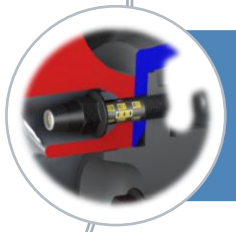
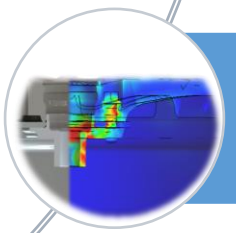
ABC Umformtechnik
Fastener Load Data Simulation and Measurement

ABC Umformtechnik - company and products

Dynamic Fastener Loads and Failure Modes

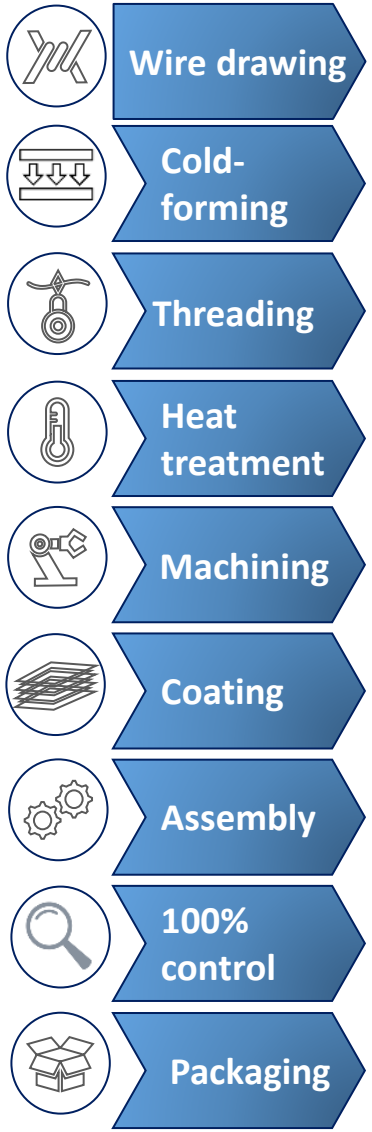


Experimental Load Data Measurement



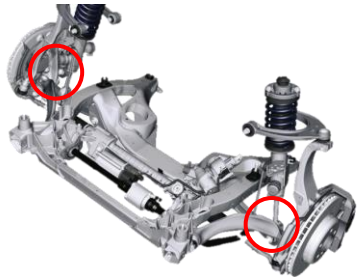
Numerical Load Data Simulation

- Founded in 1823 in Gevelsberg
- 315 employees
- Production area: 18,700 m²
- Production capacity 20,000 tons
- 80% of production processes in-house
- Bolt Diameter M5 – M16

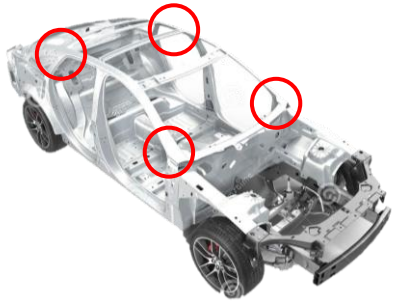


Driveshaft Fasteners

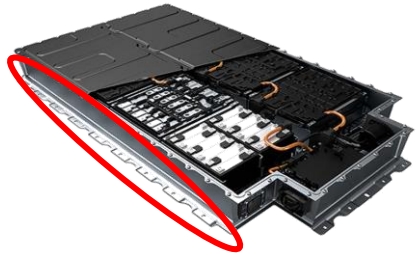
Chassis Fasteners



Weld Fasteners



Electrical Fasteners



Wheel Fasteners

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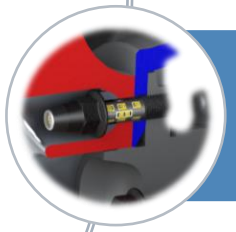
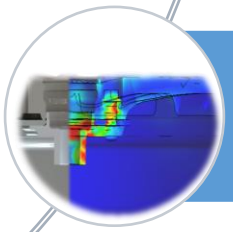
Dynamic Fastener Loads and Failure Modes



Experimental Load Data Measurement



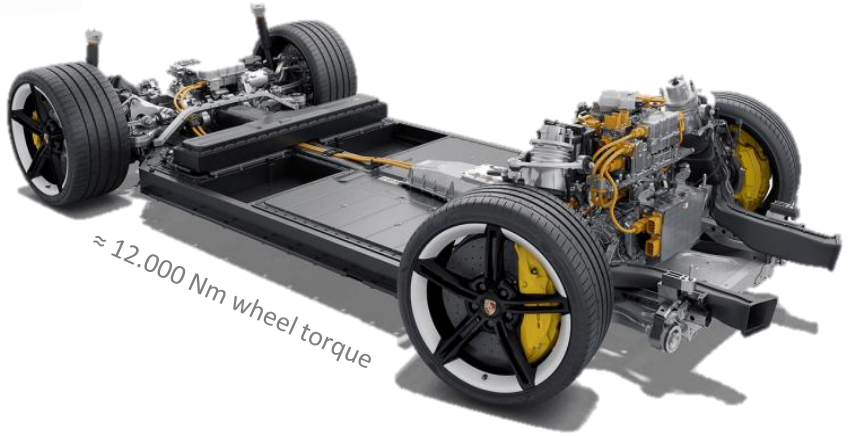
Numerical Load Data Simulation

Dynamic Fastener Loads and Failure Modes – Wheel Fastener Challenges

SUV Trend

Customer requirements

Aero wheels



SUV Trend

- **SUV trend** → **vehicle mass**
- **SUV driving perf.** → **wheel loads**
- **Tire performance** → **wheel loads**
- **Electrification** → **vehicle mass**
- **Electrification** → **wheel torque**
- **Electrification** → **new load cases**
- **CO2** → **aerodynamic wheels**
- **CO2** → **lightweight design**
- **Customer** → **wheel sizes**
- **Customer** → **acceler. performances**
- **Quality** → **corrosion performance**
- **Financial** → **fasteners cost reduction**

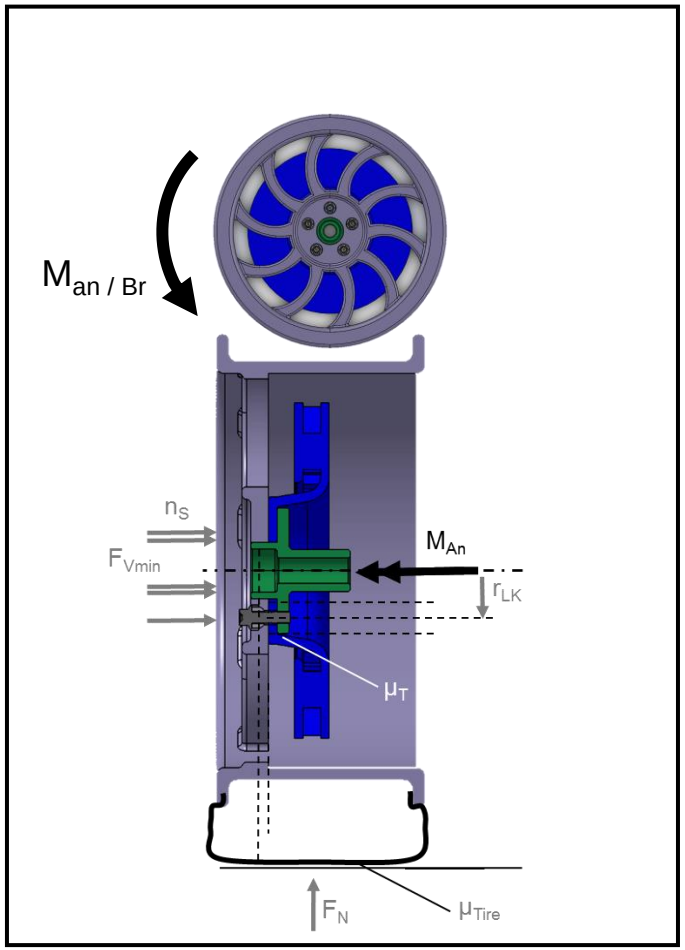
Sources: www.porsche.com/germany/models/macan/macan-models/ ; https://www.theverge.com/2019/4/15/18311526/vw-electric-suv-id-roomzz-shanghai-auto-show-2019; https://newsroom.porsche.com/de/produkte/taycan/antrieb-18543.html; https://www.ohmwheels.com/explore-ohm-custom-wheels/tesla-model-3-wheels-rims-guide.php; https://www.automobil-produktion.de/hersteller/neue-modelle/akkutechnik-der-zukunft-am-rande-der-belastbarkeit-332.html

https://www.pff.de/thread/2647885-wenn-die-radschrauben-zu-kurz-sind/

https://www.pff.de/thread/263248-alternative-radbolzen/

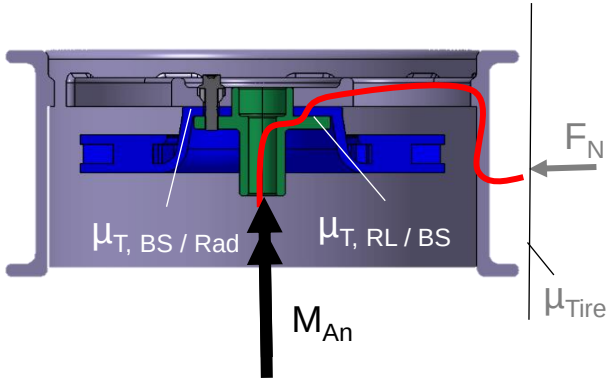
https://www.motor-talk.de/bilder/radschrauben-gebrochen-gerissen-2-stueck-an-gleichem-rad-g59873590/img-20131010-172829-1-i206297911.html

Wheel load situation

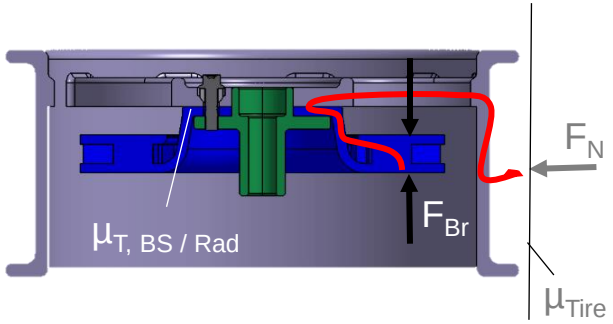


Wheel attachment load situation

Acceleration / Recuperation

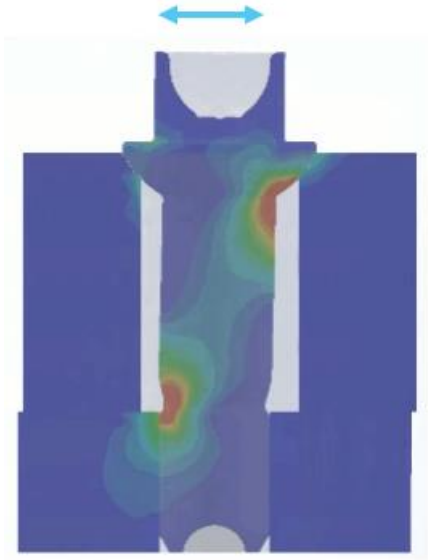


Braking



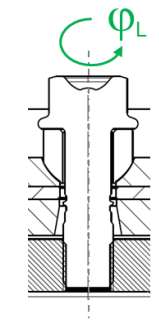
Wheel fastener load situation

Transverse fastener load

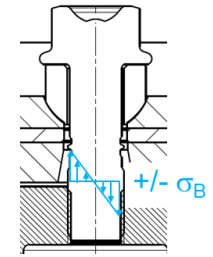


Failure Mode

Self Loosening



Fatigue



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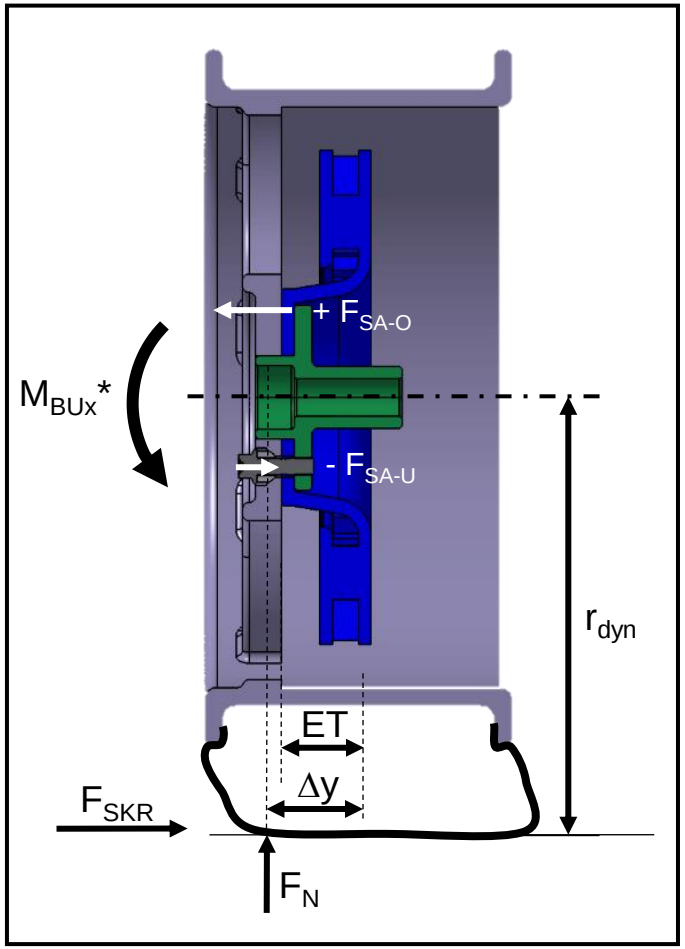
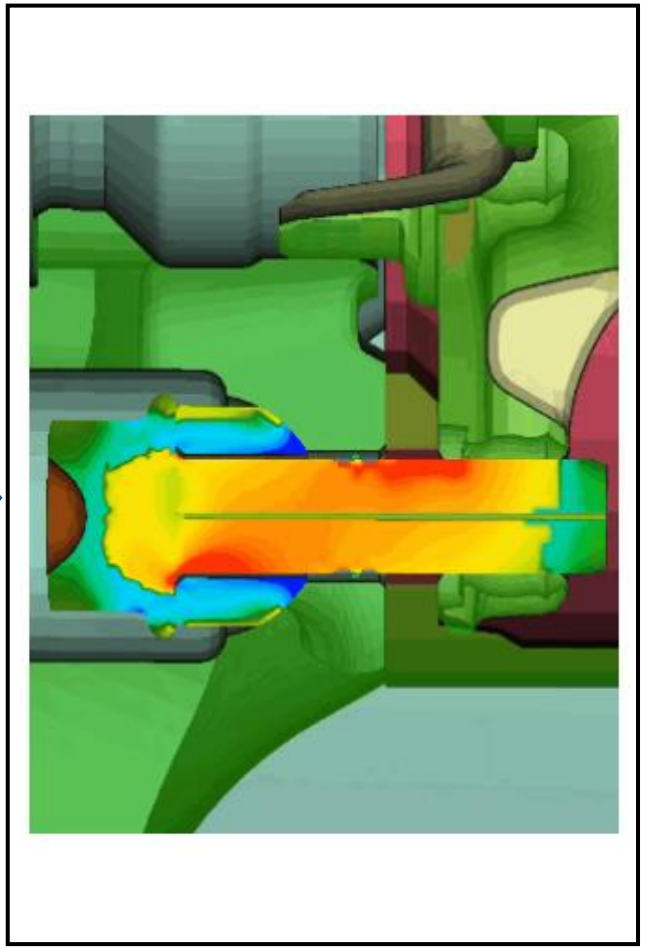
Wheel load situation

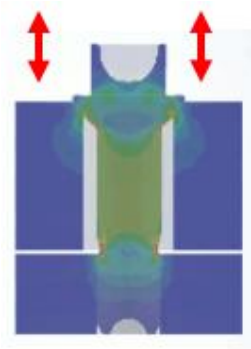


Wheel attachment load situation

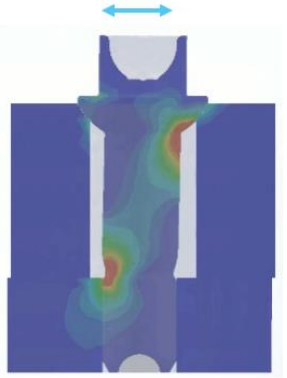


Wheel fastener load situation

Axial Fastener Load

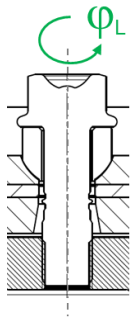


Transverse Fastener Load

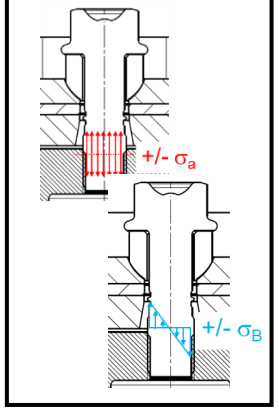


Failure Mode

Self Loosening



Fatigue



Dynamic Fastener Loads and Failure Modes – Wheel Fasteners – ABC R&D Test Capacity

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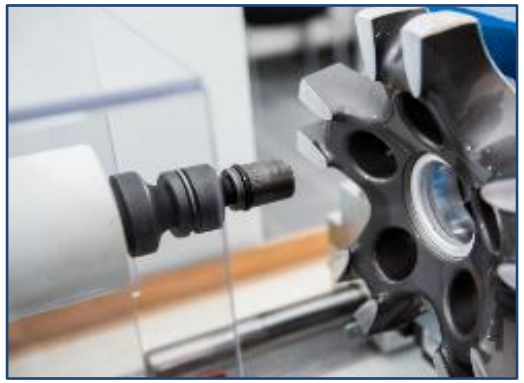

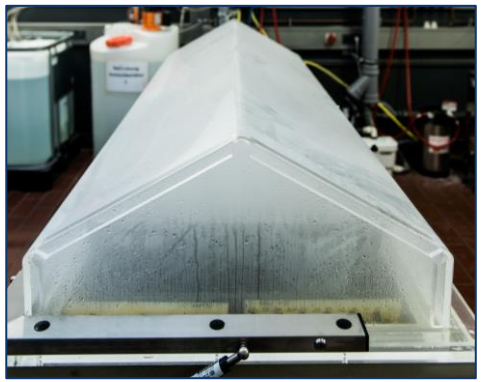

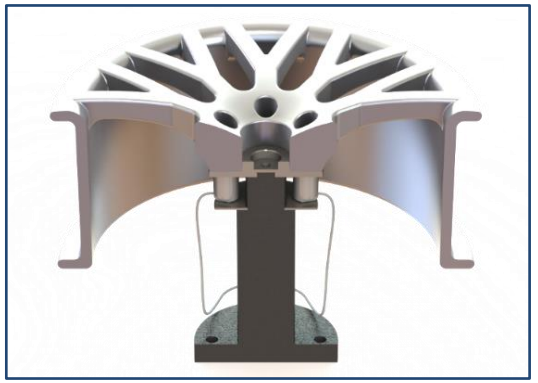

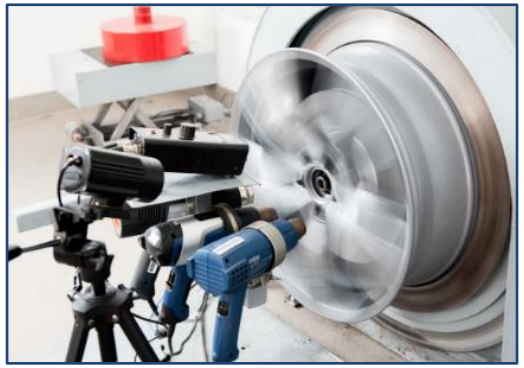

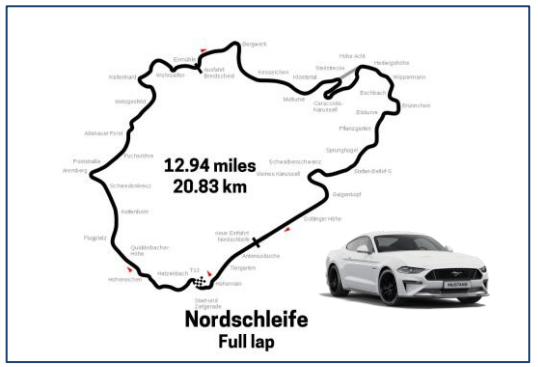

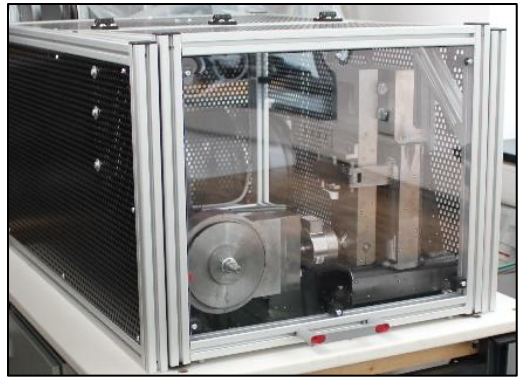

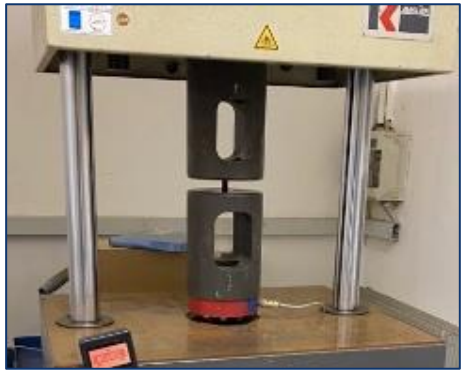

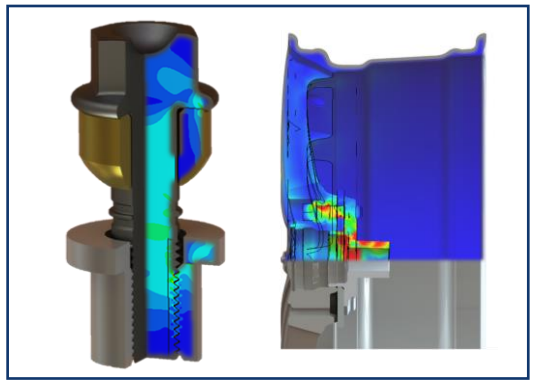

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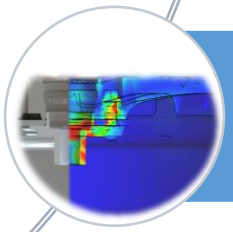
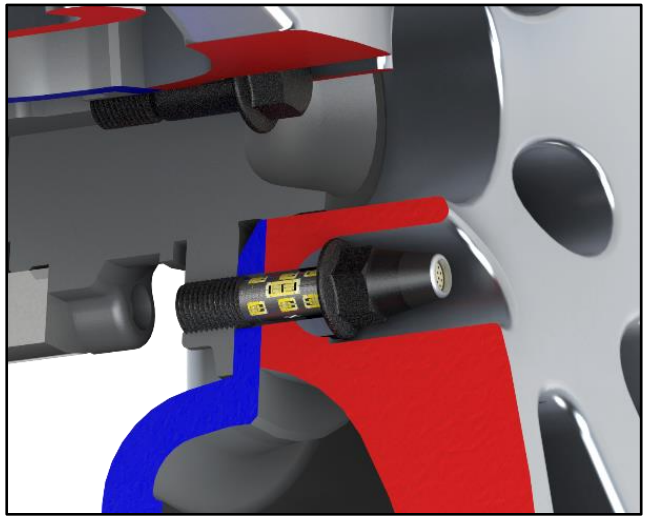
Dynamic Fastener Loads and Failure Modes

Experimental Load Data Measurement

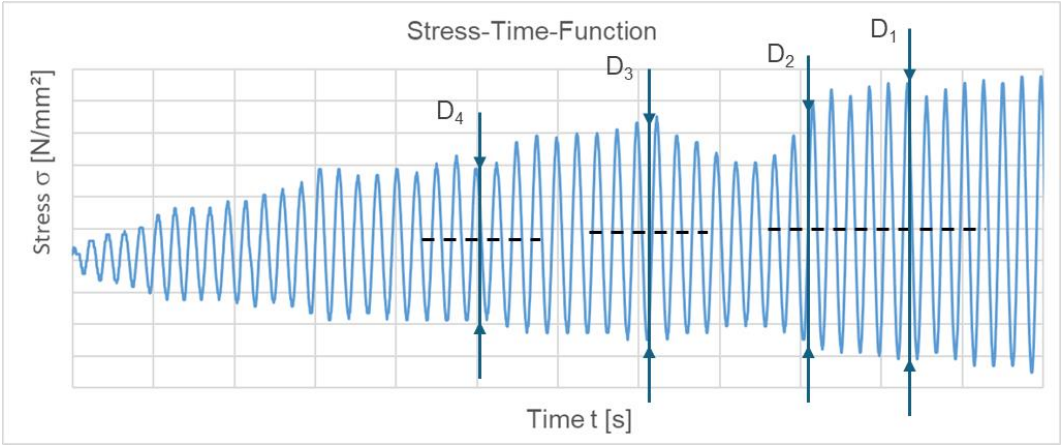


Numerical Load Data Simulation

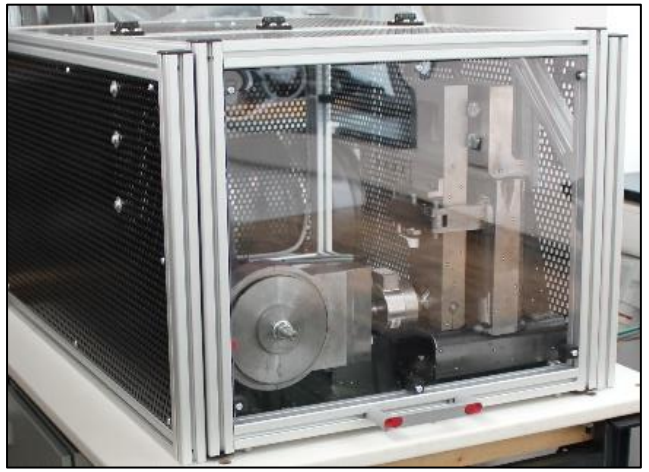
ABC Multi Sensor Bolts



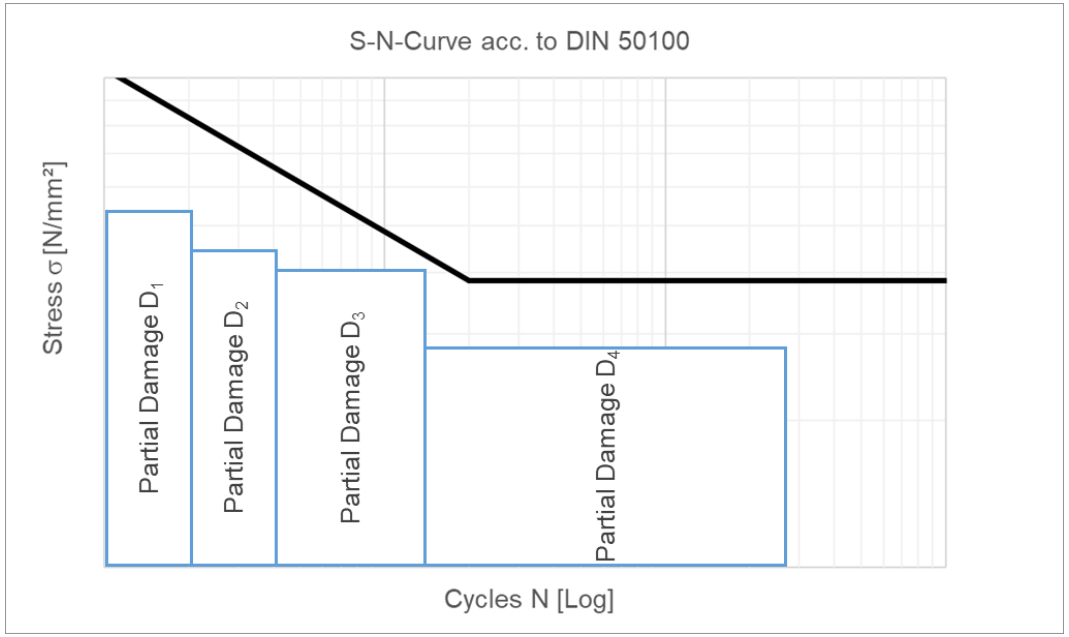
1. Stress
Axial- & Bending Stress Information of Fastener

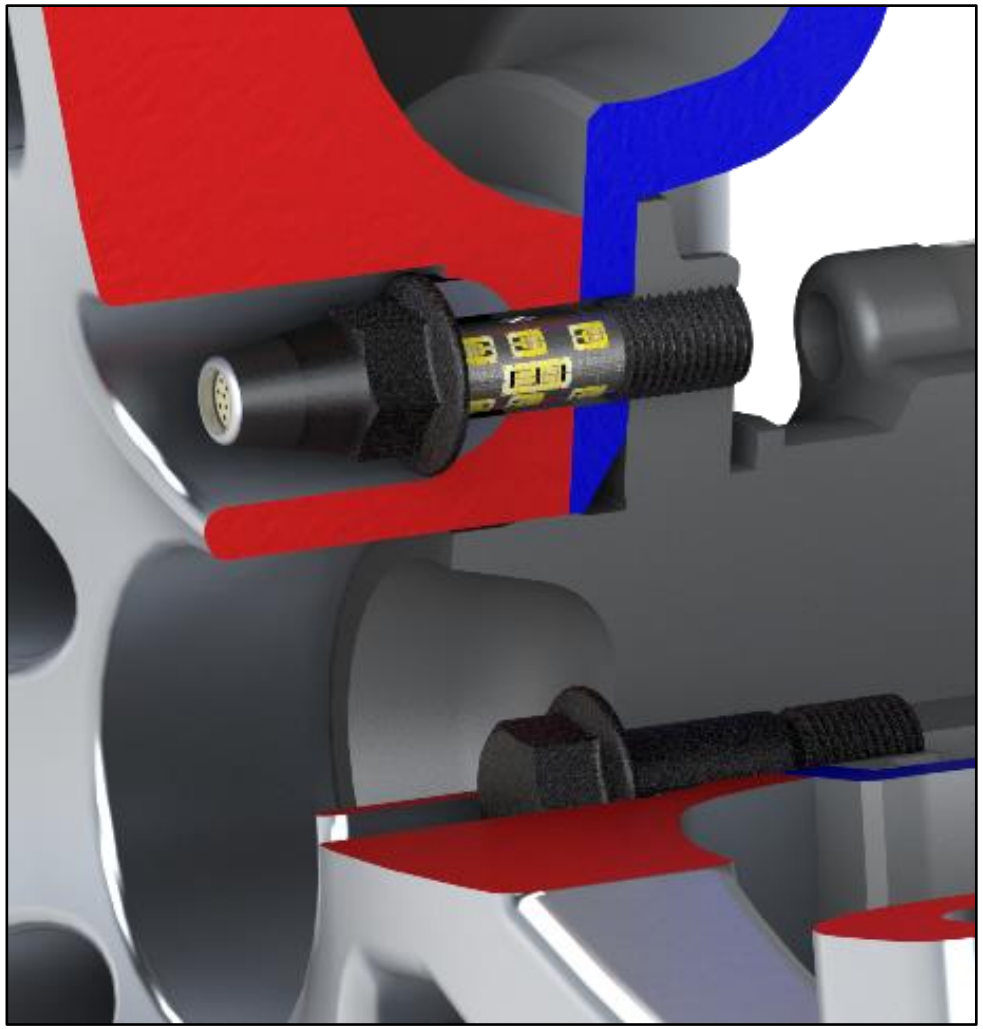


ABC Fatigue Testing

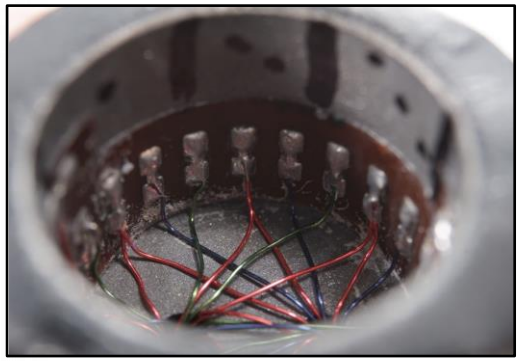


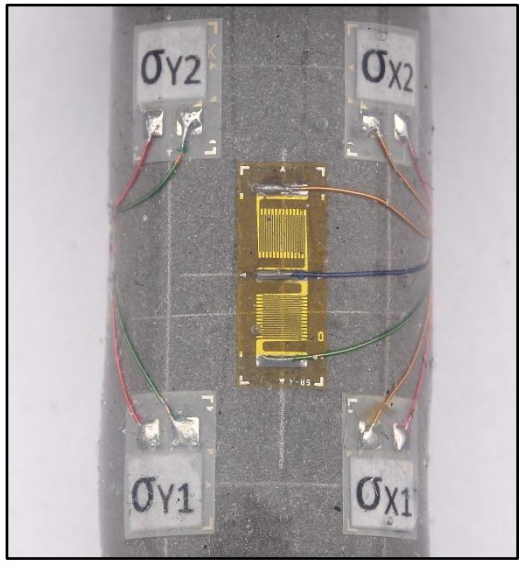
2. Stress ability
S-N-Curves by ABC fatigue testing (Axial & Bending)



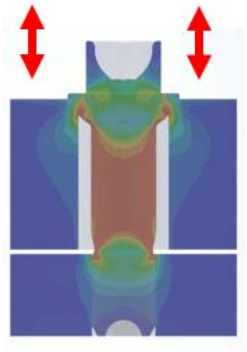


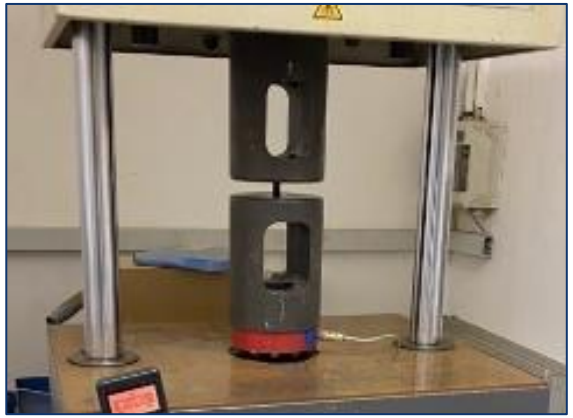

σY1
σX1



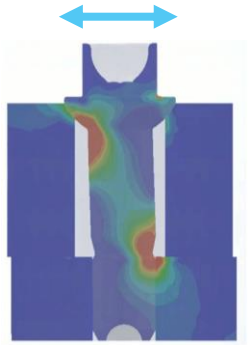

σY2
σX2
σY1
σX1

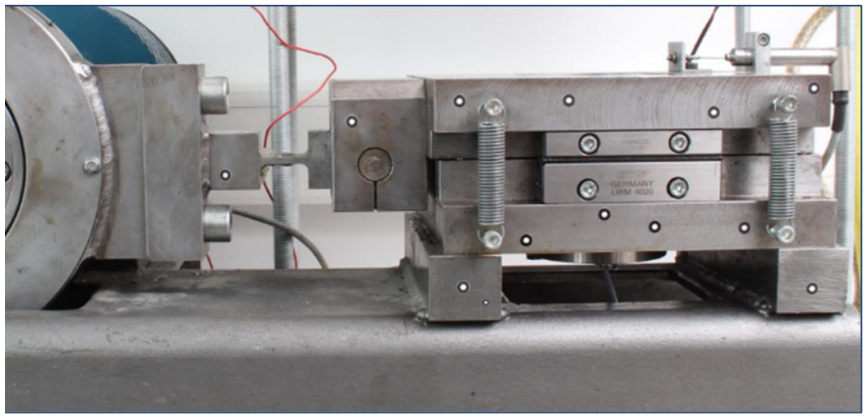
Axial Stress ability
Resonant Pulsator



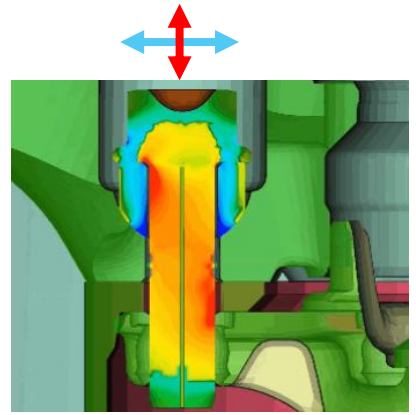


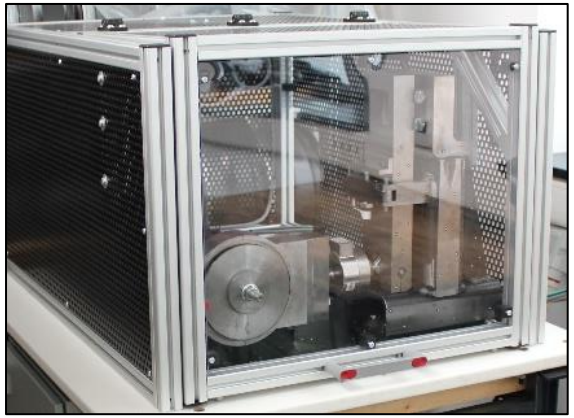
Bending Stress ability
Dynamic Transversal Load Test Rig





Multi axial Stress ability
Dynamic Excentric Axial Test Rig





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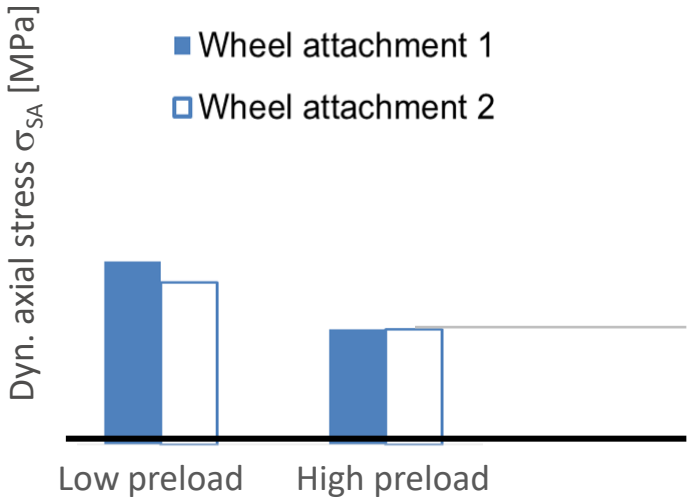
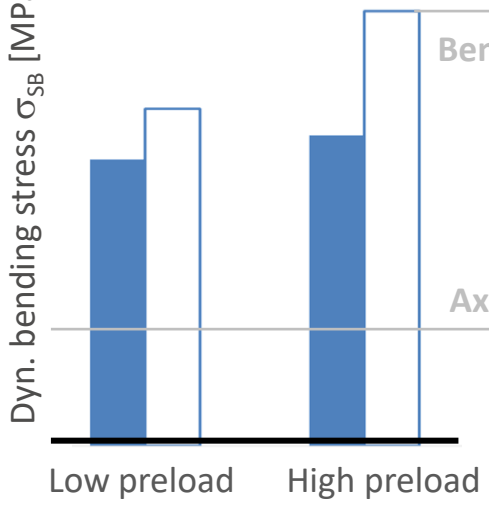
1. Stress

ABC Multi Sensor Bolts





2. Stress ability

S-N-Curves

Axial Fatigue

Bending Fatigue

Self-Loosening

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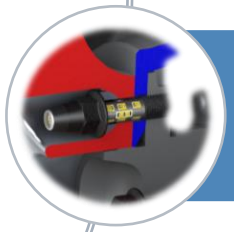
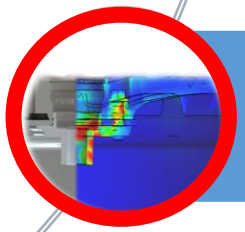
Dynamic Fastener Loads and Failure Modes



Experimental Load Data Measurement



Numerical Load Data Simulation

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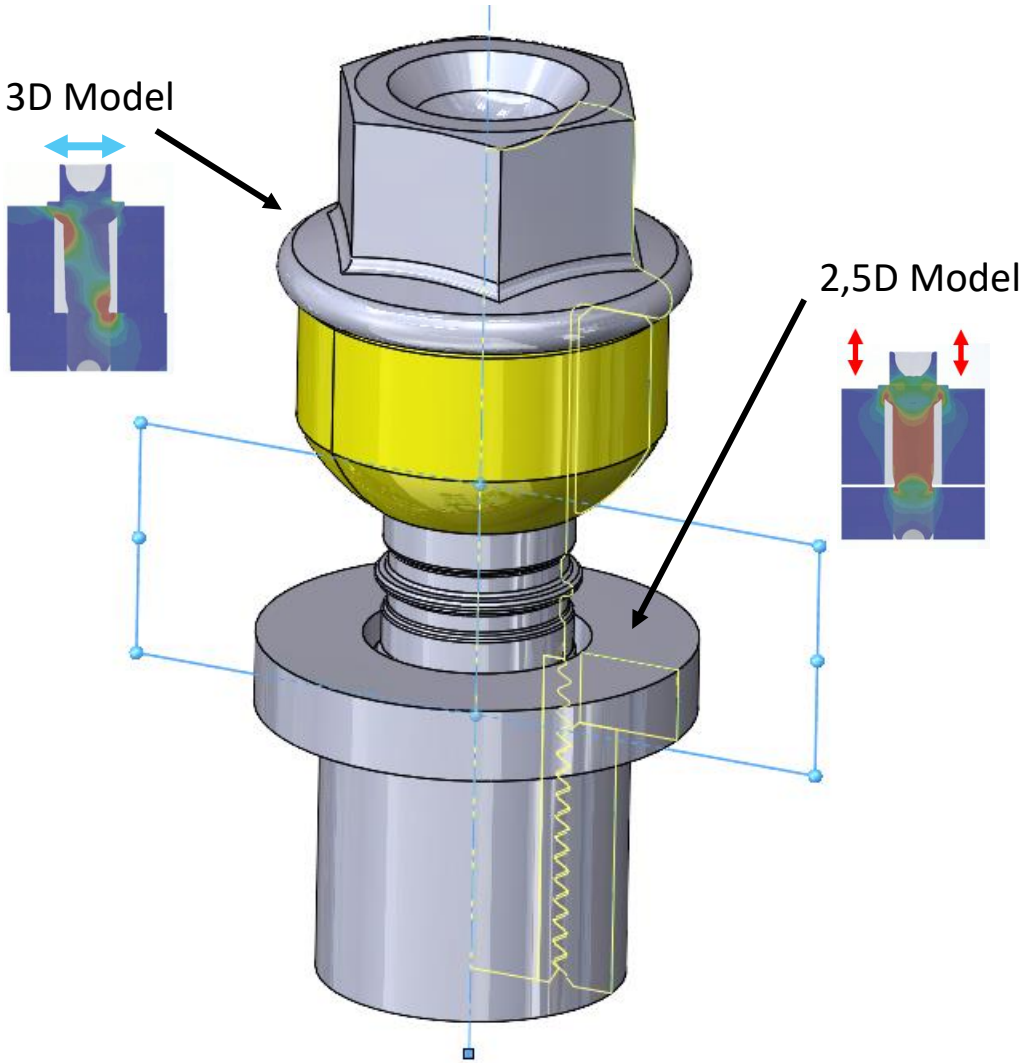
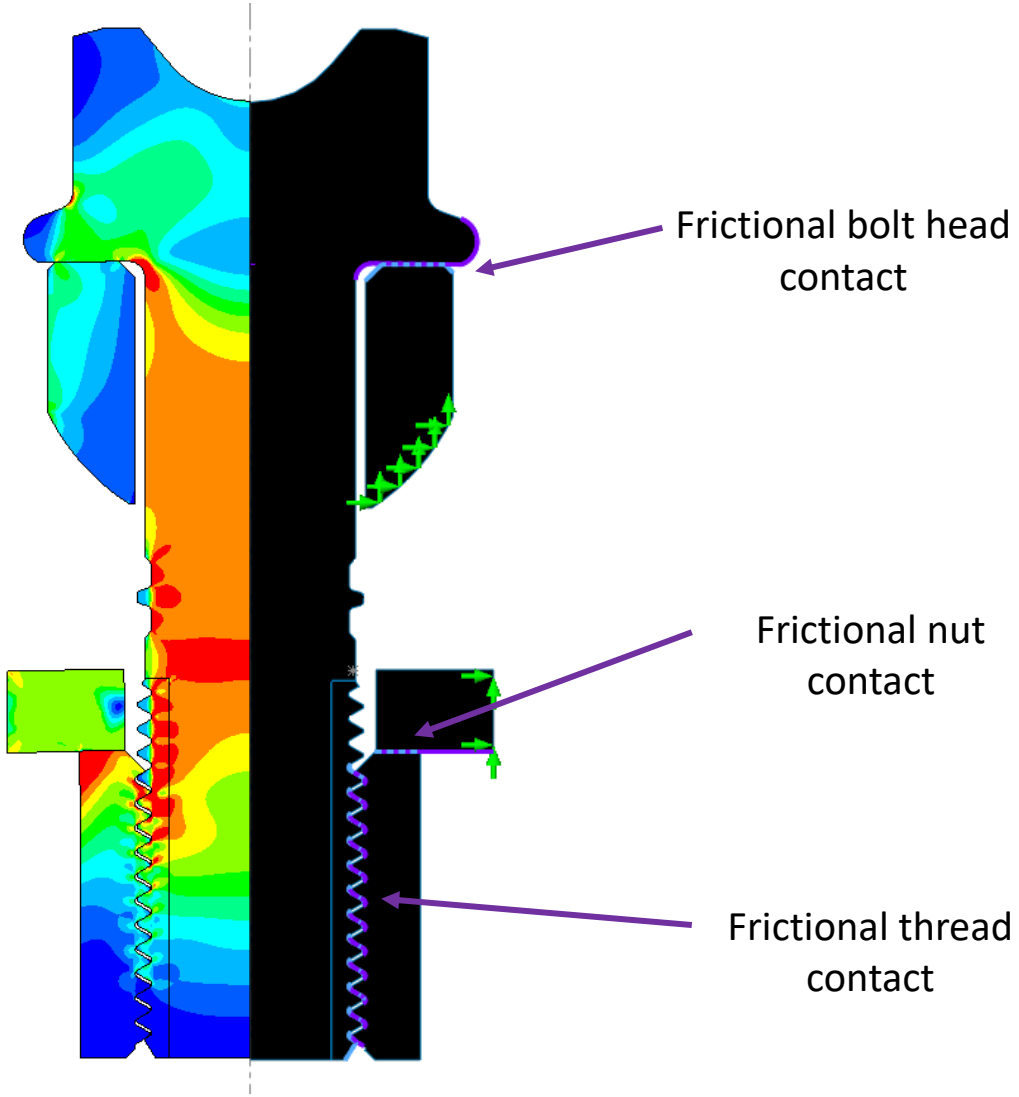
Model complexity



Contact behaviour



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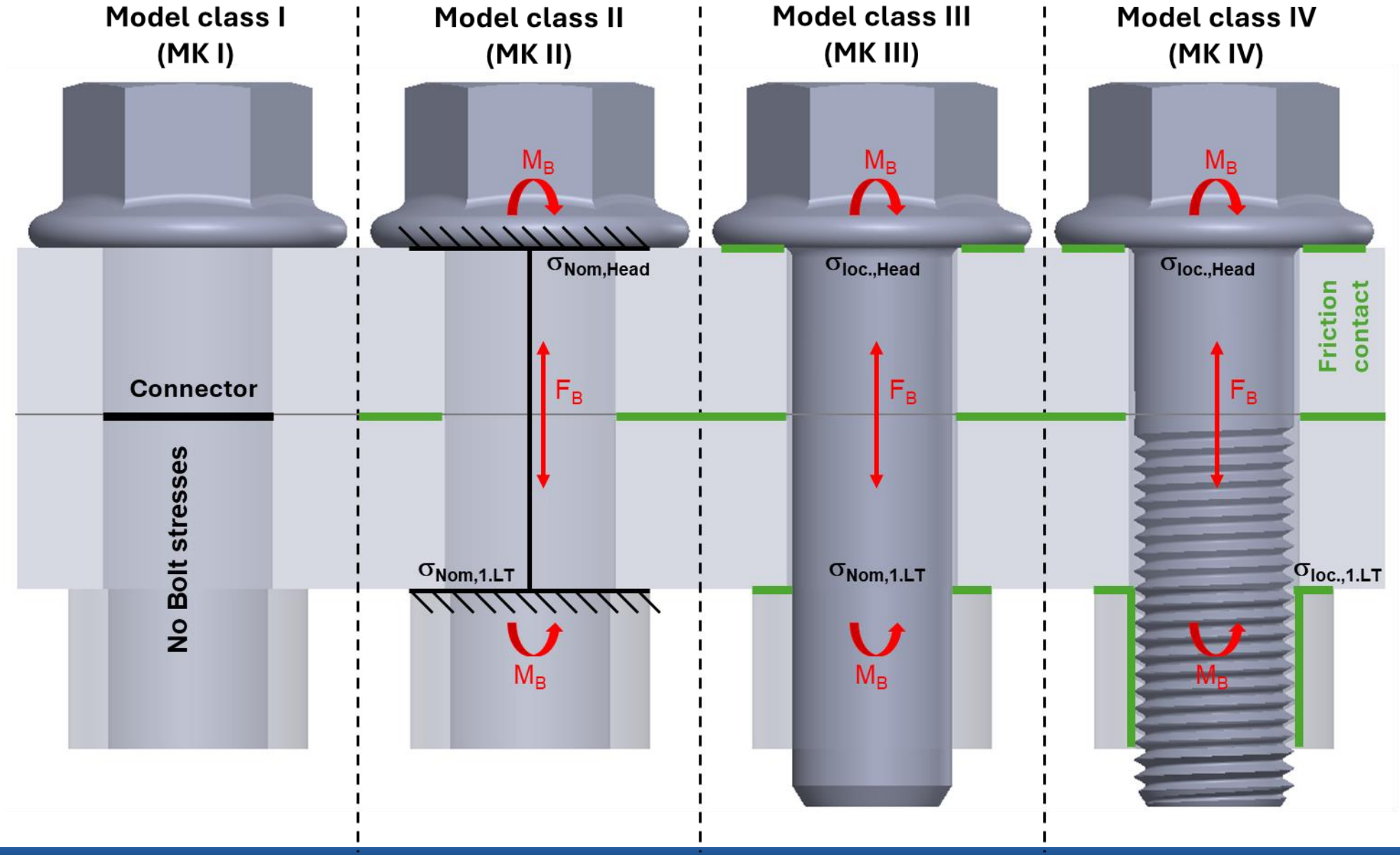
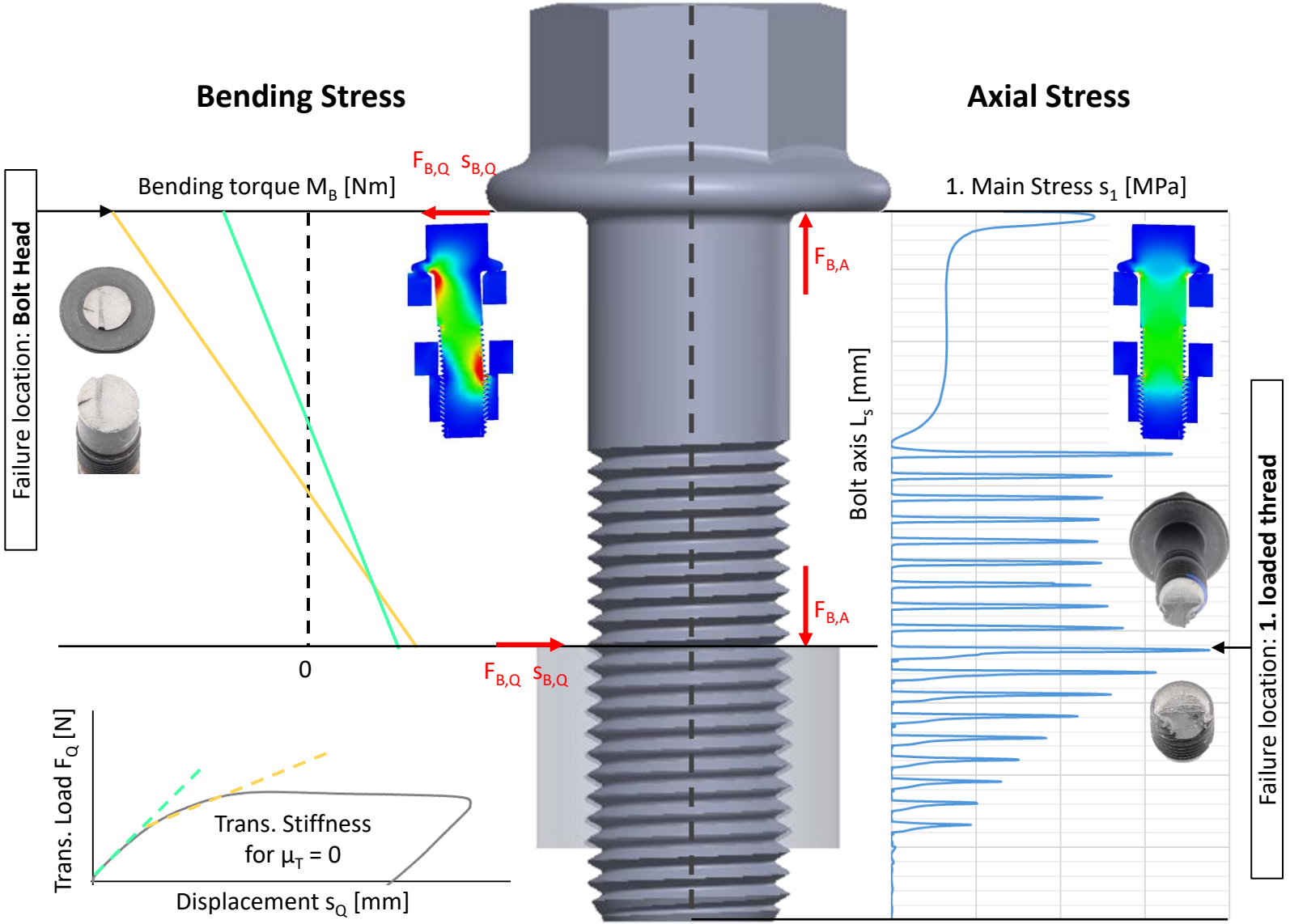
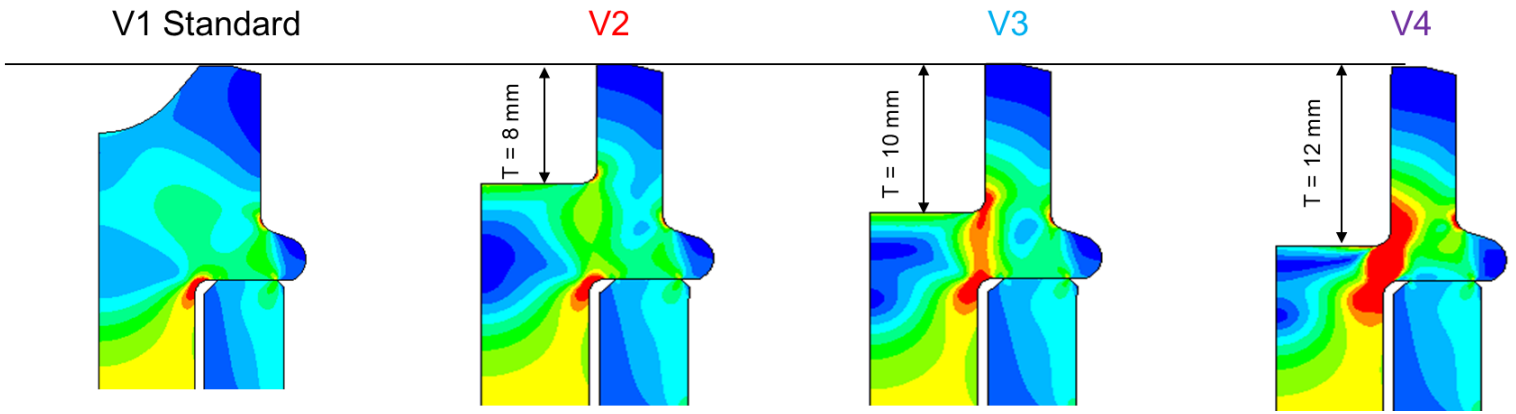



Bending Stress
Axial Stress
Bending torque M_B [Nm]
1. Main Stress s_1 [MPa]
$F_{B,Q}$ $s_{B,Q}$
$F_{B,A}$
$F_{B,A}$
$F_{B,Q}$ $s_{B,Q}$
Bolt axis L_s [mm]
Failure location: **Bolt Head**
Failure location: **1. loaded thread**
0
Trans. Load F_Q [N]
Trans. Stiffness
for $\mu_T = 0$
Displacement s_Q [mm]

Numerical Load Data Simulation – Location of Failure



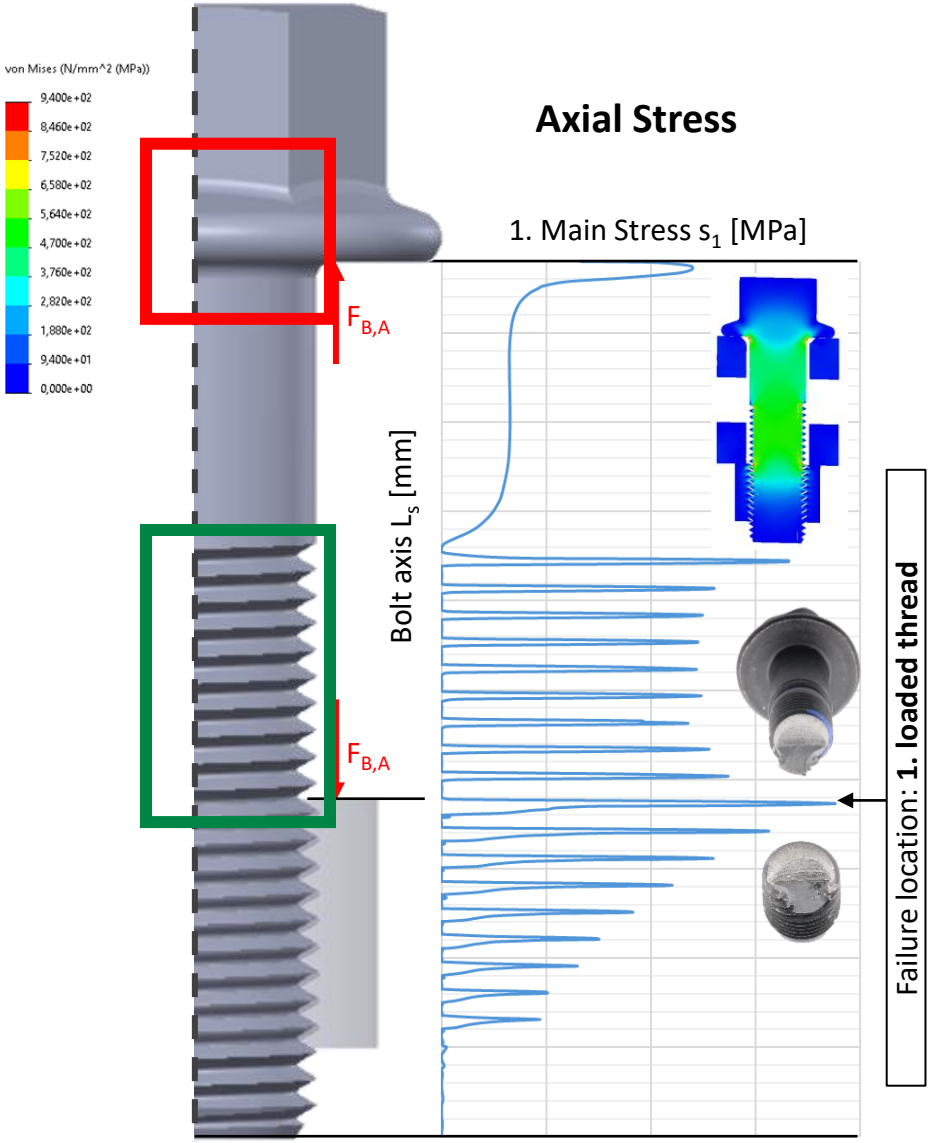
Static load → Failure location = thread

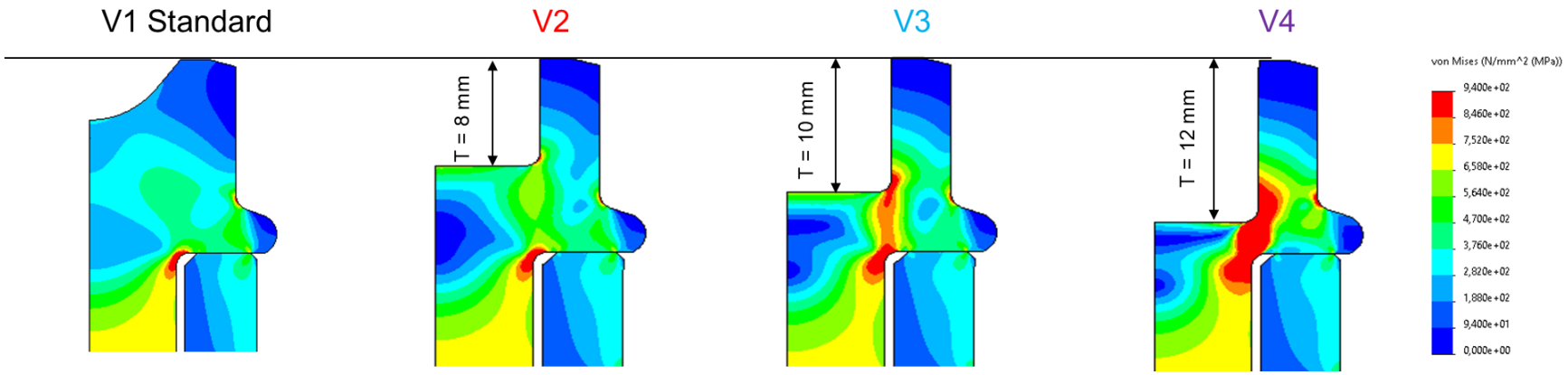
Static load → Failure location = thread

Static load → Failure location = thread

Static load → Failure location = bolt head

„Schwachkopfschraube“
„Weakhead Bolt“

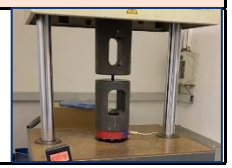


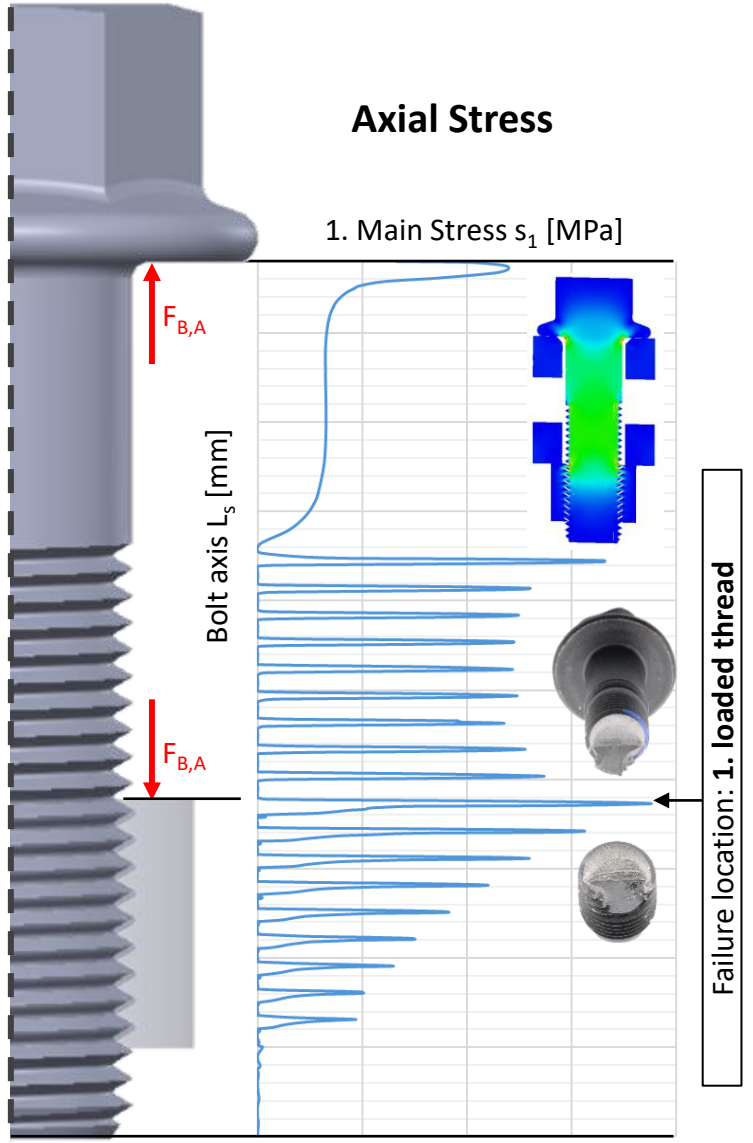


Failure location of Lightweight optimized Bolts

Load F_A	Bolt	Variant			
		V1 - Standard	V2 - 8 mm	V3 - 10 mm	V4 - 12 mm
± 18 kN	1	1. LT.	1. LT.	1. LT. + Crack on Bolt Head	Bolt Head
	2	1. LT.	1. LT.	Bolt Head	Bolt Head
	3	1. LT.	1. LT.	Bolt Head	Bolt Head
	4	1. LT.	1. LT.	Bolt Head	Bolt Head
	5	1. LT.	1. LT.	1. LT. + Crack on Bolt Head	Bolt Head
± 12 kN	6	1. LT.	1. LT.	1. LT. + Crack on Bolt Head	Bolt Head
	7	1. LT.	1. LT.	Bolt Head	Bolt Head
	8	1. LT.	1. LT.	1. LT.	Bolt Head
	9	1. LT.	1. LT.	1. LT.	Bolt Head
	10	1. LT.	1. LT.	Bolt Head	Bolt Head

1. LT. = 1. Loaded Thread
1.LT. + Crack on Bolt Head = Fracture on 1. LT. and Crack on Bolt Head
Bolt Head = Fracture on Bolt Head





Numerical Load Data Simulation – Location of Failure

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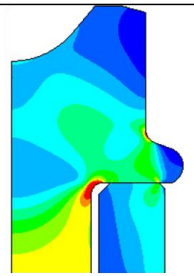
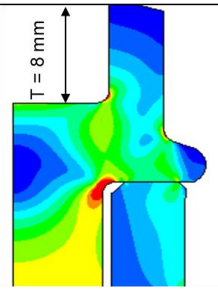
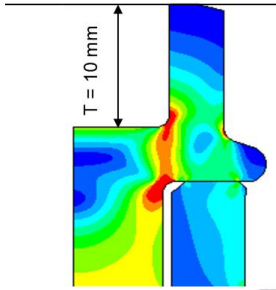
V1 Standard



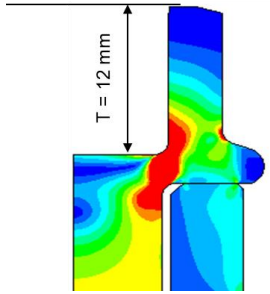
V2



V3



V4



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	8	1. LT.	1. LT.	1. LT.	Bolt Head
	9	1. LT.	1. LT.	1. LT.	Bolt Head
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Bolt Head = Fracture on Bolt Head

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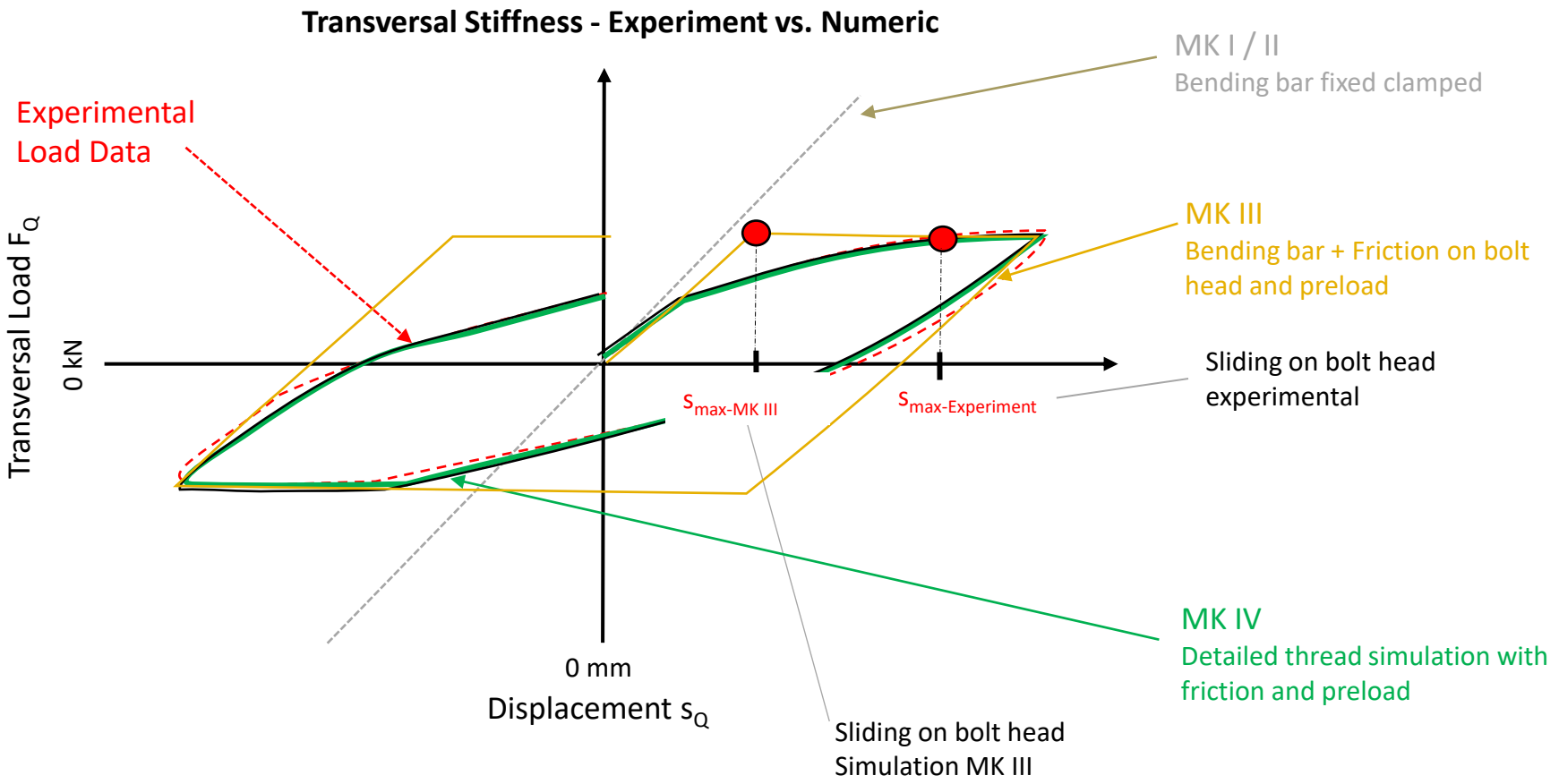
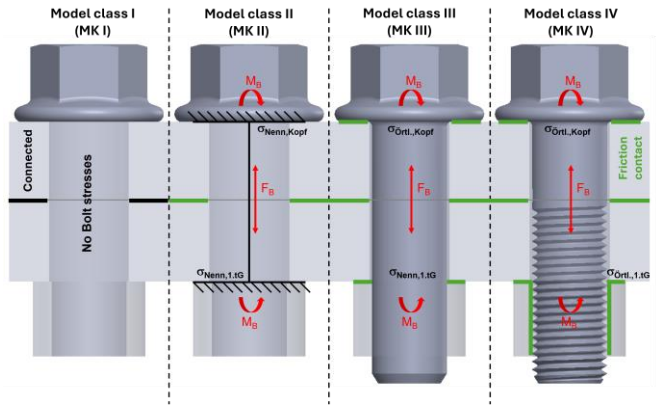
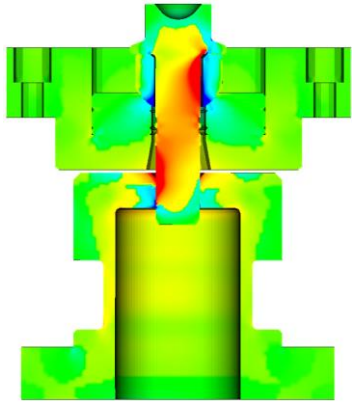
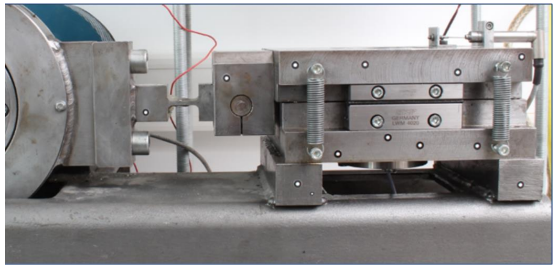




F_Q / s_Q





Literature: Dr. Y Öngün, Prof. M Klöcker,Dr. D. Koch; K. Teitscheid; Dynamische Querbelastbarkeit von vorgespannten Schraubenverbindungen

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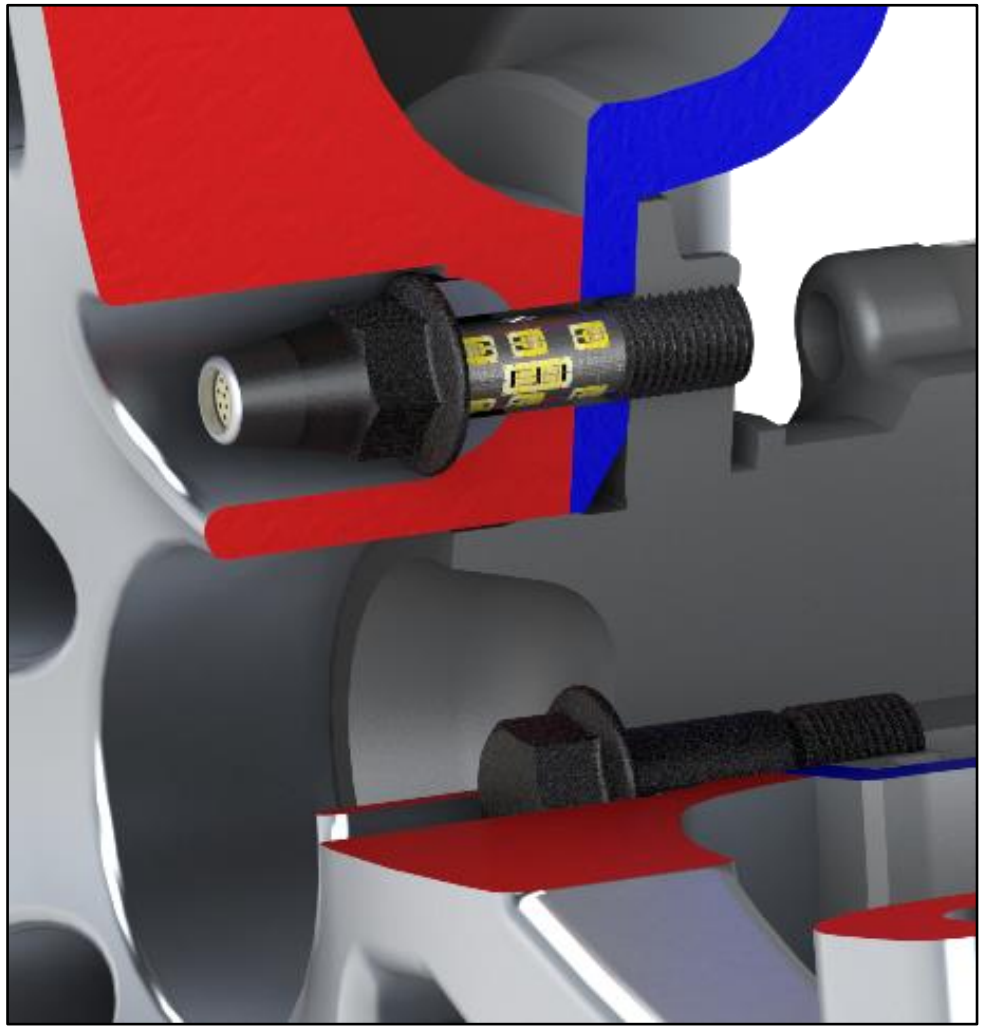
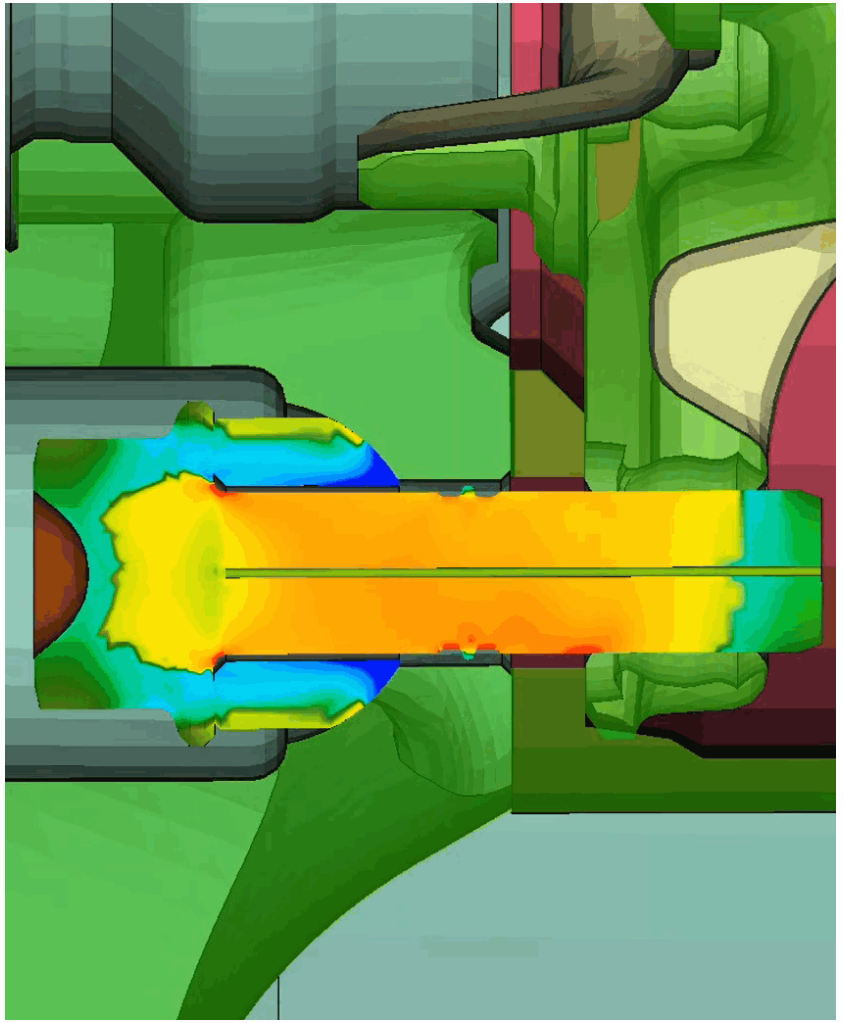
ABC Multi Sensor Bolts



VS.

Customer Simulation



Summary

- New challenges for fatigue resistance of multi axial loaded fasteners due to lightweight designs
- Special “Know how” for fastener simulation is required due to complexity of contact behaviour
- Benefit of load data measurement of ABC Multi Sensor Bolts to optimise simulation quality
- Special SN-curves for multi axial stresses on ABC test benches enable the evaluation of fatigue life

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