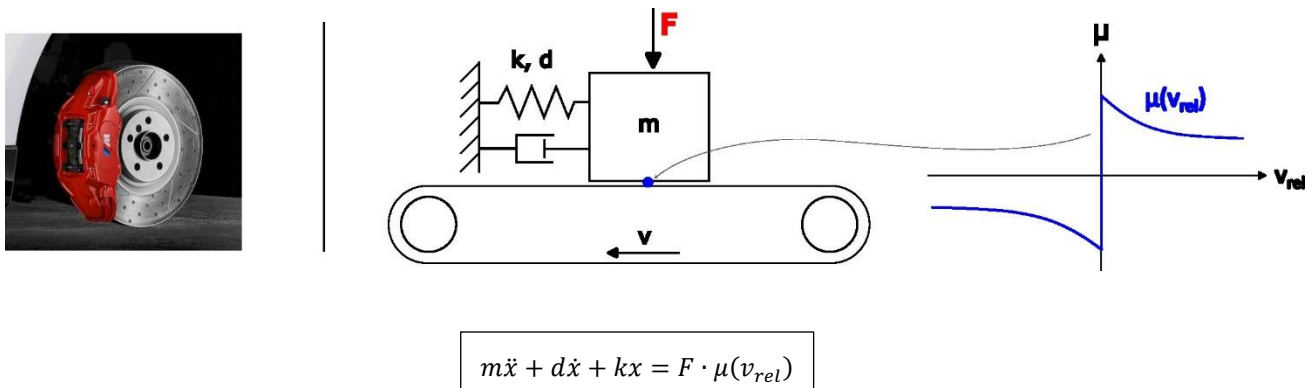


Bachelor's Thesis

Numerical Simulation of Minimal Models for Brake Creep Groan

Motivation

Brake Creep Groan is a low frequency noise phenomenon, which can occur when brakes are applied or released in the low-speed range. It arises from a stick-slip movement between brake disk and brake pad, which leads to an intense vibration in the entire axle-brake corner and hence to an unpleasant noise in the passenger cabin. To better understand the underlying physics as well as investigate influencing parameters on creep groan, minimal models can be considered. Below is shown the most prominent 1 DOF model which represents the stick-slip effect in a car brake during creep groan:



The underlying equation of motion of this 1 DOF model involves a discontinuity in the right-hand-side which results from the friction model. Hence, the numerical solution highly depends on the integration scheme as well as the integration parameters.

Tasks

In the scope of this thesis different multi-DOF creep groan models should be implemented and investigated. First, a robust integration scheme for the above 1 DOF model should be developed. Subsequently, the integration scheme should be applied to different multi-DOF models. These should be derived from literature as well as from real vehicle measurements and should be implemented in Matlab / Simulink. The models should be validated by measurement data provided by BMW. Ultimately, a suitable model should be chosen to study the effects of different parameters on the vibration behavior. The thesis can be written in German or English.

Project Stages

- Familiarization with brake creep groan, the stick-slip effect and Matlab / Simulink
- Derivation of the analytical solution of a simple 1 DOF minimal model
- Implementation of a robust numerical integration scheme for the 1 DOF model
- Implementation of different multi-DOF creep groan models (from literature / measurement data)
- Parameter study of one multi-DOF model
- Documentation and visualization of the results

Literature

- [1] S. Hegde (2015): Study of Friction Induced Stick-Slip Phenomenon in a Minimal Disc Brake Model. In *Journal of Mechanical Engineering and Automation*. DOI: 10.5923/c.jmea.201502.20
- [2] D. Meng *et al.* (2019): Sensing and Quantifying a New Mechanism for Vehicle Brake Creep Groan. In *Shock and Vibration*, vol. 2019, Article ID 1843205, DOI: 10.1155/2019/1843205
- [3] S. Huemer-Kals *et al.* (2022): Advancements on bifurcation behavior and operational deflection shapes of disk brake creep groan. In *Journal of Sound and Vibration* Vol. 534. DOI: 10.1016/j.jsv.2022.116978
- [4] R. I. Leine *et al.* (1998): Stick-Slip Vibrations Induced by Alternate Friction Models. In *Nonlinear Dynamics* Vol. 16, pp. 41-54. DOI: 10.1023/A:1008289604683

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