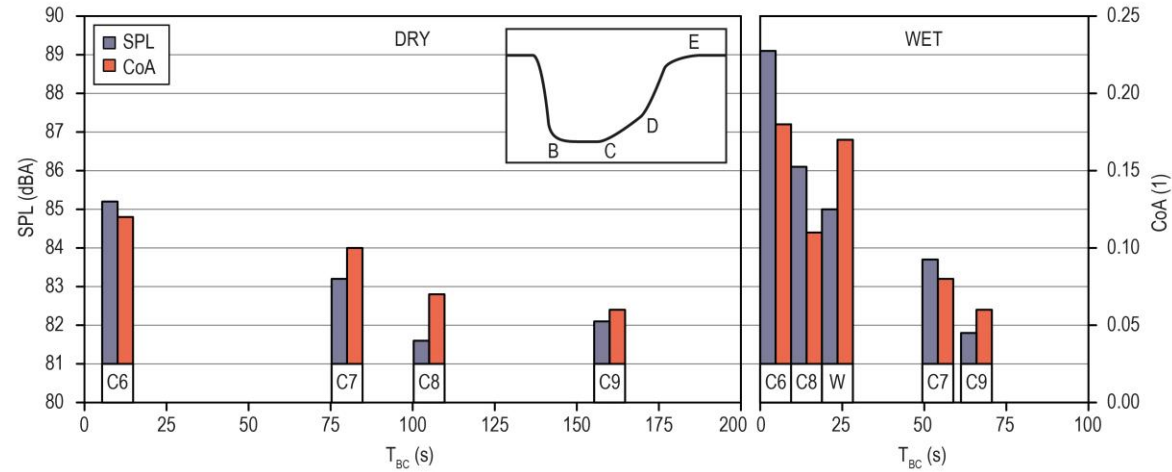
Paper 1

Q1



Paper 1

Q1

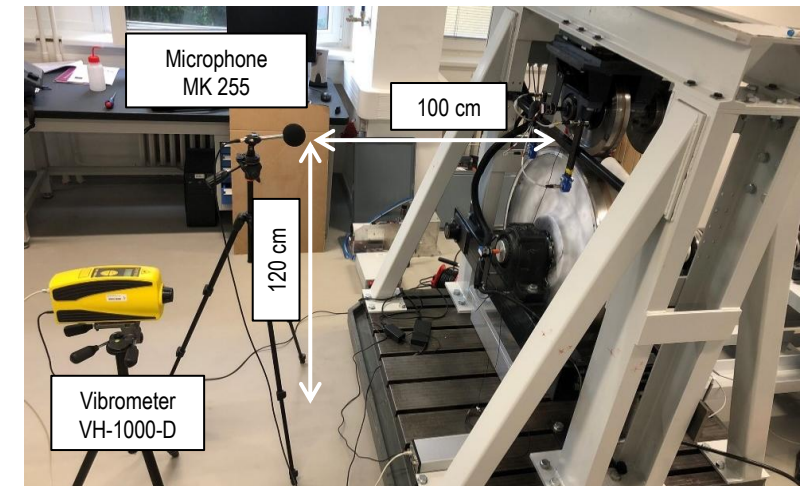
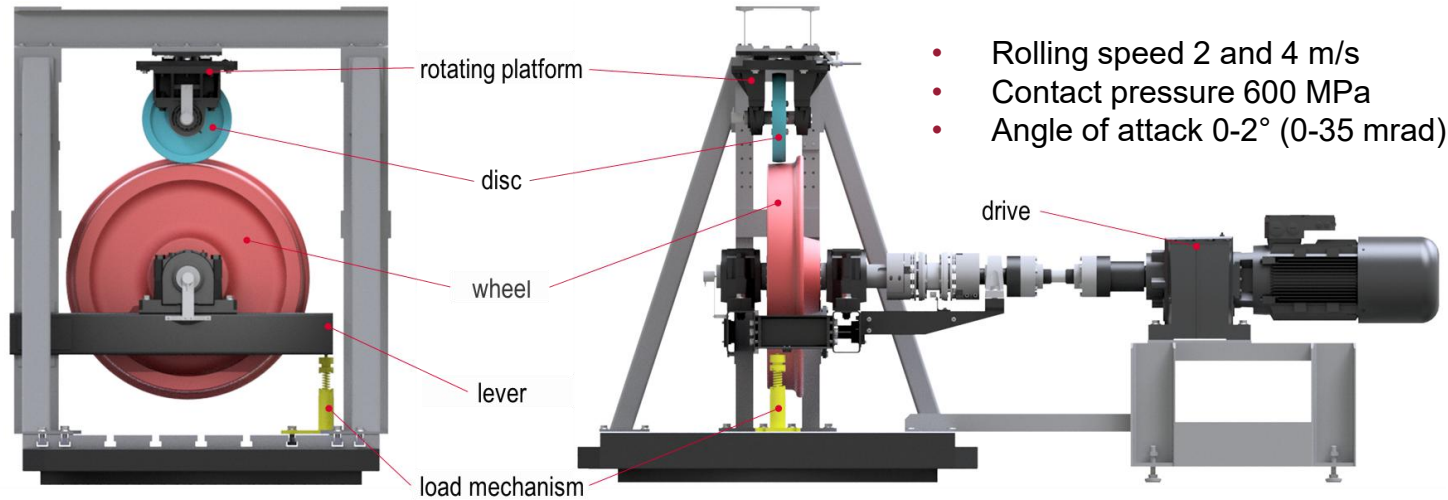


NAVRÁTIL, V.; GALAS, R.; Klapka, M.; KVARDA, D.; OMASTA, M.; SHI, L.; DING, H.; WANG, W.; KŘUPKA, I.; HARTL, M. Wheel Squeal Noise in Rail Transport: The Effect of Friction Modifier Composition. *Tribology in Industry*, 2022, **44**(3), 361-373. ISSN: 0354-8996. doi: 10.24874/ti.1579.11.23.01

Paper 2

Q2

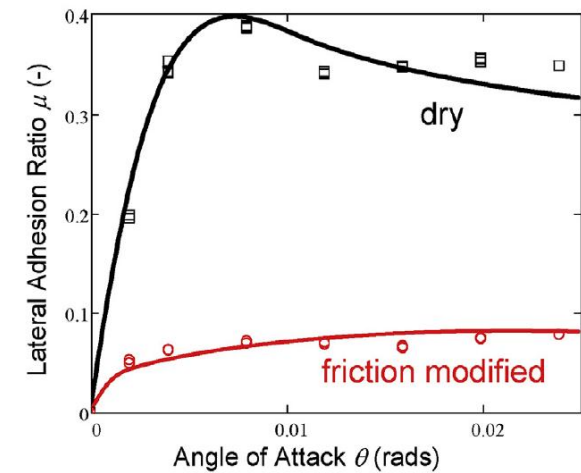
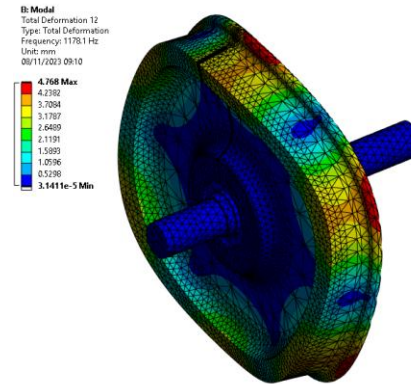
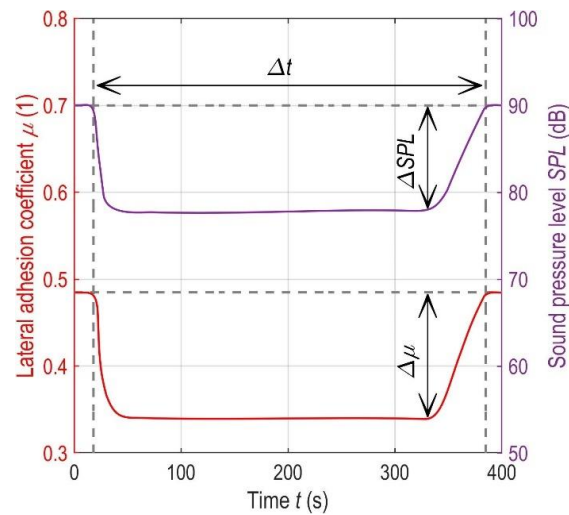
Set	Applied substance	Test Type	Monitored variables
1	None	Reference test with dry contact	Noise
2	Water	Tests with fully flooded contact	Adhesion
3	Water	Effect of the amount of water	Vibration



Paper 2

Q2

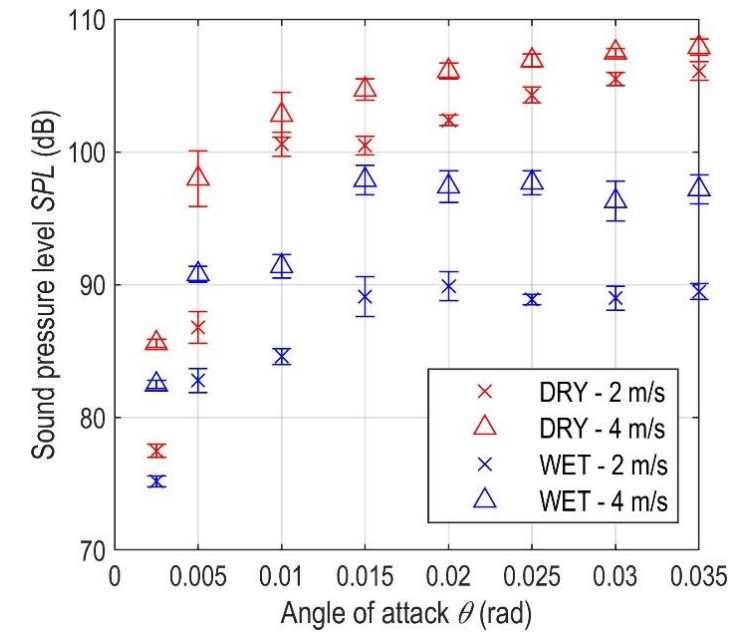
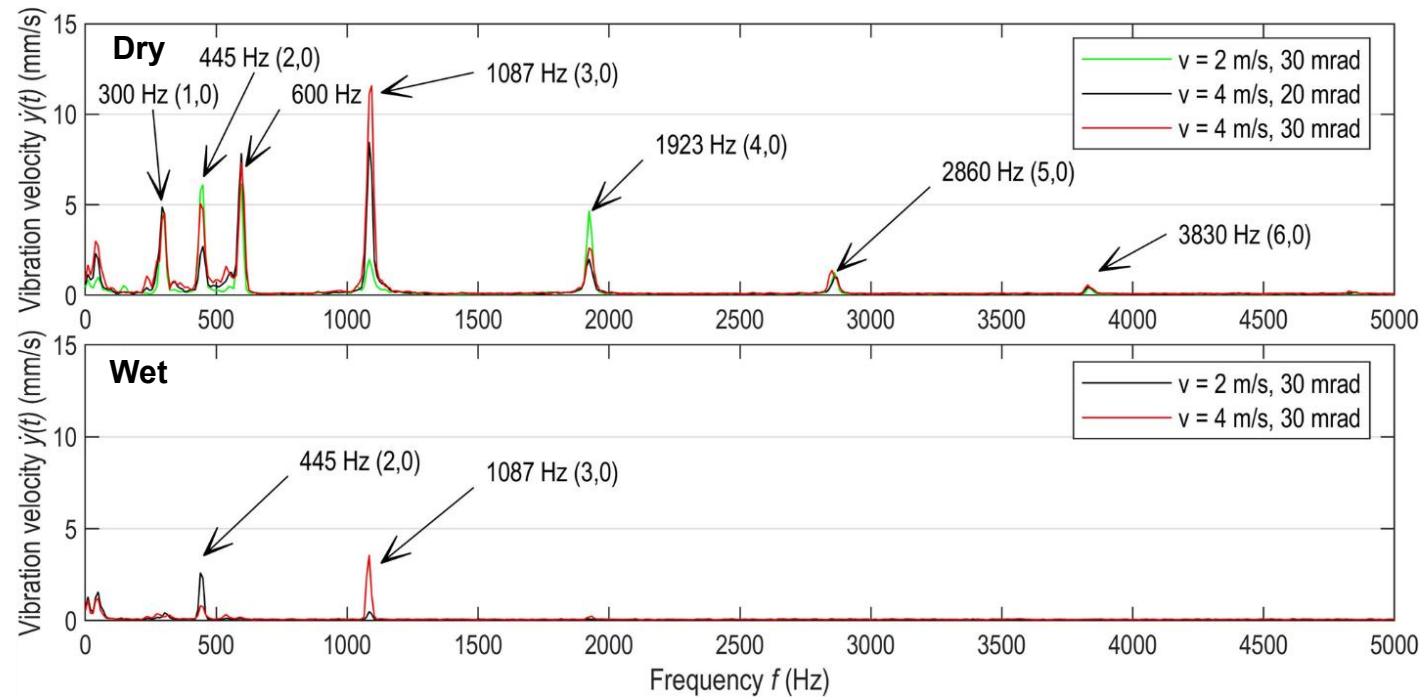
Set	Applied substance	Test Type	Monitored variables
1	None	Reference test with dry contact	Noise
2	Water	Tests with fully flooded contact	Adhesion
3	Water	Effect of the amount of water	Vibration



(Meehan & Liu, 2019)

Paper 2

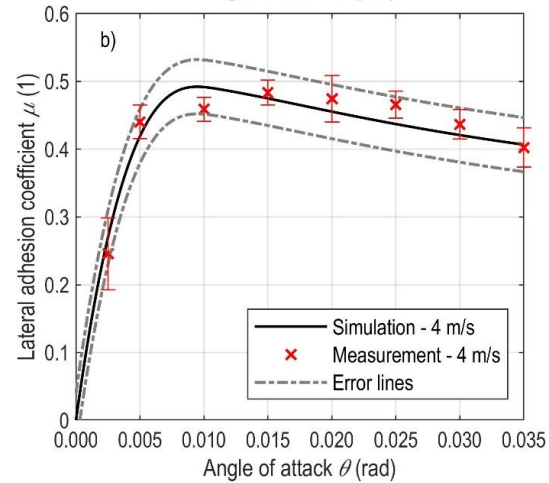
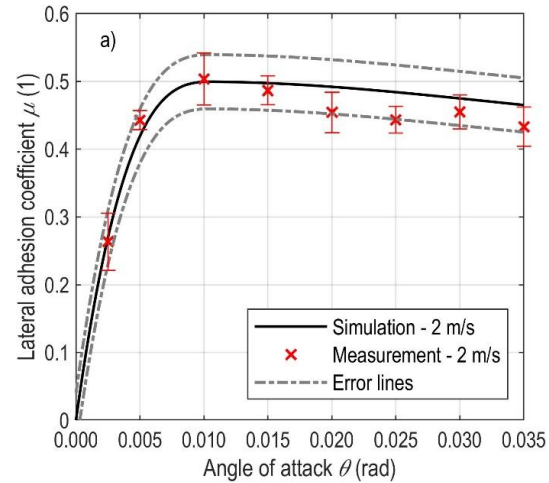
Q2



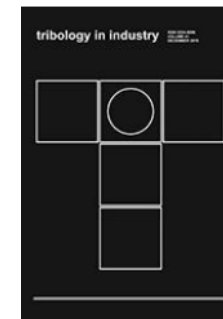
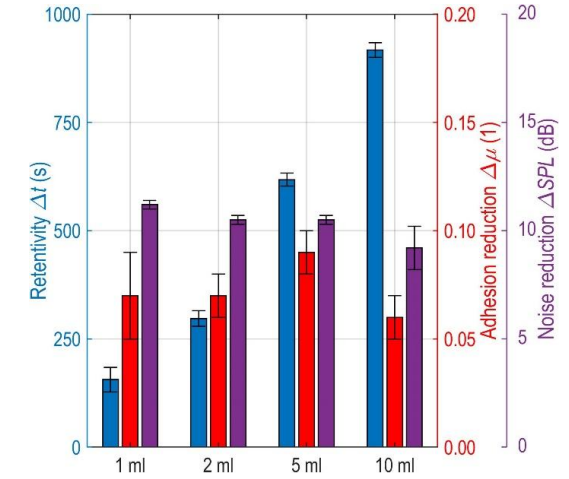
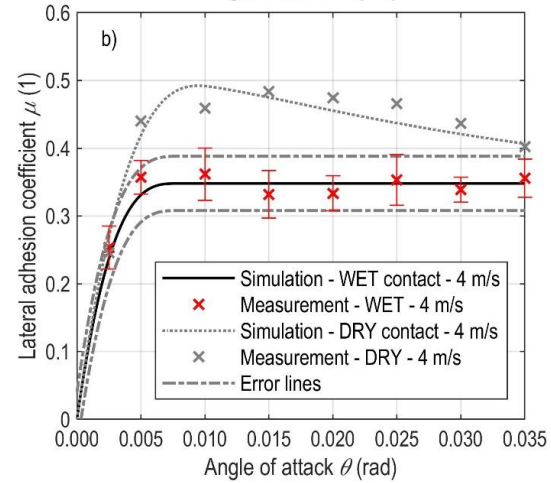
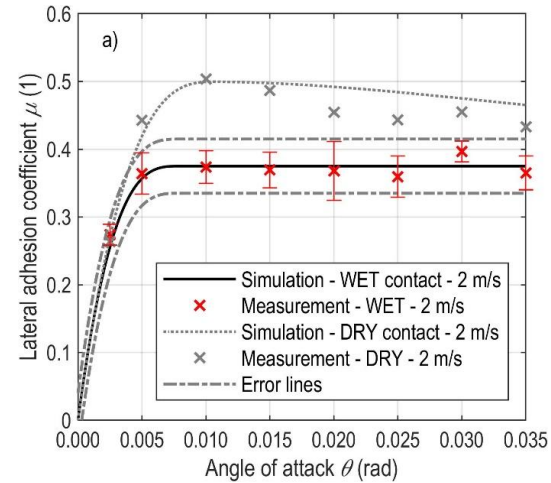
Paper 2

Q2

Dry



Wet

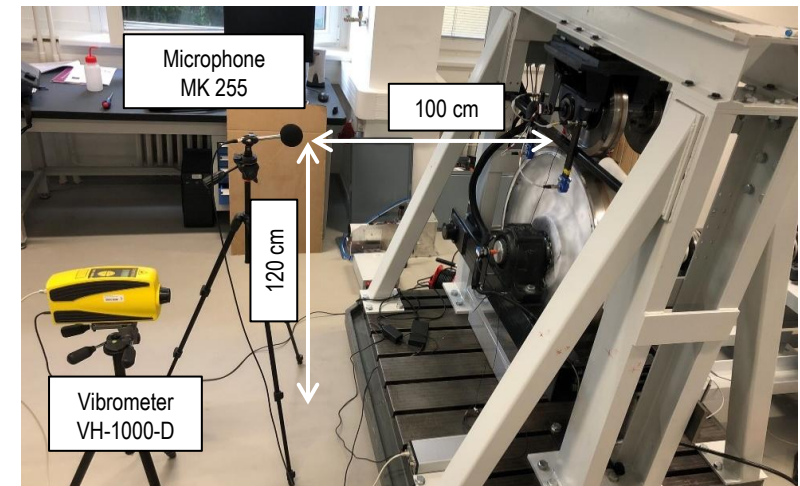
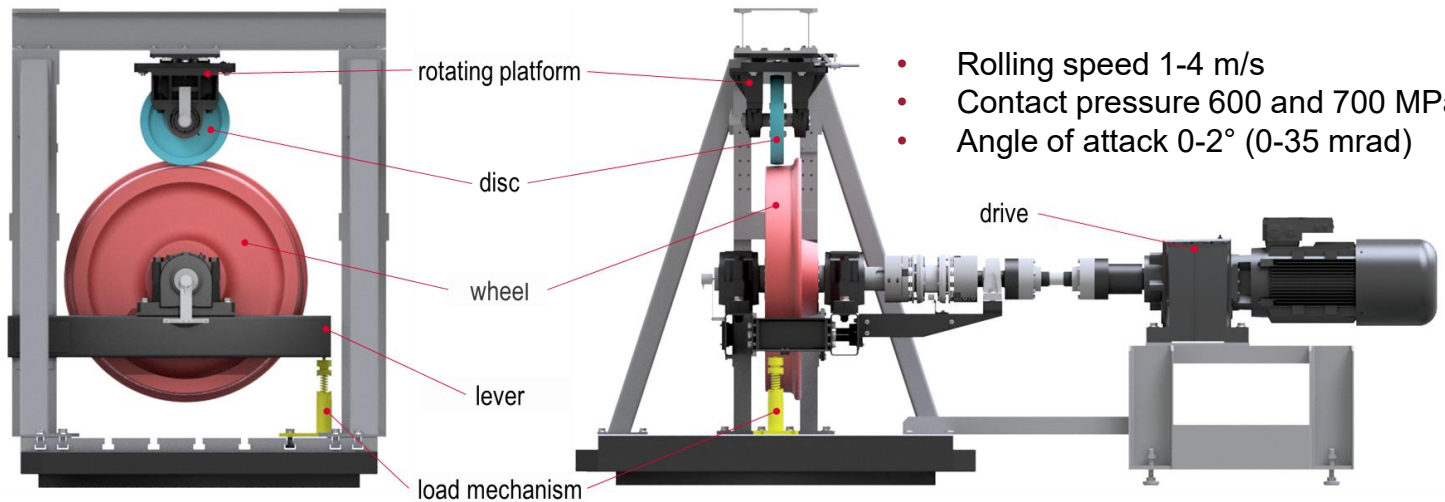


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Paper 3

Q3

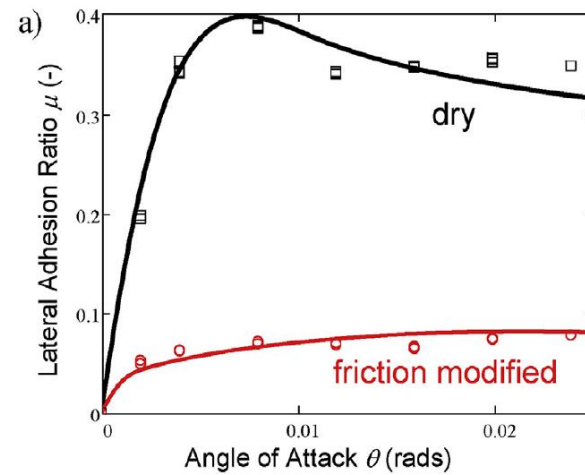
Set	Applied substance	Test Type	Monitored variables
1	None	Test with under dry conditions and load 600 MPa	Noise
		Test with under dry conditions and load 700 MPa	
2	Water	Test with under wet conditions and load 600 MPa	Adhesion
		Test with under wet conditions and load 700 MPa	



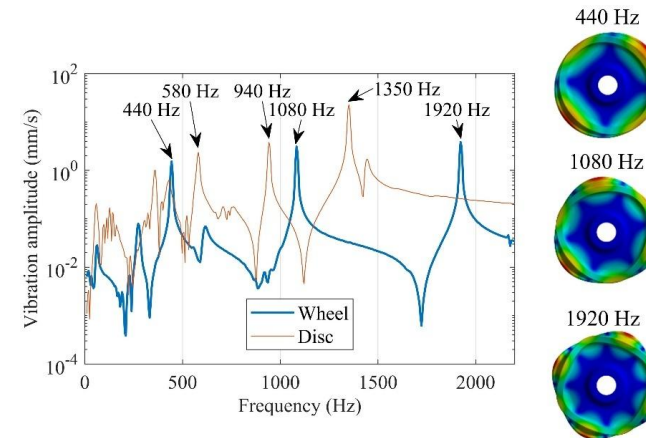
Paper 3

Q3

Set	Applied substance	Test Type	Monitored variables
1	None	Test with under dry conditions and load 600 MPa	Noise Adhesion
		Test with under dry conditions and load 700 MPa	
2	Water	Test with under wet conditions and load 600 MPa	Vibration
		Test with under wet conditions and load 700 MPa	

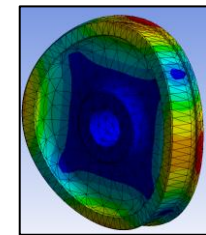
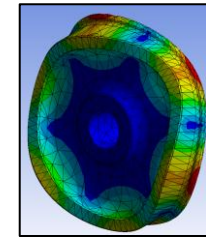
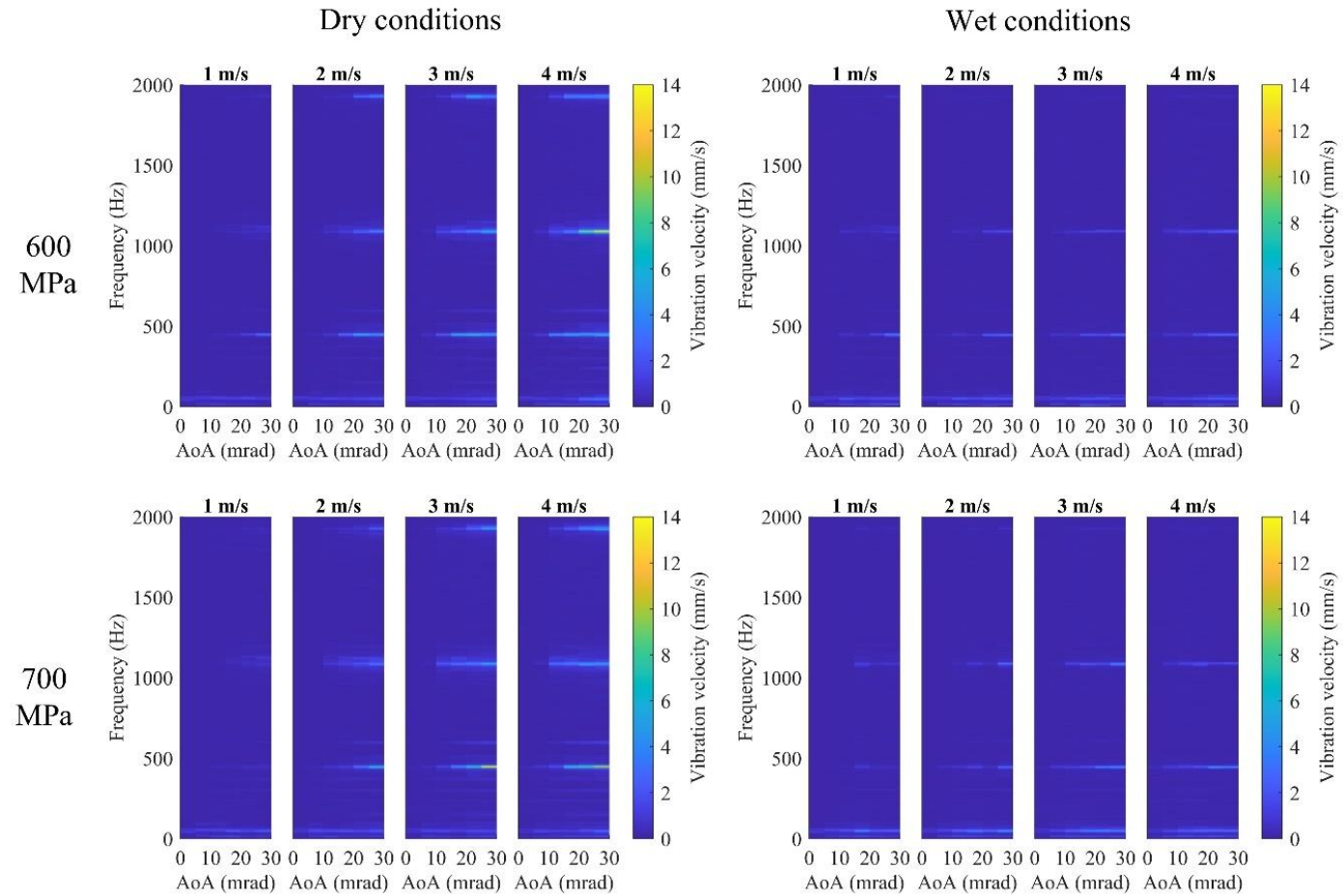


(Meehan & Liu, 2019)



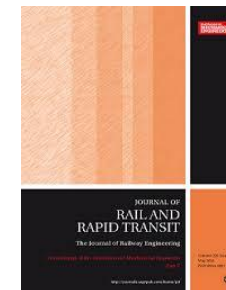
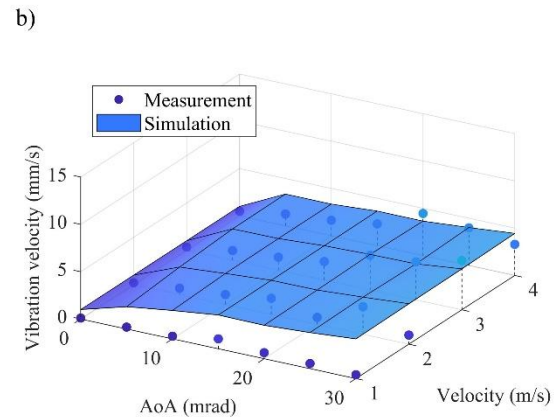
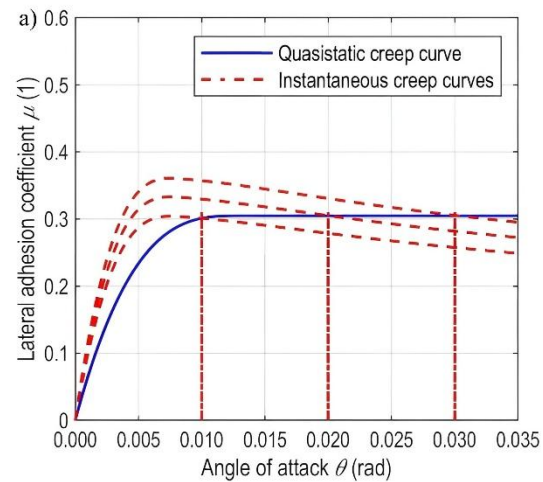
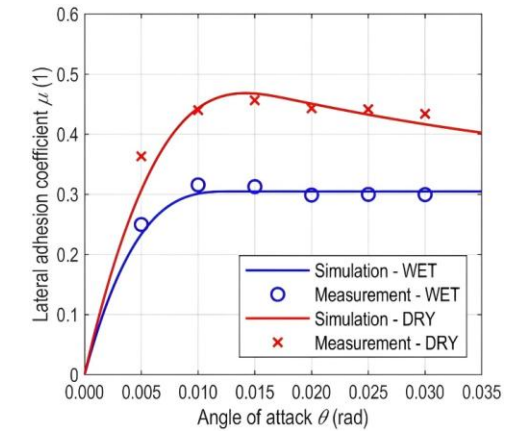
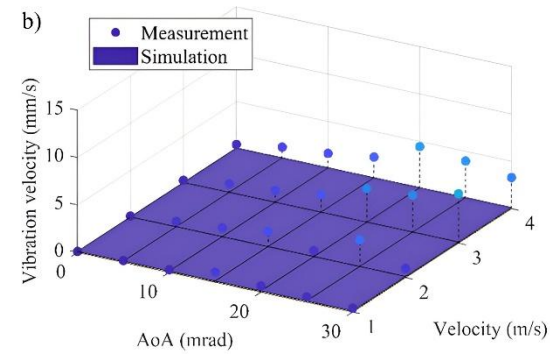
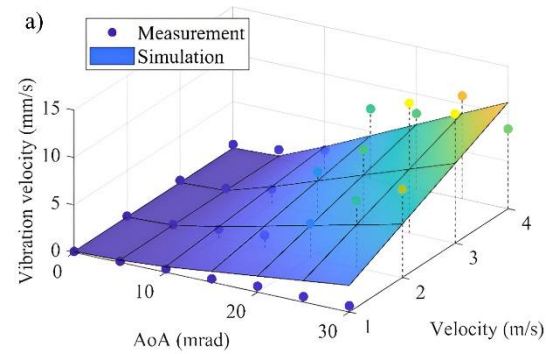
Paper 3

Q3



Paper 3

Q3



NAVRÁTIL, V., KVARDA, D., Klapka, M., GALAS, R., OMASTA, M., KRUPKA, I., HARTL, M. Investigation of squeal noise generation in wheel-rail contact under wet conditions using a twin-disc test rig. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*, 2025; 239(8), 635-645. doi:10.1177/09544097251339854

Conslusions

Q1

- ✓ Water can reduce noise while maintaining adhesion on intermediate levels.
- ✓ The addition of typical TOR product component can prolong retentivity of water.
- Promising results were achieved mainly by the most complex compositions.

Q2

- ✓ Water can reduce noise while maintaining adhesion on intermediate levels.
- ✓ Water reduces noise by changing the negative slope of traction curve to neutral.
- ✓ The way how water is applied could affect the retentivity.
- Water does not eliminate the wheel vibration, it only reduces the vibration.

Q3

- ✓ Vibration mode could be dependent on contact pressure.
- ✓ Results support the theory of quasi-static and instantaneous traction curves.
- It is necessary to focus on deeper validation of the theory.
- Possible negative effects of water application should be studied.

Thank you for your attention

Václav Navrátil, Ing.

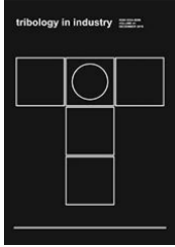
Vaclav.Navratil@vutbr.cz



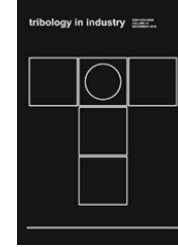
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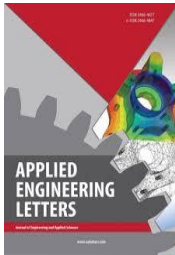
Conclusions



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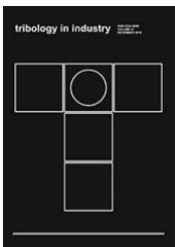
VALENA, M., OMASTA, M., KLAPKA, M., GALAS, R., NAVRÁTIL, V., KŘUPKA, I., HARTL, M. Case Study: Correlations Between Curve Squeal, Weather Conditions, and Traction in a Tram Loop. *Tribology in Industry*, 2024, **46**(4), 695-708, DOI: 10.24874/ti.1728.07.24.10 [Citescore = 2.8]



OMASTA, M.; NAVRÁTIL, V.; GABRIEL, T.; GALAS, R.; KLAPKA, M. Design and development of a twin disc test rig for the study of squeal noise from the wheel – rail interface. *Applied Engineering Letters*, 2022, **7**(1), 10-16. ISSN: 2466-4677. [Citescore = 1.6]



NAVRÁTIL, V., KVARDA, D., KLAPKA, M., GALAS, R., OMASTA, M., KŘUPKA, I., HARTL, M. Investigation of squeal noise generation in wheel-rail contact under wet conditions using a twin-disc test rig. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*, 2025; **239**(8), 635-645. doi:10.1177/09544097251339854



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