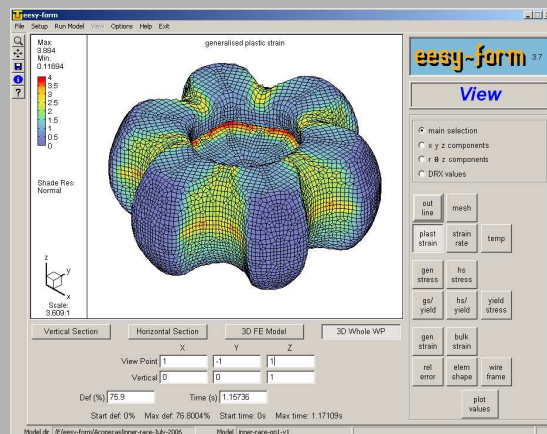


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**Engineering Approach to use a Hybrid Simulation System  
for Process and Tool Design**

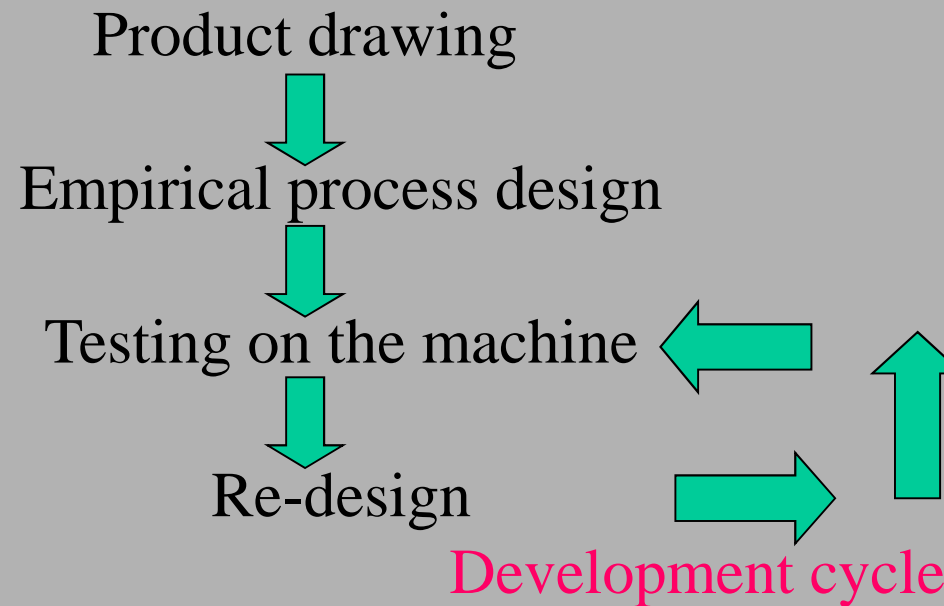
**Dr. G.H. Arfmann, Dr. M. Twickler**



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*Principle of Process Design Work*



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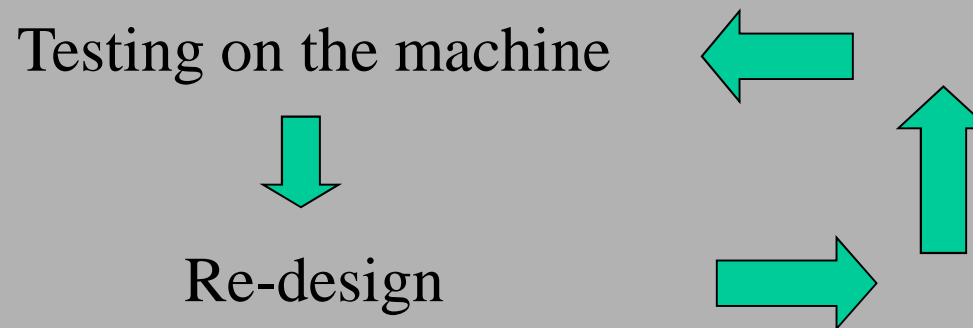


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*Principle of Process Design Work*

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



Development cycle

**Engineering Approach to use a Hybrid Simulation System for Process and Tool Design**  
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*Application of FEM in Process Design*

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

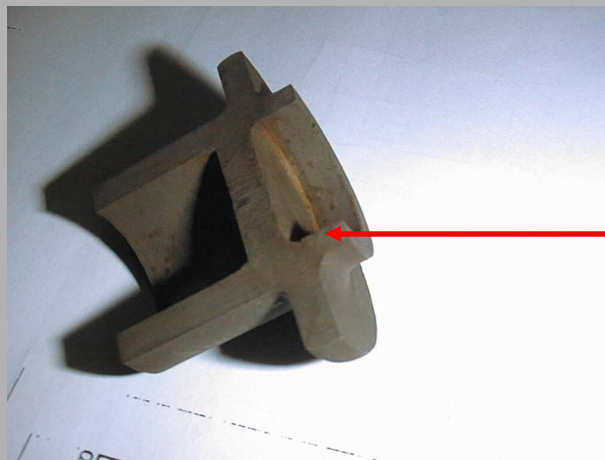
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*Typical geom. failures in Process Design*  
*- Folding -*



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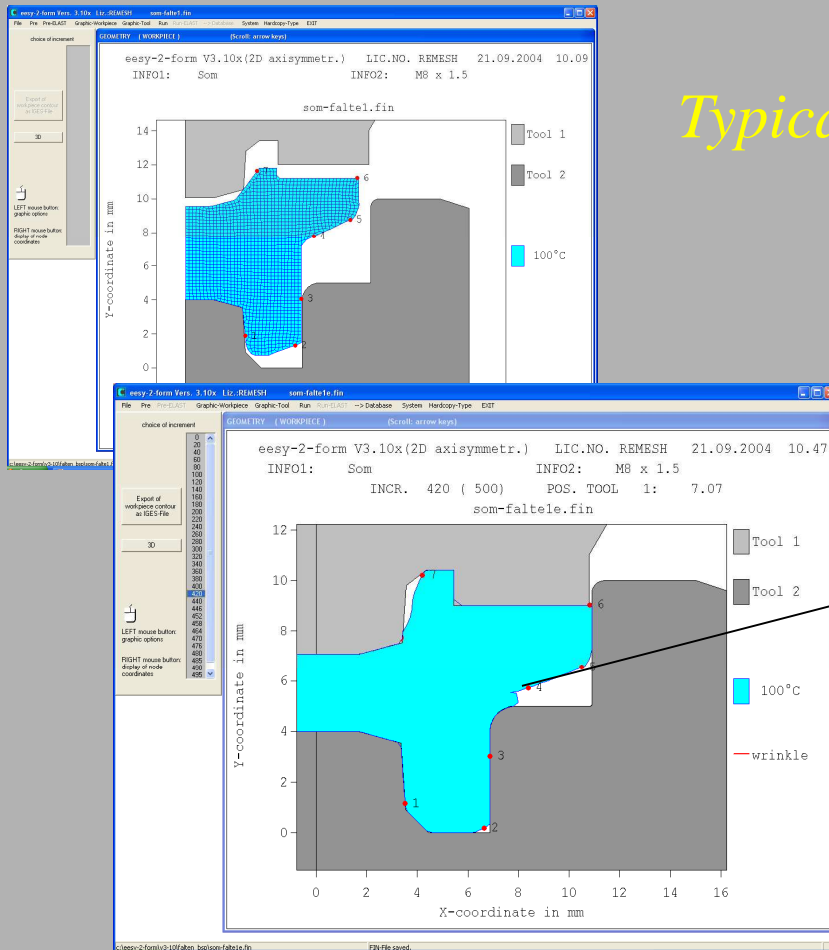


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# Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

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*Typical geom. failures in Process Design*



**Folding at the part Surface**

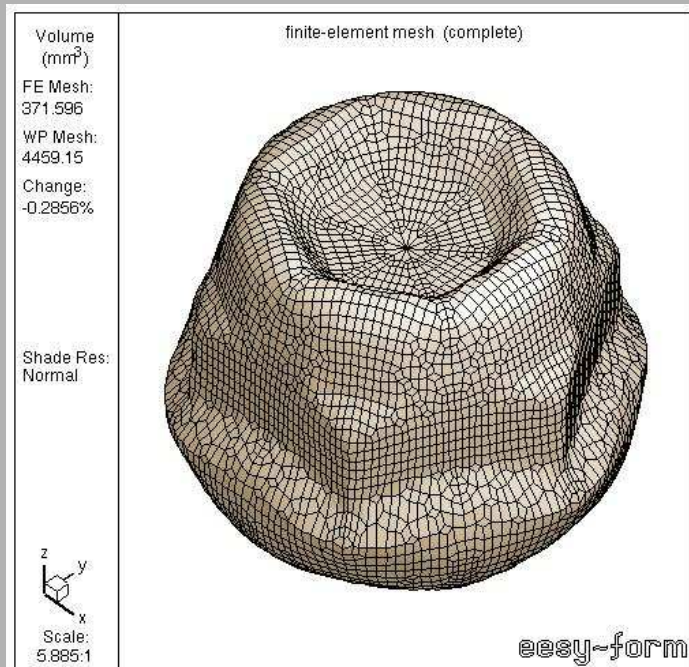
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*Typical geom. failures in Process Design*



Filling

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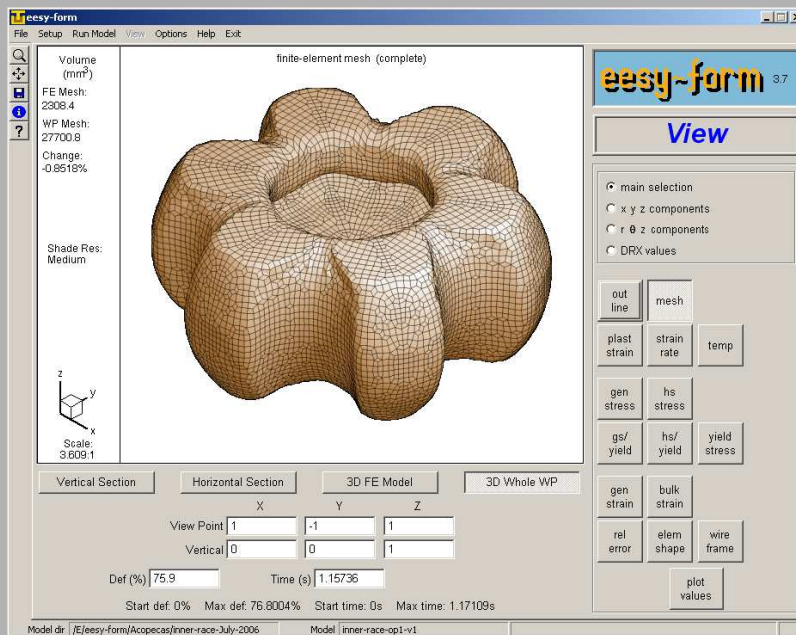


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*Typical geom. failures in Process Design*



**Folding / Filling**

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*Prediction of cracks in a part*



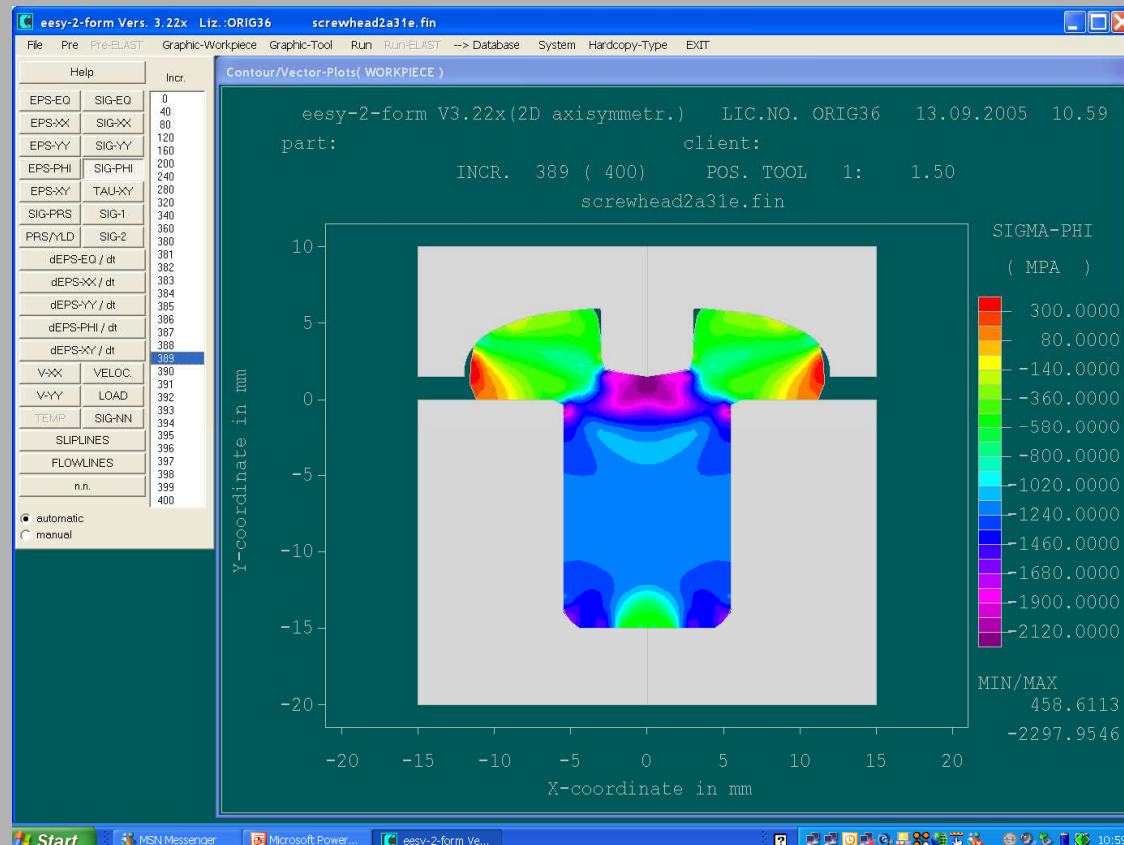
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*Analysis of tool failure*



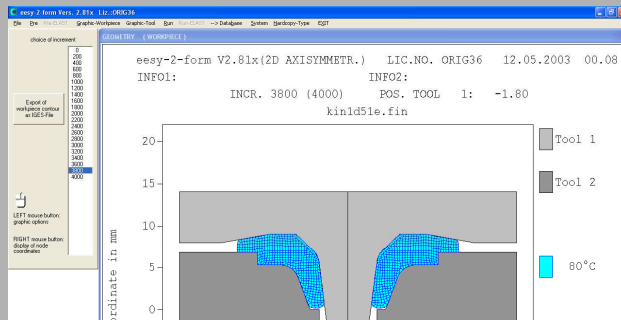
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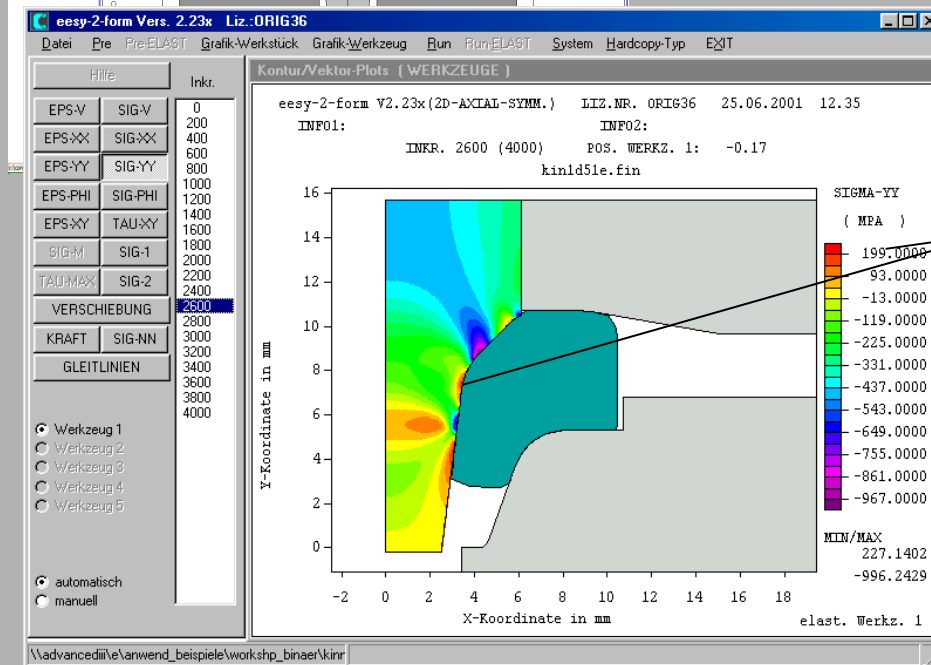
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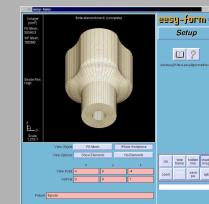


• Avoiding of failures



Failure of a punch

wrong pre-form design



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*Analysis of tool failure*



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*Analysis of tool failure*



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*POA, Brazil*

*Analysis of tool failure*

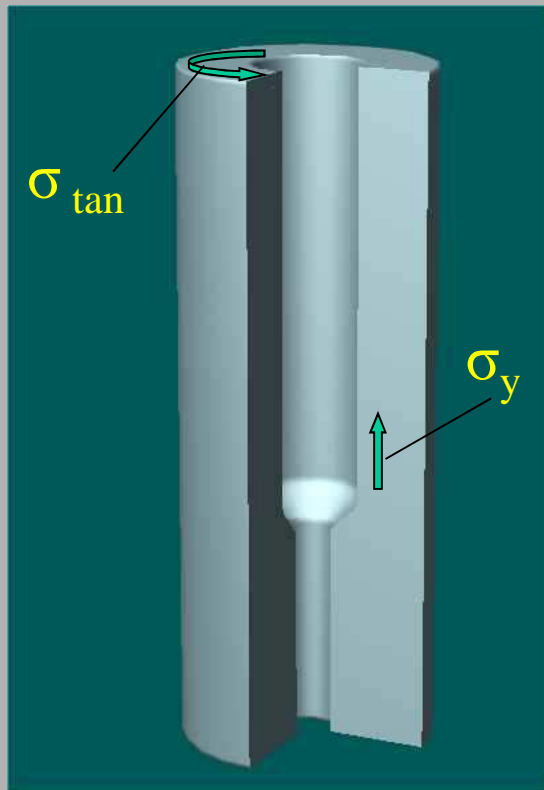


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*Principle of Die Design*

$\sigma_{tan}$ : critical for axial crack

$\sigma_y$ : critical for horizontal crack

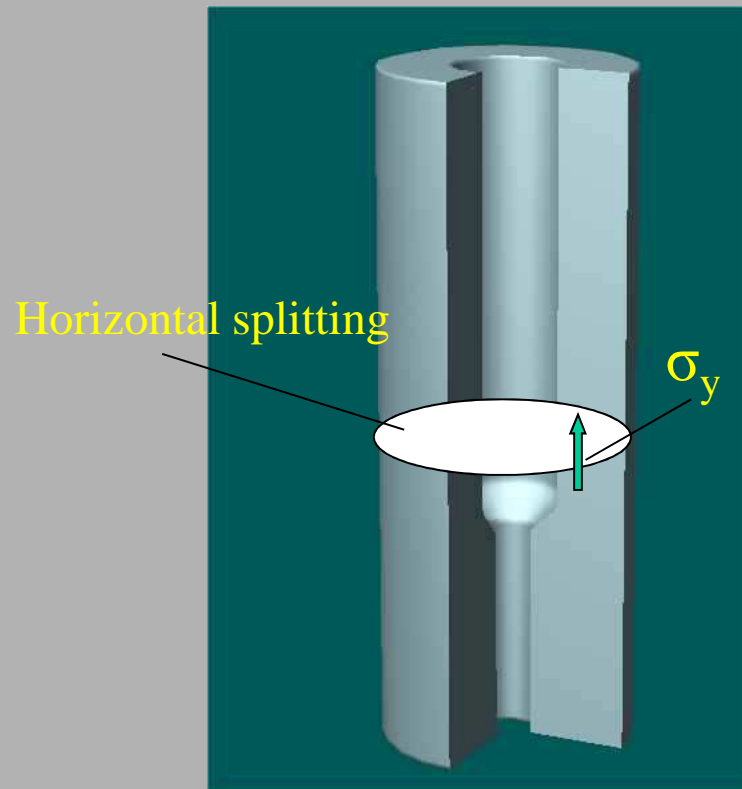
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*Principle of Die Design*

$\sigma_y$ : critical for horizontal crack

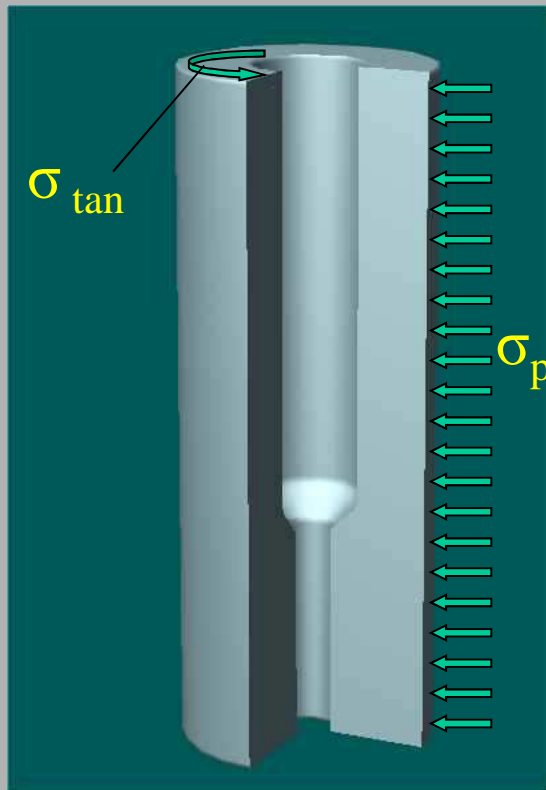
➔ horizontal split of the insert

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*Principle of Die Design*

$\sigma_{tan}$ : critical for axial crack

➔ Pre-stressing of the insert

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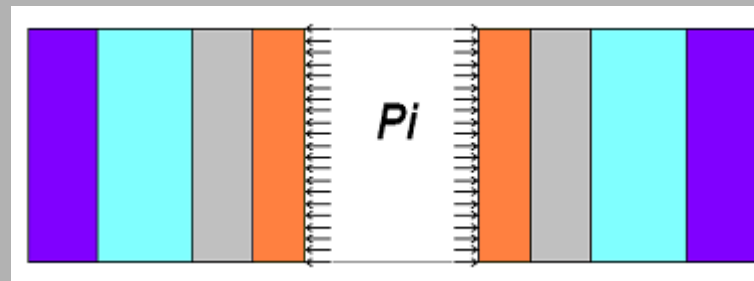


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*Die Design using a simplified approach*

*Principle*



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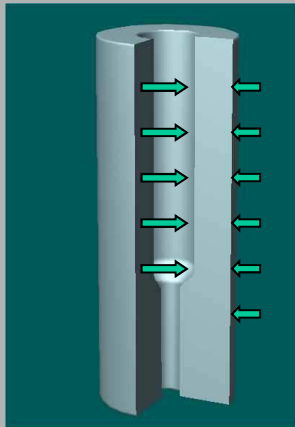


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*Die Design using a simplified approach*

*Principle*



Simplified Methode

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

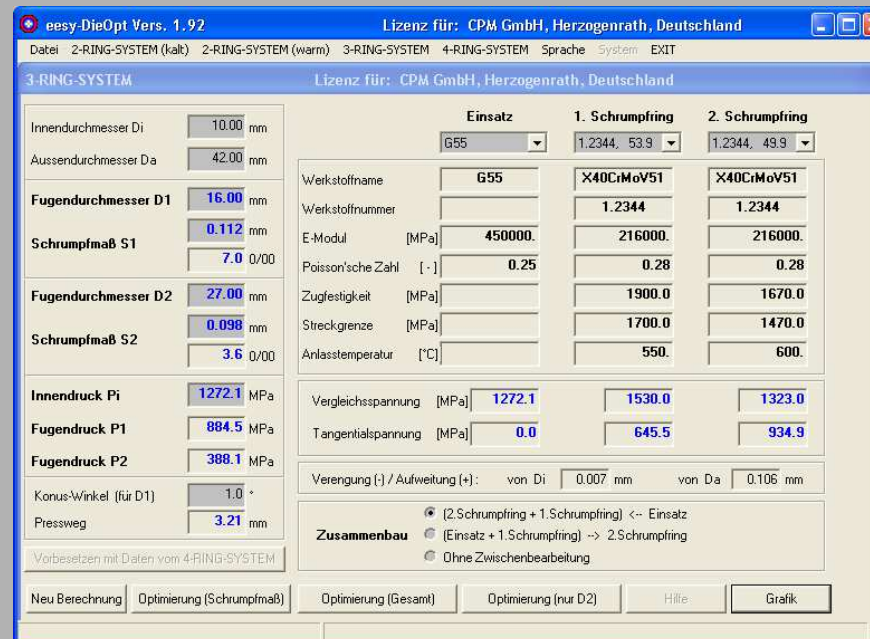
$P_i$  – inner pressure,  $d_i$  – inner diameter

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

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## Die Design using a simplified approach

*Application*



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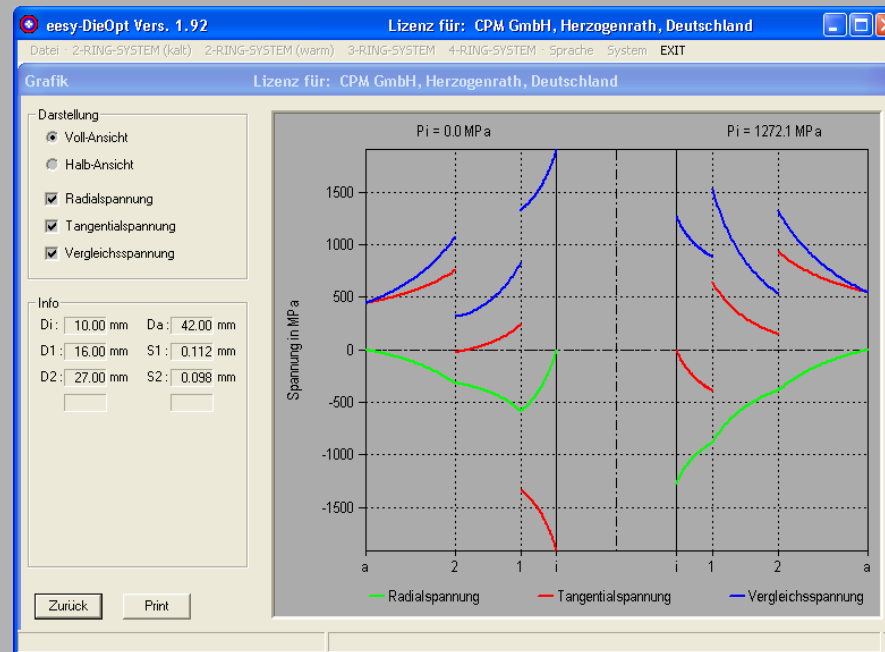
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# Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

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## *Die Design using a simplified approach*

### *Application*



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*Using FEM and Die Design Software together*

Tool analysis (insert) by FEM

Pre – stressing system layout  
with analytical methode

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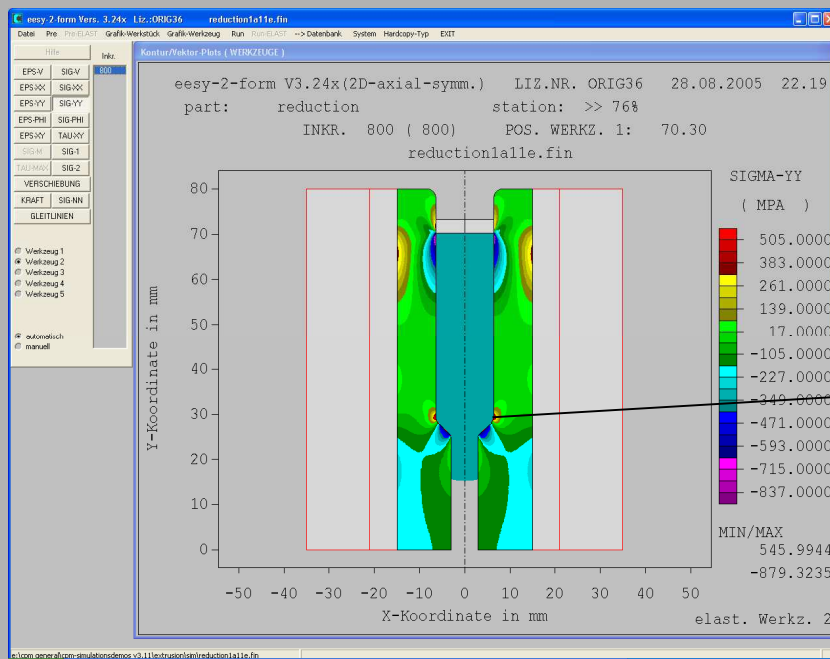


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**Engineering Approach to use a Hybrid Simulation System for Process and Tool Design**  
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*Using FEM and Die Design Software together*

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



Splitting of the die  
due to high axial  
stresses

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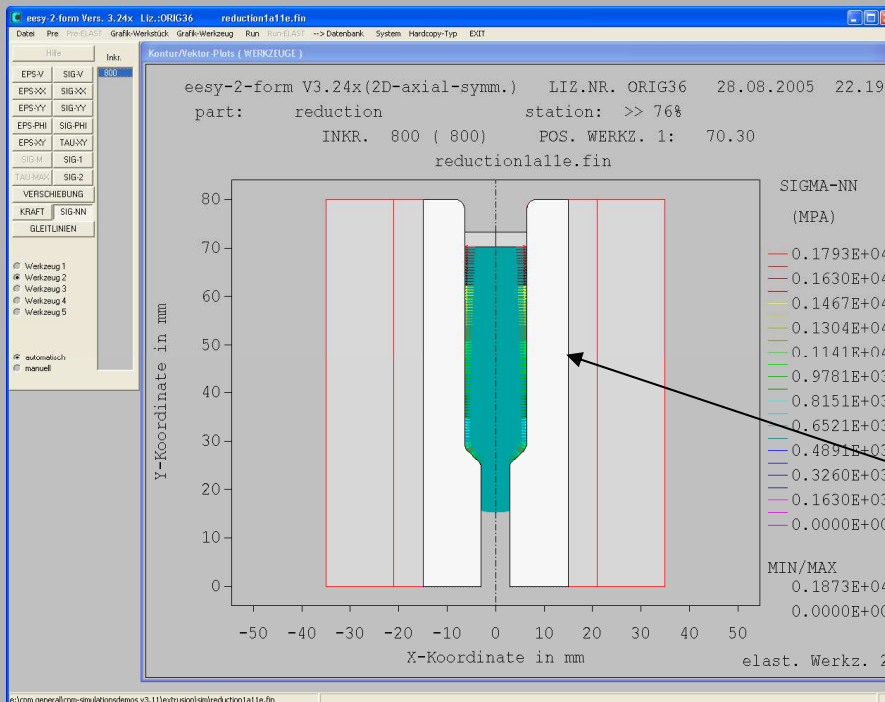
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*Using FEM and Die Design Software together*



Tool design

Die insert without pre-stressing

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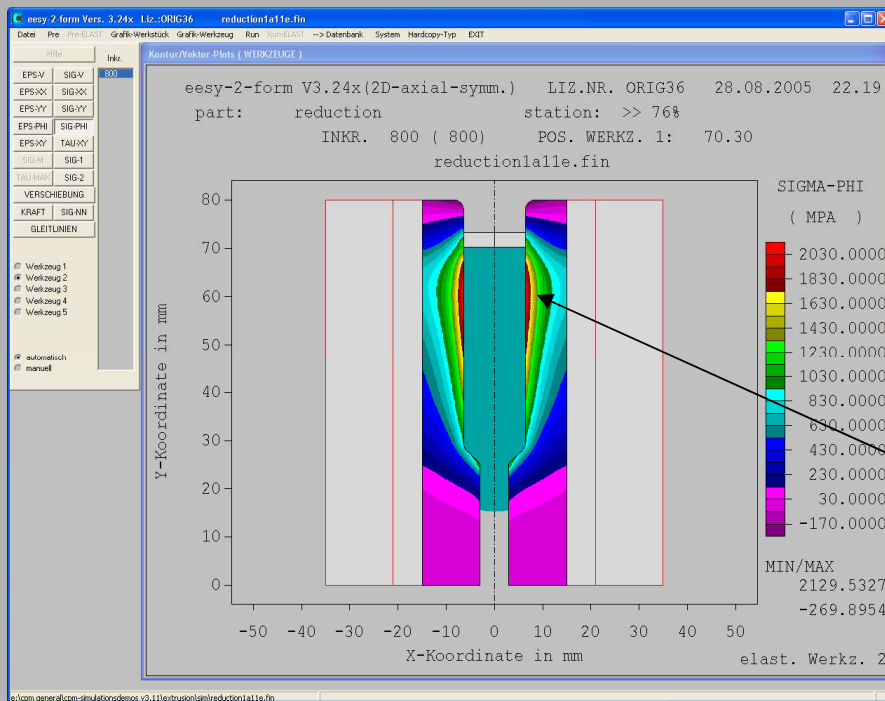


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# Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

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*Using FEM and Die Design Software together*



Tool design

Positive stress in the die without pre-stressing

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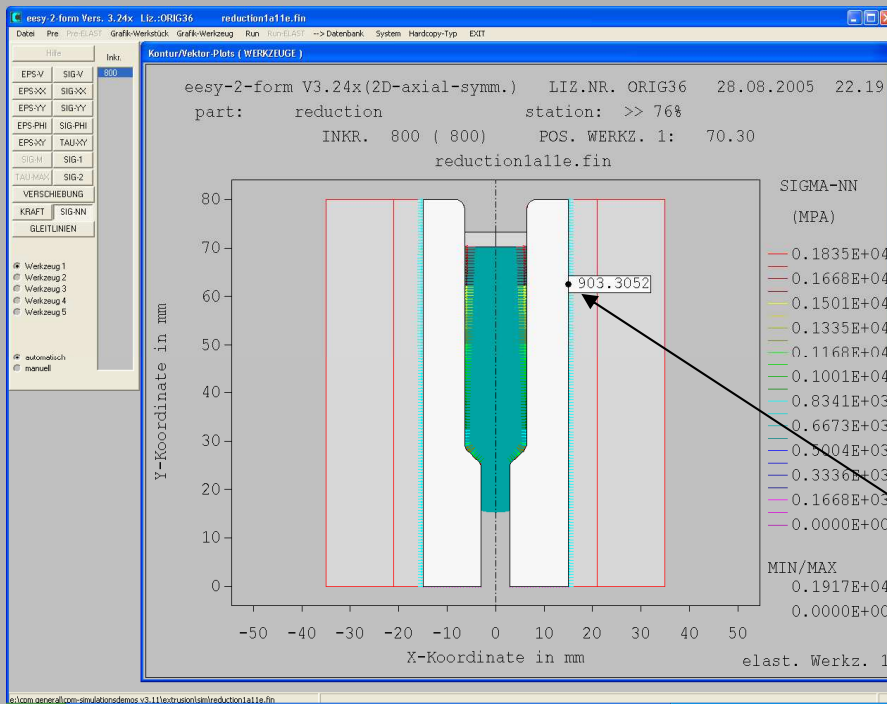


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# Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

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*Using FEM and Die Design Software together*



Tool design

Die with pre-stressing (900 MPa)

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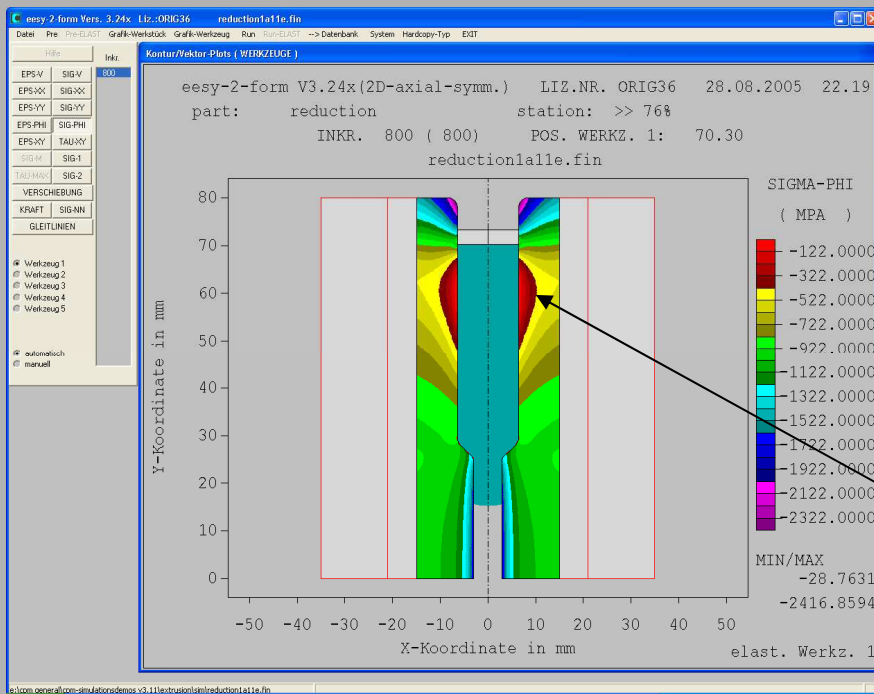


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# Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

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*Using FEM and Die Design Software together*



Tool design

Pressure in the die  
with pre-stressing

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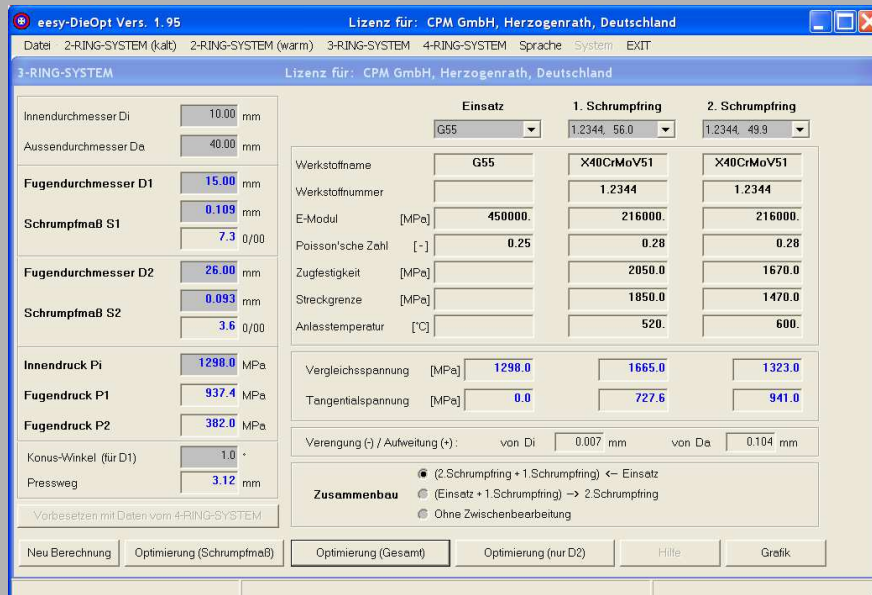


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*Using FEM and Die Design Software together*



Design of a  
multi-ring pre-  
stressing-system

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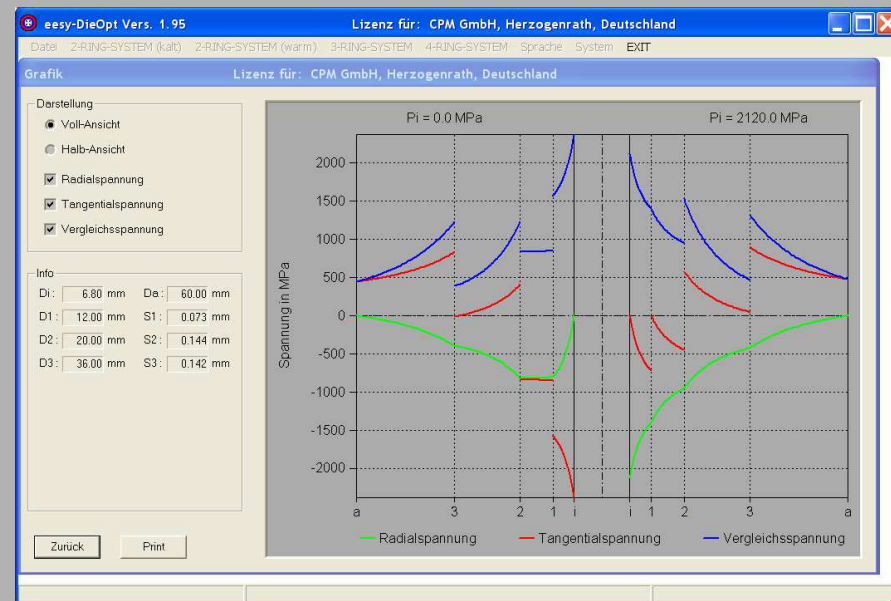
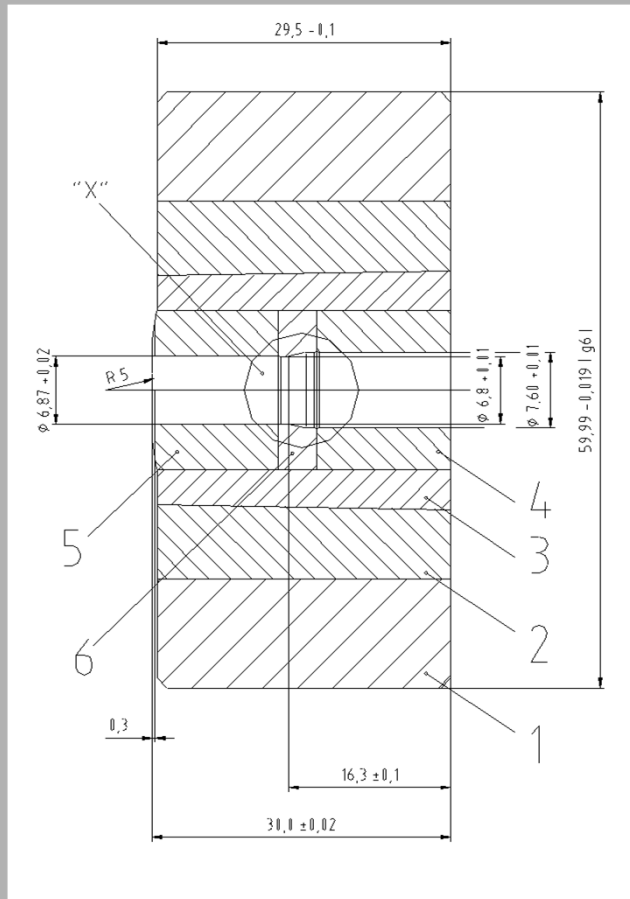
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# Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

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*Using FEM and Die Design Software together*

- Even complex design could be realized



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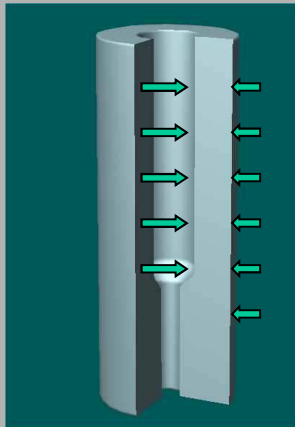
## Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

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### *New Approach - Hybrid System*

*Using FEM with integrated Die Design Software*

### *Principle*



Simplified methode for die design

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

$P_i$  – inner pressure,  $d_i$  – inner diameter

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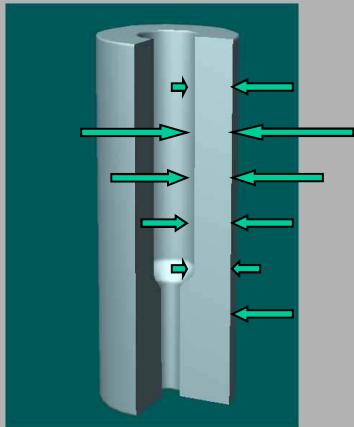
## Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

*XXVI SENAFOR, X CONFERENCIA INTERNACIONAL DE FORJAMENTO, POA, Brazil*

### *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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*New Approach - Hybrid System*  
*Using FEM with integrated Die Design Software*

*Principle*

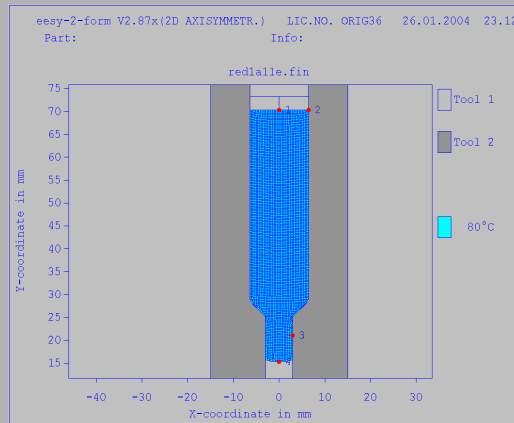
**The new method with integrated die design -**

- 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**

**Engineering Approach to use a Hybrid Simulation System for Process and Tool Design**  
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*New Approach - Hybrid System*  
*Using FEM with integrated Die Design Software*

*Example of application*



The same example as before will be used to show the advantages of the new method

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

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### *New Approach - Hybrid System*

*Using FEM with integrated Die Design Software*

### **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

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

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## *New Approach - Hybrid System* *Using FEM with integrated Die Design Software*

### *Calculation of Die Layout*

The screenshot shows the 'esy-DieOpt Vers. 1.92' software interface. The main window is titled '3-RING-SYSTEM' and contains various input fields and a table of material properties.

	Einsatz	1. Schrupfring	2. Schrupfring
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]	1621.9	1757.5	1396.5
Tangentialspannung [MPa]	0.0	695.4	961.7

Additional parameters shown in the interface include:

- Innendurchmesser Di: 12.80 mm
- Aussendurchmesser Da: 70.00 mm
- Fugendurchmesser D1: 23.00 mm
- Schrumpfmaß S1: 0.187 mm
- Schrumpfmaß S1: 8.1 0/00
- Fugendurchmesser D2: 43.00 mm
- Schrumpfmaß S2: 0.178 mm
- Schrumpfmaß S2: 4.1 0/00
- Innendruck Pi: 1621.9 MPa
- Fugendruck P1: 1062.1 MPa
- Fugendruck P2: 434.8 MPa
- Konus-Winkel (für D1): 1.0 °
- Pressweg: 5.36 mm

Buttons at the bottom include: 'Neu Berechnung', 'Optimierung (Schrumpfmaß)', 'Optimierung (Gesamt)', 'Optimierung (nur D2)', 'Hilfe', and 'Grafik'.

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*New Approach - Hybrid System*  
*Using FEM with integrated Die Design Software*

*Transfer of the  
calculated data  
into the FEM Code*

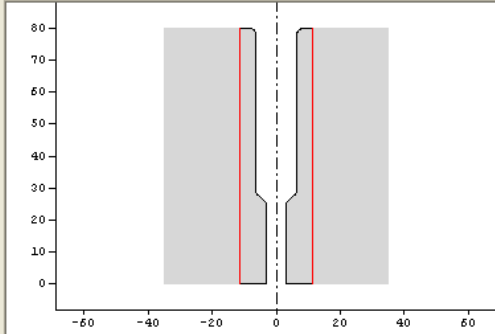
**Werkzeug-Vorspannung**

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 S1	0.190 mm	Schrumpfmass S2	0.180 mm	Schrumpfmass S3	

Material:

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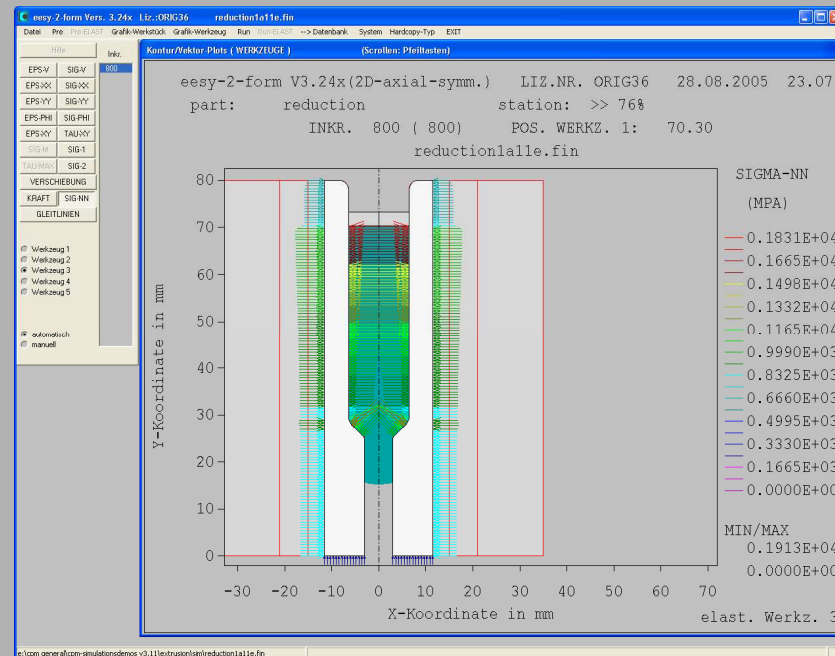
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# Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

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## New Approach - Hybrid System Using FEM with integrated Die Design Software

The pre-stress on the insert shows a distribution due to the non homogeneous pre-stress reaction to the inner load distribution



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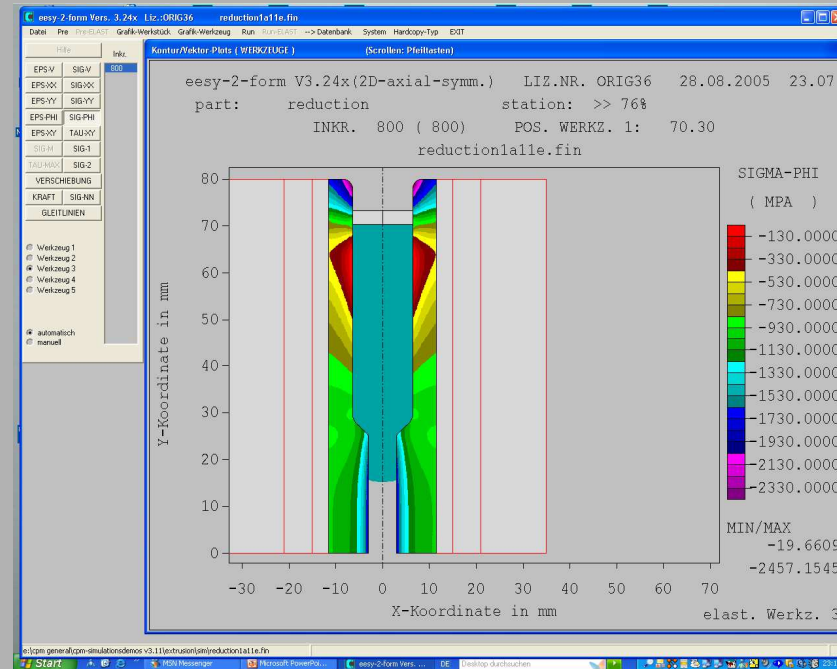
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# Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

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## New Approach - Hybrid System Using FEM with integrated Die Design Software

The stress distribution  
in the insert is  
different, too



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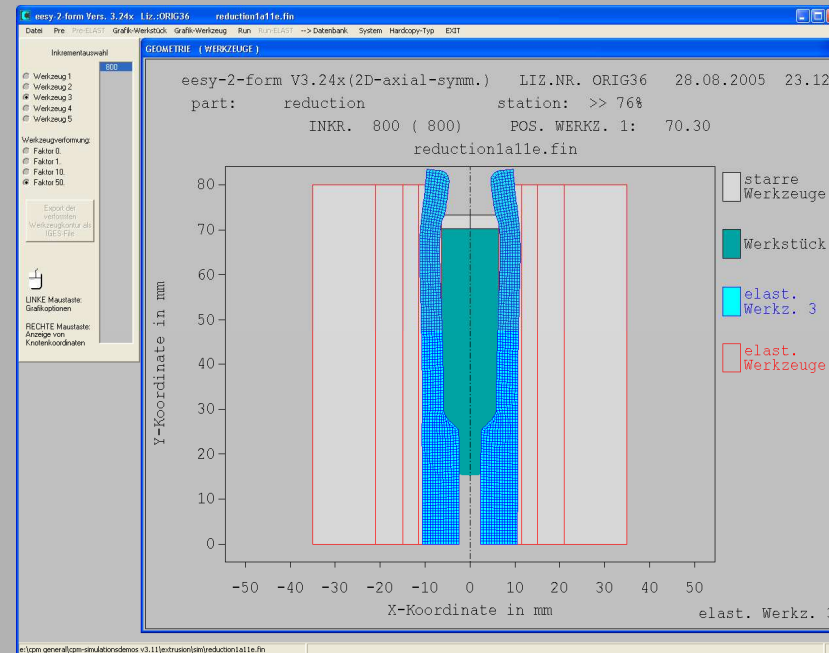


# Engineering Approach to use a Hybrid Simulation System for Process and Tool Design

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## New Approach - Hybrid System Using FEM with integrated Die Design Software

Magnified distortion  
in the insert



19th of October 2006



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

*XXVI SENAFOR, X CONFERENCIA INTERNACIONAL DE FORJAMENTO, POA, Brazil*

### *New Approach - Hybrid System*

*Using FEM with integrated Die Design Software*

### *Conclusions:*

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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