

*ICFG Workshop Simulation, Schanghai 2004*

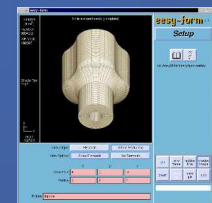
*The variability of  
Material Property Measurements*

*The importance of proper yield stress-strain curves  
for simulation results*

*G. H. Arfmann, M. Twickler  
CPM GmbH, Herzogenrath*

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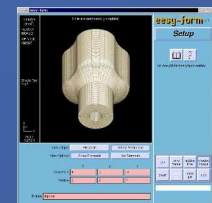
# *ICFG Workshop Simulation, Schanghai 2004*

## The variability of Material Property Measurements

- Simulation applications
  - Geometry, Material flow
  - Stresses, Tool failure
  - Grain distribution
- Material data requirements to do a proper simulation
  - Complete set of data
  - Method of measurement
  - accurate measurement
- Methods to measure yield stress – strain curves
- Problems of standardization
  - Curves from different origin and the Influence on results
- Conclusions

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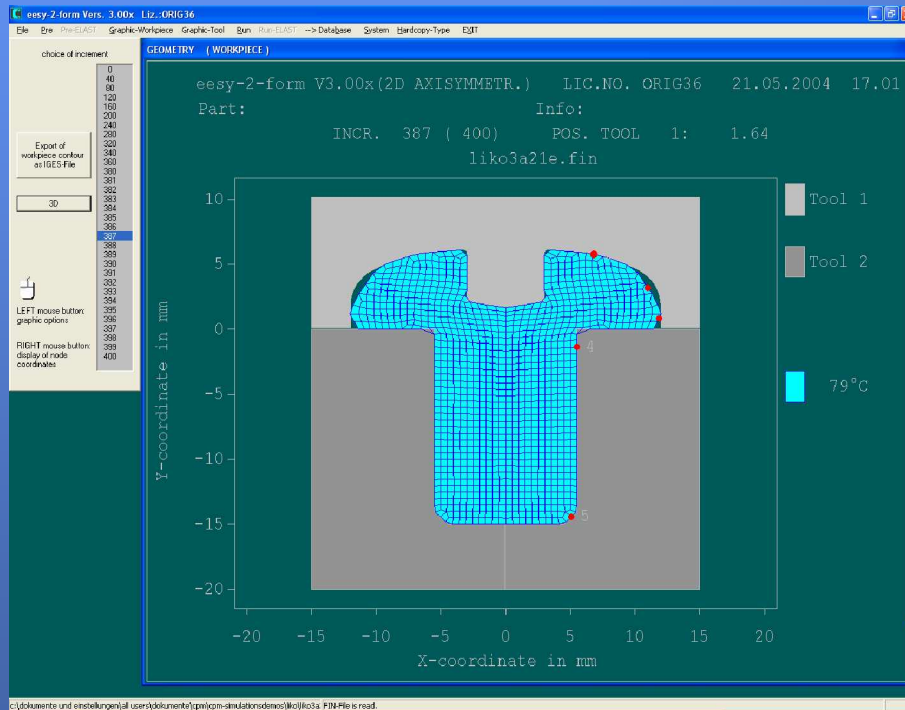


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## The variability of Material Property Measurements

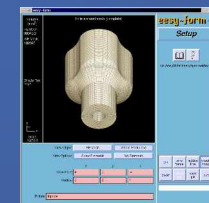
- Diagnostic of failures during process design

Failure of a punch  
Wrong preform design



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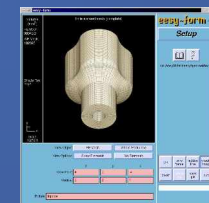
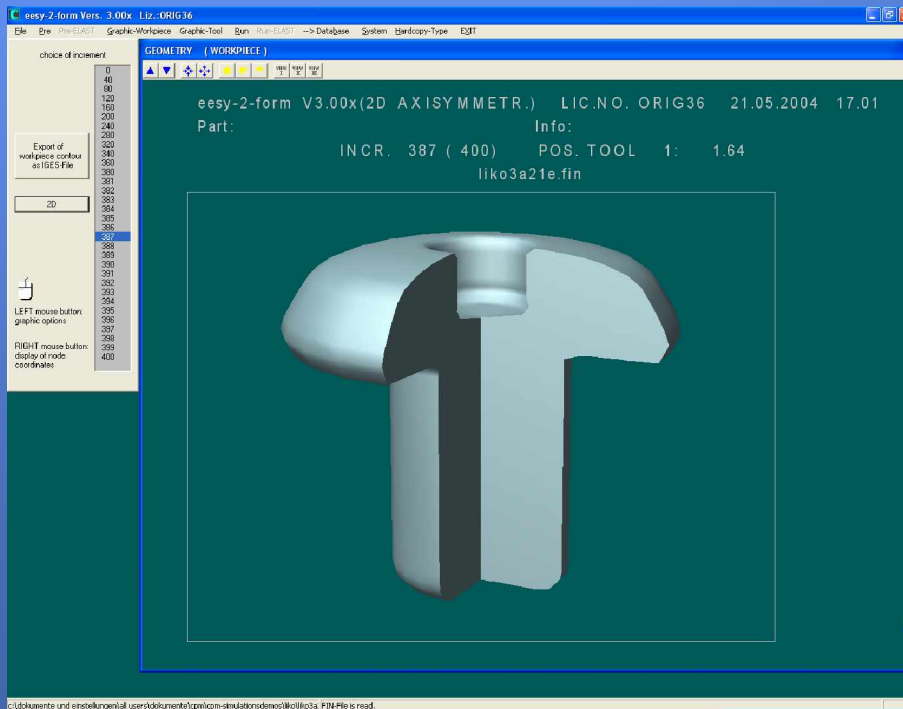


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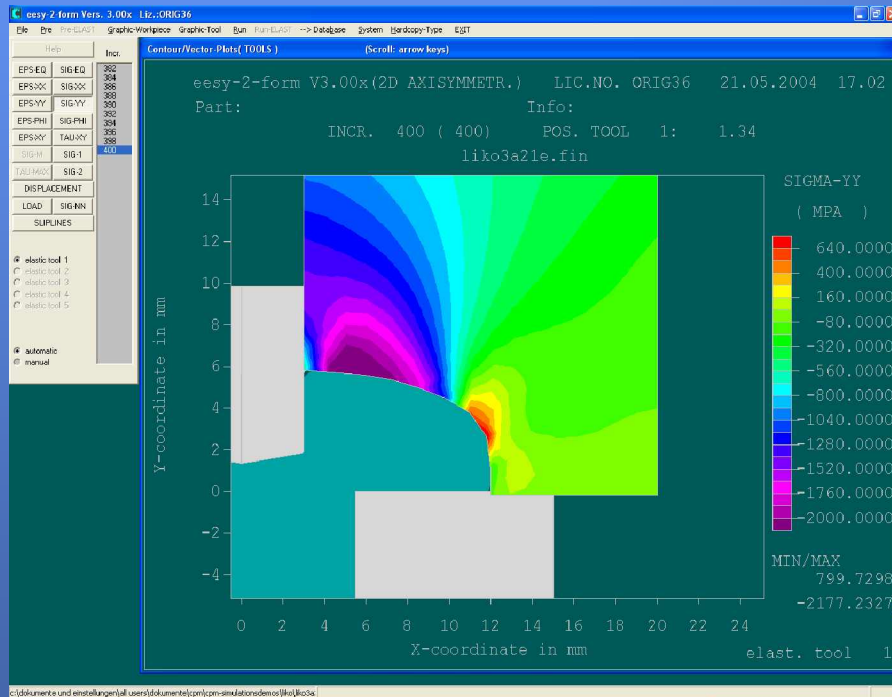
**CPM**

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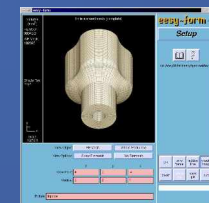
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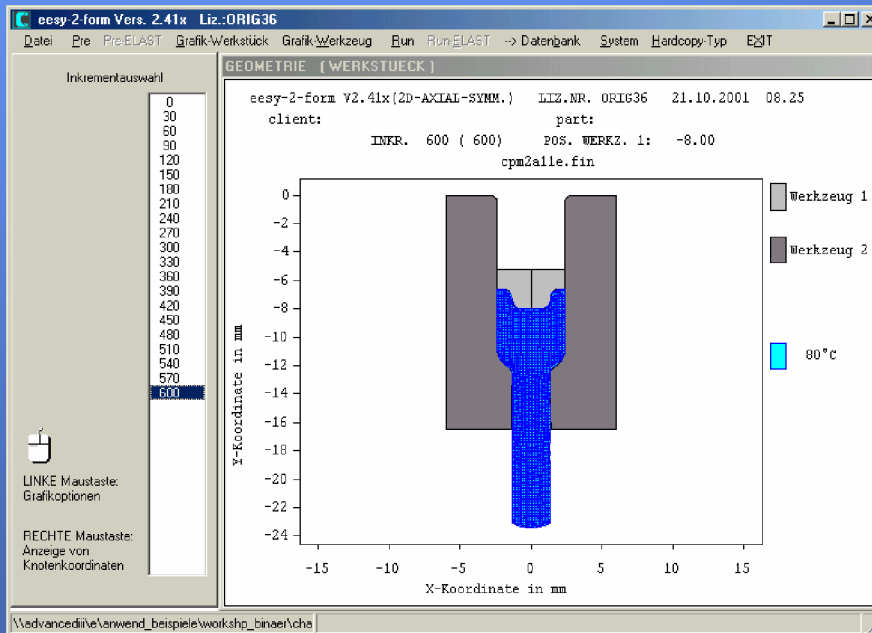


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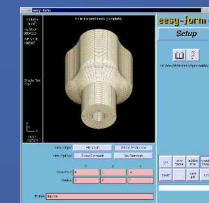
Failure of a punch  
Wrong progression  
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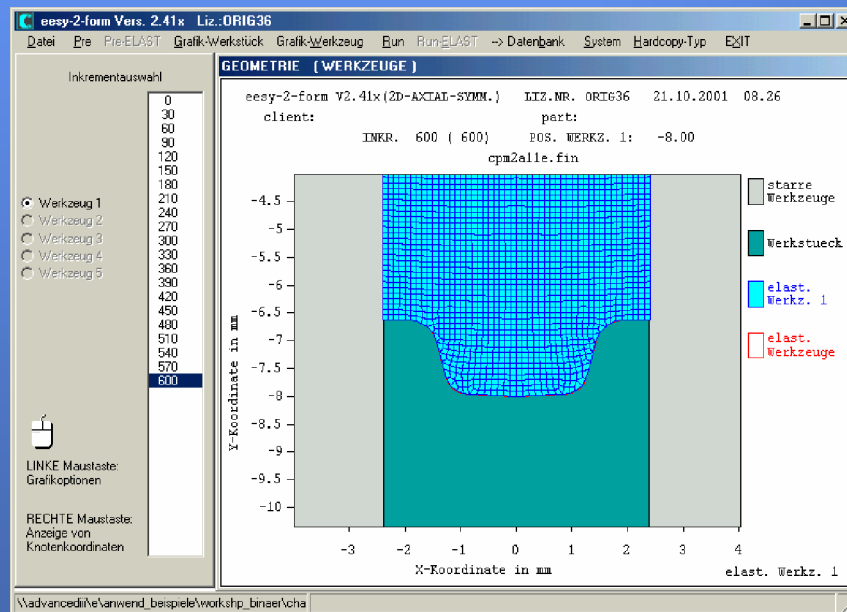


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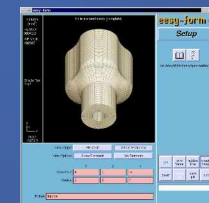
Failure of a punch  
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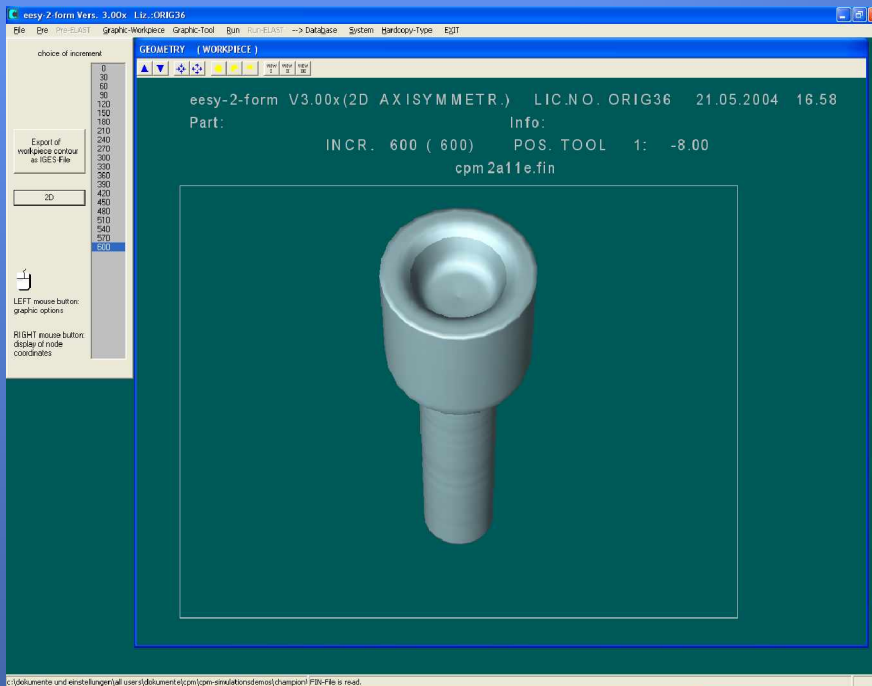


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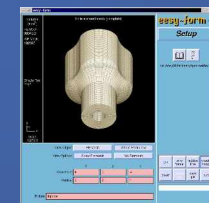
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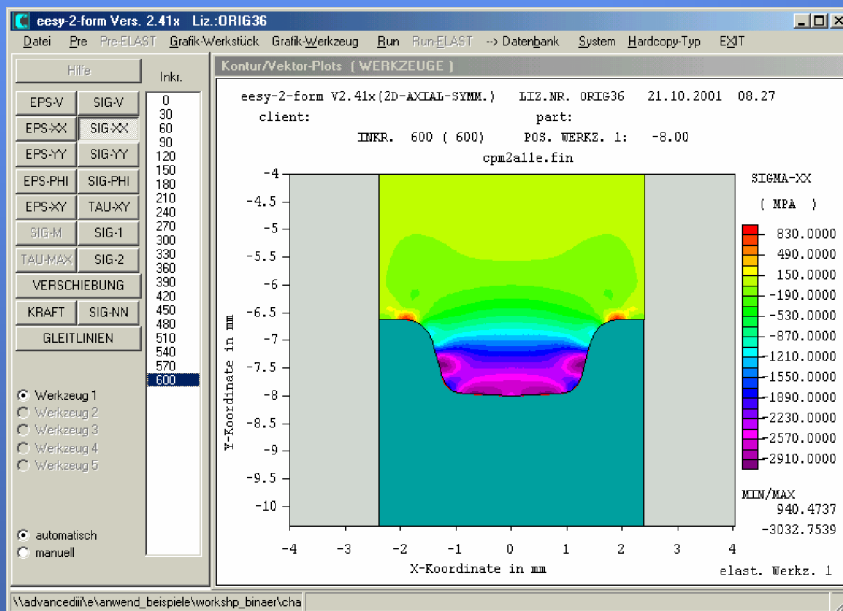


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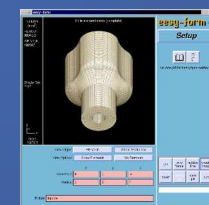
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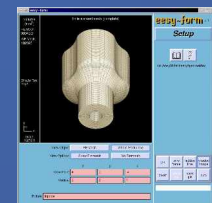


- Diagnostic of failures during process design

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## The variability of Material Property Measurements



- Diagnostic of failures during process design

Failure of a punch  
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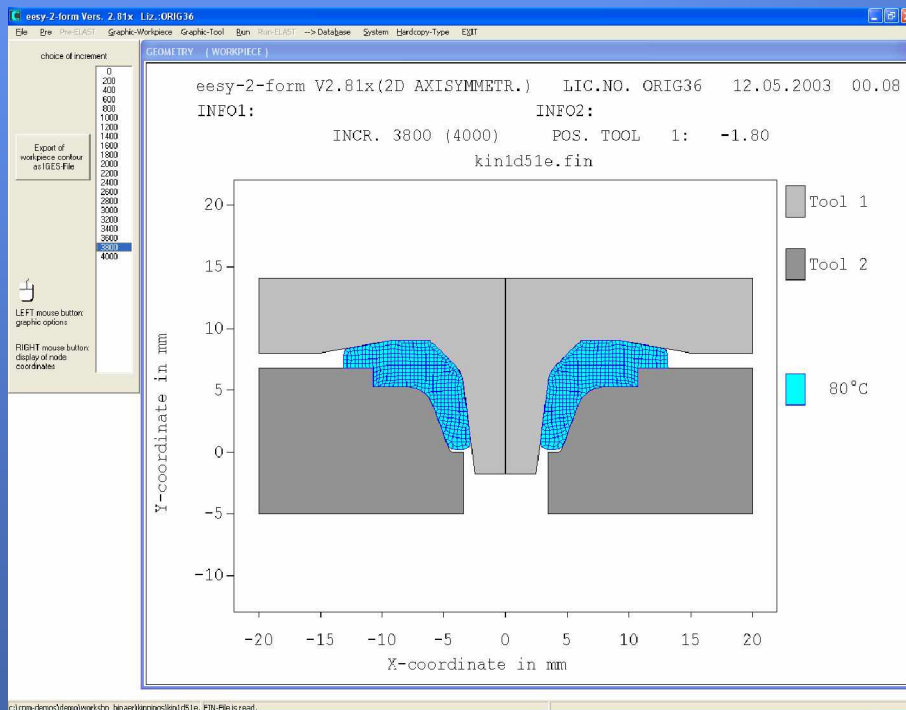


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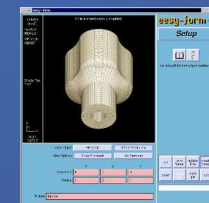
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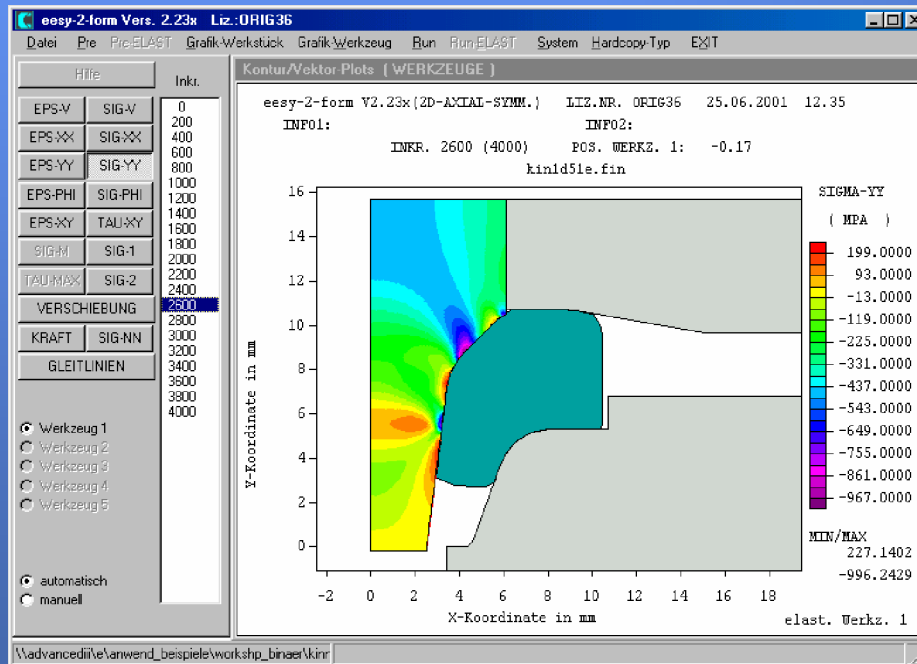


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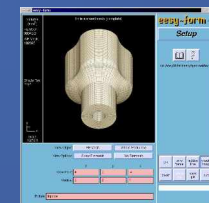
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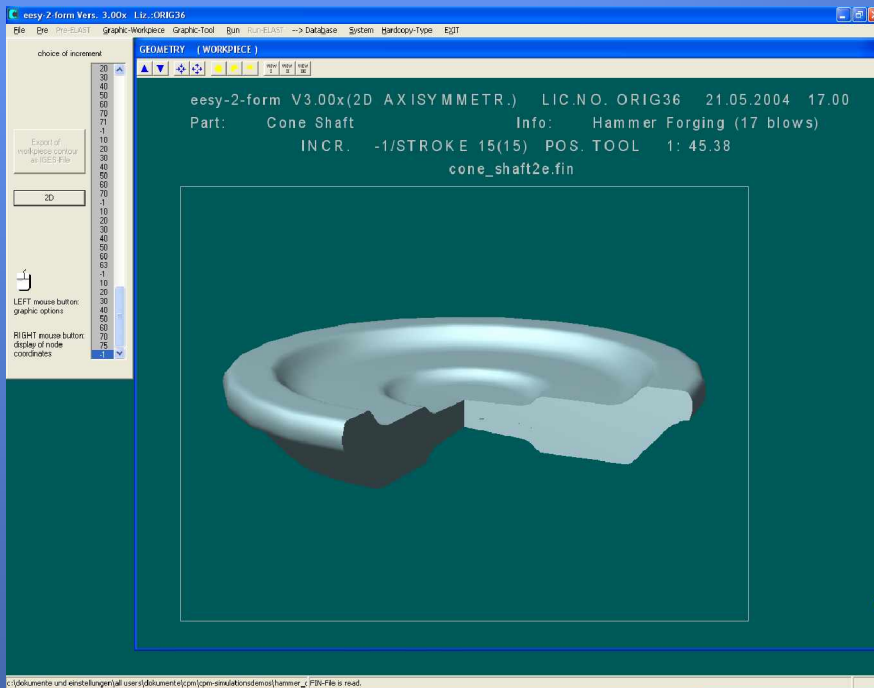


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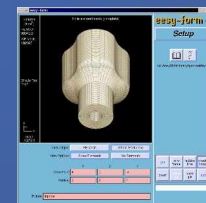
- Hammer forging

Analysis of the  
Temperature  
distribution after 18  
blows



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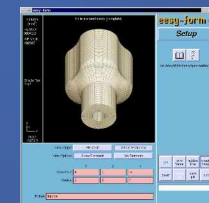
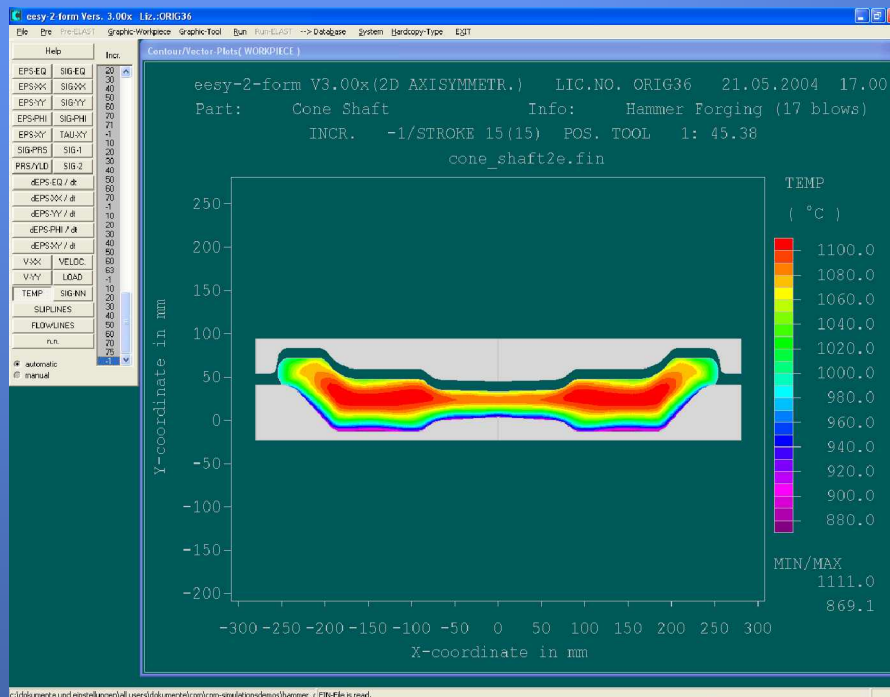


# ICFG Workshop Simulation, Schanghai 2004

## The variability of Material Property Measurements

- Hammer forging

### Analysis of the Temperature distribution after 18 blows



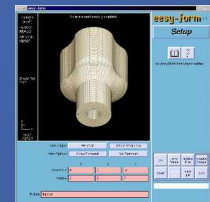
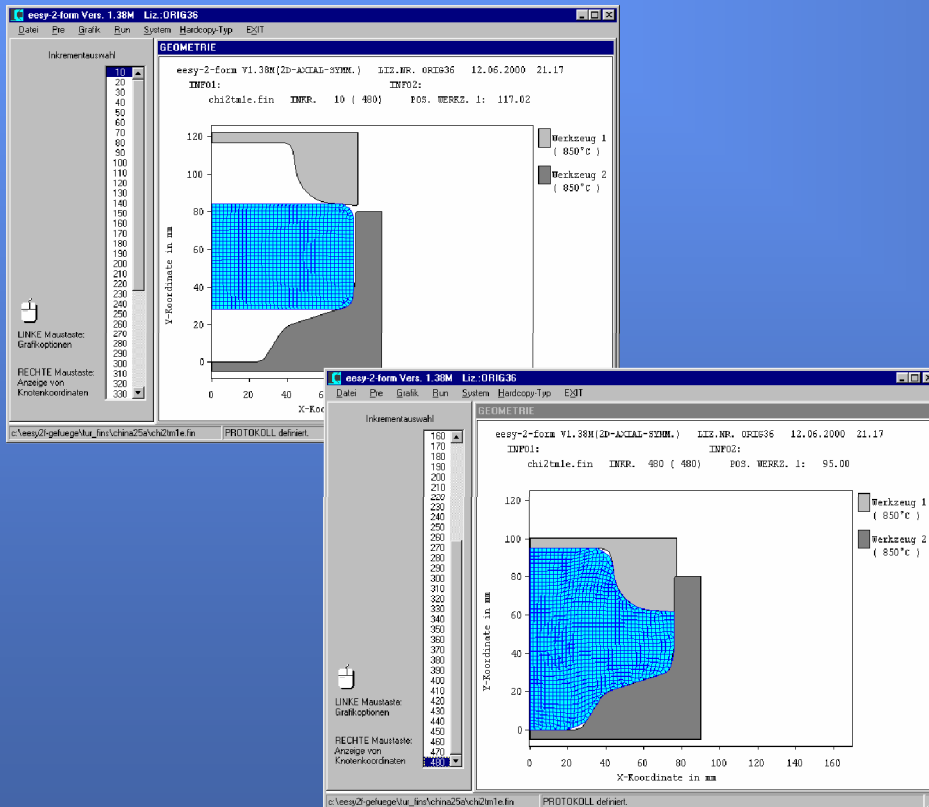
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## The variability of Material Property Measurements

- Prediction of grain size distribution during forging

Correct modeling of all boundary conditions:

- Temperature
- Machine
- Material
- .....

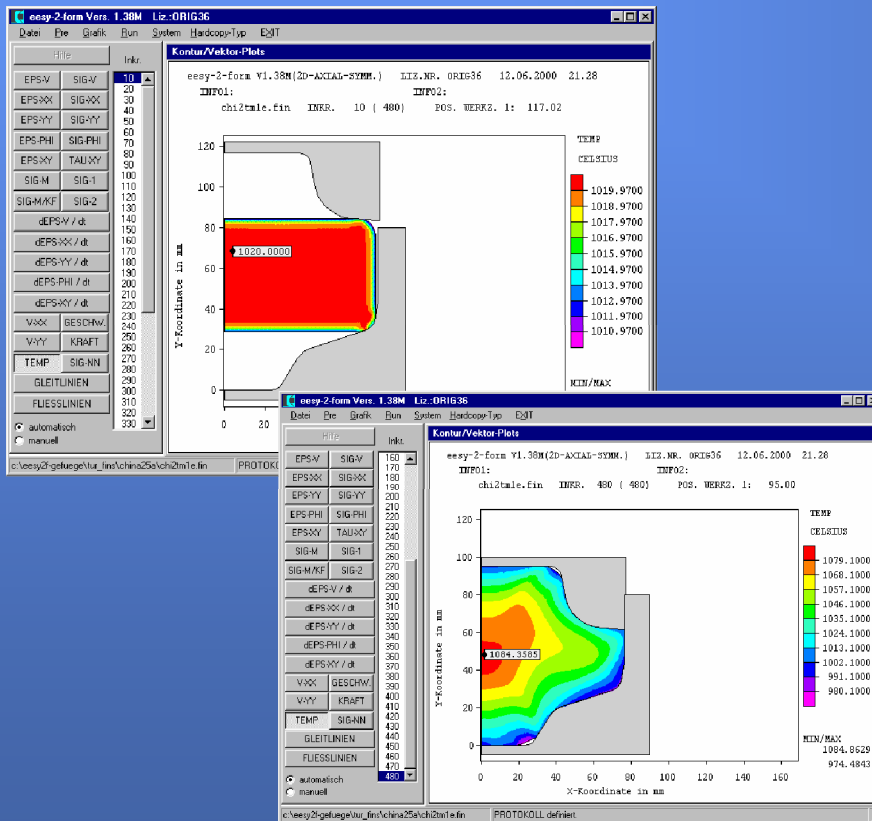




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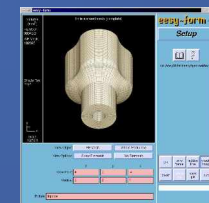
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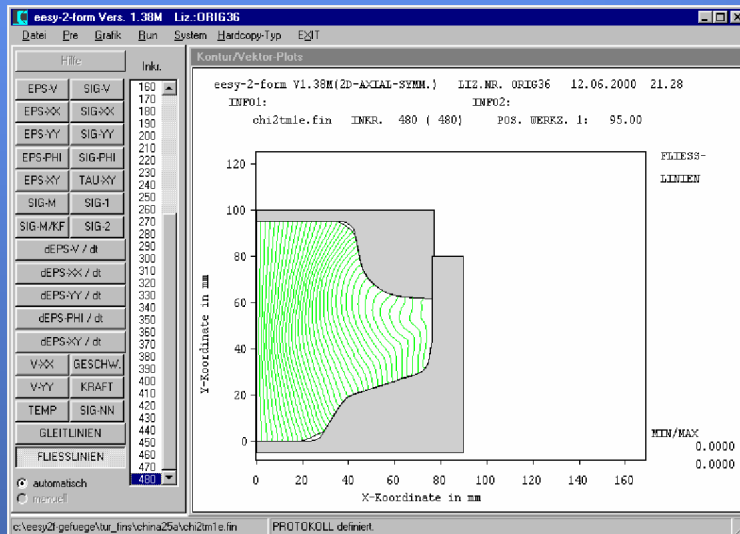
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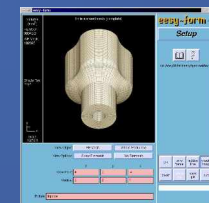
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- .....



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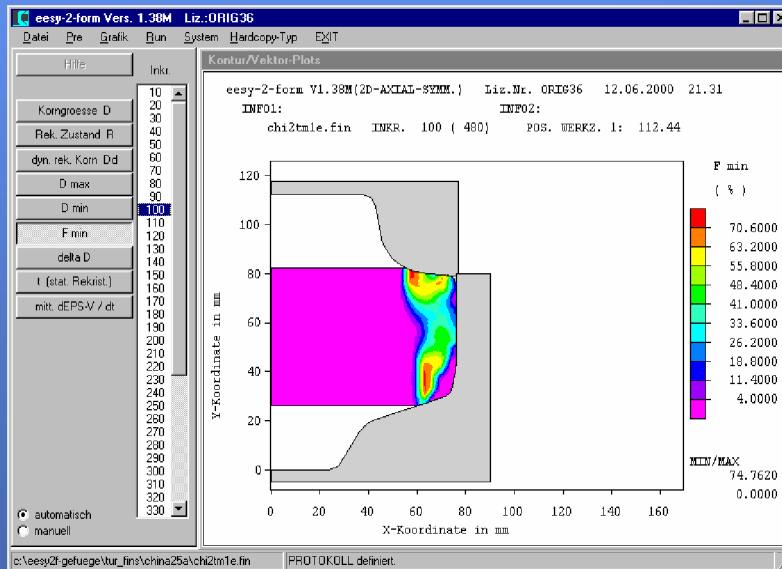
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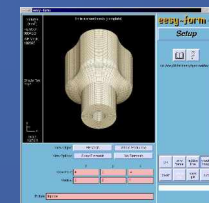
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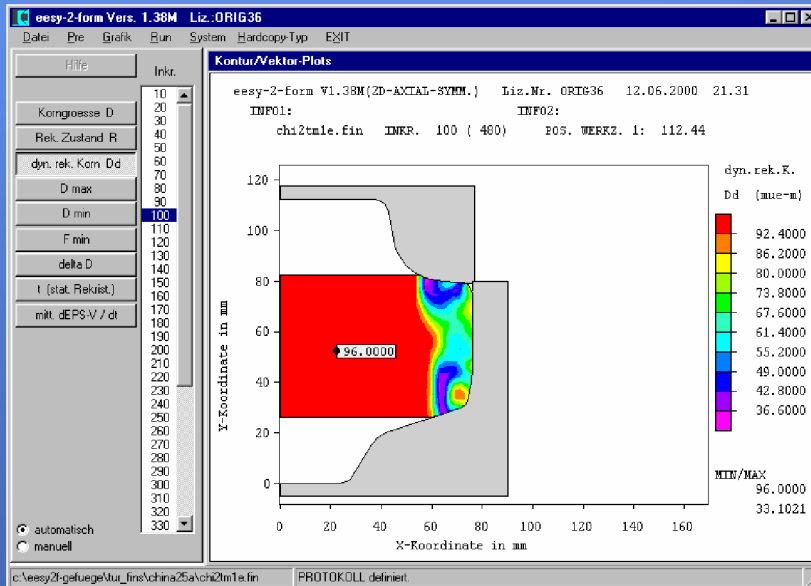
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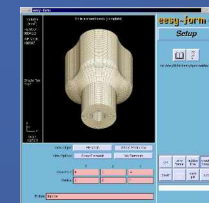
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- Material

- .....



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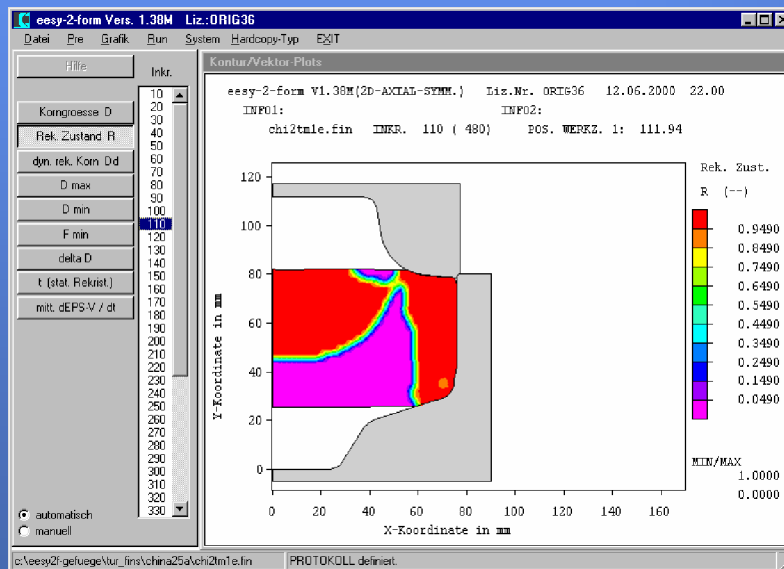
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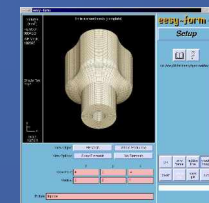
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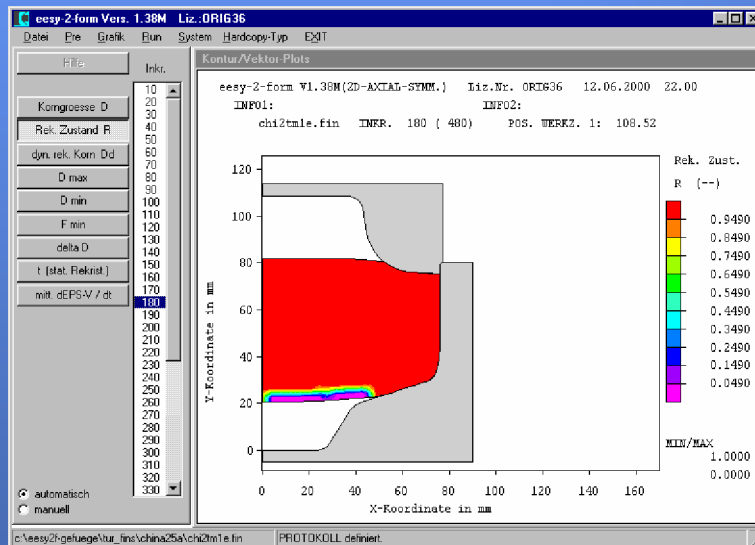
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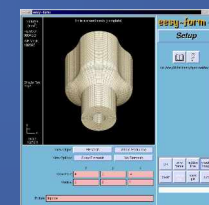
Correct modeling of all boundary conditions:

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- .....



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The variability of Material Property Measurements

## **To get a good simulation result we need**

**a good understanding of the process and the relevant models to be used in simulation**

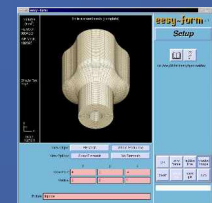
**the best available data to describe the physical behavior of the material**

**etc.....**

**The most important data are YS-Strain curves.**

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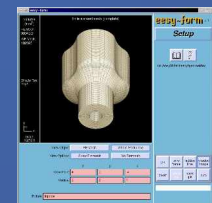
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## The variability of Material Property Measurements

### Stress Strain Curve data

has to be

- complete, covering the range of temperature, strain rate, strain etc. of the application
- reliable, not depending where it is coming from
- precise
- .....



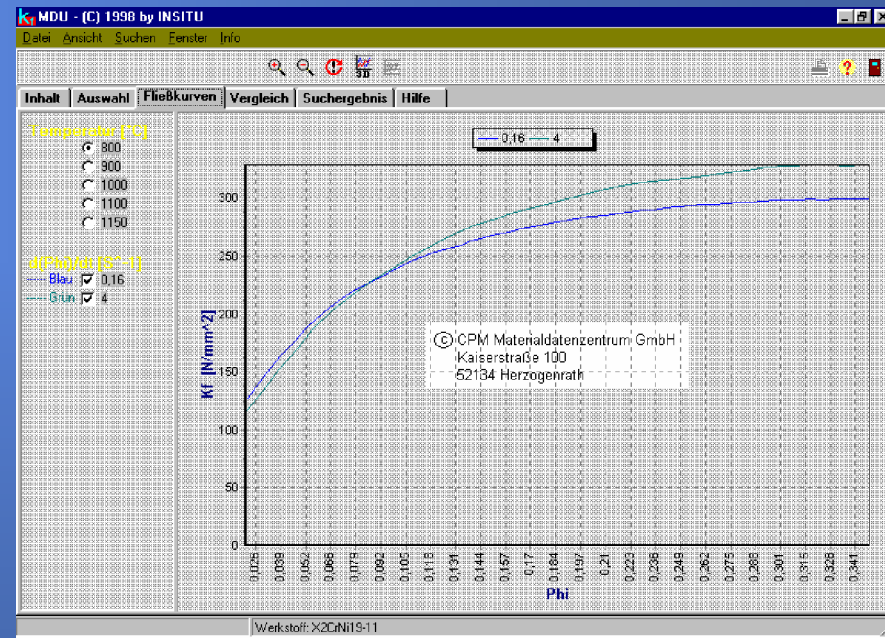


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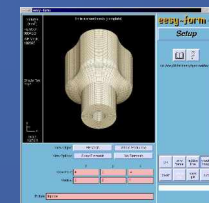
### Stress Strain Curve

Quality  
Source  
Documentation



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The variability of Material Property Measurements

## Stress Strain Curve

Quality

Source (Type of Test)

Documentation

Tension test

**Compression Test**

Torque Test

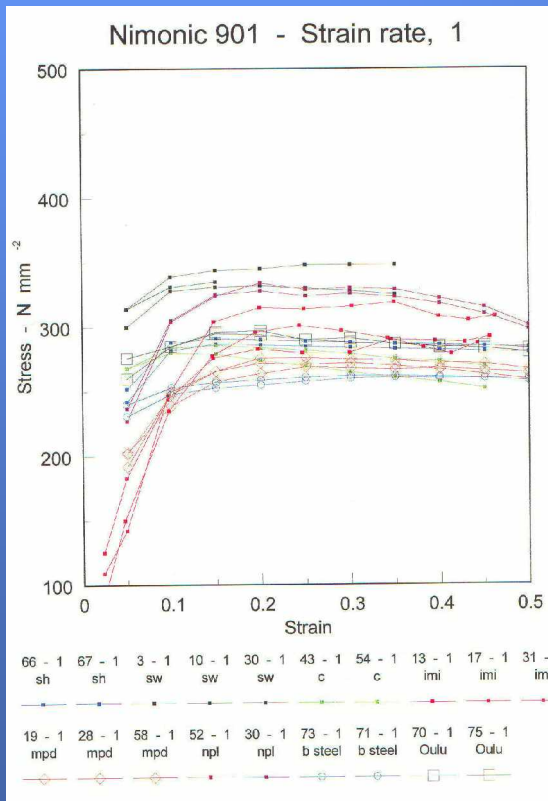
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## The variability of Material Property Measurements



## Stress Strain Curve

Quality

Source (different locations)

Documentation

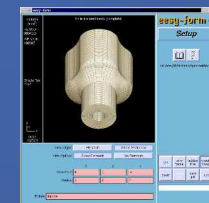
## Compression Test

non reliable data form different sources

Based on a study of NPL, UK

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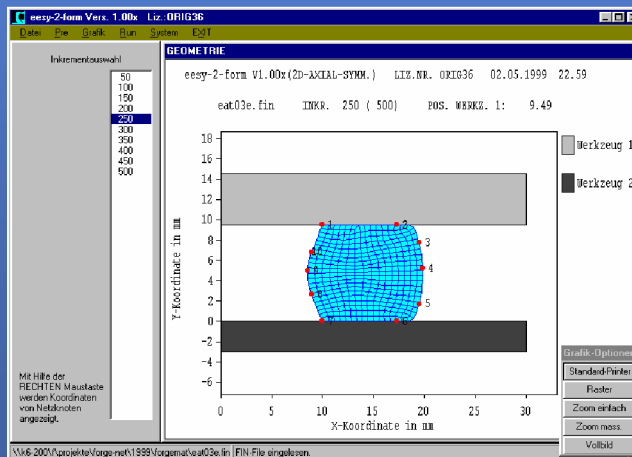
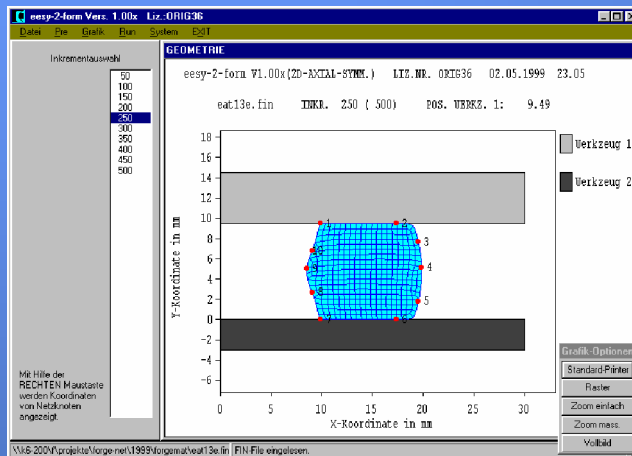
## The variability of Material Property Measurements

### Stress Strain Curve

Quality

Source

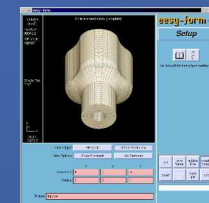
Documentation



### Influence on geometry

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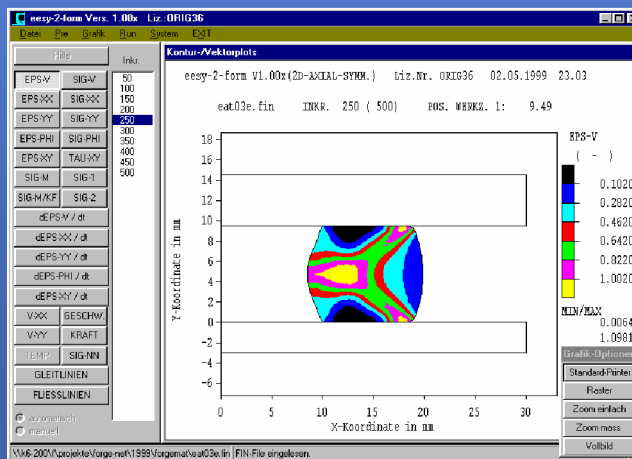
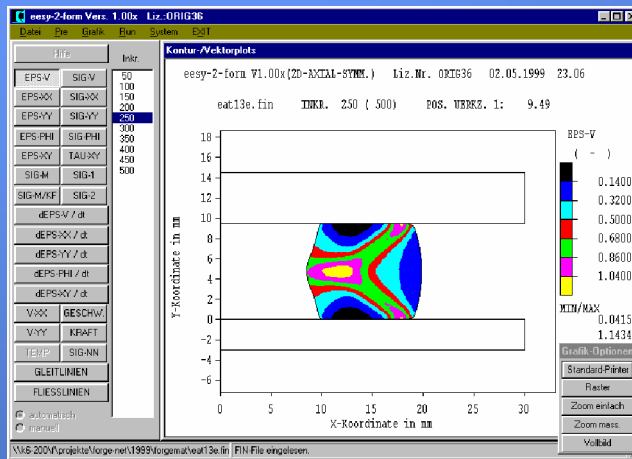
## The variability of Material Property Measurements

Stress Strain Curve

Quality

Source

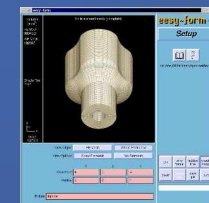
Documentation



Influence on local deformation

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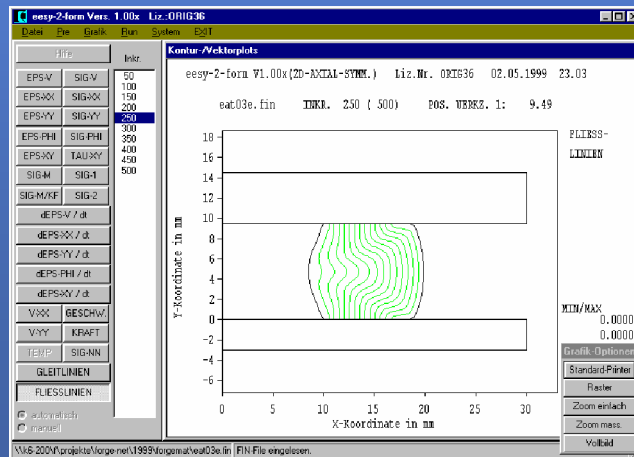
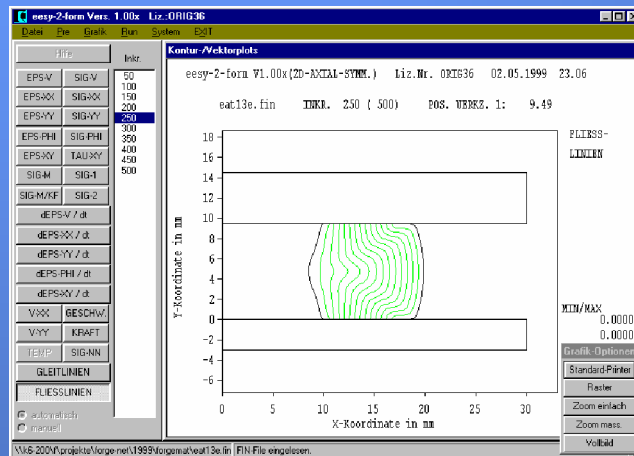
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Stress Strain Curve

Quality

Source

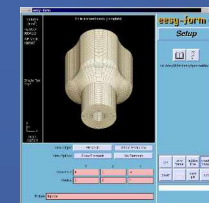
Documentation



Influence on material flow

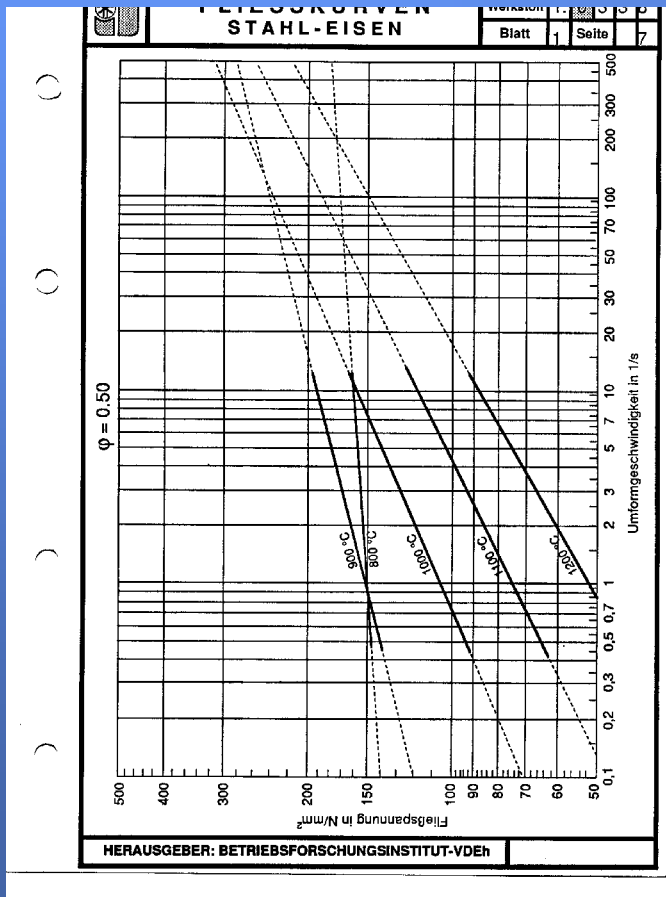
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## The variability of Material Property Measurements



## Stress Strain Curve

Quality

Source

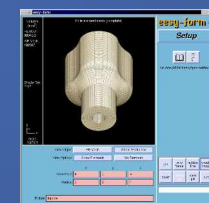
Documentation

## Different sources

Source: BFI/VDEH

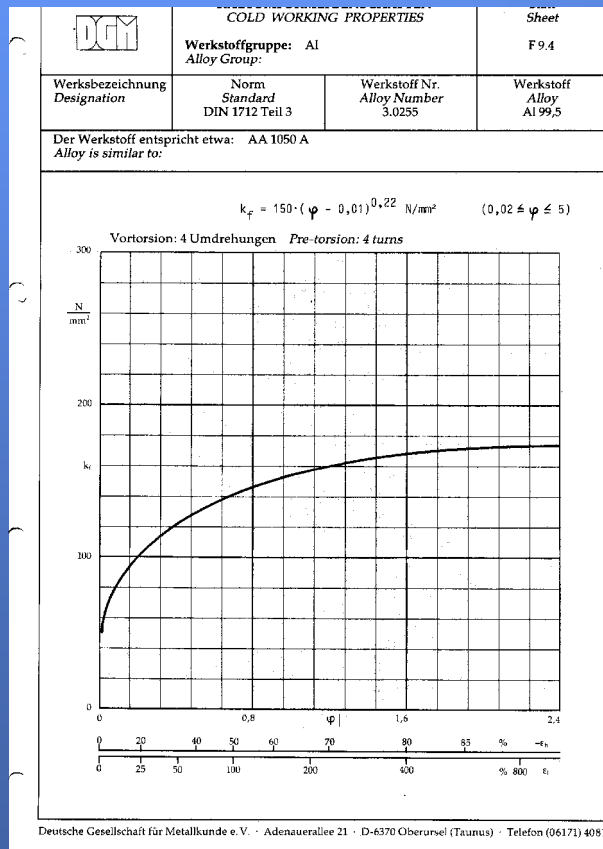
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## The variability of Material Property Measurements



## Stress Strain Curve

Quality

Source

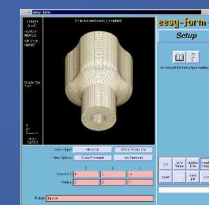
Documentation

## Different sources

Source: DGM

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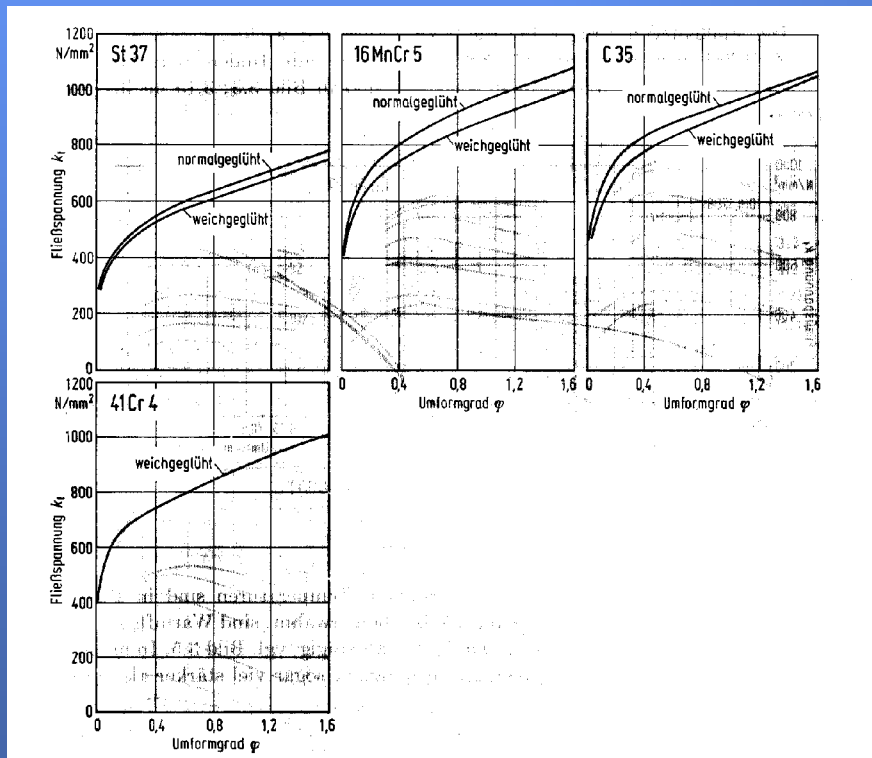
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## The variability of Material Property Measurements



## Stress Strain Curve

Quality

Source

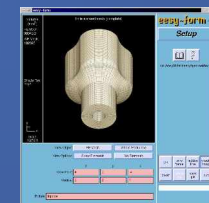
Documentation

## Different sources

Source: Umformtechnik, Lange

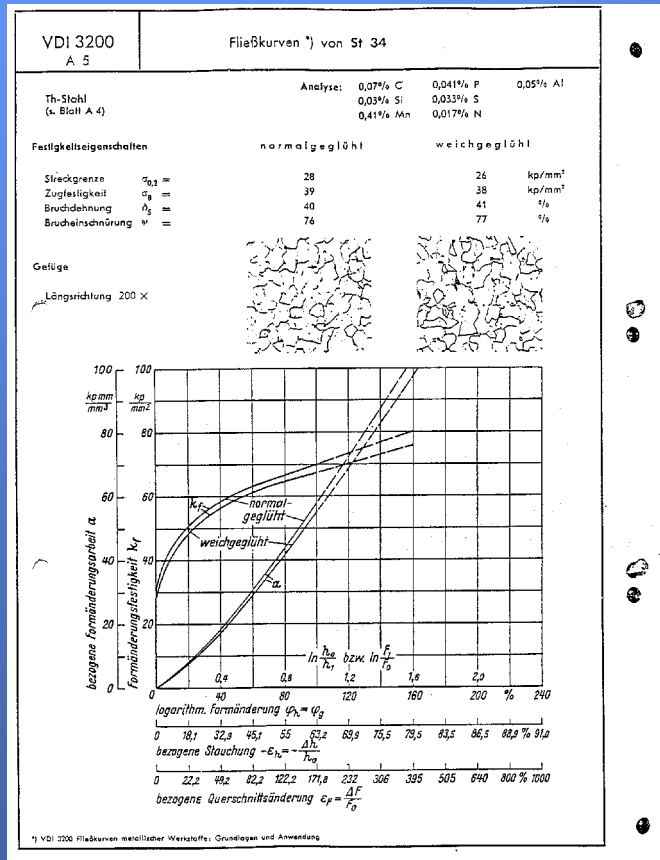
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## The variability of Material Property Measurements



Stress Strain Curve

Quality

Source

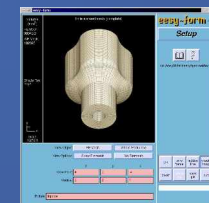
Documentation

Different sources

Source: VDI

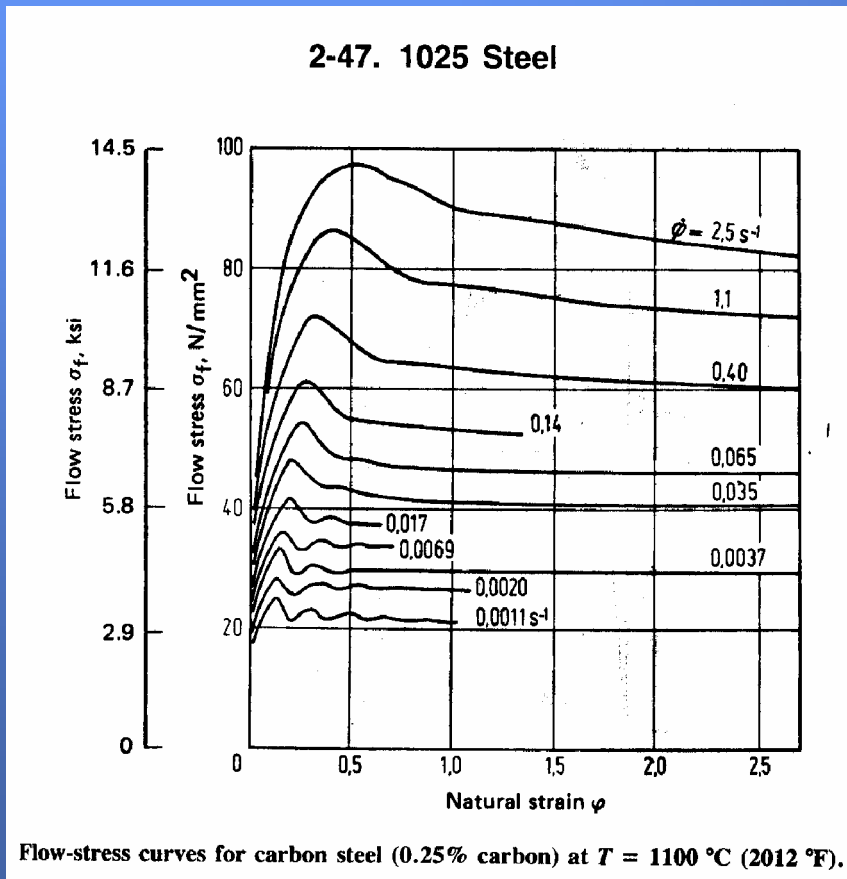
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## The variability of Material Property Measurements



## Stress Strain Curve

Quality

Source

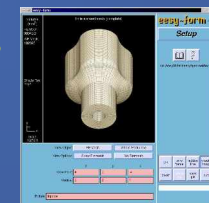
Documentation

## Different sources

Source: ASM Atlas of Stress-Strain Curves

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## The variability of Material Property Measurements

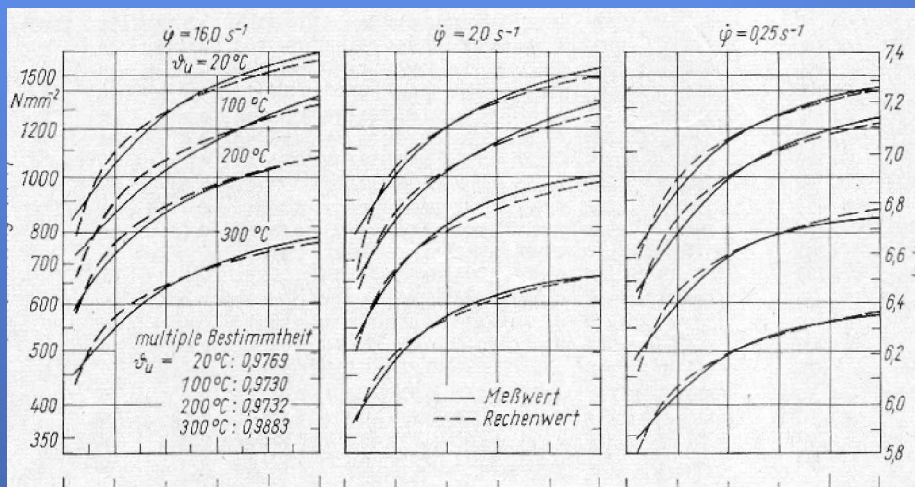
### Stress Strain Curve

Quality

Source

Documentation

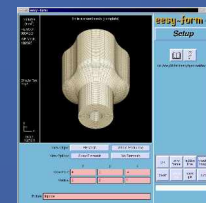
### Different sources



Source: Hensel/Spittel

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## The variability of Material Property Measurements

### Stress Strain Curve

Quality

Source

Documentation

Different sources have different approaches to do the testing, proccession and documentation.

Results from different sources are different.

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## Stress Strain Curve

Quality

Source

Documentation

Material

History

Test parameter

Data

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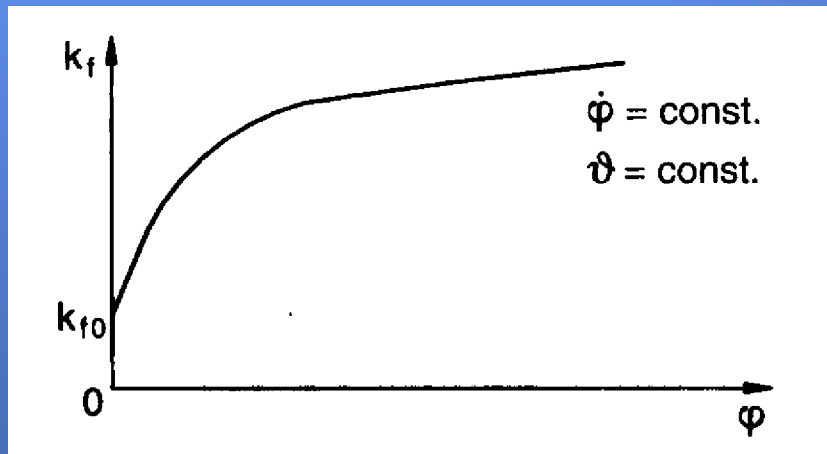
The variability of Material Property Measurements

## Stress Strain Curve

Quality

Source

Documentation (of Data)



YS – Strain curve

Cold

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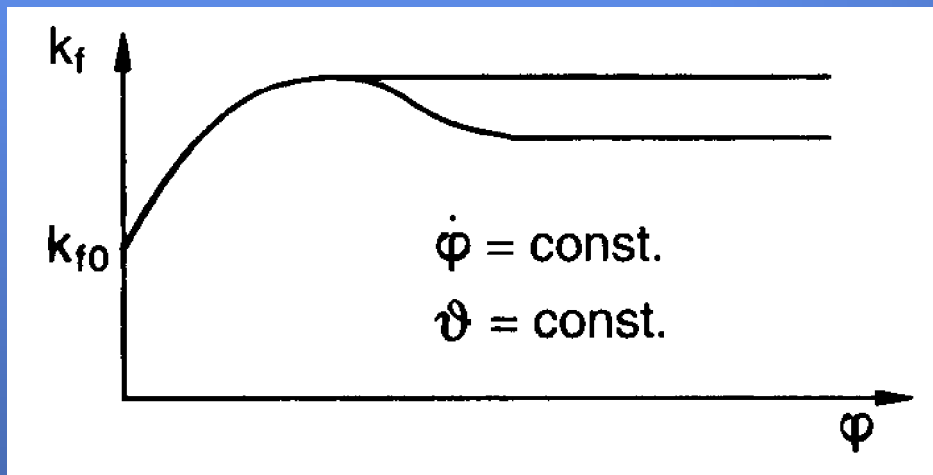
The variability of Material Property Measurements

## Stress Strain Curve

Quality

Source

Documentation (of Data)

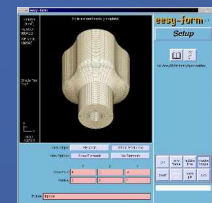


YS – Strain curve

Warm

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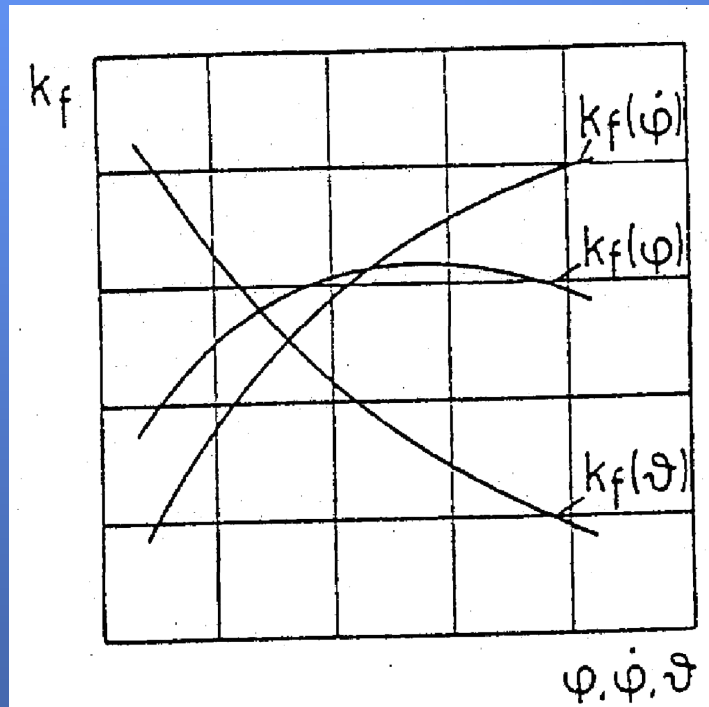
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## Stress Strain Curve

Quality

Source

Documentation (of Data)

## YS – Strain curve

Decomposition to describe the curve by a math. Regression analysis

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### Stress Strain Curve

Quality

Source

Documentation (of Data)

Most of the sources use mathematical models to describe the YS-Strain curves.

This is a manipulation which might end up negative on the quality.

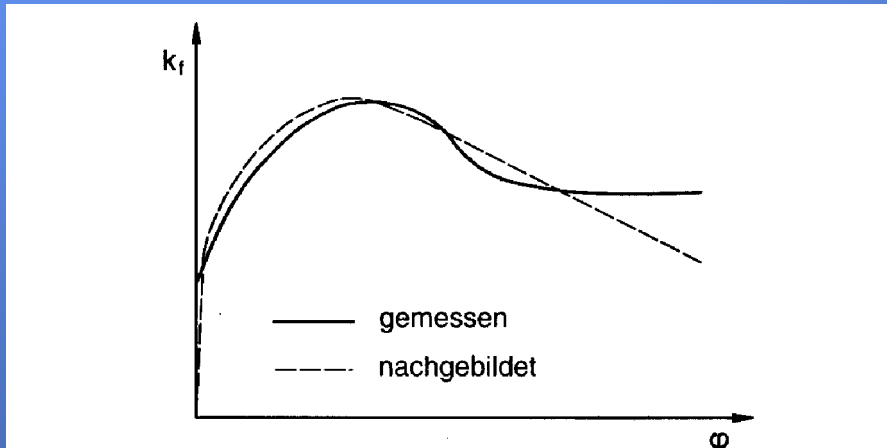
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## The variability of Material Property Measurements



## Stress Strain Curve

Quality

Source

Documentation (of Data)

## YS – Strain curve

Failure caused by  
mathematical description

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The variability of Material Property Measurements

## Stress Strain Curve

Quality

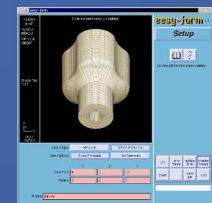
Source

Documentation of Data

Material data should be made available in it's measured quality (corrected because of failures caused by the measurement method only)!

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The variability of Material Property Measurements

## Stress Strain Curve

Quality of data

Source

Documentation

Material data should be investigated along scientifically agreed best practice standards !

**These still have to be developed.**

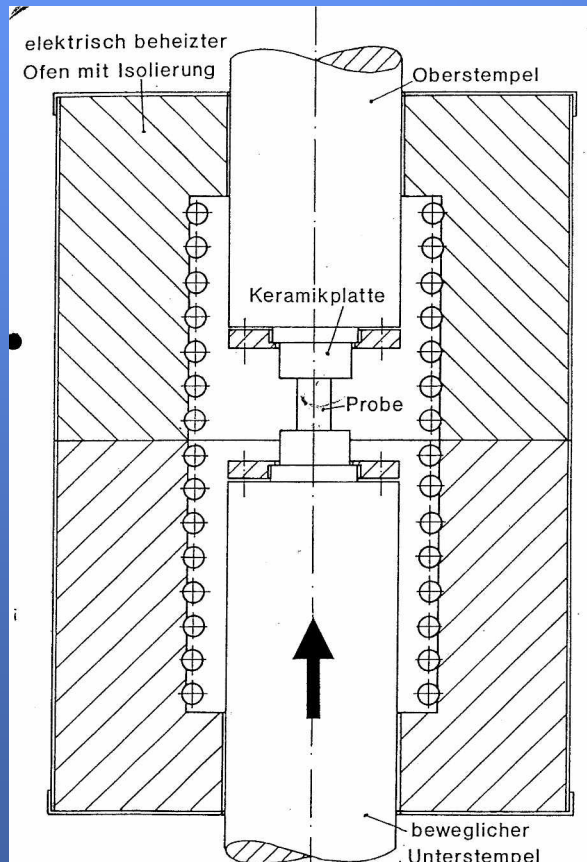
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## The variability of Material Property Measurements



Stress – Strain Curve

Quality

Source

Documentation

Example of a good approach

Tooling inside a furnace

Drawing courtesy of CPM Materialdatenzentrum

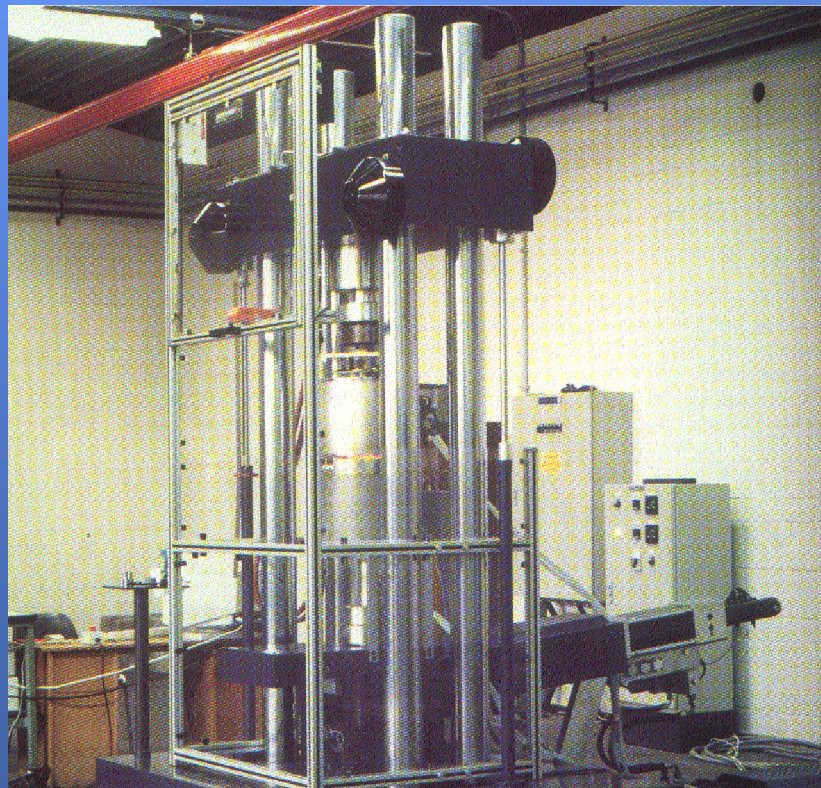
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Stress – Strain Curve

Quality

Source

Documentation

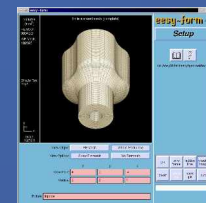
Example of a good approach

Servo-hydraulic press

Photo courtesy of Servotest

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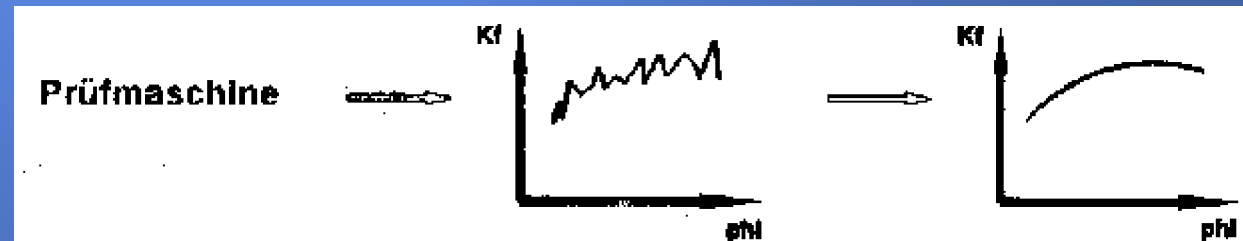
## The variability of Material Property Measurements

Stress – Strain Curve

Quality

Source

Documentation



Example of a good approach

## Filtering of data

Drawing courtesy of CPM Materialdatenzentrum

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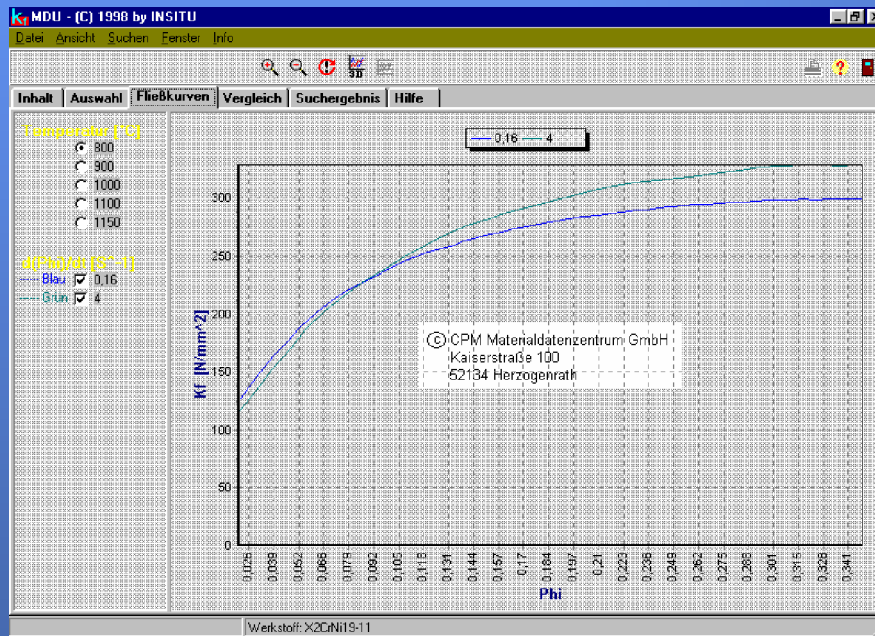
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## The variability of Material Property Measurements



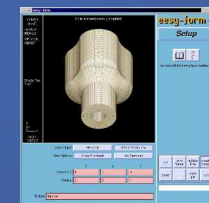
Stress – Strain Curve  
Quality  
Source  
Documentation

Example of a good approach

Storing the data

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## The variability of Material Property Measurements

### Stress – Strain Curve

Quality

Source

Documentation

### Results

Standards of best practice must be developed!

Sources today use varying methods with different quality

Beside other important things the data should be provided in the measured form without any mathematical regressions done. Such regressions etc should be done in the application at the responsibility of the user

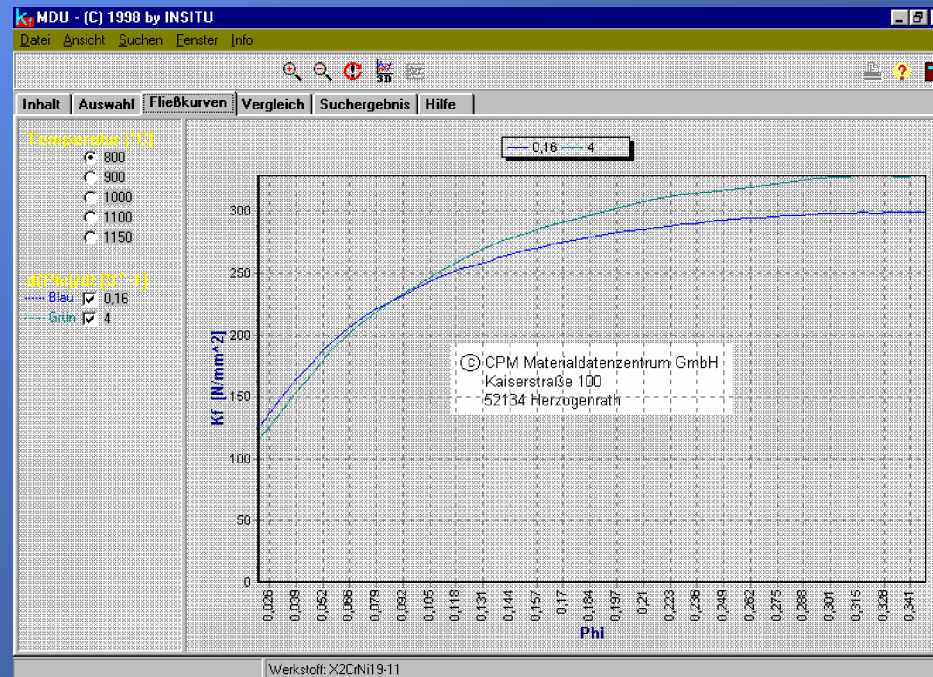


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## The variability of Material Property Measurements

- Thank you for your Interest

Please feel free to contact us



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