

Engineering Approach to use a Hybrid Simulation System for Process and Tool Design
11th International Cold Forming Congress, 11.09.05-13.09.05, Chester, UK

**Engineering Approach to use a Hybrid Simulation System
for Process and Tool Design**

Dr. G.H. Arfmann, Dr. M. Twickler

13th of September 2005



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Part 0: Process design (General Remarks)

Principle of Process Design Work

Typical obstacles in Process Design

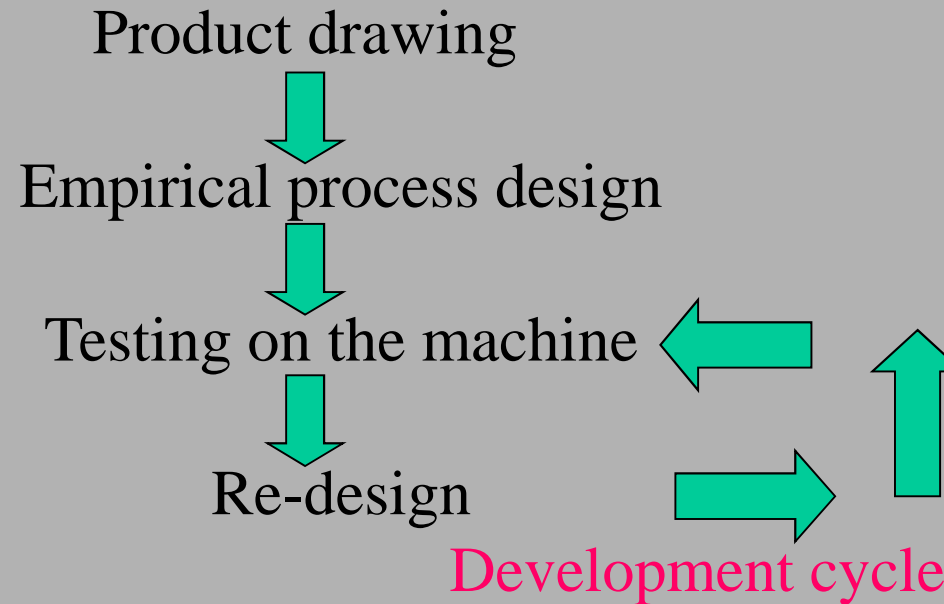
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Traditional way of process development



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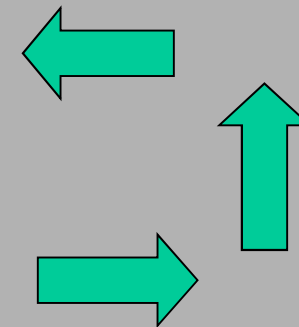
Traditional way of process development

**The development cycle is very cost intensive
and covers a lot of uncertainties**

Testing on the machine



Re-design



Development cycle

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Part 1: Application of FEM (General Remarks)

Typical geom. failures in Process Design
Prediction of cracks in a part
Analysis of tool failure

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Part 1: Application of FEM (General remarks)

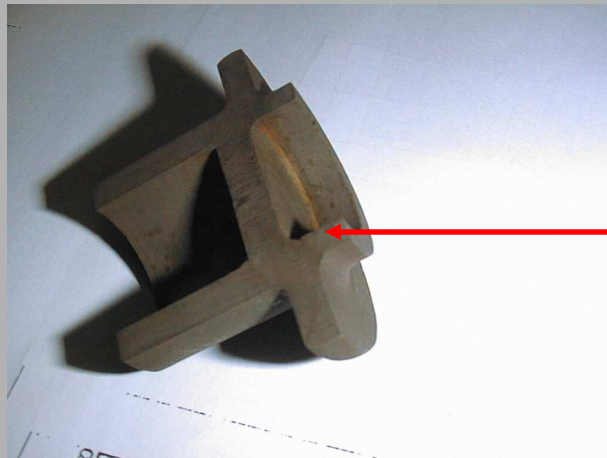
Typical geom. failures in Process Design

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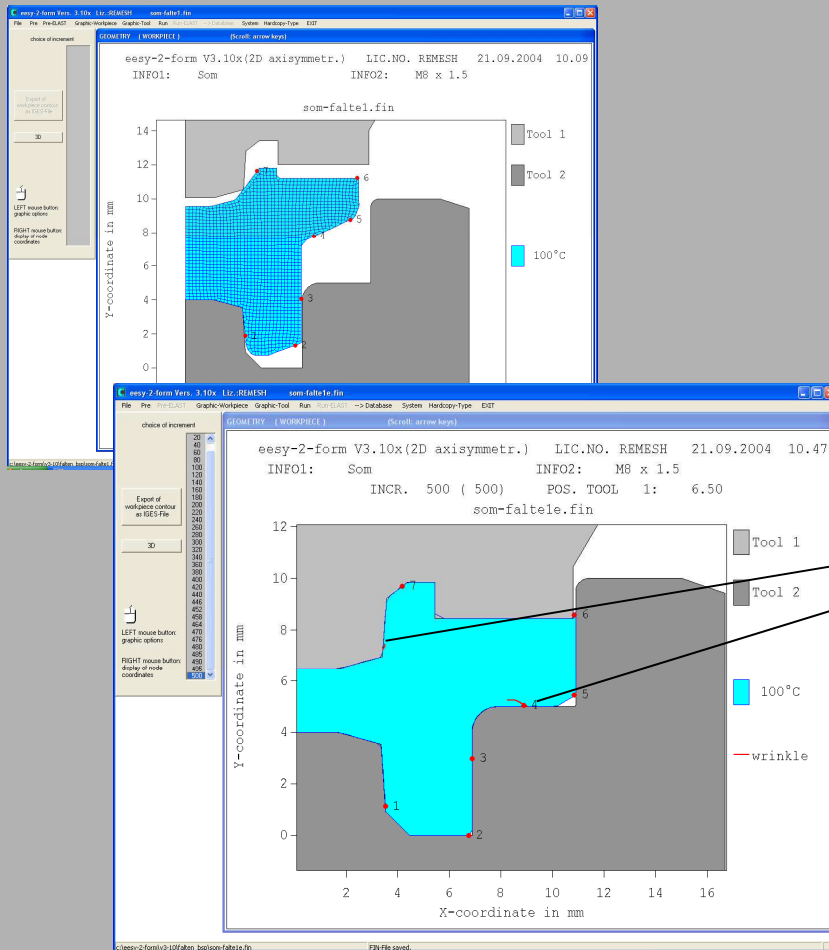
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- Avoiding of failures

Folding at the part surface

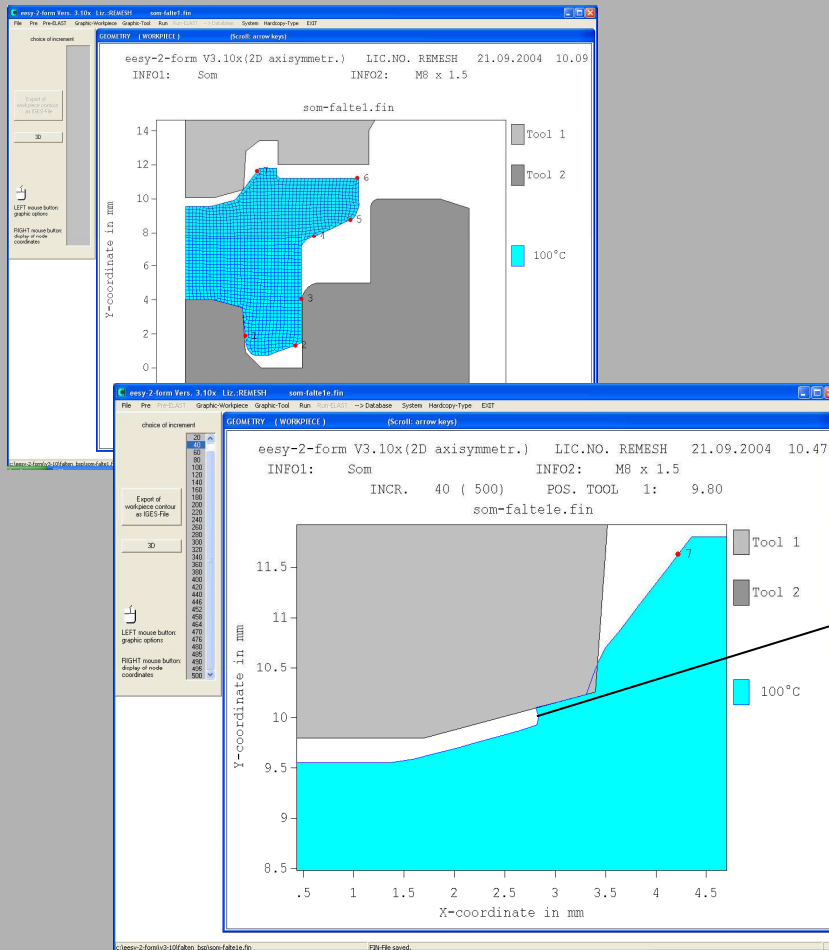
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- Avoiding of failures

Folding at the part surface

Generation

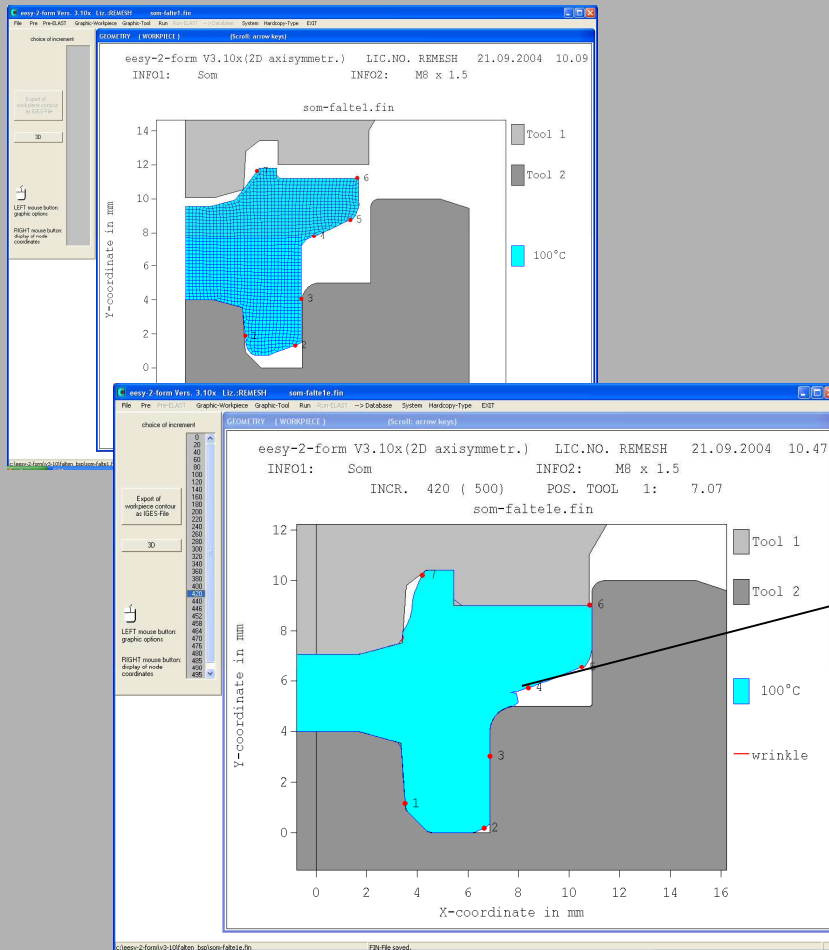
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- Avoiding of failures

Folding at the part
Surface

Generation

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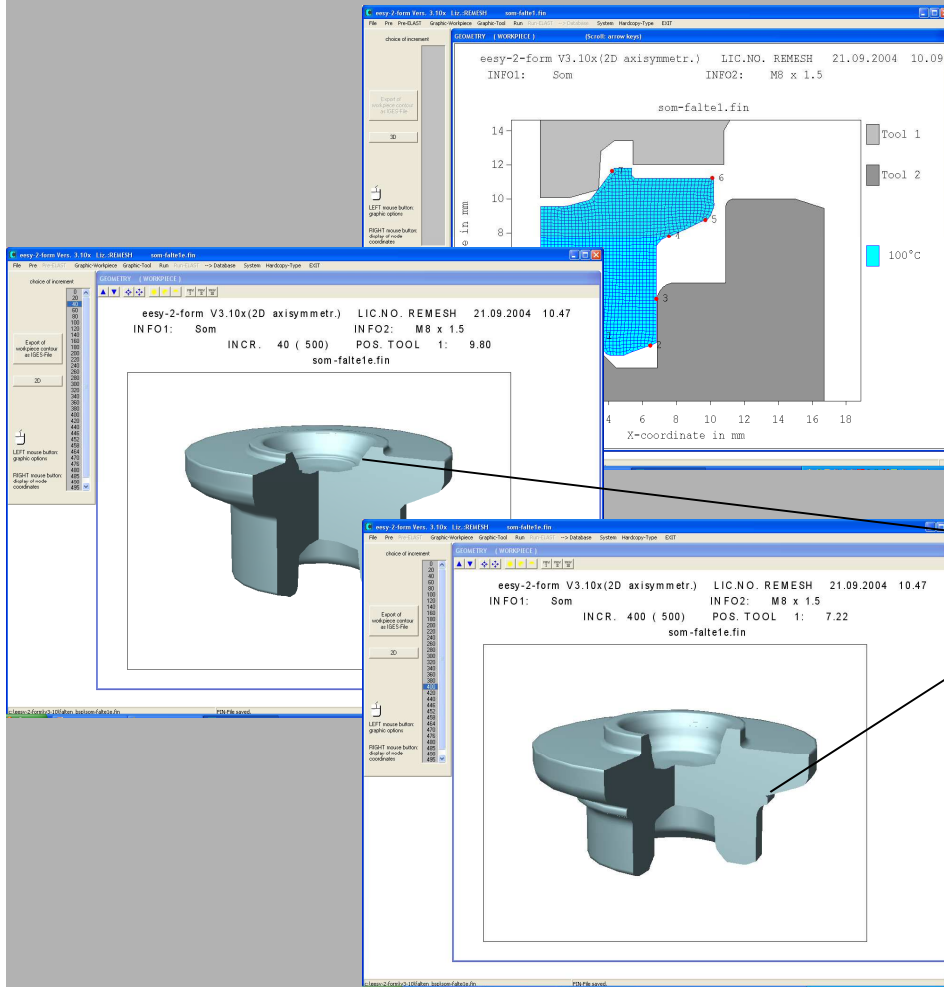
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- Avoiding of failures

Folding at the part surface

Generation



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Part 1: Application of FEM (General remarks)

Prediction of cracks in a part

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Part 1: Application of FEM (General remarks)

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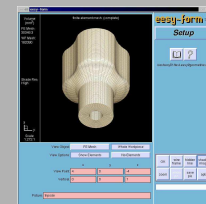


- Avoiding of failures

Failure of a punch

wrong pre-form design

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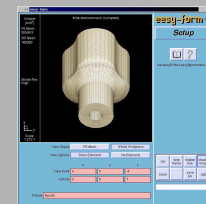


- Avoiding of failures

Failure of a punch

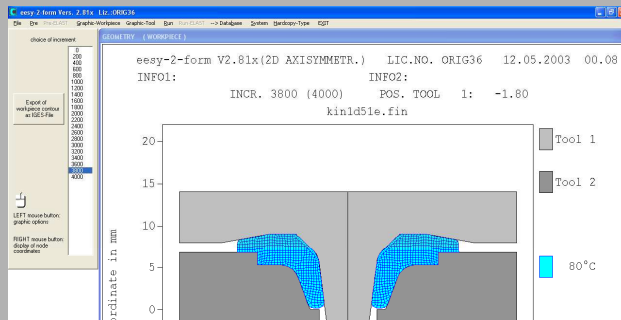
wrong pre-form design

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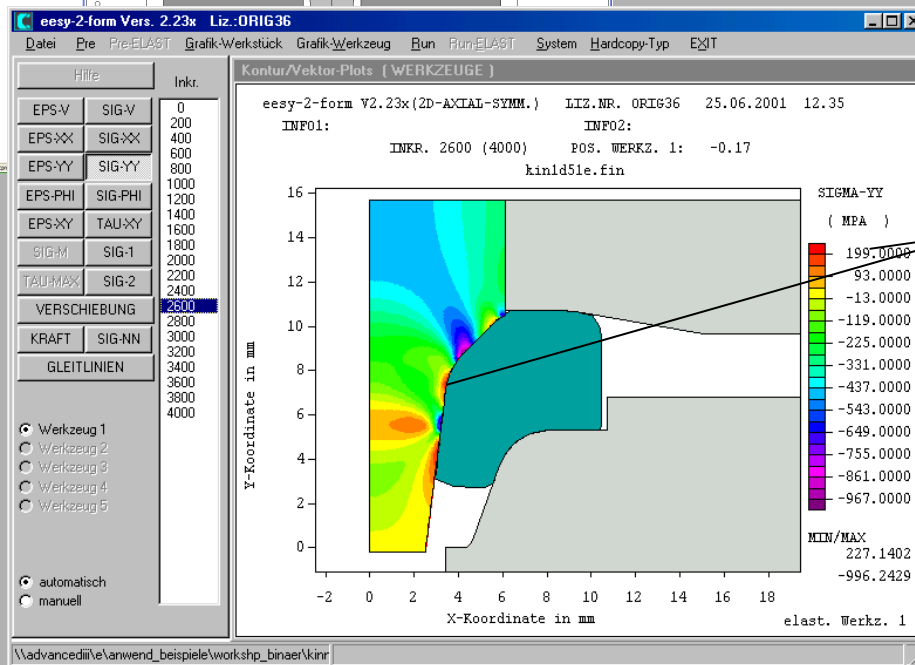


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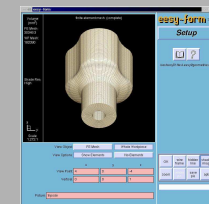


• Avoiding of failures



Failure of a punch

wrong pre-form design



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Part 2: Die Design

Principle of Die Design
Examples of failures

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Part 2: Die Design

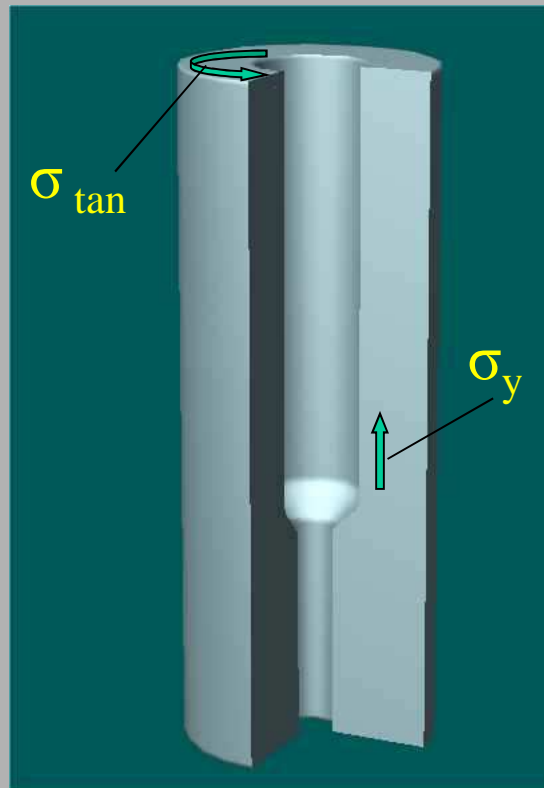
Principle of Die Design

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σ_{tan} : critical for axial crack

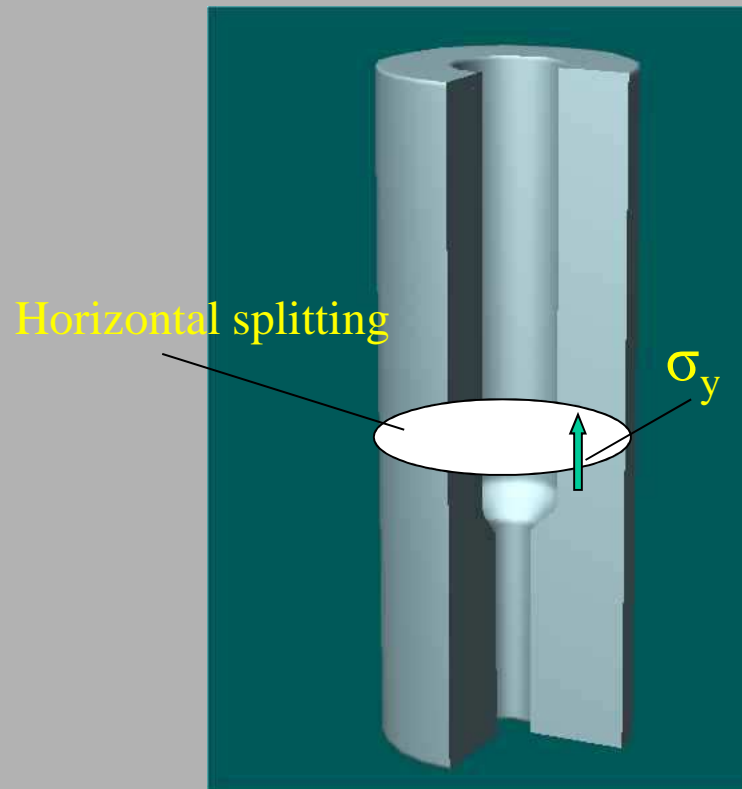
σ_y : critical for horizontal crack

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σ_y : critical for horizontal crack

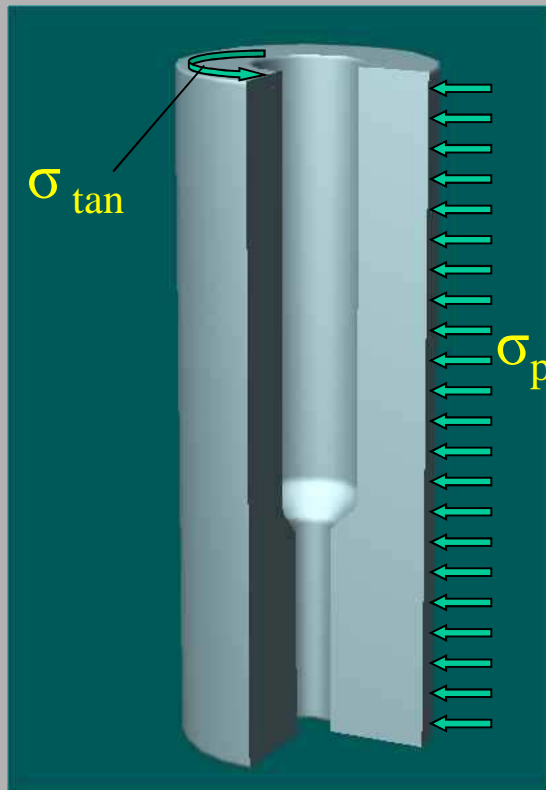
➔ horizontal split of the insert

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σ_{tan} : critical for axial crack

➔ Pre-stressing of the insert

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Part 2: Die Design

Examples of failures

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Part 3: Die Design using a simplified approach (lamé equation)

Principle

Application

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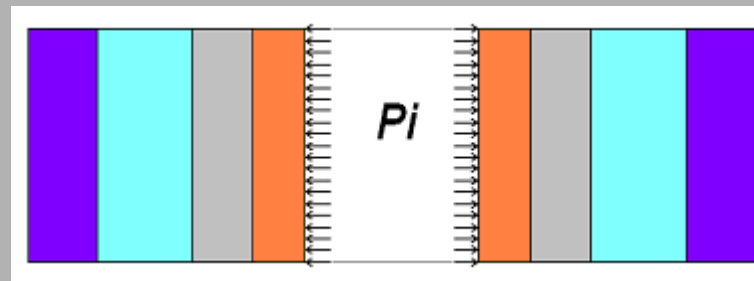


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Part 3: Die Design using a simplified approach (lamé equation)

Principle



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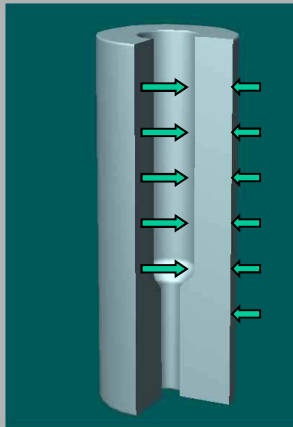


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Part 3: Die Design using a simplified approach (lamé equation)

Principle



Simplified Methode

$$\text{Pre-stress} = f (P_i = \text{const.}; d_i = \text{const}; \dots)$$

P_i – inner pressure, d_i – inner diameter

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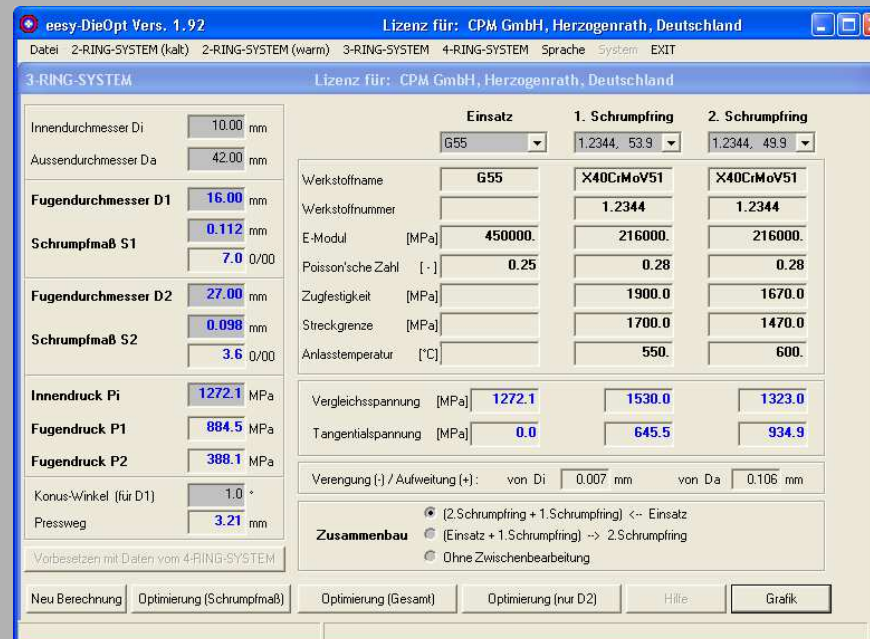
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Part 3: Die Design using a simplified approach (lamé equation)

Application



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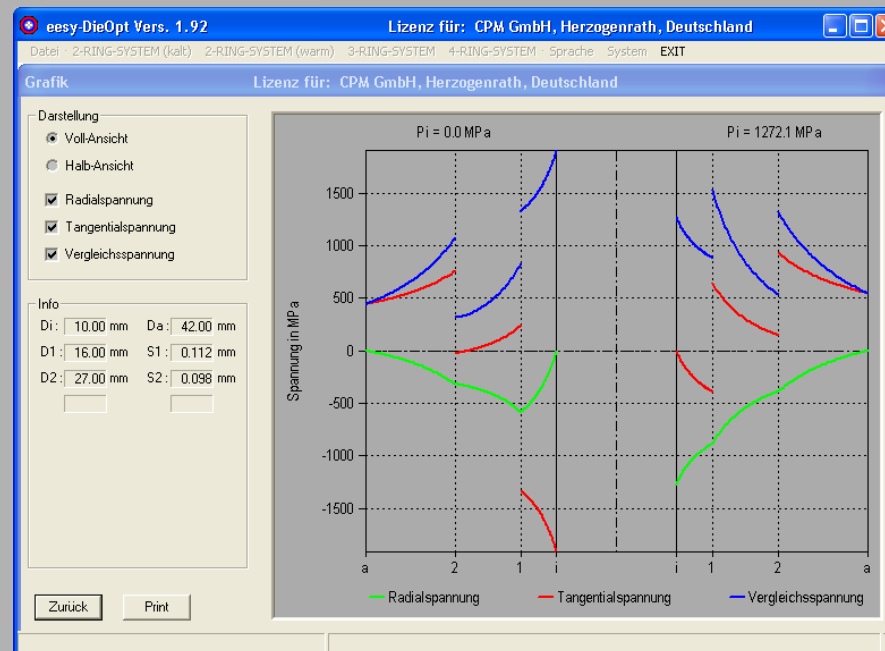


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Part 3: Die Design using a simplified approach (lamé equation)

Application



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Part 4: Using FEM and Die Design Software together

Tool analysis (insert) by FEM

Pre – stressing system layout
with analytical methode

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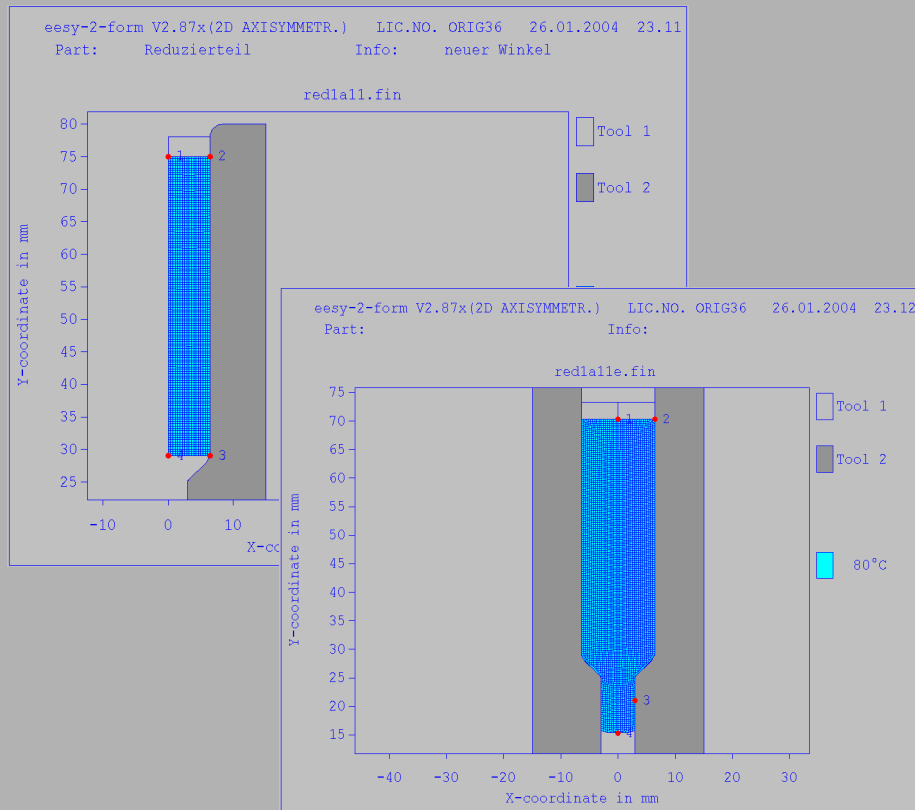
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- Design of a cold forming process

Simulation of an extrusion

Material flow

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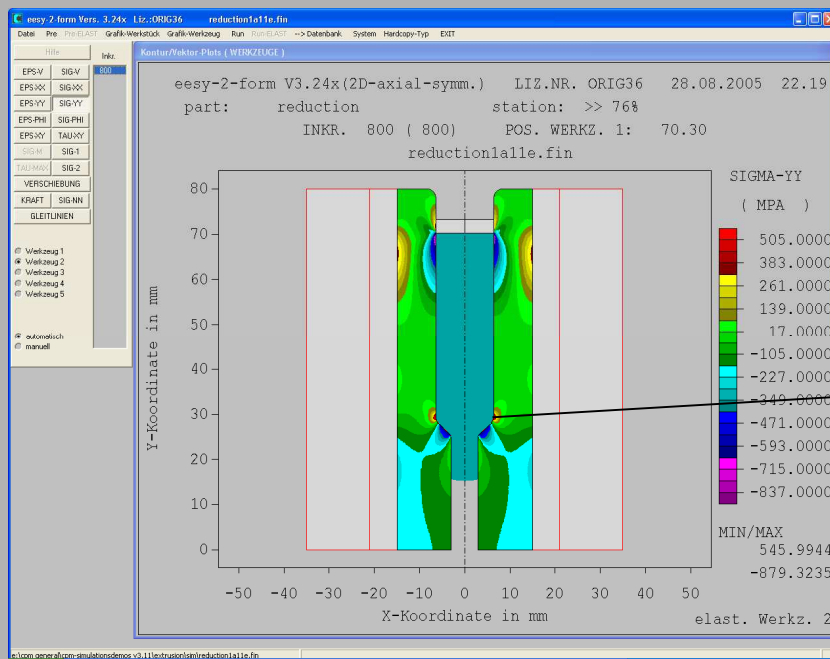


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- Avoiding of failures (elastic analysis of the insert with FEM)

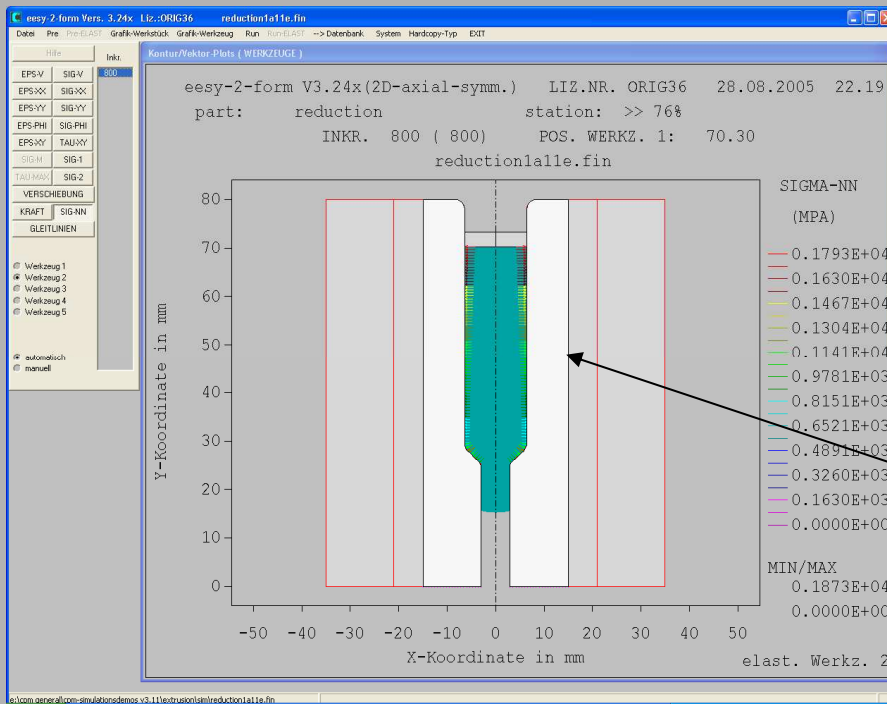


Splitting of the die due to high axial stresses

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- Design of a cold forming process



Tool design

Die insert without pre-stressing

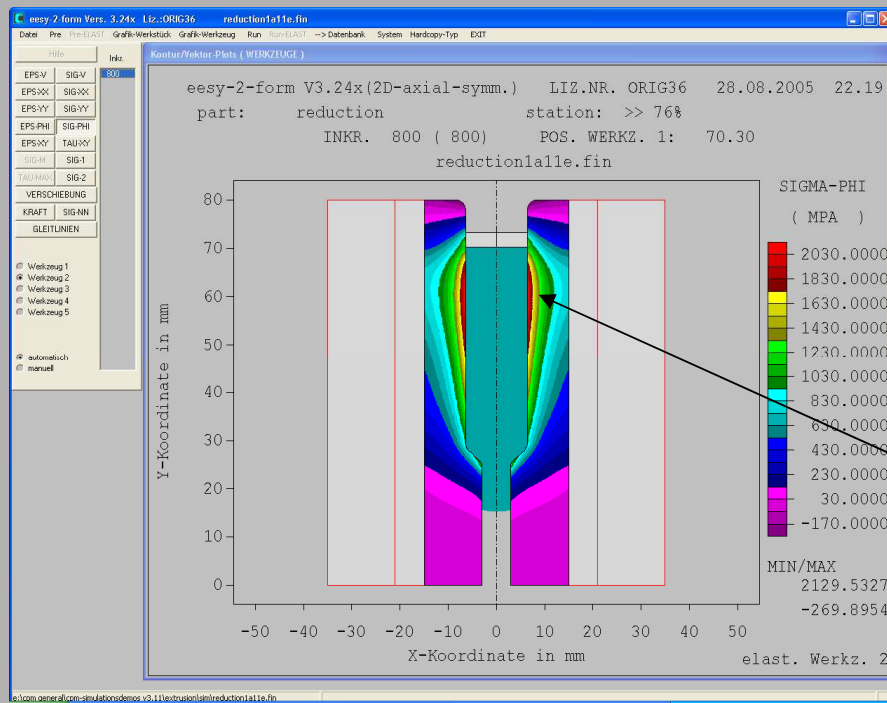
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- Design of a cold forming process

Tool design

Positive stress in the die without pre-stressing

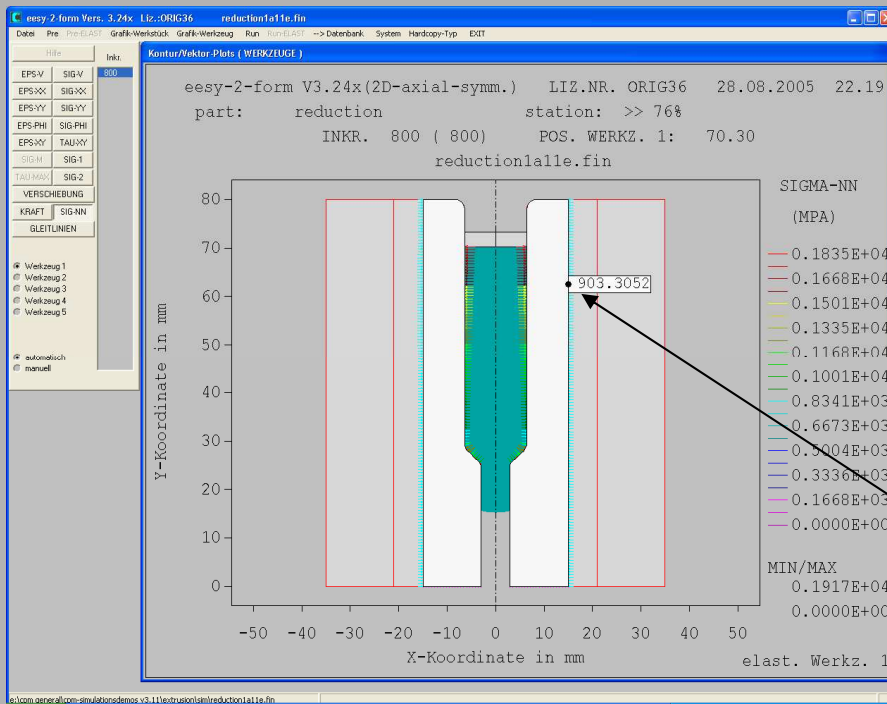
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- Design of a cold forming process

Tool design

Die with pre-stressing (900 MPa)

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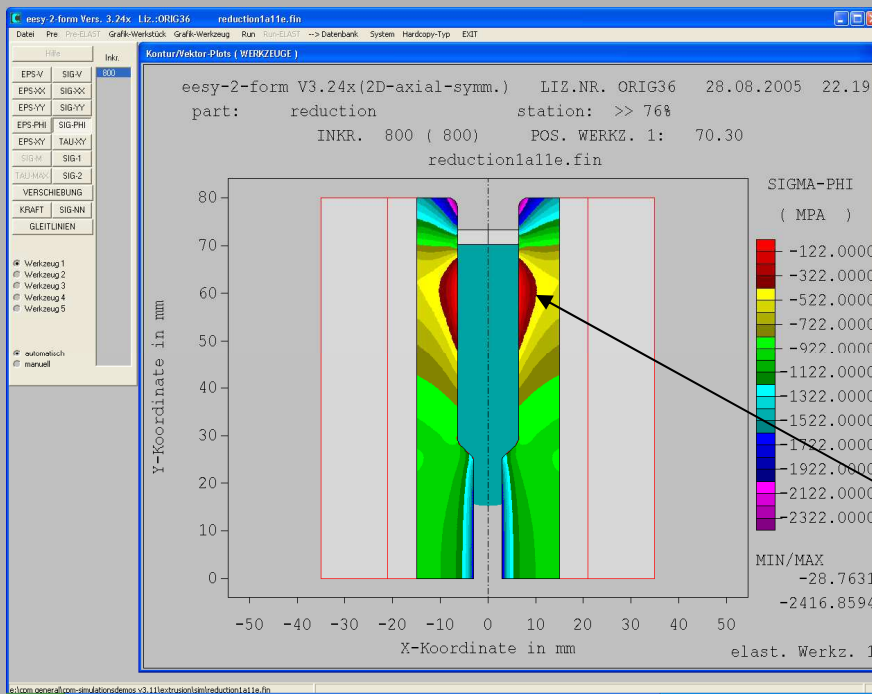


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- Design of a cold forming process



Tool design

Pressure in the die with pre-stressing

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Part 4: Using FEM and Die Design Software together

Pre – stressing system layout
with analytical methode

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- Design of a cold forming process (Tool design)

The screenshot shows the 'eesy-DieOpt Vers. 1.95' software window. The title bar indicates the license is for 'CPM GmbH, Herzogenrath, Deutschland'. The main window is titled '3-RING-SYSTEM' and contains various input fields and a data table.

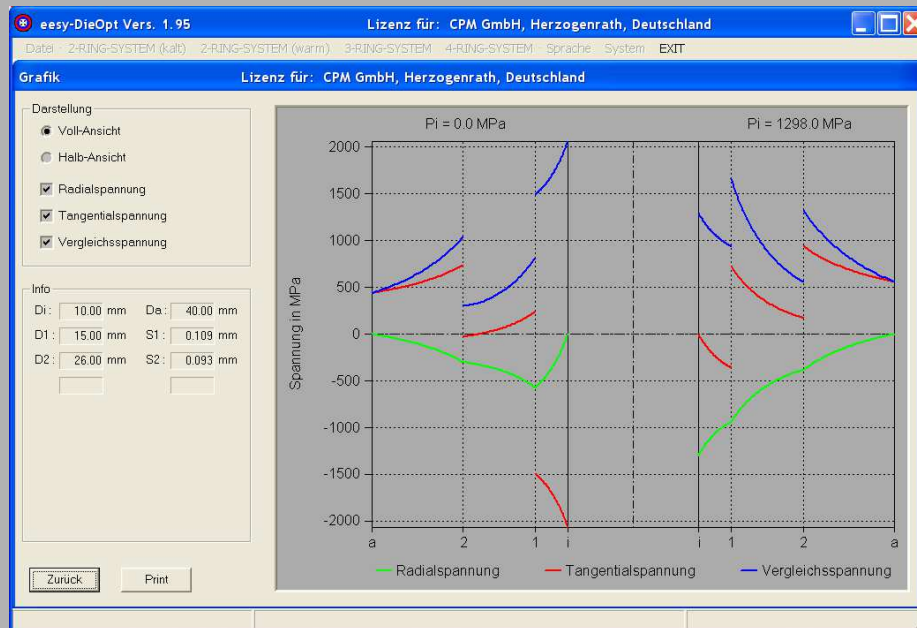
	Einsatz	1. Schrumpfring	2. Schrumpfring
Werkstoffname	G55	X40CrMoV51	X40CrMoV51
Werkstoffnummer		1.2344	1.2344
E-Modul [MPa]	450000.	216000.	216000.
Poisson'sche Zahl [-]	0.25	0.28	0.28
Zugfestigkeit [MPa]		2050.0	1670.0
Streckgrenze [MPa]		1850.0	1470.0
Anlasstemperatur [°C]		520.	600.
Vergleichsspannung [MPa]	1298.0	1665.0	1323.0
Tangentenspannung [MPa]	0.0	727.6	941.0

Additional parameters shown in the interface include: Innendurchmesser Di (10.00 mm), Aussendurchmesser Da (40.00 mm), Fugendurchmesser D1 (15.00 mm), Schrumpfmaß S1 (0.109 mm), Fugendurchmesser D2 (26.00 mm), Schrumpfmaß S2 (0.093 mm), Innendruck Pi (1298.0 MPa), Fugendruck P1 (937.4 MPa), Fugendruck P2 (382.0 MPa), Konus-Winkel (für D1) (1.0 °), and Pressweg (3.12 mm).

Design of a multi-ring pre-stressing-system

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- Design of a cold forming process (Tool design)

Design of a multi-ring prestressing-system

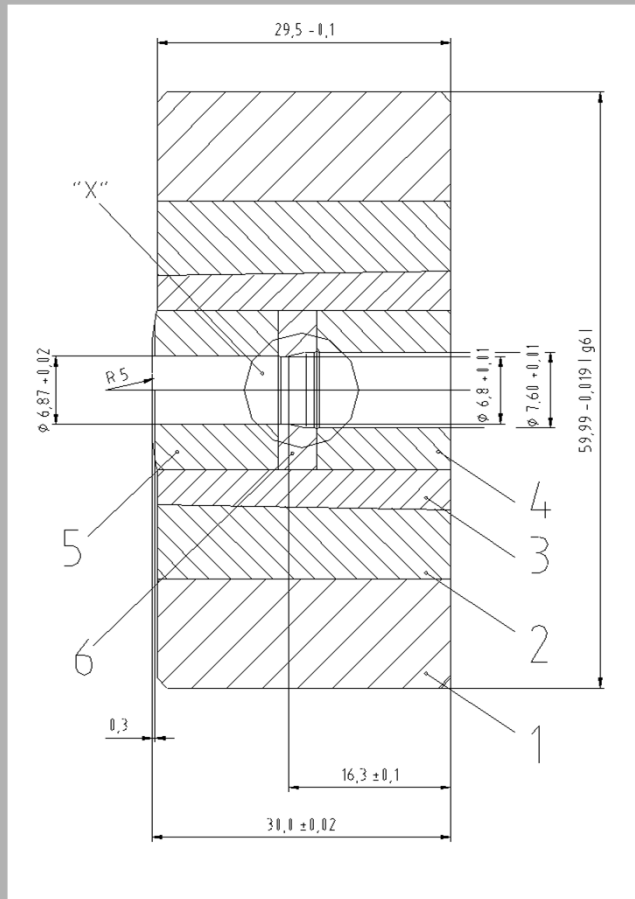
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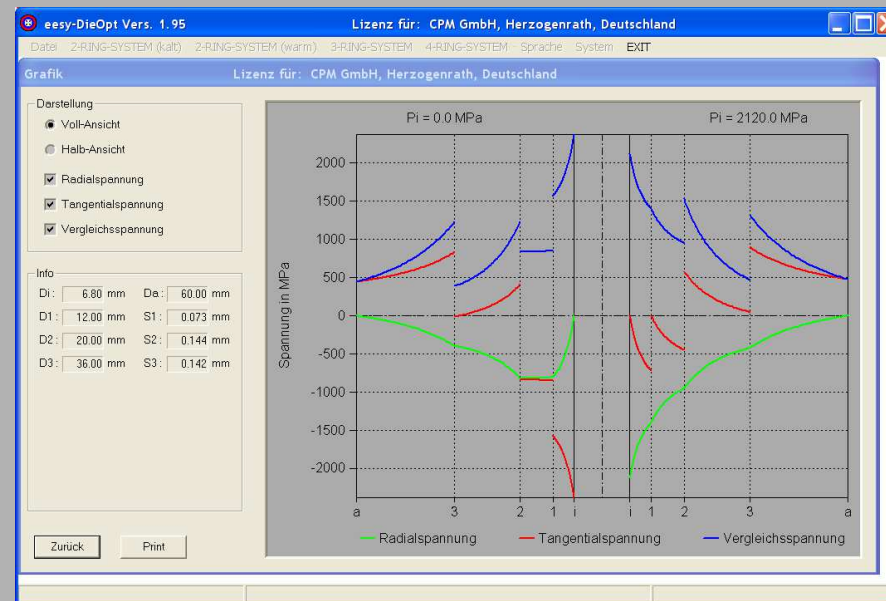
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- Even complex design could be realized



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(c) WALLRAM



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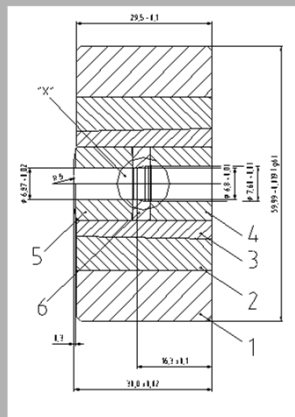
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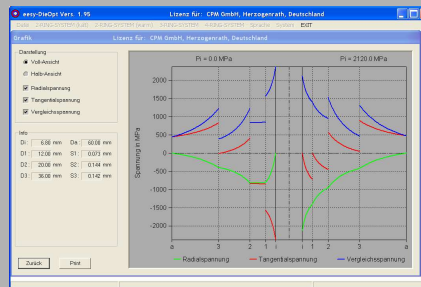
But.....

There are still assumptions in this approach that may lead to big mistakes

One of them is the homogeneous pre-stressing of the insert.....



- Even complex design could be realized



(c) WALLRAM

To overcome these problems a new method is introduced.....

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Part 5: New Approach - Hybrid System

Using FEM with integrated Die Design Software

Principle

Example of application

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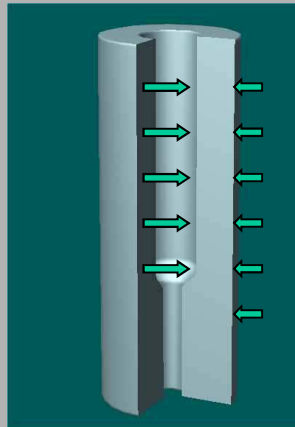
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Part 5: New Approach - Hybrid System

Using FEM with integrated Die Design Software

Principle



Simplified methode for die design

$$\text{Pre-stress} = f (P_i = \text{const.}; d_i = \text{const}; \dots)$$

P_i – inner pressure, d_i – inner diameter

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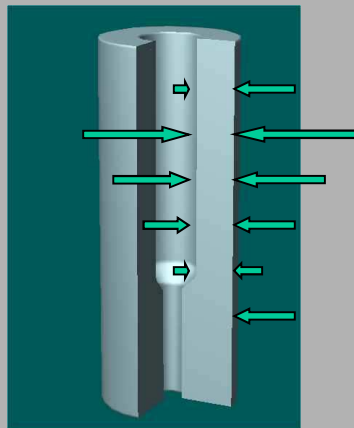
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Part 5: New Approach - Hybrid System

Using FEM with integrated Die Design Software

Principle



New methode for die design

$$\text{Pre-stress} = f (P_i(t,y); d_i(y); y; \dots)$$

P_i – inner pressure, d_i – inner diameter, t – time (increment), y – axial location

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Part 5: New Approach - Hybrid System

Using FEM with integrated Die Design Software

Principle

The new method with integrated die design -

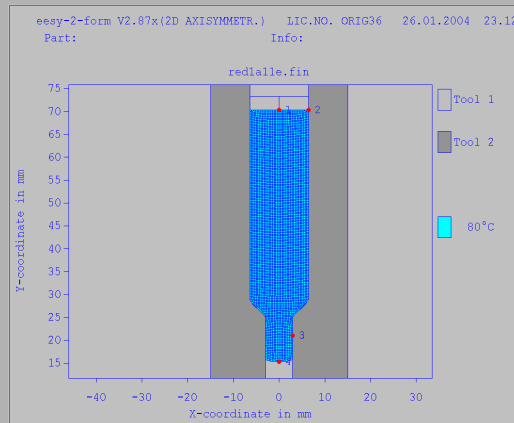
- allows to apply the **lamé equation** locally in axial direction for the pre-stressing ring and case layout**
- is completely integrated in the FEM code which simulates the elastic behaviour in insert, rings and case**
- uses a discretisation which is as fine as the FEM mesh in the insert**

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Part 5: New Approach - Hybrid System

Using FEM with integrated Die Design Software

Example of application



The same example as in part 4 will be used to show the advantages of the new method

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Part 5: New Approach - Hybrid System

Using FEM with integrated Die Design Software

Example of application

Procedure

After the FEM analysis of the part an optimal design layout is calculated with the die-design system

The results (diameters, interferences etc) are provided to the FEM code with integrated die-design software

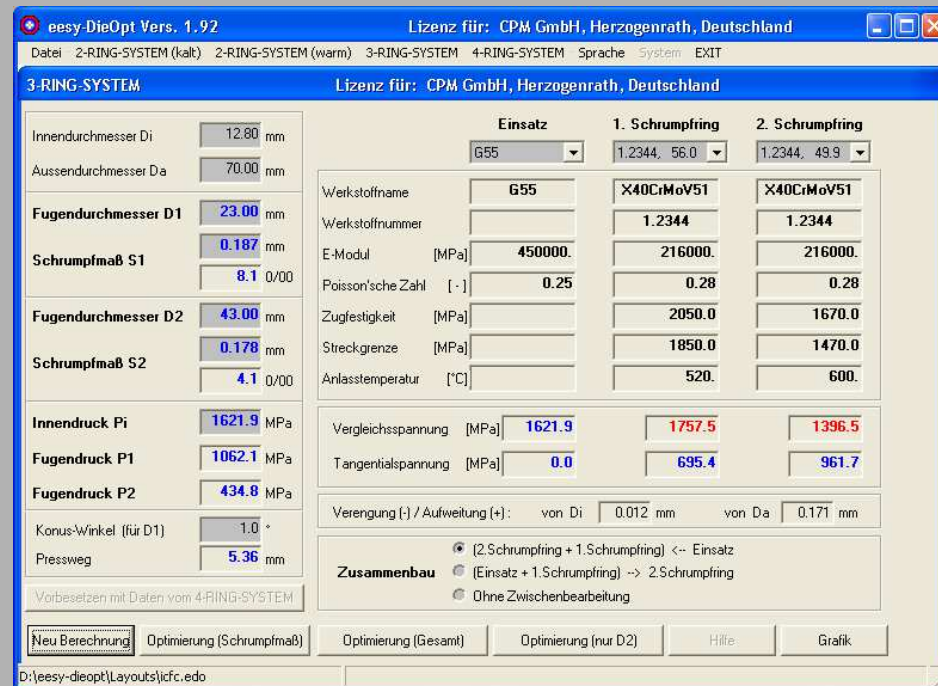
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Part 5: New Approach - Hybrid System

Using FEM with integrated Die Design Software

Example of application



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Example of application

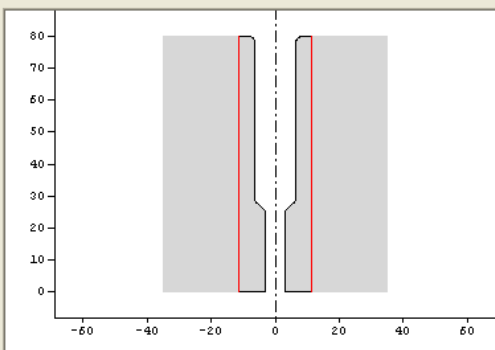
Werkzeug-Vorspannung

Werkzeugverband

- Einsatz + Schrumpfring
- Einsatz + 2 Schrumpfringe (aussen -> innen)
- Einsatz + 2 Schrumpfringe (innen -> aussen)
- Einsatz + 3 Schrumpfringe (aussen -> innen)
- Einsatz + 3 Schrumpfringe (innen -> aussen)
- Einsatz + 3 Schrumpfringe ((1+2) -> [3+4])

Funktion im Werkzeugverband

- Einsatz
- 1. Schrumpfring
- 2. Schrumpfring
- 3. Schrumpfring



Innendurchmesser gegeben

Fugendurchmesser	Fugendurchmesser D1	Fugendurchmesser D2	Fugendurchmesser D3	Aussendurchmesser
	23.00 mm	42.00 mm		70.00 mm
Schrumpfmass	Schrumpfmass S1	Schrumpfmass S2	Schrumpfmass S3	
	0.190 mm	0.180 mm		

Material: Hartmetall (G5) | Ferritischer St | Ferritischer St

Querkontraktionszahl: 0.25 | 0.30 | 0.30

E-Modul: 450000 | 211000 | 211000

Cancel OK

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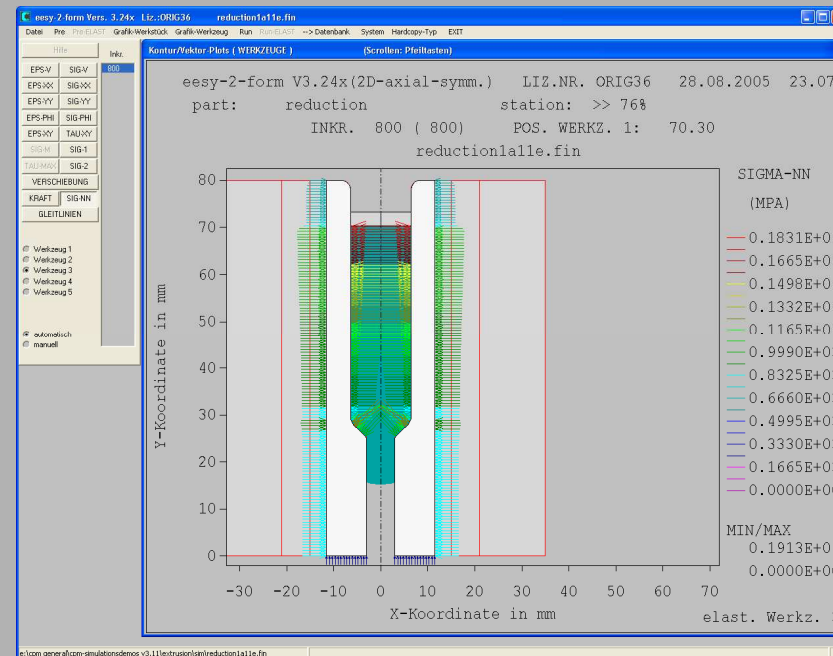
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Using FEM with integrated Die Design Software

Example of application

The pre-stress on the insert shows a distribution



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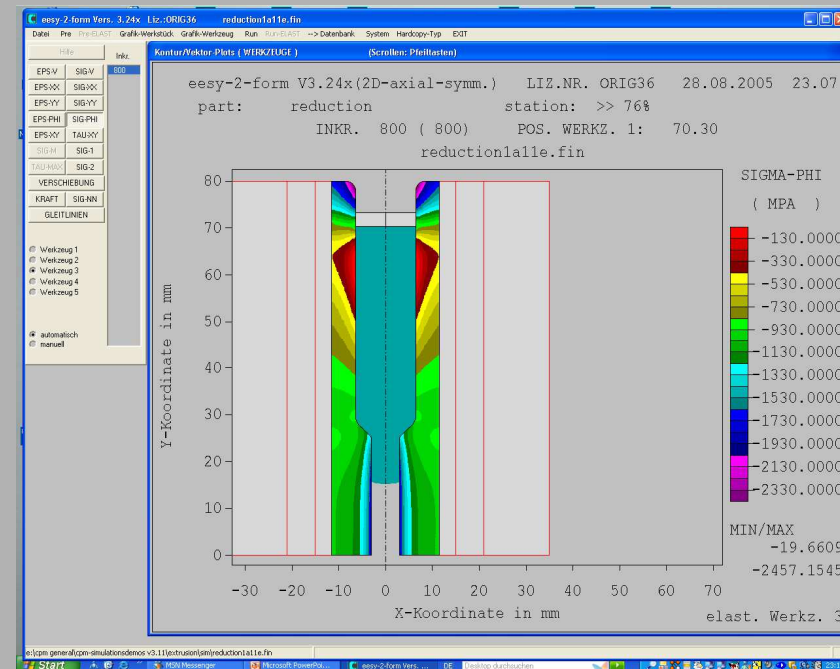
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Part 5: New Approach - Hybrid System

Using FEM with integrated Die Design Software

Example of application

The stress distribution in the insert is different, too



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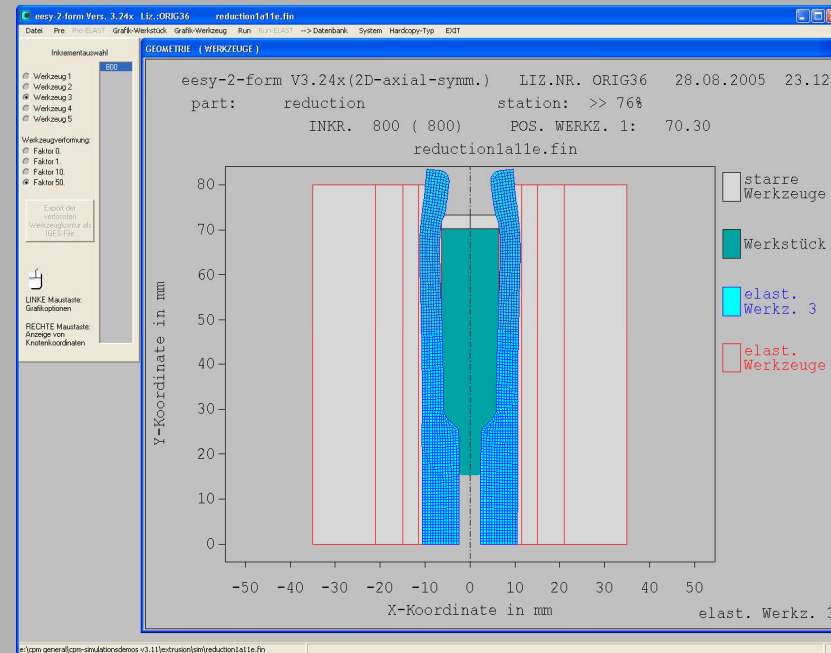
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Part 5: New Approach - Hybrid System

Using FEM with integrated Die Design Software

Example of application

Magnified distortion
in the insert



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Part 5: New Approach - Hybrid System

Using FEM with integrated Die Design Software

Example of application

The new method allows for a much more precise study of the stresses in the die assembly

... it is still a simplified approach

... but it helps to solve a lot of practical design tasks in an easy, simple and fast way

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