Joints Workshop Technical Talk

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Important Topics in our Area

- Nonlinear or Linearized Joint Modeling

Industrial Problems

- Local Joint Models
- Nonlinear FE Joint Models
  (Zero Thickness Elements)
- Linearized FE Joint Models
  (Thin Layer Elements)

- **Identification of Joint Model Parameters from isolated joints**

- Resonator measurements,Pressfit joints
- Optoelectronic measurements

Research Problems

- Surface roughness description Herz-Mindlin Theory for single asperities
  - Greenwood Williamsen Tripp
  - Stochastic roughness models
  - Fractal surface descrition
  - Multi particle dynamics

- Nonlinear normal and tangential contact equations
- Harmonic balance description
- Modeling of Epistemic and Aleatoric uncertainties

Important Topics in our Area

Industrial Contact Problems

- SRTM 10 bay space frame with passive and semi-active joints
- Bolted housing of airbag control unit
- Damping description in design phase of
  - motors with attached gearbox (cars, trucks, yachts, ships)
  - bolted joints of cylinder head, oilpan, gearbox
  - influence of different seal systems
- Uncertainty description of assembled structures with joints
- Joints in tooling industry,Pressfit joints in turbogenerators
- Disc brake contact problems
- Bolted joint damping layers (exhaust systems)

Control problems for structures with semi-active joints

- Control concepts
  - Ljapunov controller, maximizing dissipation
  - Clipped LQG SISO-, MIMO-controller

Which Problems to Take in

SRTM 10 bay space frame with passive and semi-active joints
Optimal actuator and sensor placement concepts

- Scientific interest in collaboration with colleagues, such as the brake dynamics group organized by Harald Abendroth
- Funding offers by
  - FVV (Forschungsvereinigung Verbrennungsmotoren)
  - DFG (German Research Society)
  - Research groups
  - Transfer for Industrial problems
  - State funding (BW)

End User of Results / Funding

Who will be the end user of the results?

- Industry
  - Automotive suppliers
  - Car industry
  - Machine tools industry, Turbomachinery design
  - Optical industry
  - Biomedical industry (stent design, lithotripter design, peristaltic transport)
- Inventors
- Small business

How we get funding?

- Contact with Industry by local and international conferences
- DFG, FVV, VDMA
- Individual contacts
- Courses organized by IAM at HDT, VDI etc.

Friction-induced vibrations in brake systems

- Development of “silent” friction brakes is a major challenge in automotive industry
- Brake squeal is largely understood (qualitatively + quantitatively)
- BUT: prediction capabilities of simulation tools are poor
- State of the art tool: complex eigenvalue analysis MT1

↓

Overprediction of instabilities

- Damping and nonlinearities mainly determine stability of the brake system

⇨ Joints have to be taken into consideration

MT2

Bernhard Stingl, Merten Tiedemann, Norbert P. Hoffmann
Mechanics and Ocean Engineering

Slide 6

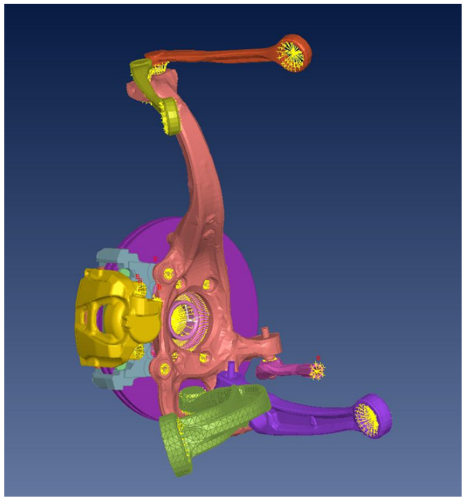
MT1 Komplexe Eigenwertanalyse eines linearen FE-Modells (MDGKN-System)
Merten Tiedemann, 8/1/2012

MT2 Wichtige Fügestellen:
- Scheibe-Belag
- Belag-Sattel
- Sattel-Halter

Merten Tiedemann, 8/1/2012

Challenges in the field of brake squeal simulation

- Characterization and description of nonlinear joint dynamics
- Implementation of joint models in commercial FE software
- Model order reduction
- Nonlinear stability analysis / limit cycle calculation

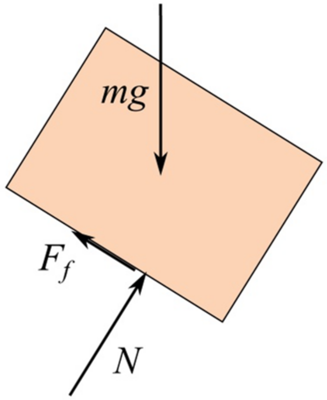


Gdaniec, P., Weiß, C., Hoffmann, N. (2010) On chaotic friction induced vibration due to dynamic friction. Mech. Res. Comm. 37, 92-95.

Hoffmann, N. (2007) Linear stability of steady sliding in point contacts with velocity dependent and LuGre type friction. Journal of Sound and Vibration 301, 1023-1034.

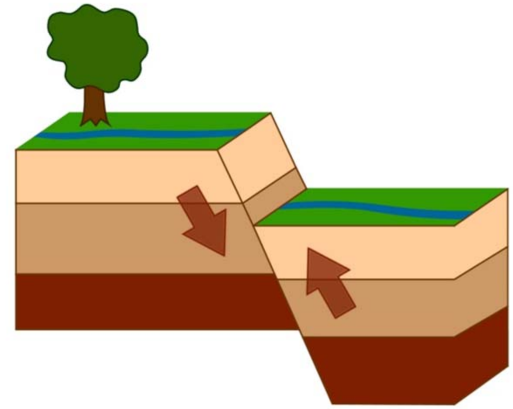
Friction as a Dynamical System?

Engineering



- material constant
- $F_f = \mu N$

Physics



- dynamical system
- $\dot{\boldsymbol{F}} = \boldsymbol{f}(\boldsymbol{x}, \dot{\boldsymbol{x}}, \boldsymbol{F})$

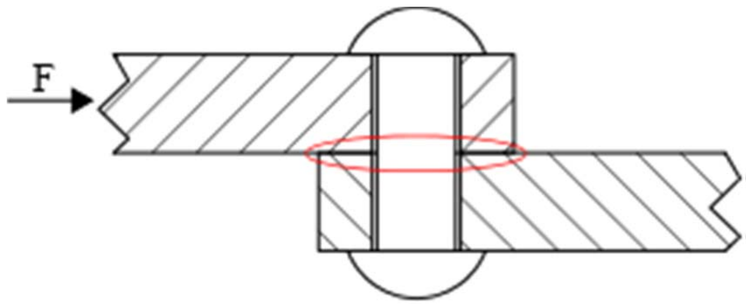
Transfer state of the art knowledge to engineering?

- Is Coulomb friction sufficient?
- Can we apply extended friction models?

Bernhard Stingl, Merten Tiedemann, Norbert P. Hoffmann
Mechanics and Ocean Engineering

Where to apply?

Failure of joints



- extended interface with stress field
- failure ≙ transition to sliding
- derivation of design rules
- monitoring systems, e.g. overload detection

Friction induced vibrations

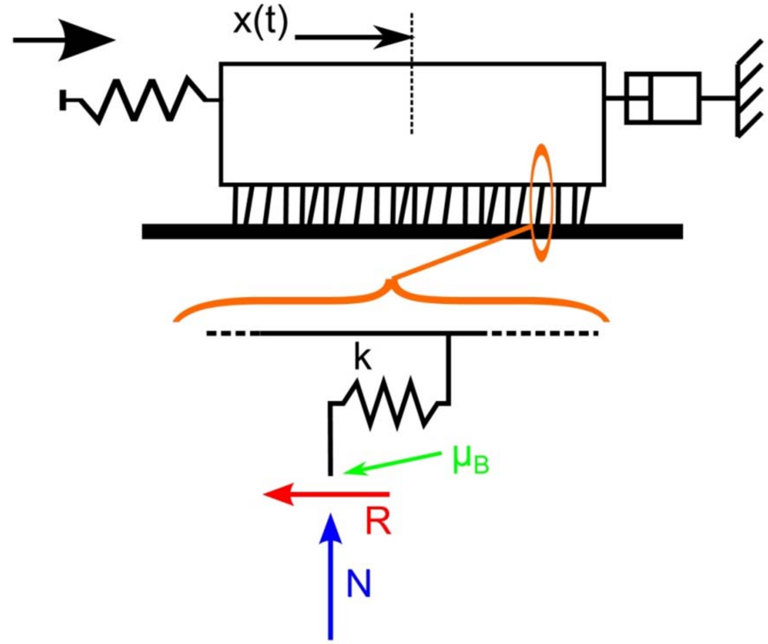
- multiscale systems: structure and interface dynamics
- scales may interact → separation of scales fails

Extended Friction Models

Roughness based

- repeated shearing, failure and reattachment of asperities

Bristle Model



- rough interface: elastic bristles

Stingl, B., Hoffmann, N. (2011) A mesoscopic friction model based on surface roughness and its statistical description. Proceedings of the ASME Annual Meeting, Denver, 2011

Experimental Model Setup

- periodic interface
- shaft-hub-connection, clutch, screw-underhead contact, …
- strain field measurement
- disturbed stress field by tilting