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automotive testingexpo 2016 europe

Multi-axial test rig for durability tests on agricultural rims

Uli Wöllner, Matthias Kröger




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TU Bergakademie Freiberg | Institute for Machine Elements, Design and Manufacturing |
Professor of Machine Elements | Prof. Dr.-Ing. M. Kröger |
Agricolastr. 1, 09599 Freiberg | phone: +49 3731 39-2986 |

imkf Institute for Machine Elements, Design and Manufacturing

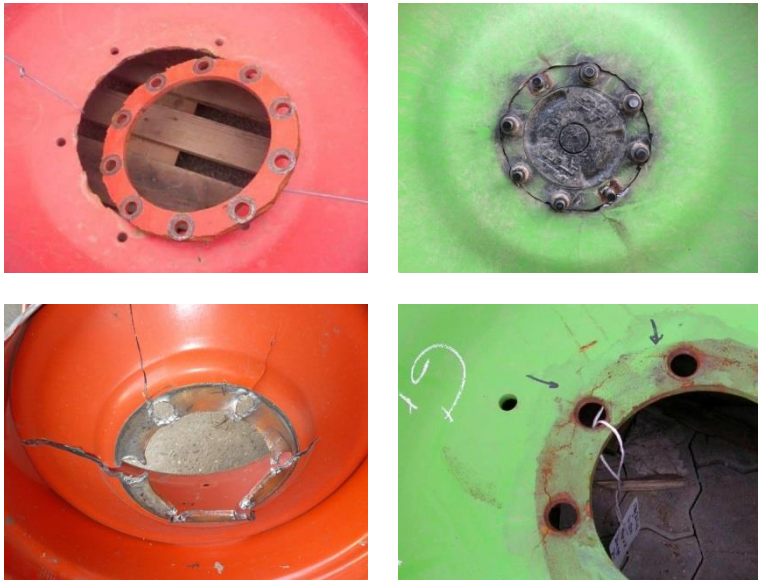
Outline

1. Introduction
2. Identification of forces and moments
3. Simulative investigations on agricultural rims
4. Test field for investigations on fatigue/durability
5. Design of a multi-axial test rig for agricultural rims
6. Experimental investigations on agricultural rims
7. Conclusion and outlook

1. Introduction

- Wheels of agricultural machines are highly loaded components
- Different driving situations
  - cornering
  - accelerating/ slowing down
  - slope rides
- Cracks and fatigue fractures in the area of screwing with the wheel hub

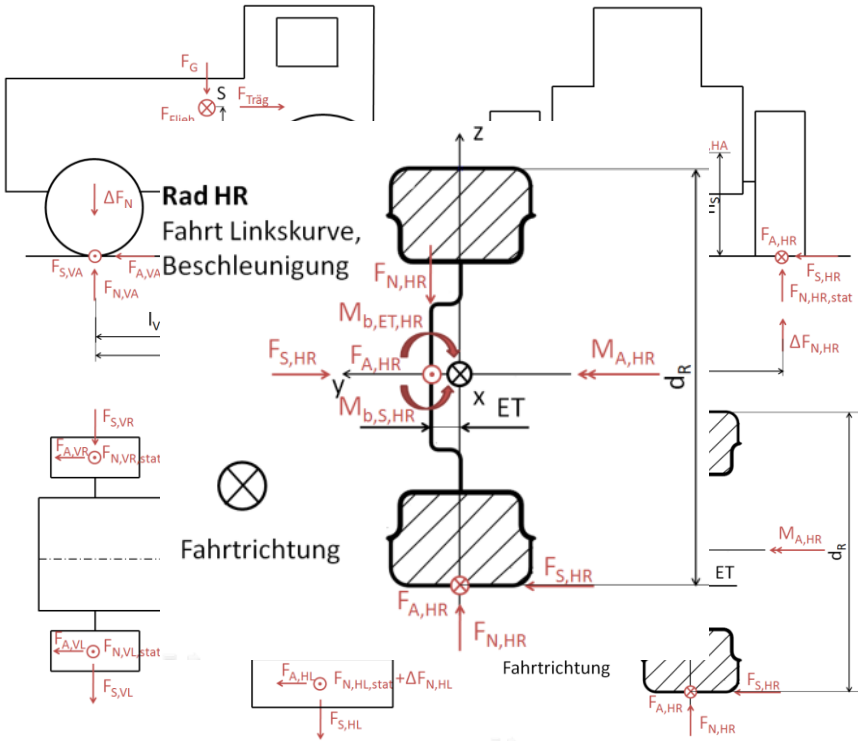
➢ Results of the cyclic stresses



Figures: Grasdorf GmbH

2. Identification of forces and moments

Identification of forces and moments occurring on a tractor wheel



considered tractor	
total mass m_{ges}	16.000 kg
tire diameter d_R	1.847 mm
offset ET	172 mm
wheelbase r_s	3.050 mm
rear track width s_h	2.050 mm
rear weight fraction	55 %
gravity height h_s	1.098 mm
friction coefficient μ_{Str}	1

agreed load cases	LC1 (dyn.)	LC2 (dyn.)	LC3 (stat.)
$F_{N,HR}$	86 kN	71 kN	0 kN
$F_{S,HR}$	86 kN	0 kN	0 kN
$F_{A,HR}$	0 kN	0 kN	0 kN
M_B	65 kNm	12 kNm	0 kNm
M_A	0 kNm	66 kNm	92 kNm

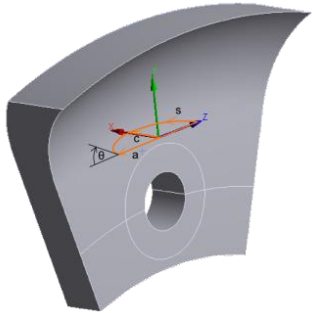
3. Simulative investigations on agricultural rims

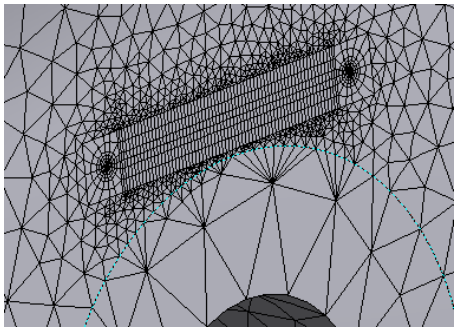
Damage by crack propagation along the geometry of the wheel hub

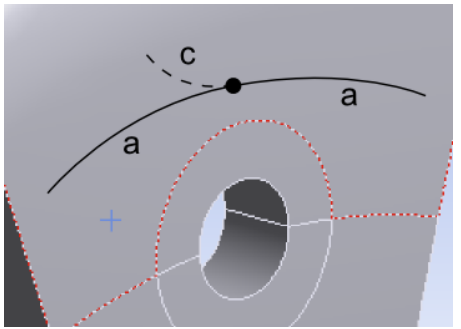
- High stresses in the area of the screw connection (tightening torque 600 Nm)
- Notch effect along the edge of the wheel hub

Figure: Grasdorf GmbH

Modelling a crack ↔ Meshing/Simulation ↔ Forecasting crack path







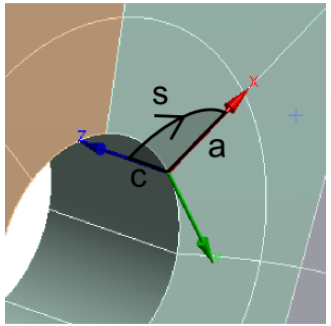
3. Simulative investigations on agricultural rims

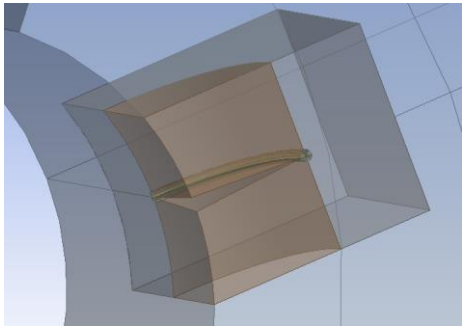
Damage caused by penetration of the lateral surface by a threaded bolt

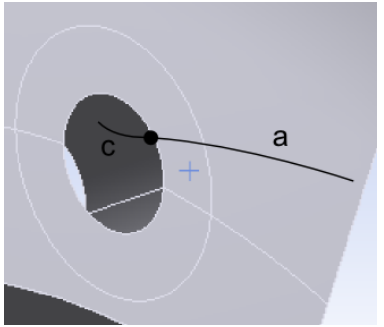
- Failure of the frictional engagement at too high driving torque (up to 92 kNm with high gear ratio)
- Impressions at the surfaces of the drillings

Figure: Grasdorf GmbH

Modelling a crack ↔ Meshing/Simulation ↔ Forecasting crack path







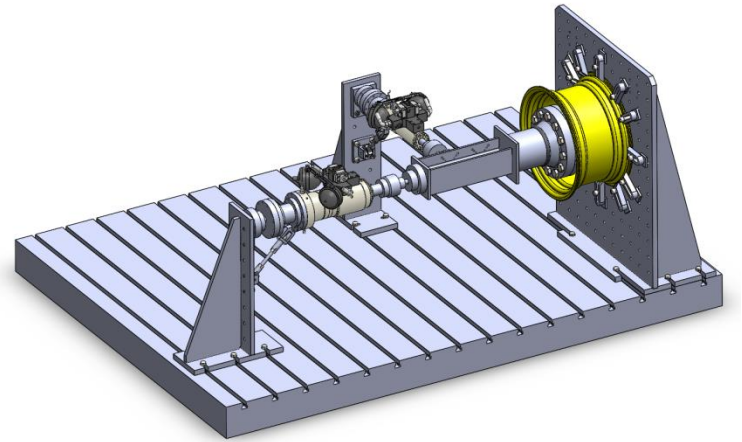
4. Testing field for investigations on fatigue/durability

- Hydraulic power unit (100 kW max.)
- Test field with base in size of 4x3 m
- IST Hydro-Puls cylinders with forces of 25 kN (2x), 63 kN and 100 kN
- MTS control for the independent driving of the cylinders
- Different angle plates with M24 hole patterns for clamping the specimens/ fitting the cylinders

5. Design of a multi-axial test rig for agricultural rims

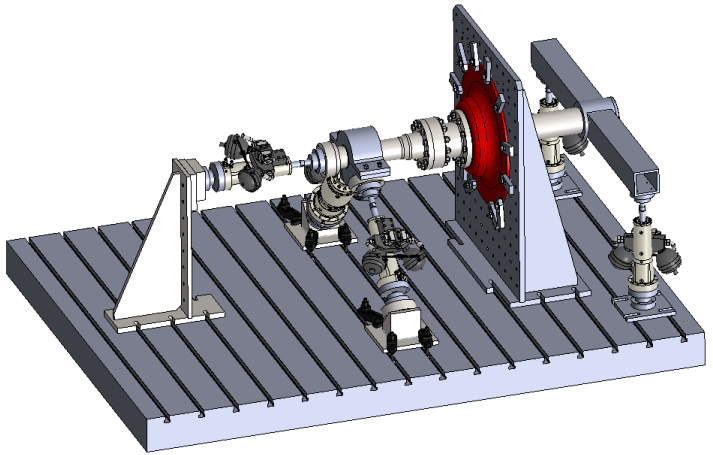
First step:

- 2 axis (dynamic bending load and tensile/pressure load)
- First investigations of phenomenon



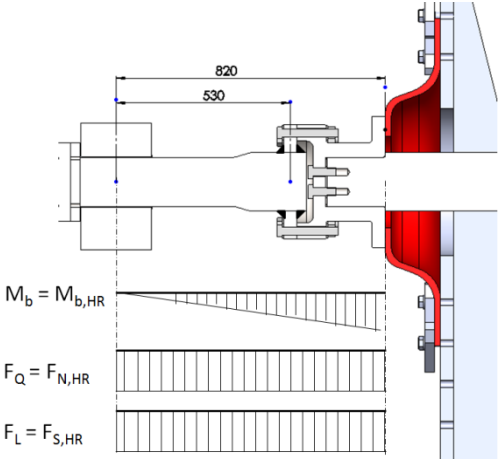
Second step:

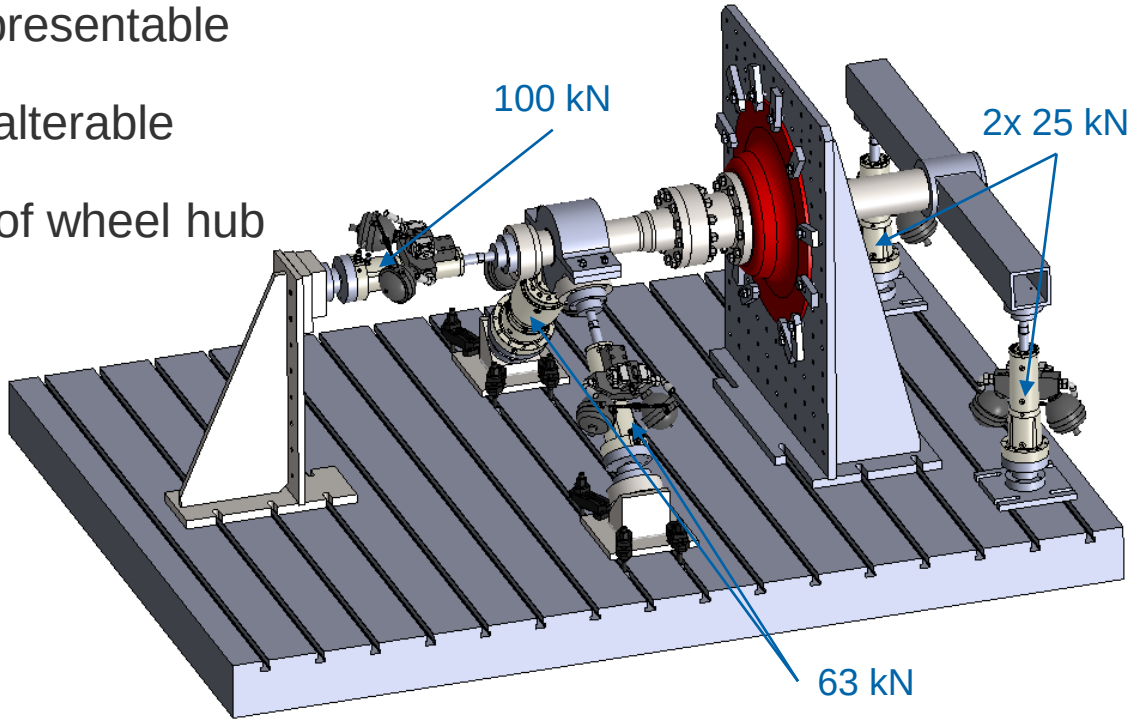
- 3 axis (dynamic rotating bending load, torsion and tensile/pressure load)
- More accurate tests possible



5. Design of a multiaxial test rig for agricultural rims

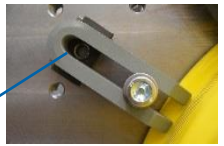
- Current design of the multiaxial test rig for tractor rims
- All load situations representable
- Position of cylinders alterable
- Complicated Design of wheel hub

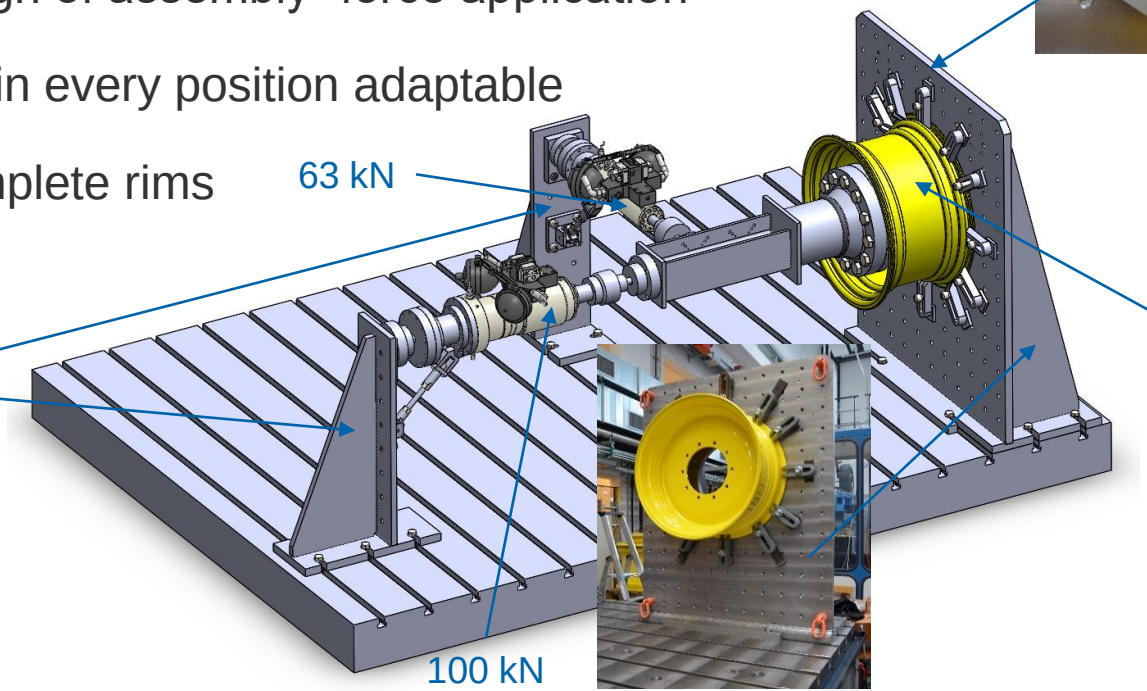




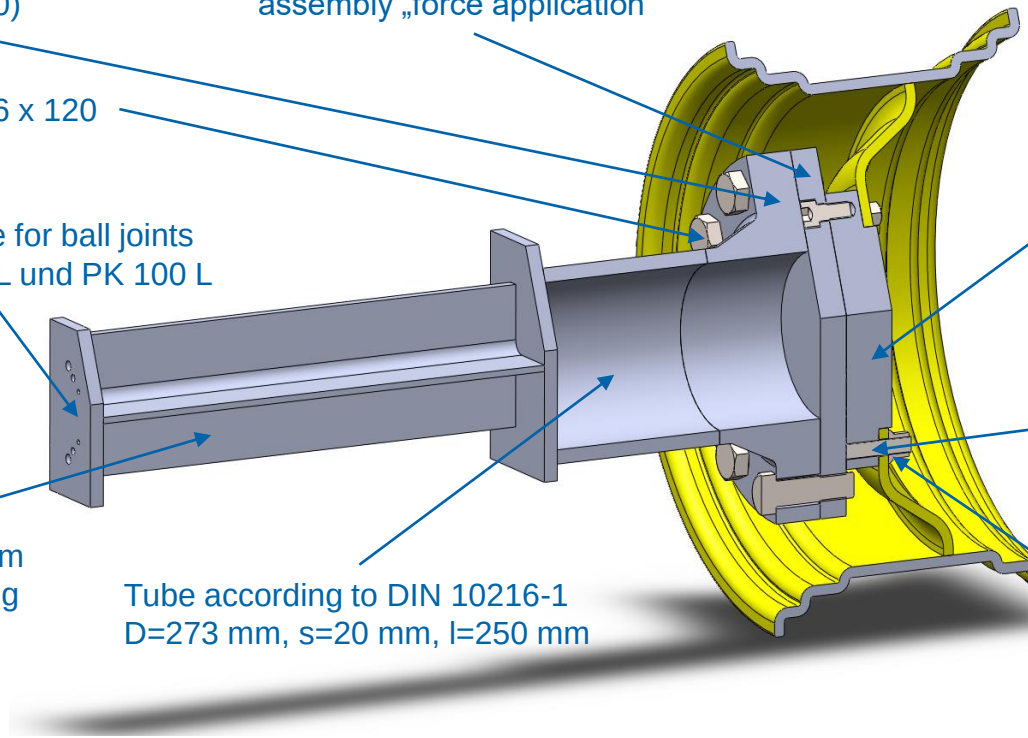
5. Design of a multi-axial test rig for agricultural rims

- Clamping with 12 clamps (DIN 6315)
- Simpler design of assembly “force application”
- All cylinders in every position adaptable
- Tests on complete rims





5. Design of a multi-axial test rig for agricultural rims



Standard flange according to DIN EN 1092-1 (DN 250, PN 160)

Connection plate for separate mounting of hub plate and assembly „force application“

Hub plate with mounting dimensions according to DIN 74361-3 (exchangeable for other bolt circles)

12x hex bolt M36 x 120

Connection plate for ball joints PK 25 L, PK 63 L und PK 100 L

10x threaded bolt M22 x 1,5

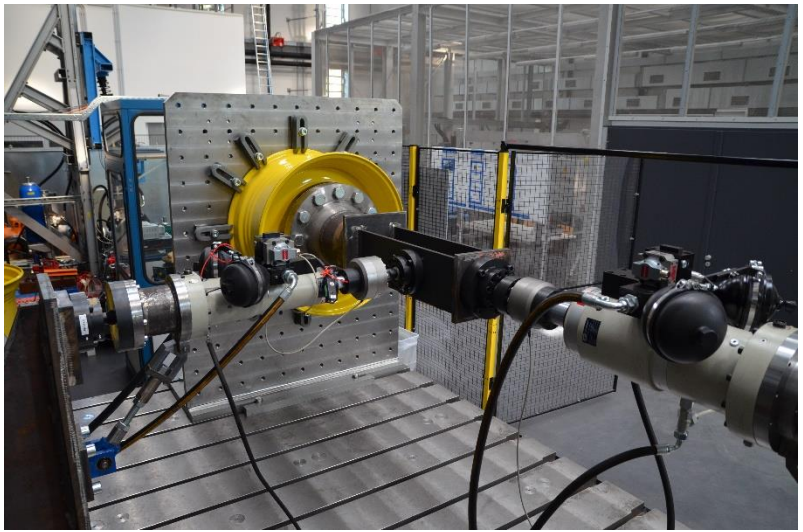
Wide flange beam IPB200 according to DIN 1025-2

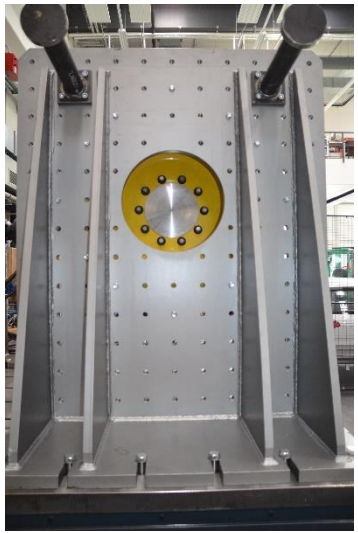
Tube according to DIN 10216-1 D=273 mm, s=20 mm, l=250 mm

Wheel nut with pressure plate according to DIN 74361-3

6. Experimental investigations on agricultural rims

- Achievable bending moment on the rim ca. 58 kNm (alternating)
- Tensile/pressure load 86 kN (statically)
- Tests with frequencies up to 10 Hz

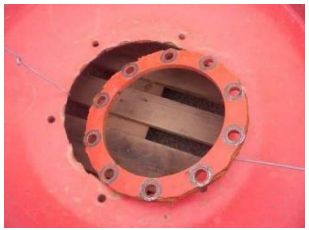




6. Experimental investigations on agricultural rims

- Determination of the tensile/pressure stiffness and the bending stiffness of the specimen wheel
  - Tensile/pressure stiffness test rig: $c_{t/p,TR} = 2.400\ kN/mm$
  - Bending stiffness test rig: $c_{b,TR} = 110\ kN/mm$

- Durability tests for a better Understanding of failure mechanisms
  - Crack initiation and propagation in the area of bolt circle
  - Failure of the screw connection of the rims
  - Application of special load spectra

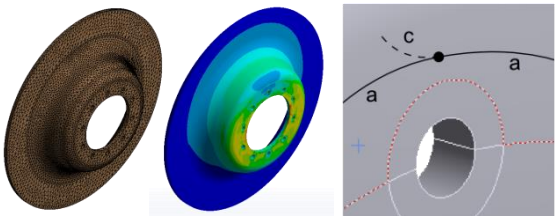


Figures: Grasdorf GmbH

7. Conclusion and outlook

- Identification of forces and moments occurring on agricultural wheels
- Complex FE-Analysis with good accordance
- Test rig available for investigations on tractor rims

- Future investigations:
  - Durability tests (force controlled, stochastic and deterministic load signals)
  - Understanding of the load combinations and the failure mechanisms leading to the damage
  - FE-analysis of linear-elastic crack propagation
  - Improvement of the wheel design



Email contact:

Uli.Woellner@imkf.tu-freiberg.de