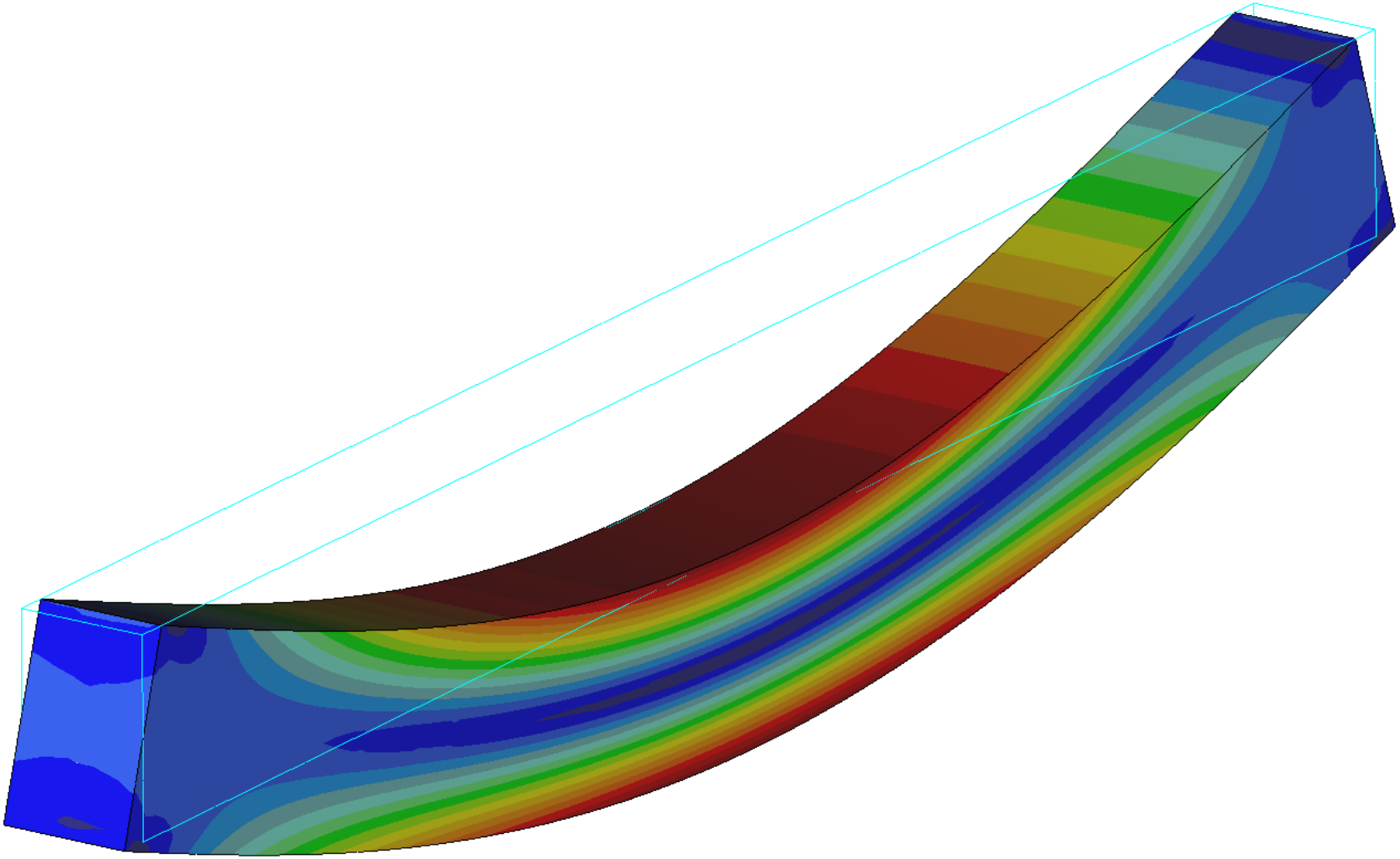
Pro/ENGINEER Mechanica Structure:
nichtlineare Simulationmöglichkeiten

11. Bayreuther 3D-Konstrukteurstag

Urs Simmler, PTC
30. Sept. 2009
MCAD-Simulation-Specialist

MECHANICA nur für Einzelteile im linearen Bereich einsetzbar ???



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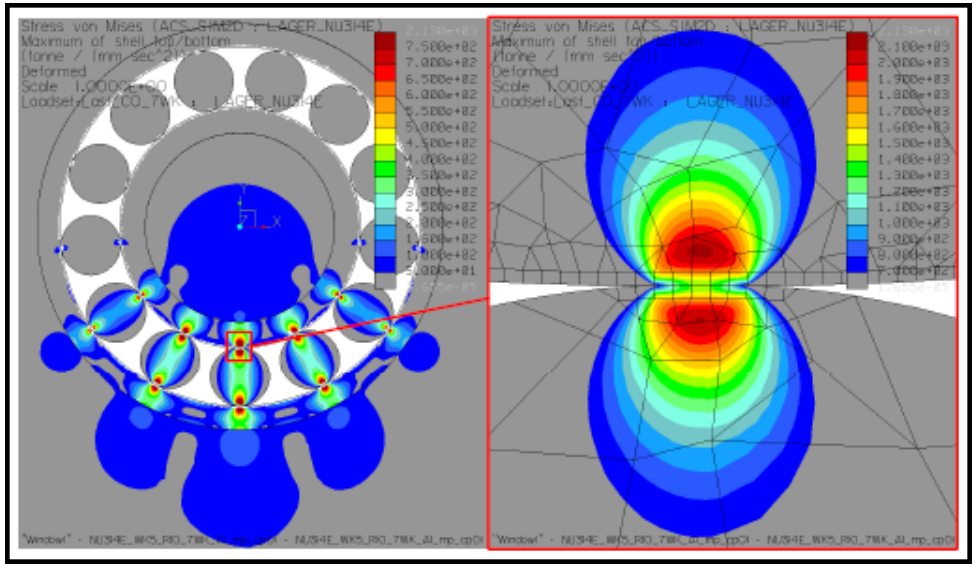
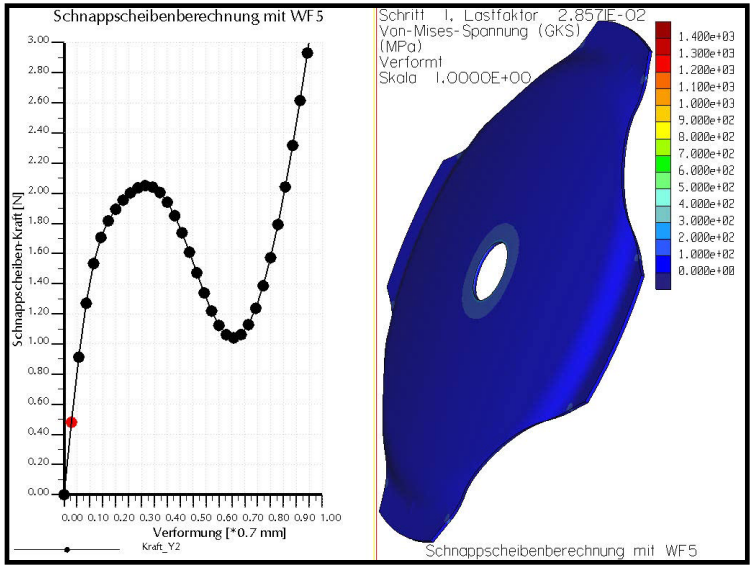
NEIN – MECHANICA löst auch komplexere Aufgaben





... und das in direkt In Pro/ENGINEER:

- **in einer benutzerfreundlichen Oberfäche**
- **mit den Vorteilen eines vollparametrischen Systems**
- **ohne Schnittstellen**
- **bei gleichzeitiger Simulations-Datenverwaltung**
- **mit der bewährten P-Element-Technologie**

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Kundenbeispiele

Carl Zeiss Optronics GmbH, located in Oberkochen, Germany, is a member of the Carl Zeiss group, a worldwide leading manufacturer of optical systems. Carl Zeiss Optronics is focused on high-precision and robust opto-electronic systems for observation and defense purposes.

ZEISS
We make it visible.

BUSINESS INITIATIVE

- Carl Zeiss Optronics includes structural analysis and dynamic optimization very early in the product development process to assure that the optical systems fulfill the high standards regarding optical precision within a rough environment. To meet the very tough development schedule, PTC Global Services was charged with the dynamic system analyses of the complete periscope of the new German Puma tank.

SOLUTION

- PTC Global Services Consulting built up the dynamic system model of the periscope in Pro/MECHANICA directly on the given Carl Zeiss Pro/ENGINEER assembly data. Shock and random response calculations were performed with this model and structural modifications proposed, elaborated with the designers and analyzed.

RESULT

- Located weak points in the initial design, implemented enhancements that significantly improve shock strength and image quality under vibration loads
- Reduced system mass by approx. 18 %
- Assured that the first prototype successfully passed the dynamic tests

"The simulation service was delivered in a high quality within the promised schedule. We appreciate the reliability of the performed work and the delivered simulation models as well as the ongoing excellent cooperation with our design team." **Dirk Weisser, Head of Zeiss Optronics Design Department**

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Kundenbeispiele

Bosch Rexroth AG, headquartered in Lohr am Main, Germany, is a developer, producer and supplier of drive and control technologies for hydraulic, electric, pneumatic or mechanical applications. In order to increase product quality in spite of reduced development time, the PTC University was charged with the further education in advanced contact and bolt analysis with Pro/MECHANICA.

Rexroth
Bosch Group

BUSINESS INITIATIVE

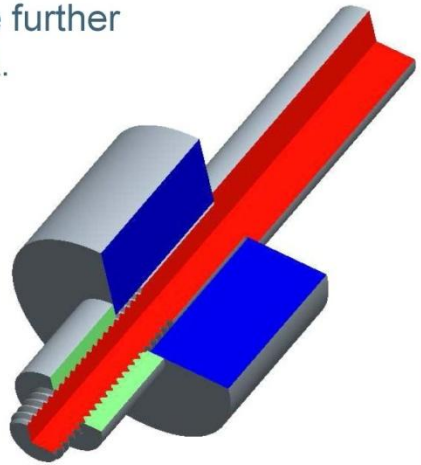
- Bosch Rexroth requested on-site Pro/MECHANICA contact & bolt simulation workshops for their design and CAE engineers developing hydraulic equipment.

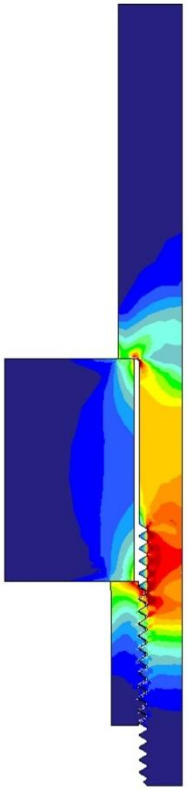
SOLUTION

- PTC offered simulation workshops providing basic principles of bolt analysis, necessary software knowledge, typical application tasks and furthermore solutions for special customer examples.

RESULT

- Acquired knowledge about the contact theory used in Pro/MECHANICA and methods to assure numeric solution quality
- Acquired solution roadmaps for typical bolt analysis tasks
- Critical bolted designs can now be analyzed and optimized in Pro/MECHANICA before prototypes are being built and tested.





One of the customer's analysis tasks solved in Pro/MECHANICA during the contact & bolt analysis workshop:

Above:
Pro/ENGINEER model of a hydraulic piston prepared for a detailed 2D axial symmetric contact analysis.

Right:
Von Mises stress in the piston assembly when preloaded and pressurized.

"The Pro/MECHANICA simulation training provided by the PTC University exactly met what we needed: Solution methods in Pro/MECHANICA for all types of bolted connections with different precision demands, starting from just obtaining force relations up to evaluating exact load and stress distributions in each single thread turn." **Dipl.-Ing. Katja Mild, Group Leader R&D, Bosch Rexroth AG**

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Kundenbeispiele

CEMEC Intelligente Mechanik GmbH located in Spalt near Nuremberg, Germany, provides product development, analysis and production services for nearly all types of electro-mechanical systems in Air & Space, medical engineering, mechatronics, optic-devices, drive technology, toolbuilding applications and more.

BUSINESS INITIATIVE

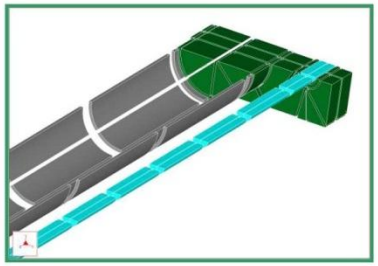
- CEMEC uses PTC product development software to design, analyze and optimize their products. When designing a new preloaded roof mounting system for solar power plants, CEMEC contacted PTC Technical Support for help in analyzing their design idea within MECHANICA.

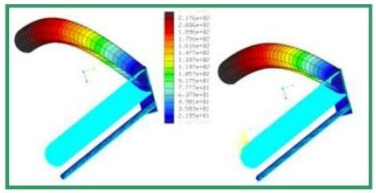
SOLUTION

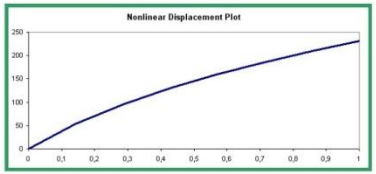
- Within the close cooperation between PTC Technical Support and PTC Global Service Organization, the request was forwarded to PTC GS engineers. Together with the customer the analysis task was clarified and a solution was worked out.

RESULT

- Given sample solution for this problem type that solves the highly nonlinear analysis task within a minute and matches very exact the experimental results of the first development test done
- Further development can be rapidly performed virtually within Pro/MECHANICA saving a high amount of lab tests.







MECHANICA brick and wedge mesh model and analysis results for a very fast nonlinear large displacement analysis of a preloaded roof system

"PTC gave us excellent, quick and technically well-founded support for our actual development project in applying Pro/MECHANICA to nonlinear analysis capabilities. The analysis results match our observations during the test exactly. This will furthermore allow us to develop our ideas much faster and with reduced test effort."

Martin Schwab, Director CEMEC GmbH

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Agenda

- Grosse Verformungen
- Kontaktberechnungen (reibfrei)
- Hyperelastisches Materialverhalten
- Kontaktberechnungen (mit „rauher“ Reibung)
- Elastoplastisches Materialverhalten
- Grosse Verformungen mit Durchschnappen

- Live-Beispiel Kabinendämpfer

- Feedback, Fragen und Antworten

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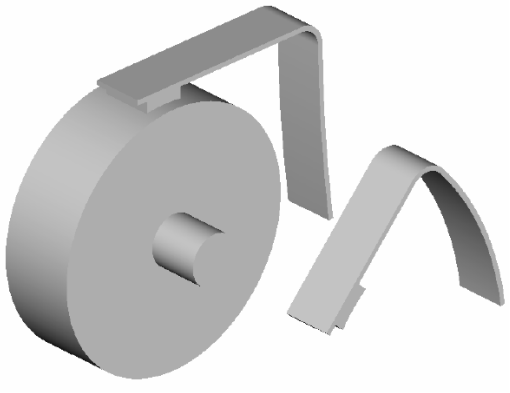
Grosse Verformungen (vor Wildfire)



Bei einer linear elastischen Berechnung gilt die Annahme, dass die Verformungen gegenüber der Bauteilgrösse klein sein müssen.
Sind die Verformungen gross, muss das Bauteil schrittweise belastet werden, die inkrementalen Verformungen werden aufaddiert.

Linear

Grosse Verformungen

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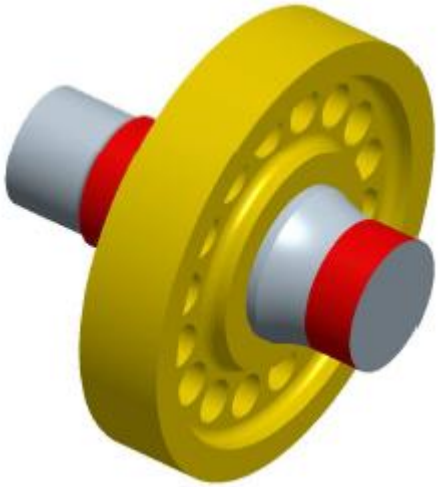
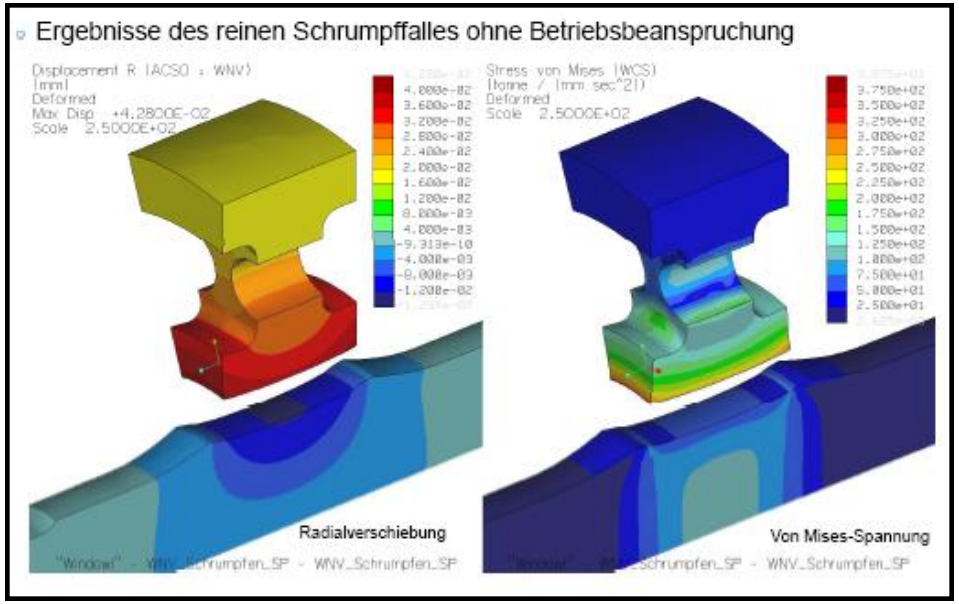
Kontaktberechnungen (reibfrei) (vor Wildfire)

Schrumpfpassungen, Hertz´sche Kontaktspannungen können reibfrei berechnet werden. Zusätzliche Randbedingungen oder Verbindungselemente (Federn, ...) verhindern ein Gleiten.





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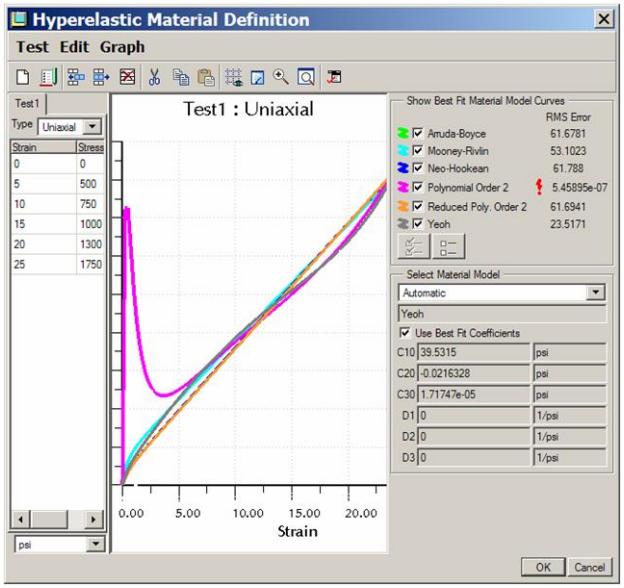
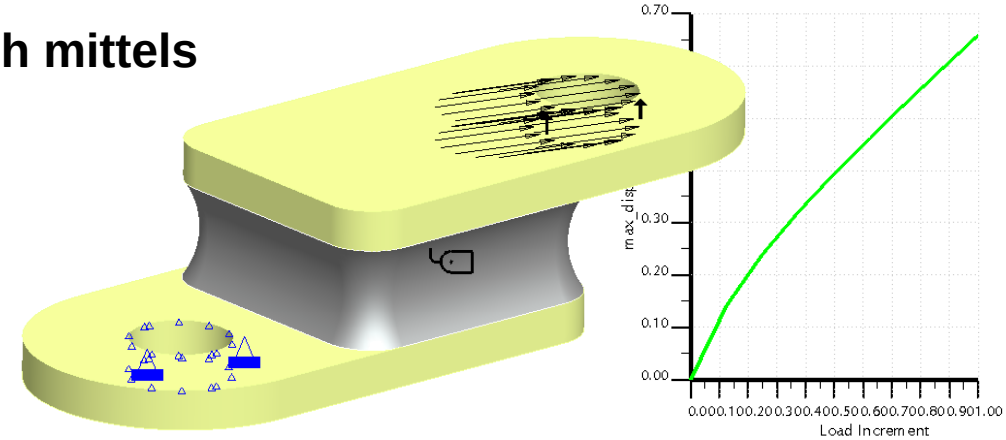
Hyperelastisches Materialverhalten (seit Wildfire 4)

Hyperelastisches Materialverhalten (z.B. Gummi: keine bleibenden Verformungen nach Entlasten) kann simuliert werden. Zur Verfügung stehen folgende Materialgesetze:

- **Arruda-Boyce**
- **Mooney-Rivlin**
- **Neo-Hookean**
- **Polynomgrad 2. Ordnung**
- **Reduzierter Polynomgrad 1 und 2**
- **Yeoh**



Die Material-Kennwerte können auch mittels Testdaten bestimmt werden.



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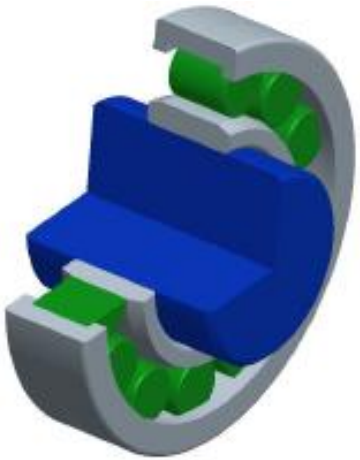
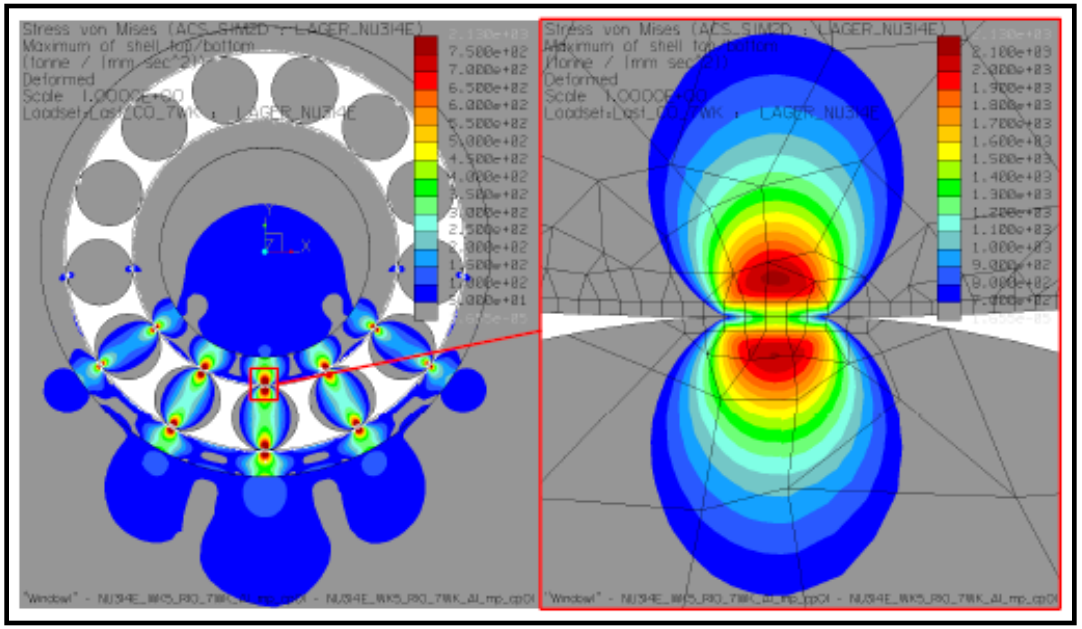
Kontaktberechnungen (mit „rauher“ Reibung) (seit Wildfire 4)

Schrumpfpassungen, Kontakte (Hertz´sche Spannungen) können mit Haftreibung definiert werden – der „Schlupf-Indikator“ zeigt an, ob ein Rutschen stattgefunden hätte.
Somit sind keine zusätzlichem Randbedingungen oder Verbindungselemente notwendig, um ein Gleiten zu verhindern.





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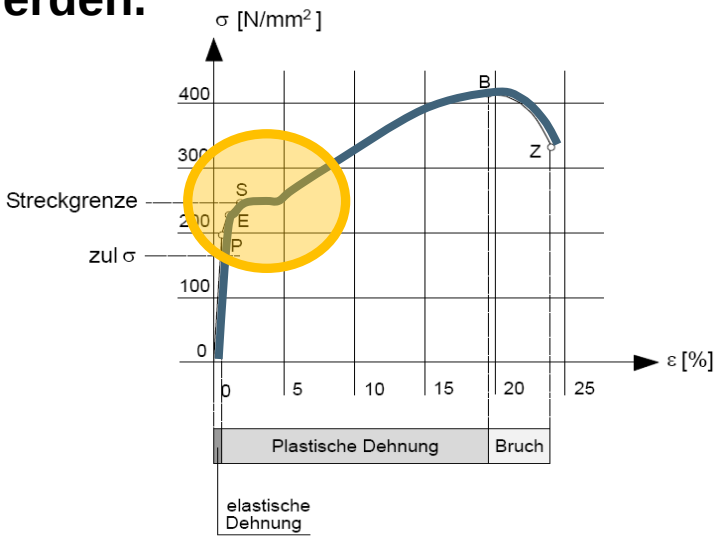
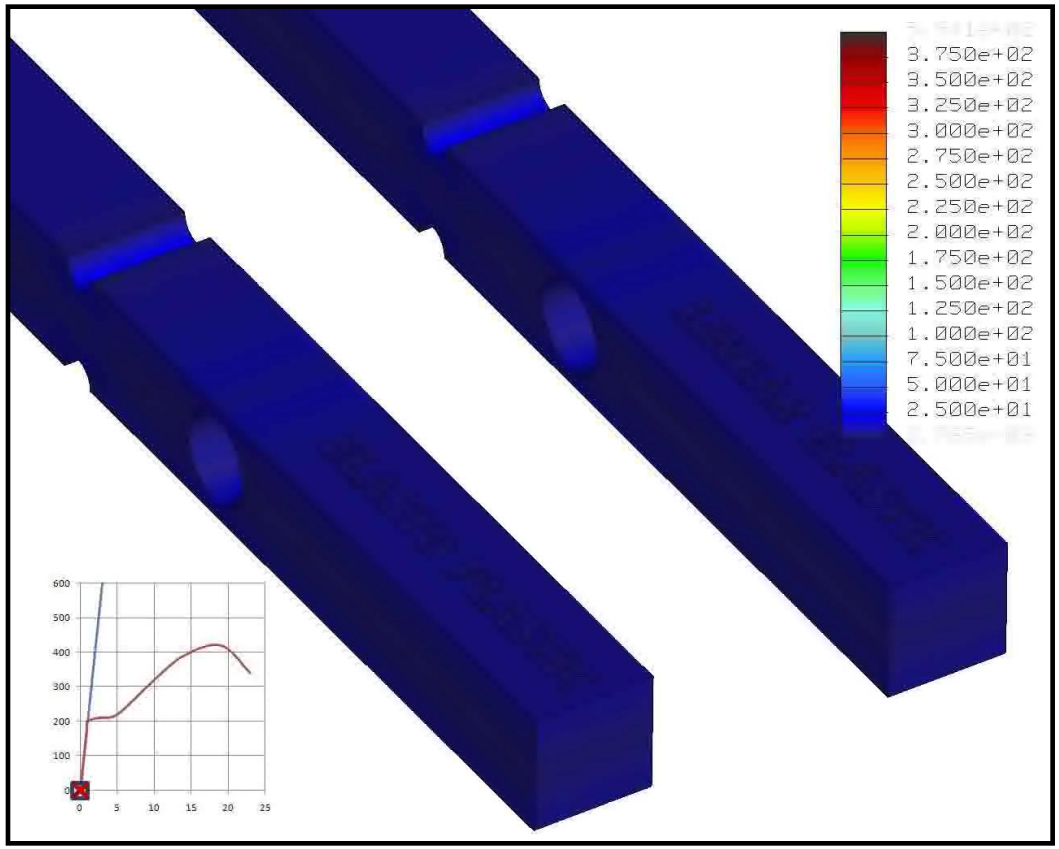
Elastoplastisches Materialverhalten (seit Wildfire 5)

Elastoplastisches Materialverhalten (z.B. Stahl) kann simuliert werden. Zur Verfügung stehen folgende Materialgesetze:

- **Linear Hardening**
- **Power Law**
- **Exponential Law**

Die Material-Kennwerte können auch mittels Testdaten bestimmt werden.





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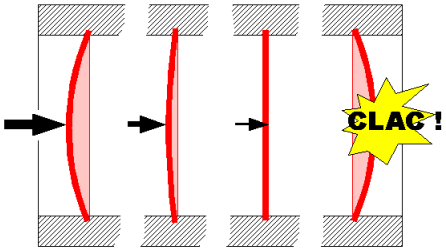
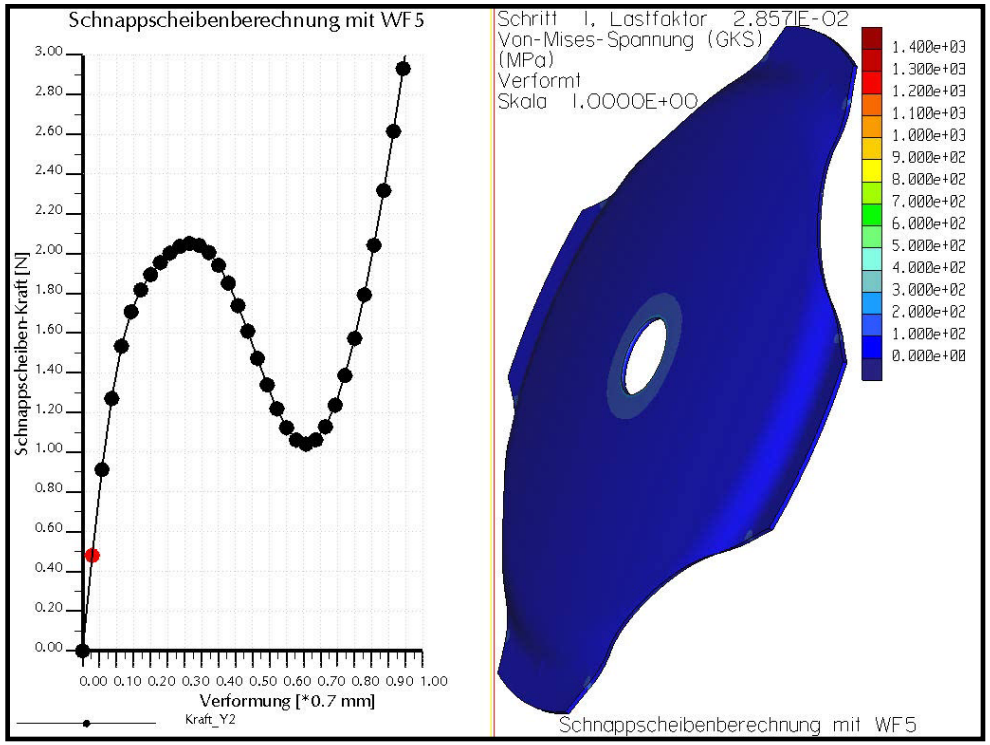
Grosse Verformungen mit Durchschnappen (seit Wildfire 5)

Die Möglichkeiten für Berechnungen mit grossen Verformungen wurden erweitert. Es können jetzt definierte Schaltpunkte und taktile Rückmeldungen simuliert werden.
Typische Beispiele sind:

- **Schappscheibe**
- **„Knackfrosch“**





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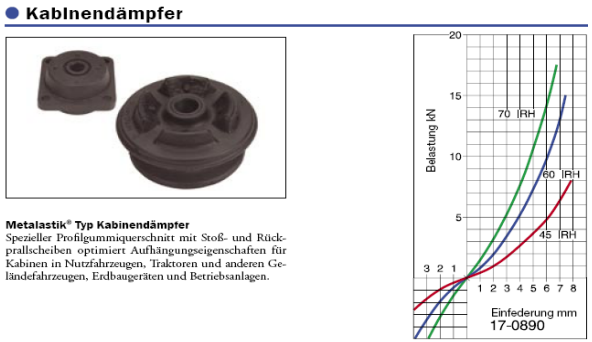
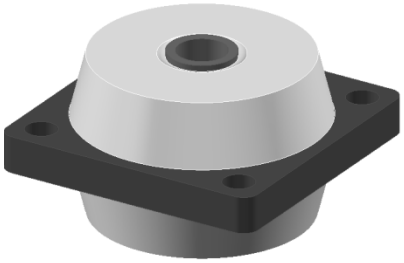
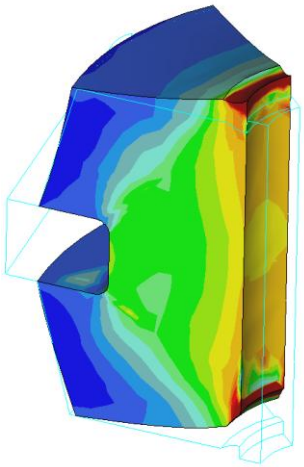
Live-Beispiel Kabinendämpfer

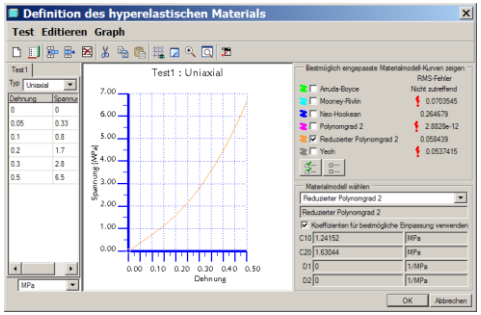
Federkennlinie des Dämpfers soll anhand von gemessenen Gummimaterial-Testdaten mit MECHANICA bestimmt werden.

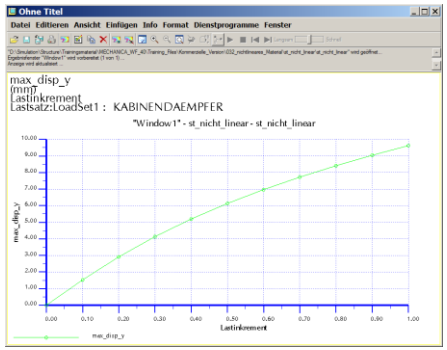




Dehnung [-]	Spannung [N/mm²]
0.00	0.0
0.05	0.3
0.10	0.7
0.20	1.6
0.30	2.6
0.50	6.0







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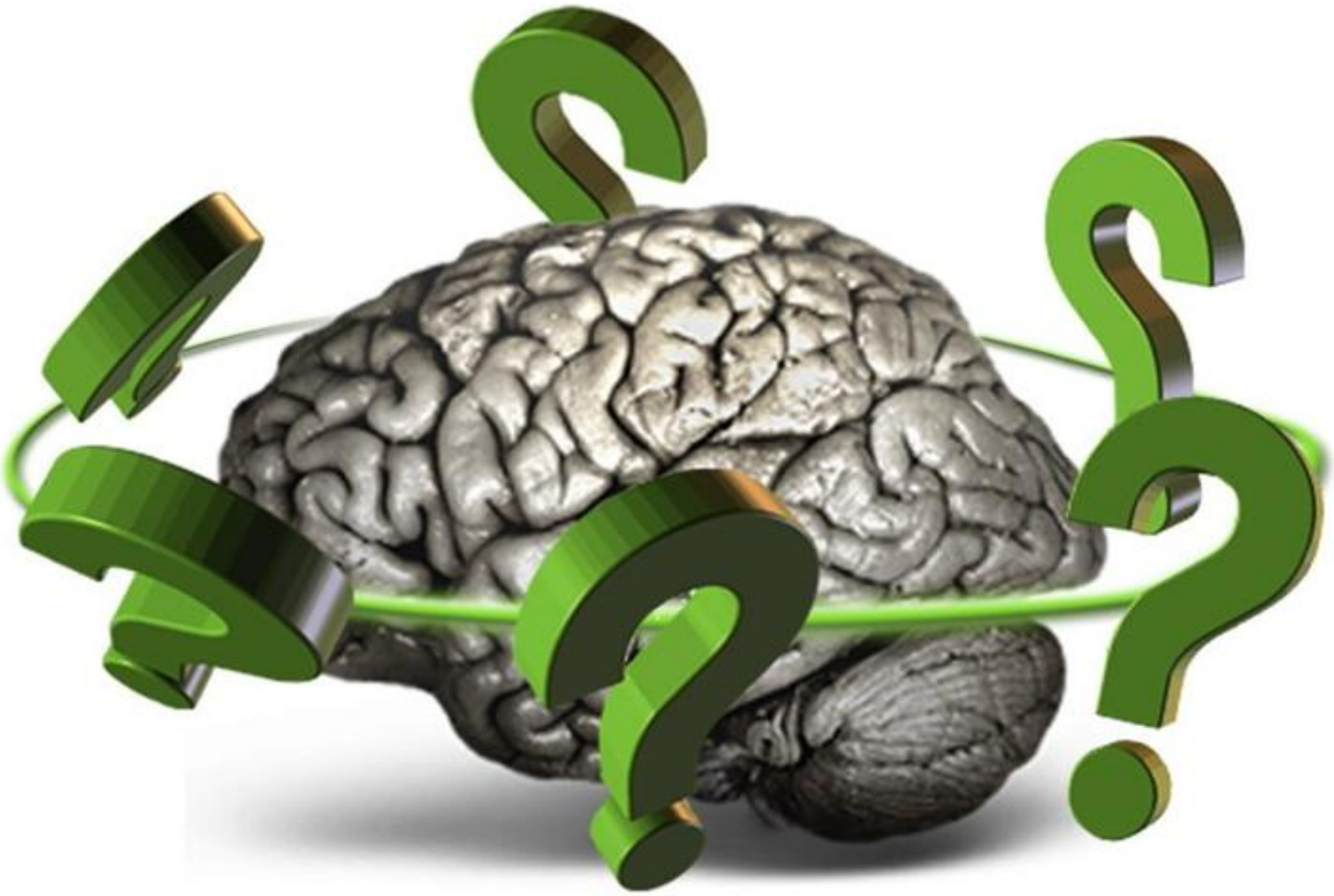
Fragen



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