Sächsisches Institut für Oberflächenmechanik

Why measurement at higher temperature is of great importance and how the results should be used (AP-4 Nr. 269)

(But without time dependency taken into account (creep), you will get a lot of nonsense)

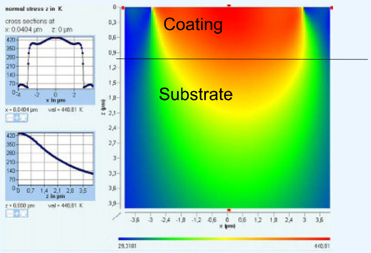
Nick Bierwisch, Dr. Norbert Schwarzer

Saxonian Institute of Surface Mechanics

Motivation

In many real work situations high temperatures occur. They can be forced by friction or high environment temperatures for example. To optimize your materials you have to know as much as possible about your material behaviour at this temperatures and take this knowledge into account.

Temperature fields evaluated, here caused by friction

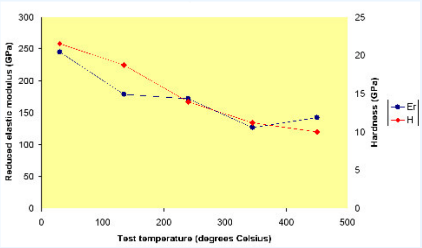


The temperature field evaluated in °C *

High environment temperatures inside an car engine and jet turbine

High temperatures occur during the drilling process

Temperature dependent properties



Data courtesy of Wilfried Helle, LOT-Oriel, Darmstadt, Germany

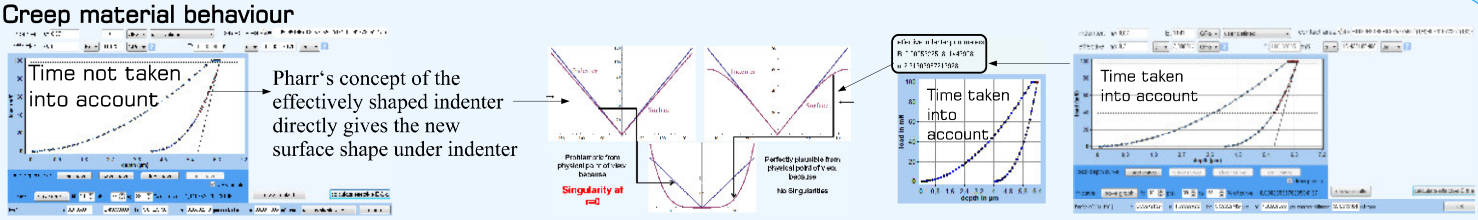
Often mechanical parameters are characterized at different temperatures than they will appear in the real contact situation. For most materials these temperature differences can lead to complete different mechanical parameters. That is why you should characterize your material at the temperature which will occur in the real contact situation. With the NanoTest hot stage of MicroMaterials you can measure mechanical properties at different temperatures up to 750°C.

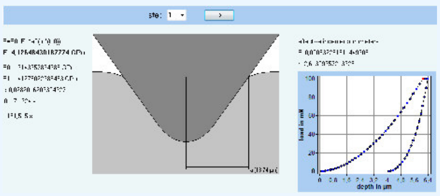
In the screenshot on the left you can see the result from a measurement at different temperatures and how the Young's modulus changes.

Caution: Most materials will creep at high temperatures. Without this taken into account, you will get physical nonsense.

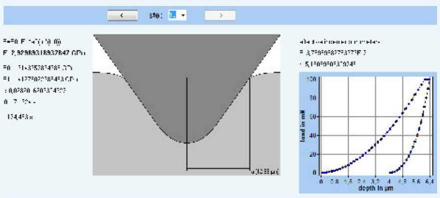
Detailed information on www.siomec.de/pubs/2010/002

Creep material behaviour





At start of hold time period *



At the end of unloading curve *

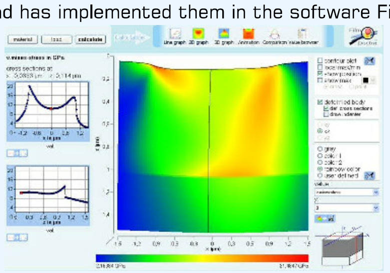
During measurements at elevated temperatures most materials will creep. The standard analyze methods can't take this material behaviour into account. SIO has developed an adaption of the classical Oliver & Pharr method, by using the hold-time part and the unloading part of the measured indentation curve (screenshots above). The results of this new method are time depending values for the young's modulus and the effective Indenter.

The screenshots on the left side show the results for two different moments. The result of the classical Oliver & Pharr method is 2,74GPa. *

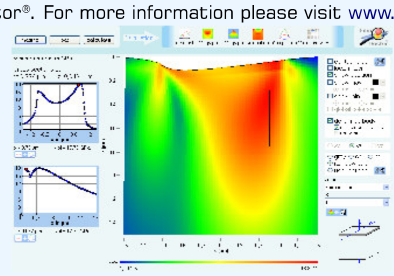
Conclusion

To analyze the measurements correctly, temperature fields, temperature and time depending mechanical parameters must be taken into account. With MicroMaterials' NanoTest hot stage, these temperature dependent parameters can be measured.

SIO® has developed analytical models, which take temperature-sensitive and time-depending mechanical parameters and temperature fields into account, and has implemented them in the software FilmDoctor®. For more information please visit www.siomec.de/FilmDoctor.



Temperature field **not** taken into account *



Temperature field taken into account *

These 2 screenshots show the different stress distributions for the same moment if the temperature field was taken into account or not. You can see a completely different stress distribution and different maximum and minimun values.

* Absolute values changed for NDA reasons.

Benefits

- ✔ Get your real mechanical parameters for your working situation
- ✔ Allows you to optimize your materials faster
- ✔ Allows more precisely lifetime prediction
- ✔ Ward off unjustified customer complaints

All the features shown and much more is included in our software FilmDoctor® (visit **www.siomec.de/FilmDoctor**).

www.siomec.de www.siomec.com