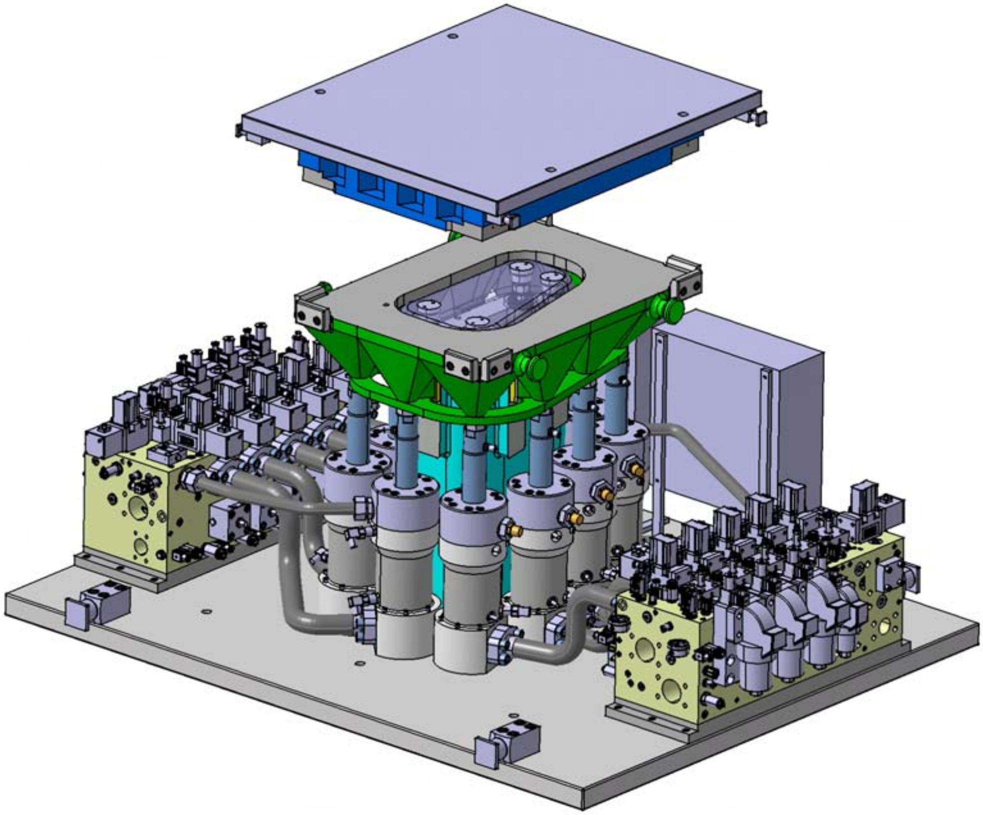
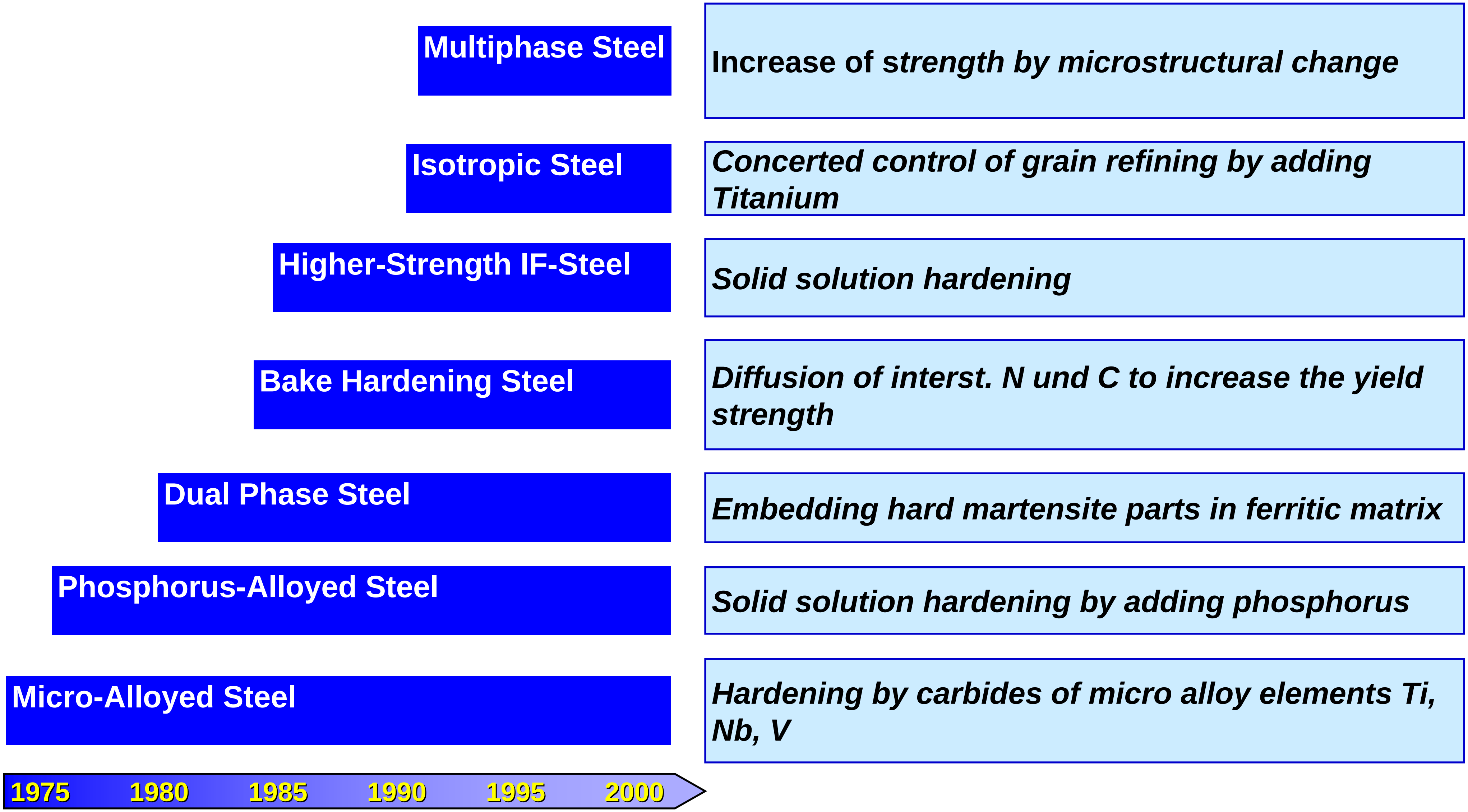
Institute for Metal Forming Technology
Prof. Dr.-Ing. Dr. h.c. Klaus Siegert

Tool and Die Design for Deep Drawing AHSS



Prof. Dr.-Ing. Dr. h.c. Klaus Siegert
Dipl.-Ing. M. Vulcan

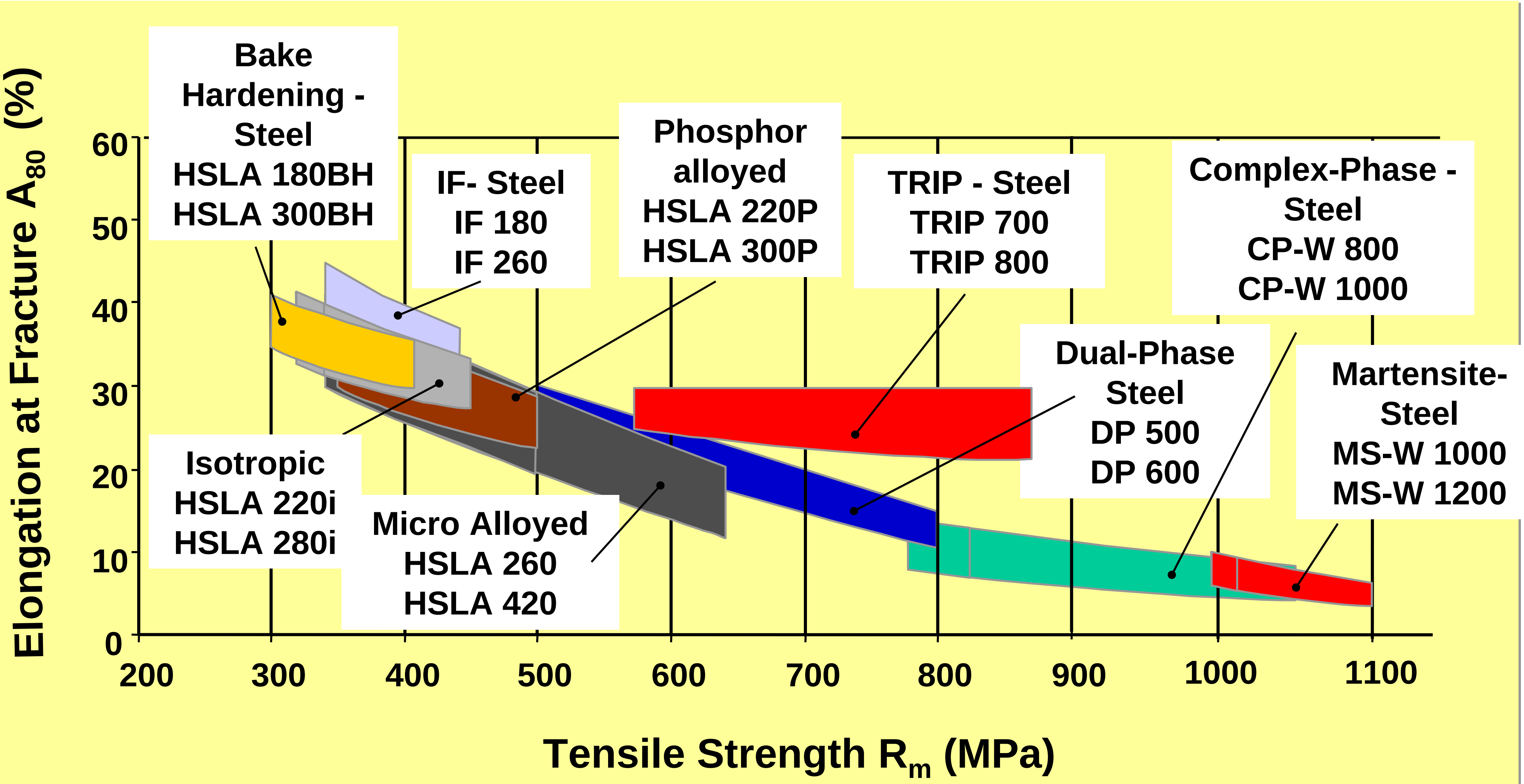
- **High Strength Steel Sheets**
- **Stretch Drawing of Flat Parts**
- **Controllable Draw Beads**
- **Cushion Systems and Die Design**
- **Summary**



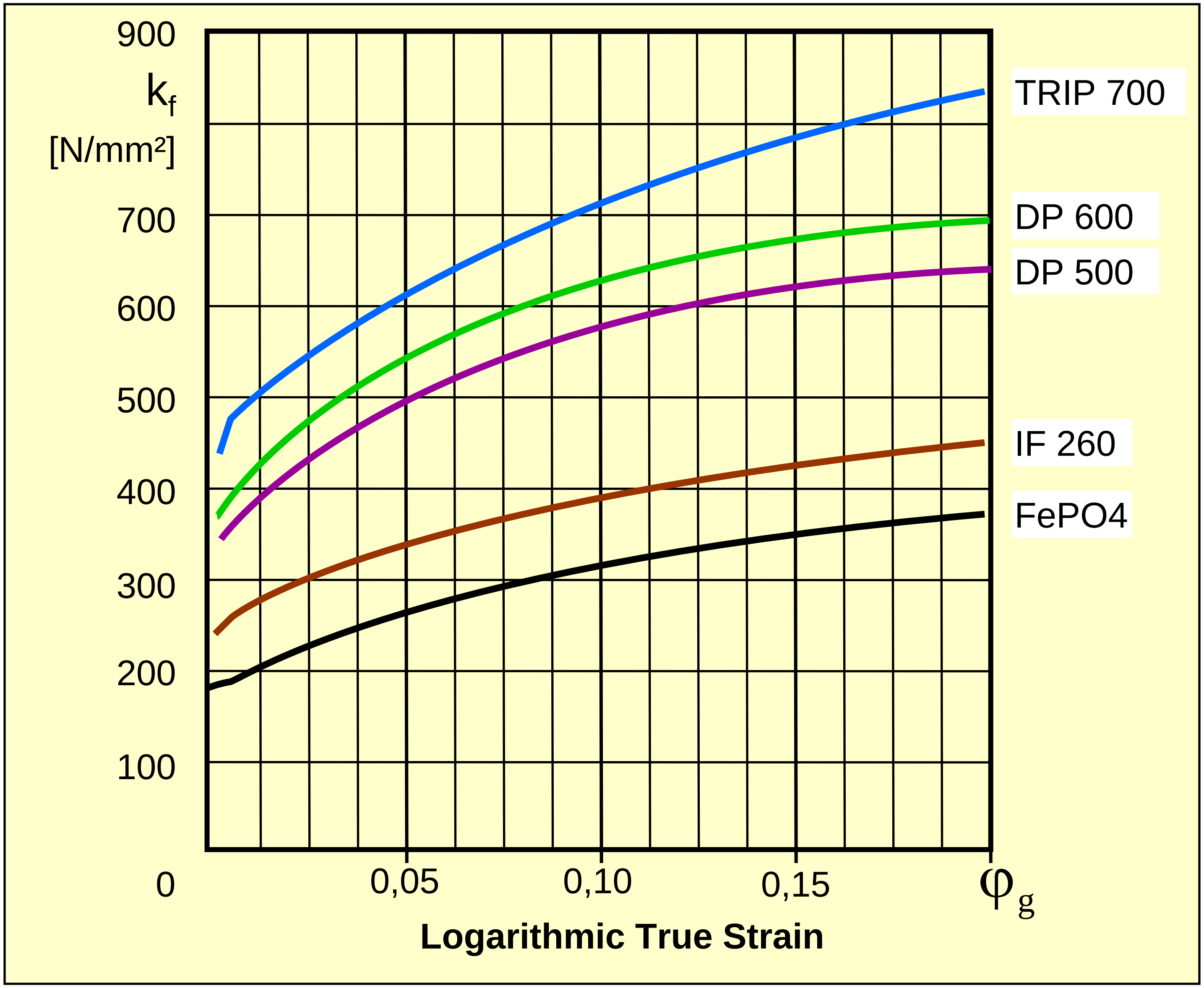
Multiphase Steel	Increase of *strength by microstructural change*
Isotropic Steel	*Concerted control of grain refining by adding Titanium*
Higher-Strength IF-Steel	*Solid solution hardening*
Bake Hardening Steel	*Diffusion of interst. N und C to increase the yield strength*
Dual Phase Steel	*Embedding hard martensite parts in ferritic matrix*
Phosphorus-Alloyed Steel	*Solid solution hardening by adding phosphorus*
Micro-Alloyed Steel	*Hardening by carbides of micro alloy elements Ti, Nb, V*

Source: Thyssen

Development of High Strength Steels



Comparison of Different Steel Grades



Source: IFU

Flow Curves of Actual Sheet Metals

	Yield Strength in MPa		UTS in MPa		Elong. at Fracture A_{80} in %	R-Value		
	min	max	min	max		0°	45°	90°
High Strength Bake-Hardening Steels								
HSLA 180 BH	180	240	300	380	32	$r_m = 1{,}9$		
HSLA 220 BH	220	280	320	400	30	$r_m = 1{,}5$		
HSLA 260 BH	260	320	360	440	28	$r_m = 1{,}4$		
HSLA 300 BH	300	360	400	480	26	$r_m = 1{,}3$		
High and Advanced High Strength Steels								
DP 600	381		574		23			0,9
DP 700	583		735		16			
DP 800	567		869		10			
TRIP 700			680	850	20-30			0,8
CP 800	793		903		14			
MS 1200	1150		1350		6			0,7

Source: Birzer

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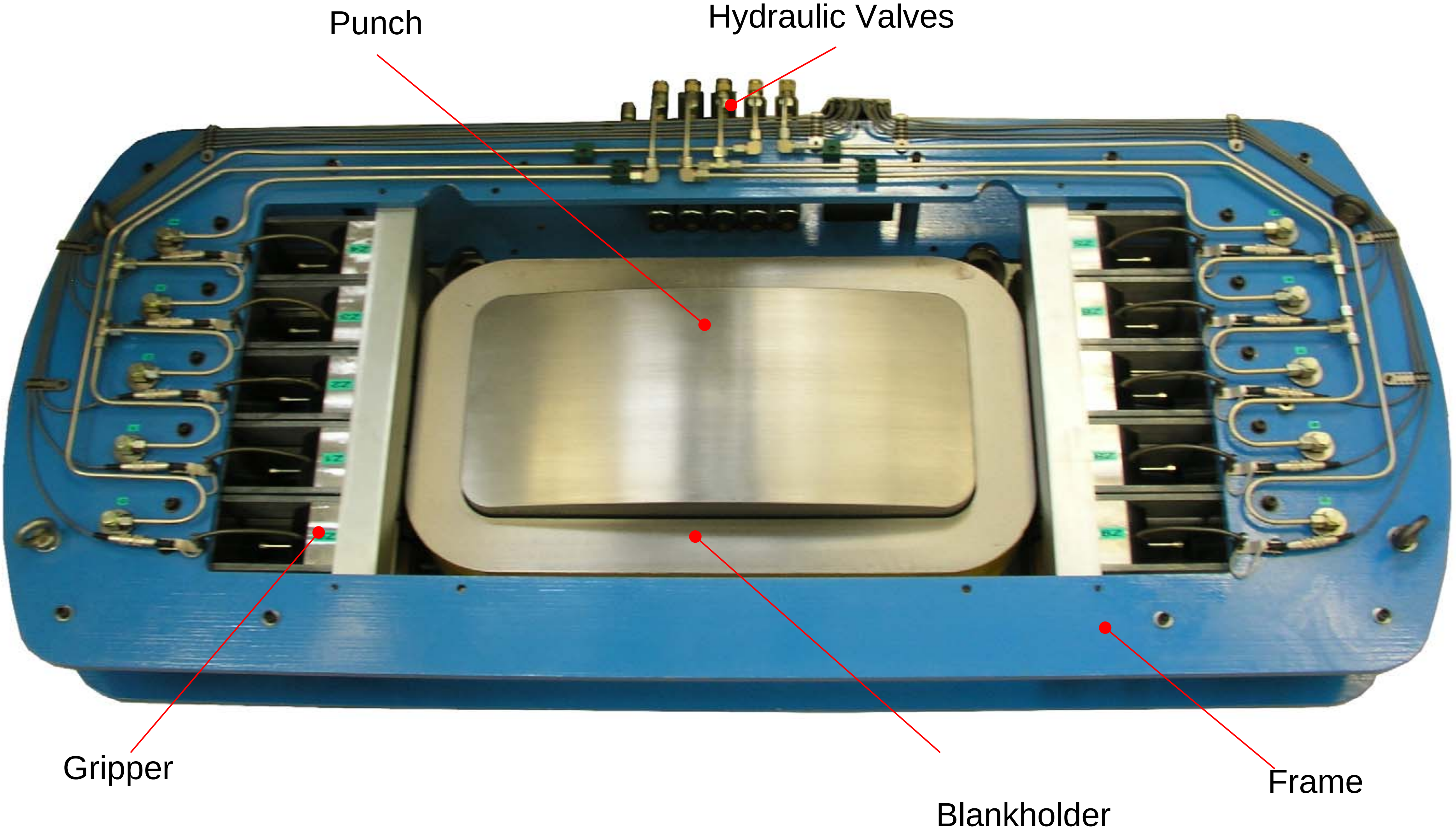
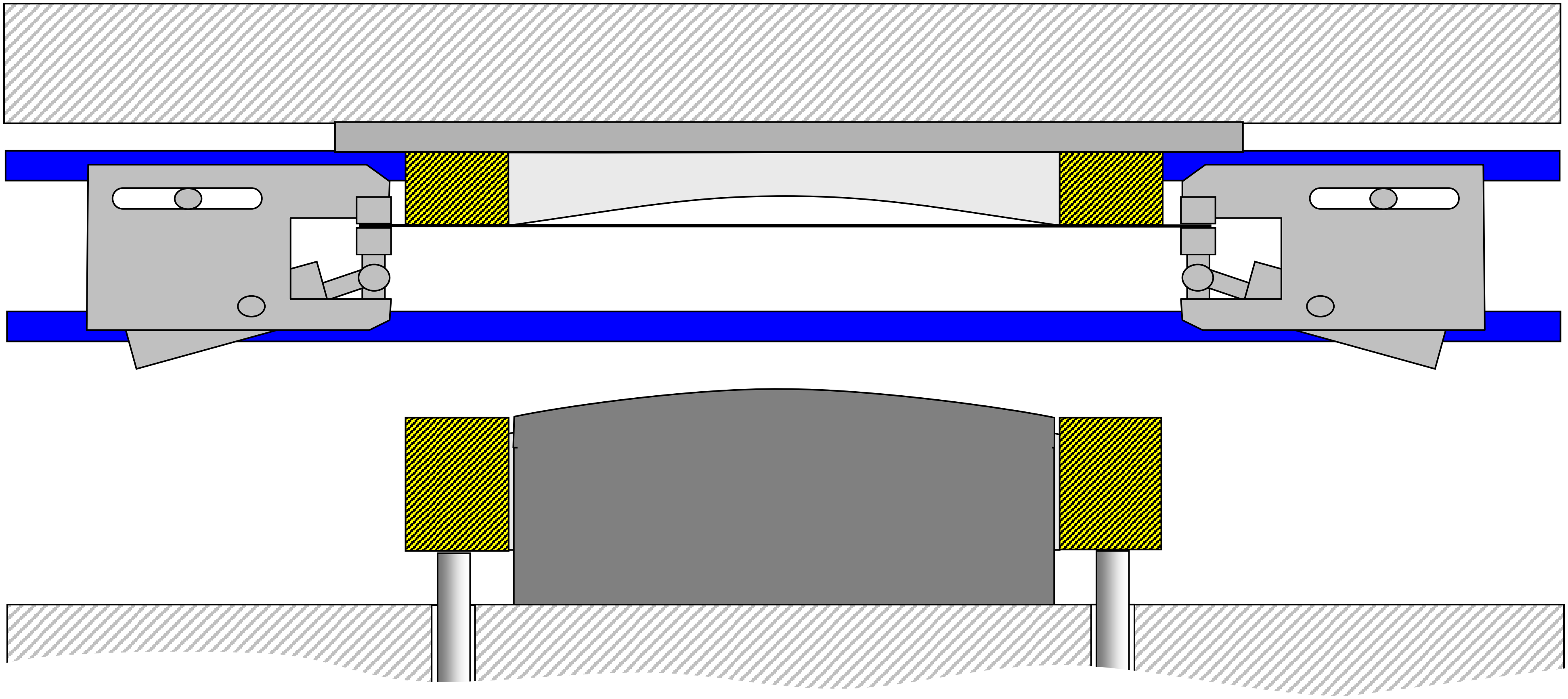


Source: T. Krockenberger, IFU

Test Equipment for Stretch Drawing followed by Deep Drawing

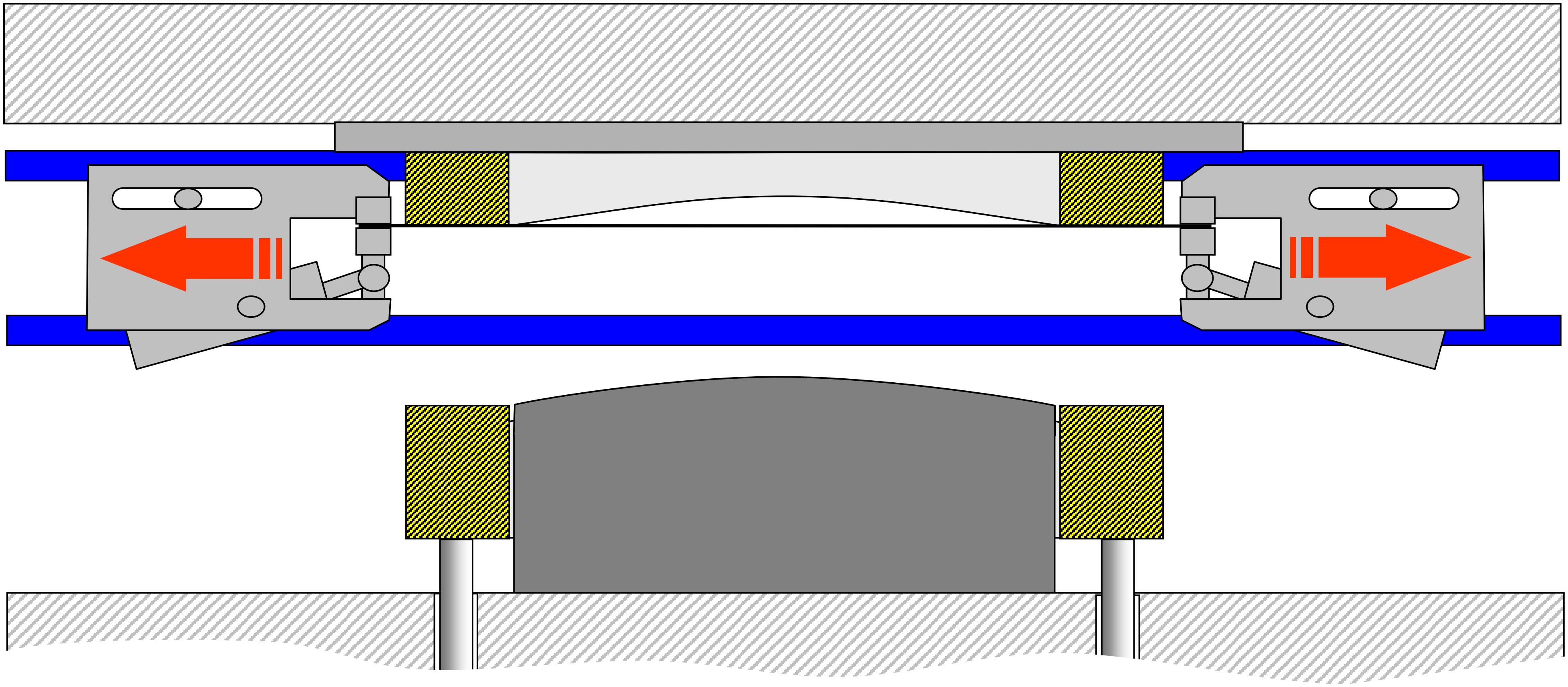
Source: T. Krockenberger, IFU

Test Equipment for Stretch Drawing followed by Deep Drawing, Installed in Single Acting Hydraulic Press at IFU



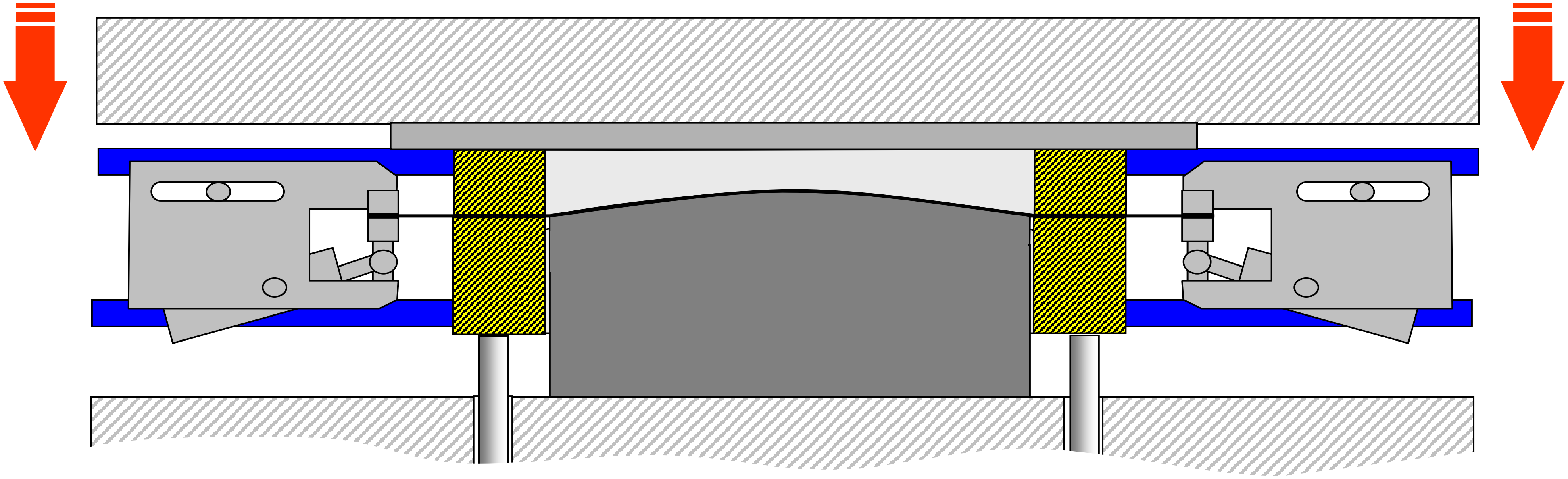
Source: D. Vlahovic, IFU

First Stage: Clamping the Sheet



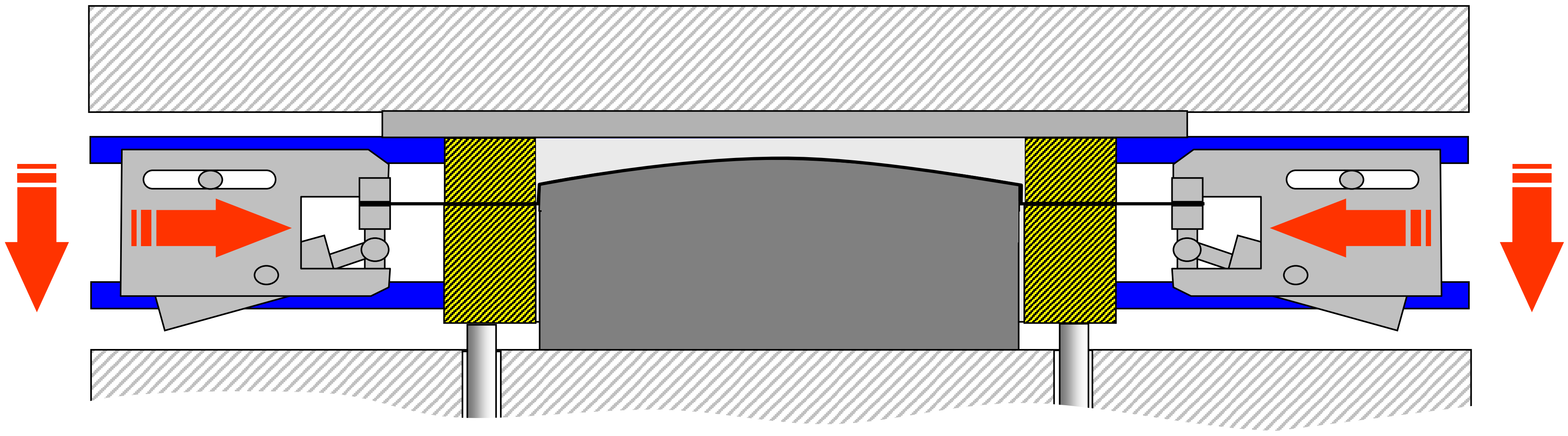
Source: D. Vlahovic, IFU

Second Stage: Predefined Stretching of the Sheet



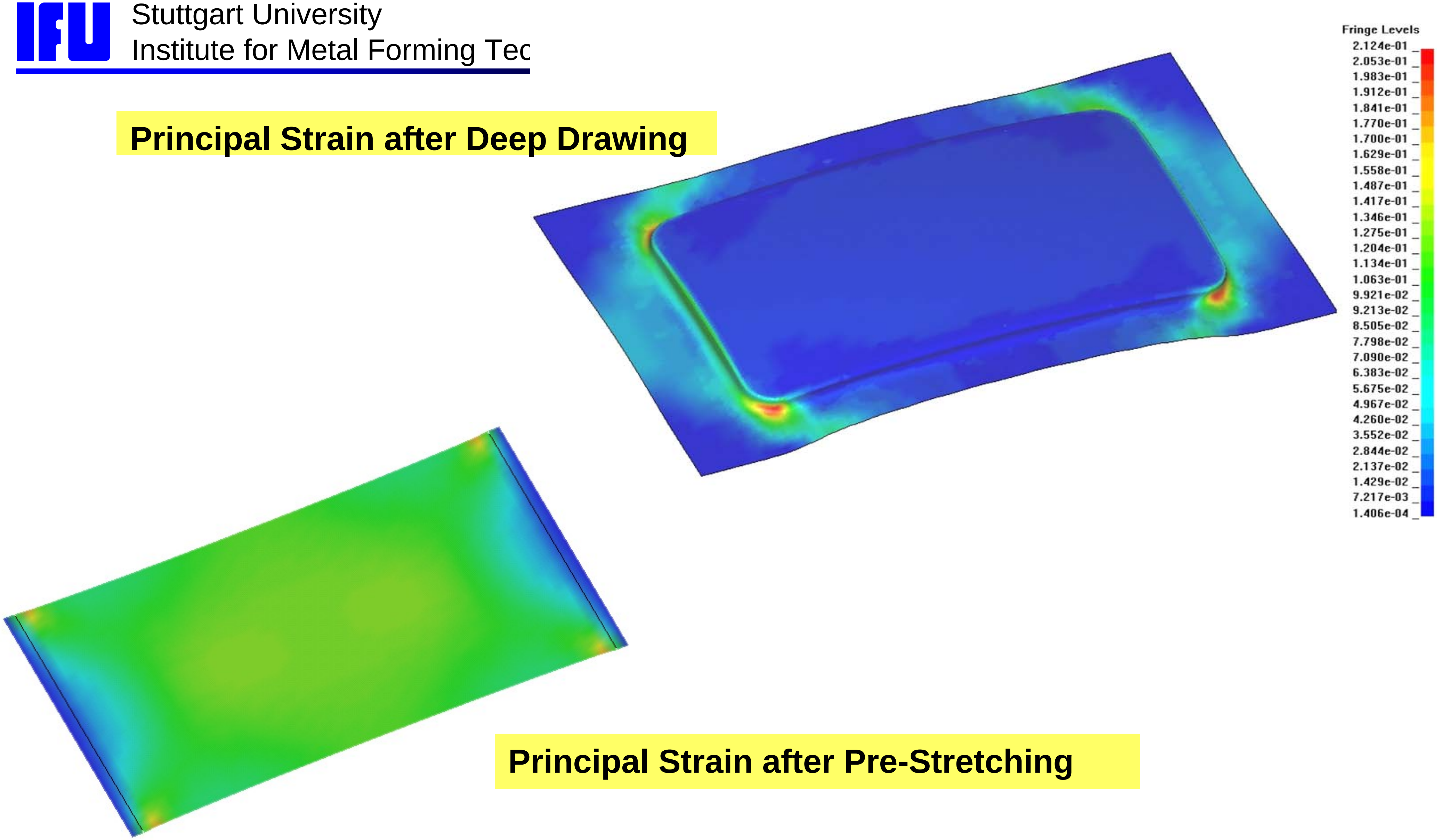
Source: D. Vlahovic, IFU

Third Stage: Tool Closing



Source: D. Vlahovic, IFU

Last Stage: Deep Drawing of the Sun Roof Panel



Principal Strain after Deep Drawing

Principal Strain after Pre-Stretching

Source: D. Vlahovic, IFU

Results FEM Process Simulation

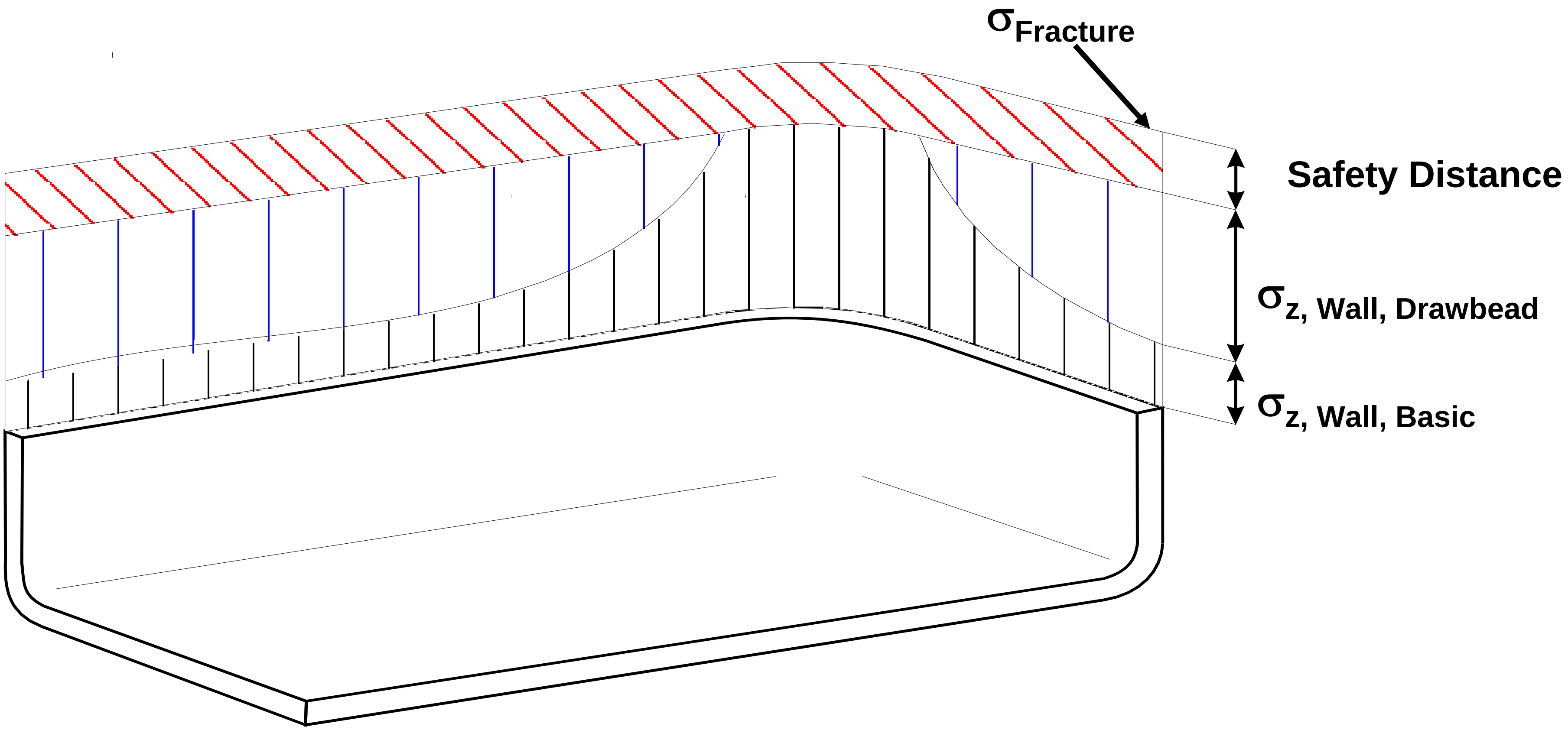
- High Strength Steel Sheets
- Stretch Drawing of Flat Parts
- **Controllable Draw Beads**
- Cushion Systems and Die Design
- Summary

Springback Reduction:

Increased Wall Stresses in the Straight Sides by Driving the Active Drawbeads Upwards.

Guideline: $\sigma_{Wall} < 0,8\ \sigma_{Fracture}$

→ Safety Factor



$\sigma_{Fracture}$

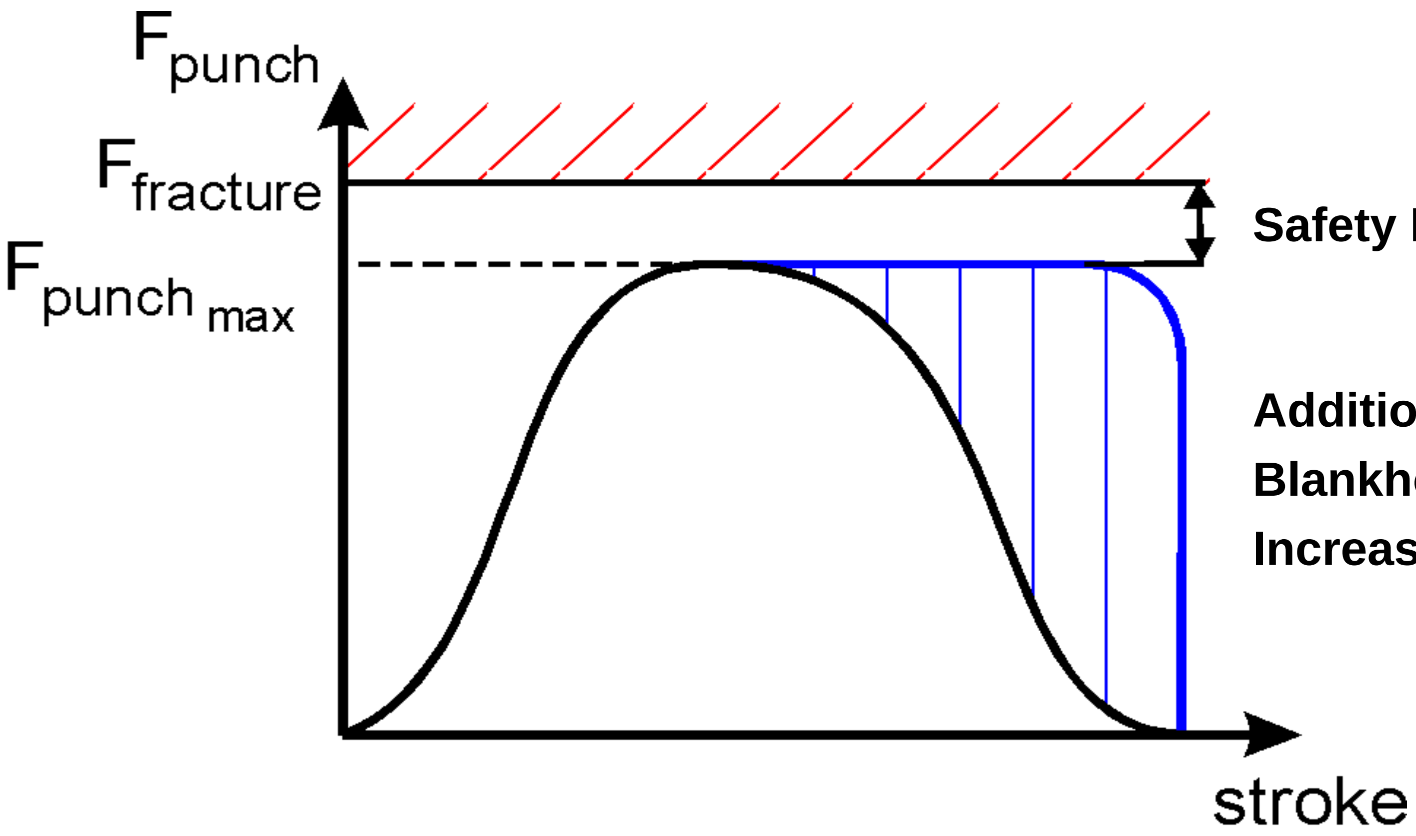
Safety Distance

$\sigma_{z,\ Wall,\ Drawbead}$

$\sigma_{z,\ Wall,\ Basic}$

Source: S. Beck, IFU

Desired Wall Stress Distribution



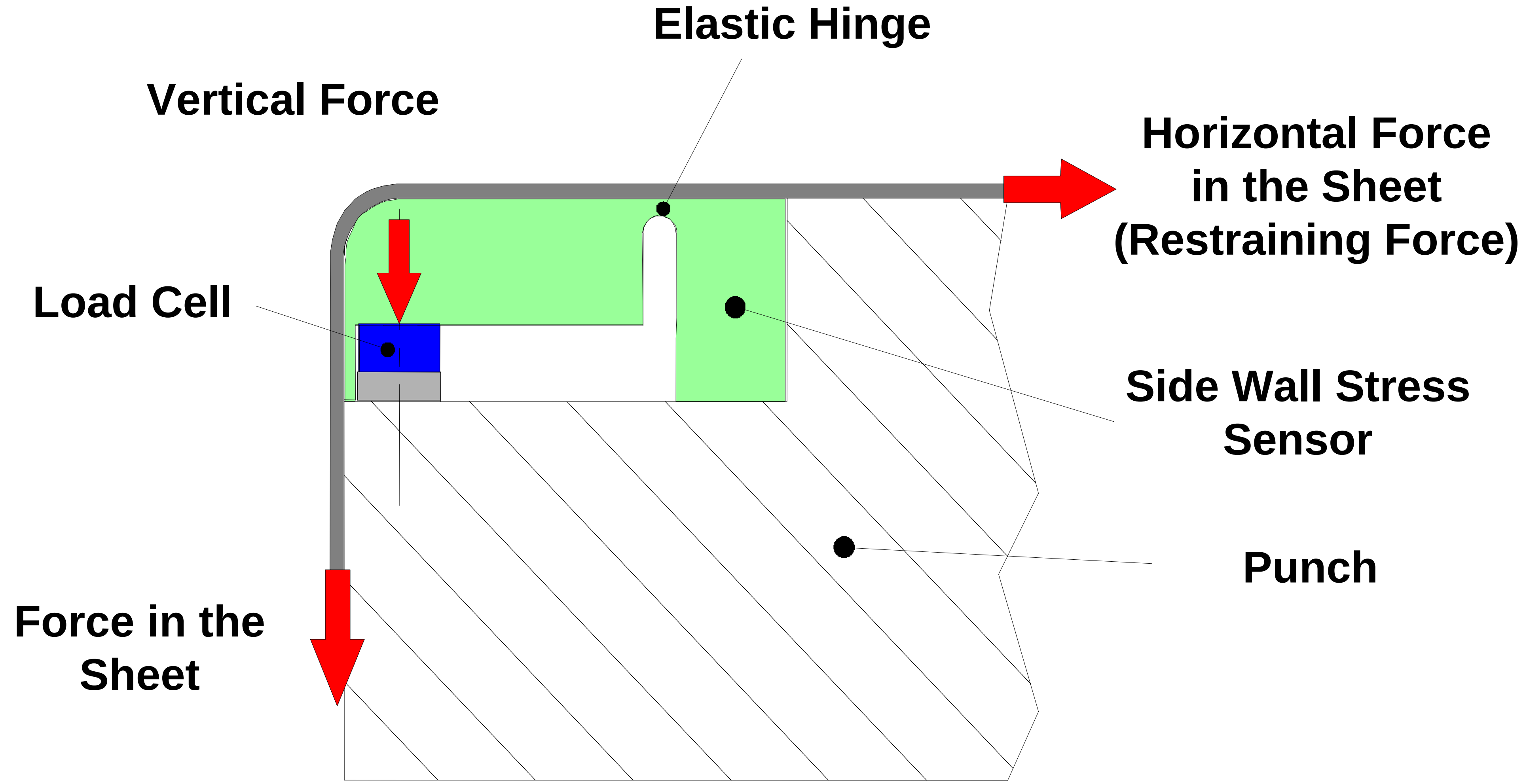
Safety Distance

Additional Force by Increased Blankholder Force and/or Increased Drawbead Height

Intention: Improved Wall Quality by Introducing Additional Forces

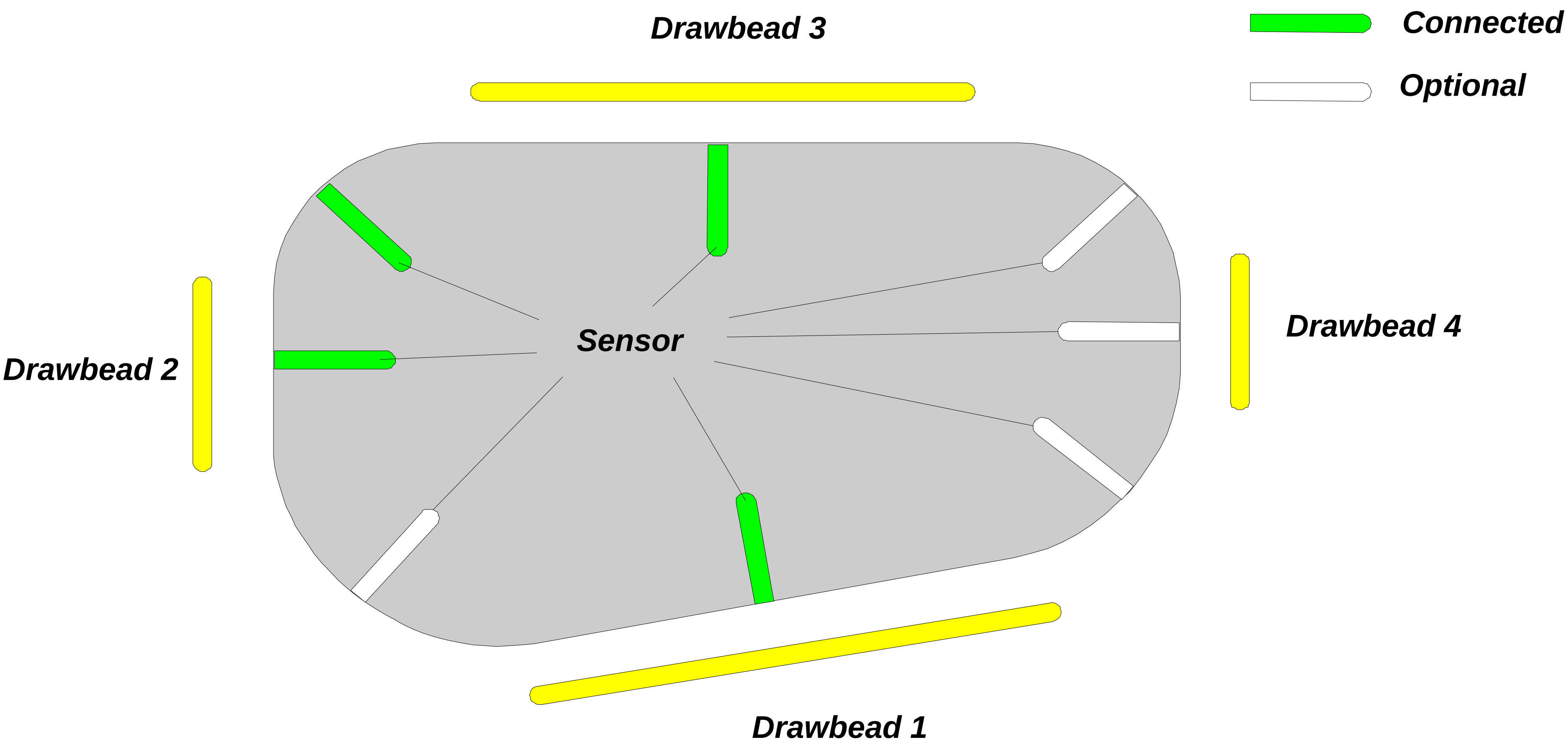
Source: S. Beck, IFU

Desired Punch Force Trajectory



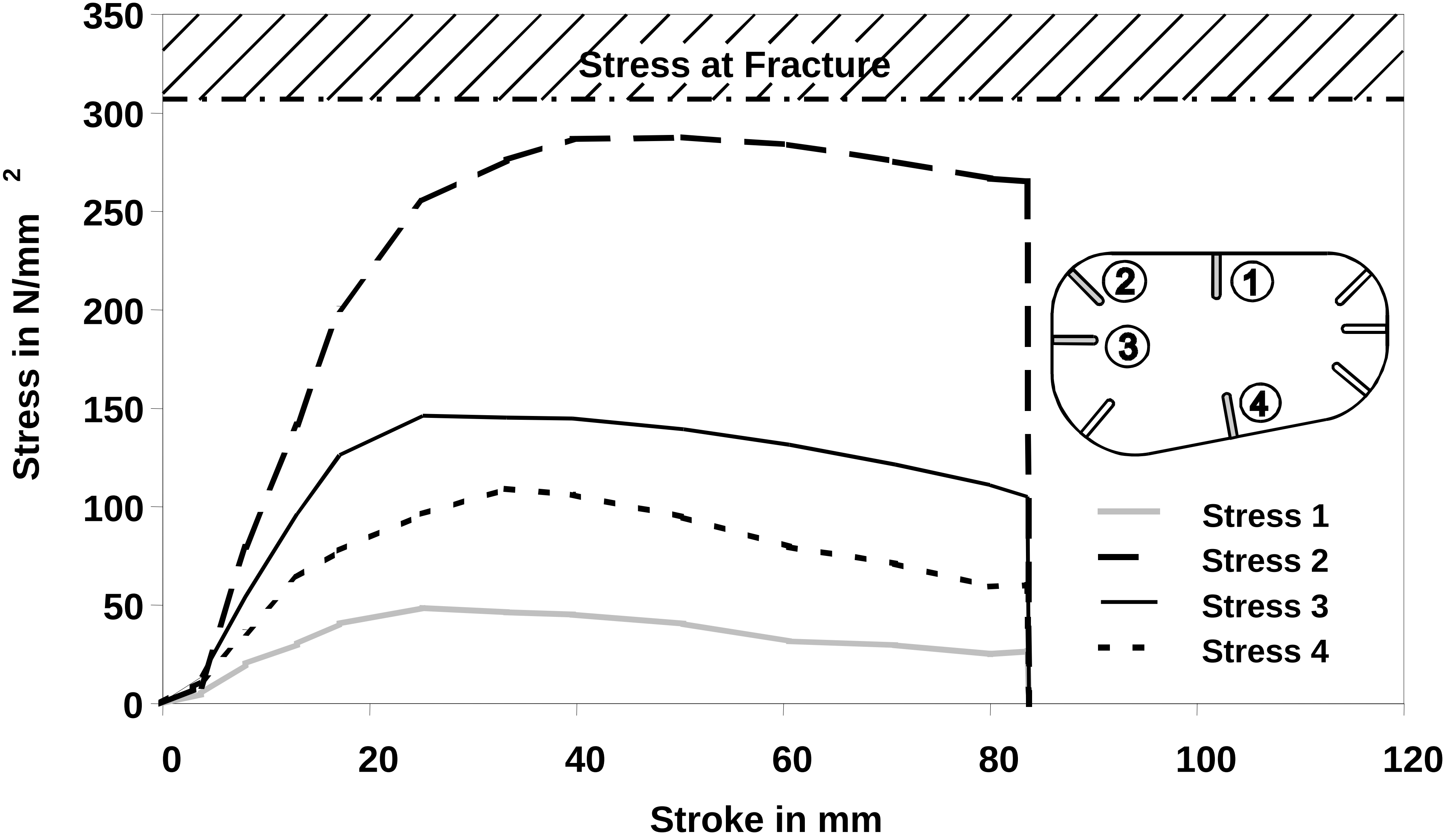
Source: S. Beck, IFU

Side Wall Stress Sensor



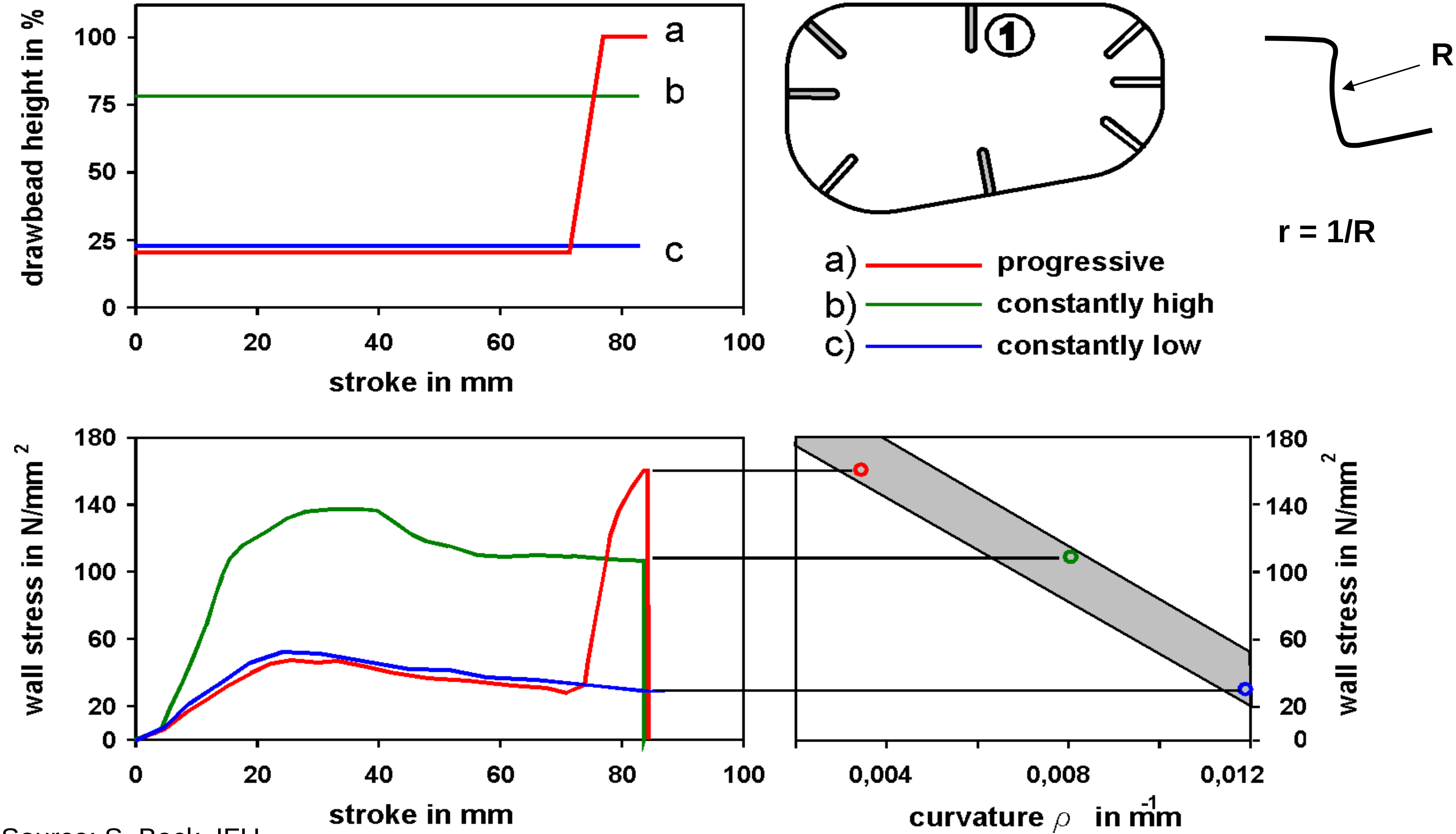
Source: S. Beck, IFU

Position of the Wall Stress Sensors and Position of the Drawbeads



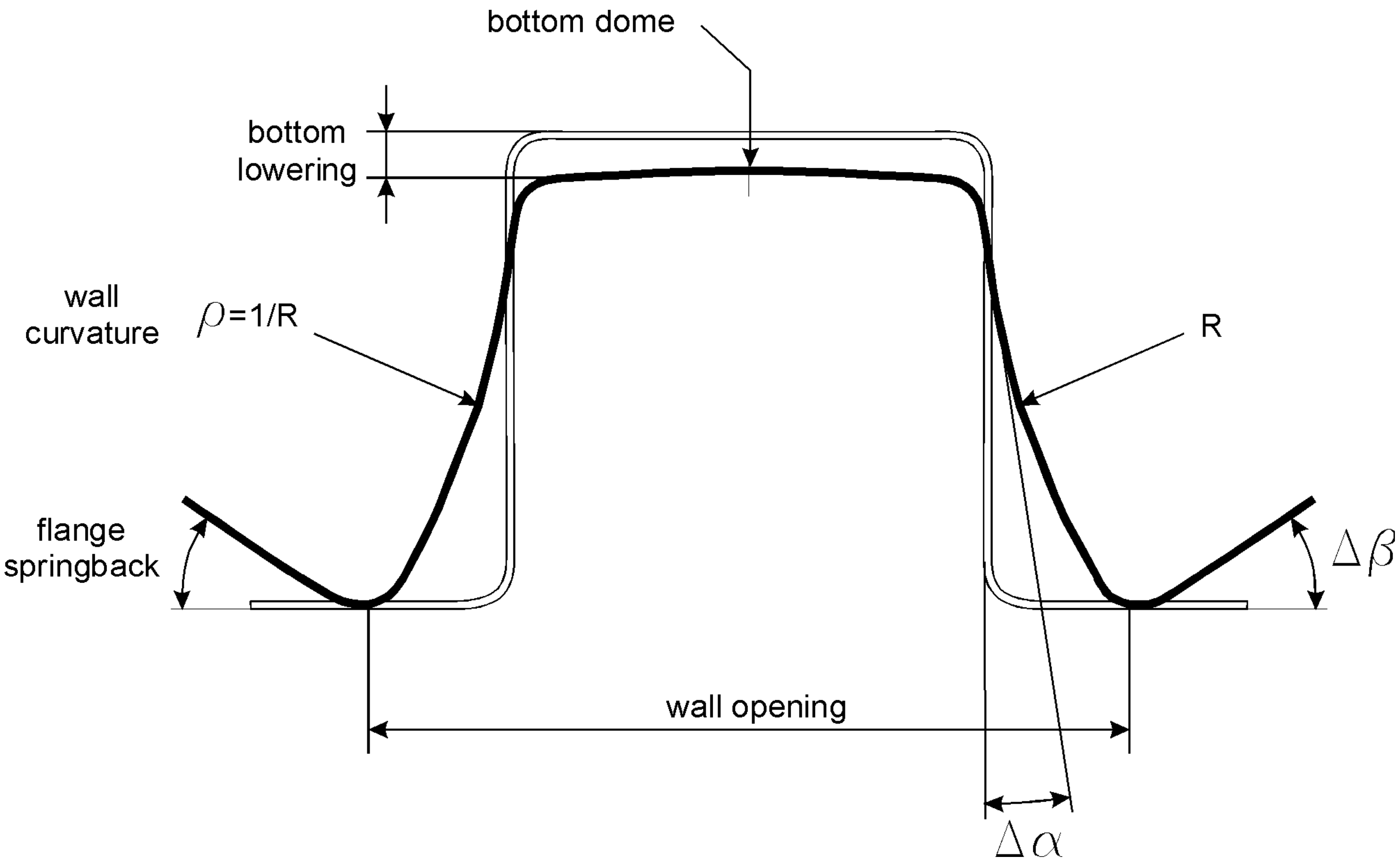
Quelle: S. Beck, IFU

Side Wall Stress vs. Stroke for Constant Draw Bead Heights



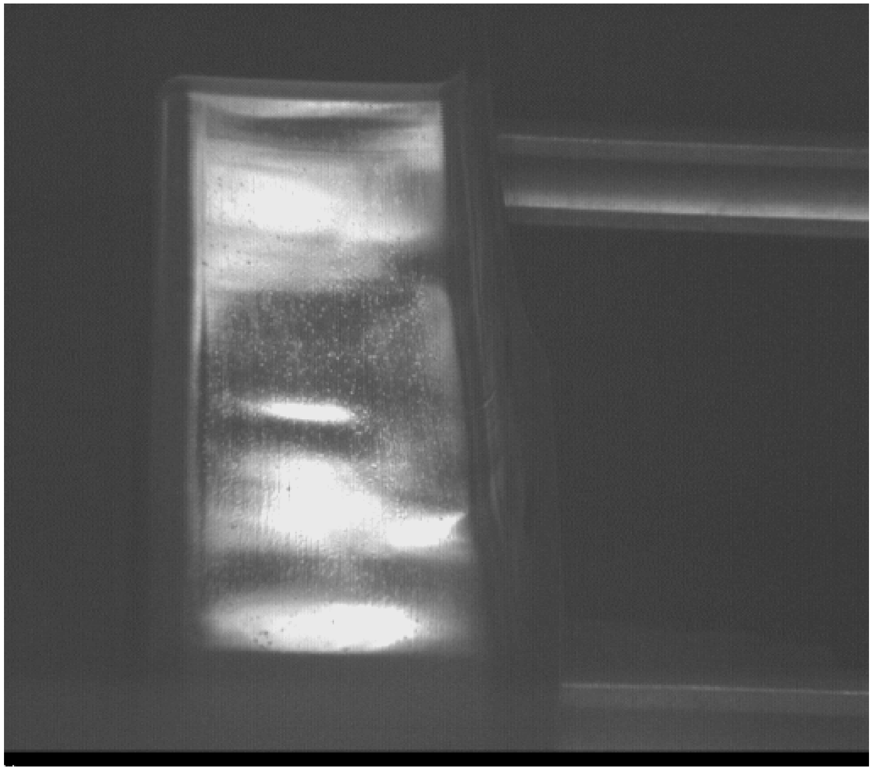
Source: S. Beck, IFU

Curvature of the Side Wall for Variable Draw Bead Heights vs. Stroke

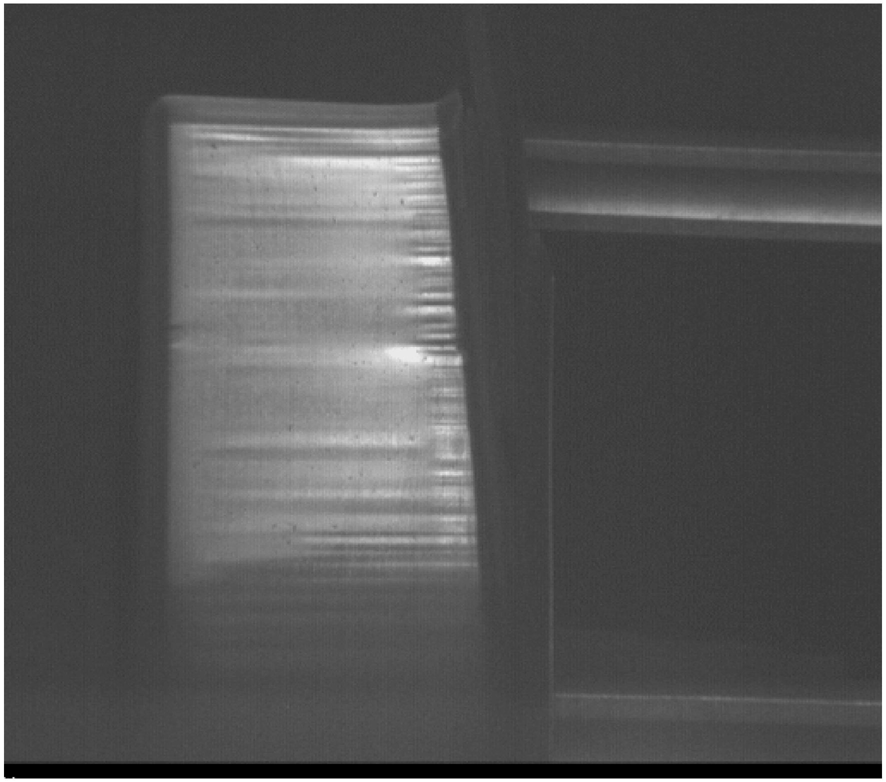


Source: M. Beth

Springback Phenomena when Drawing U-Profiles



Sidewall of the Part, drawn without Drawbeads



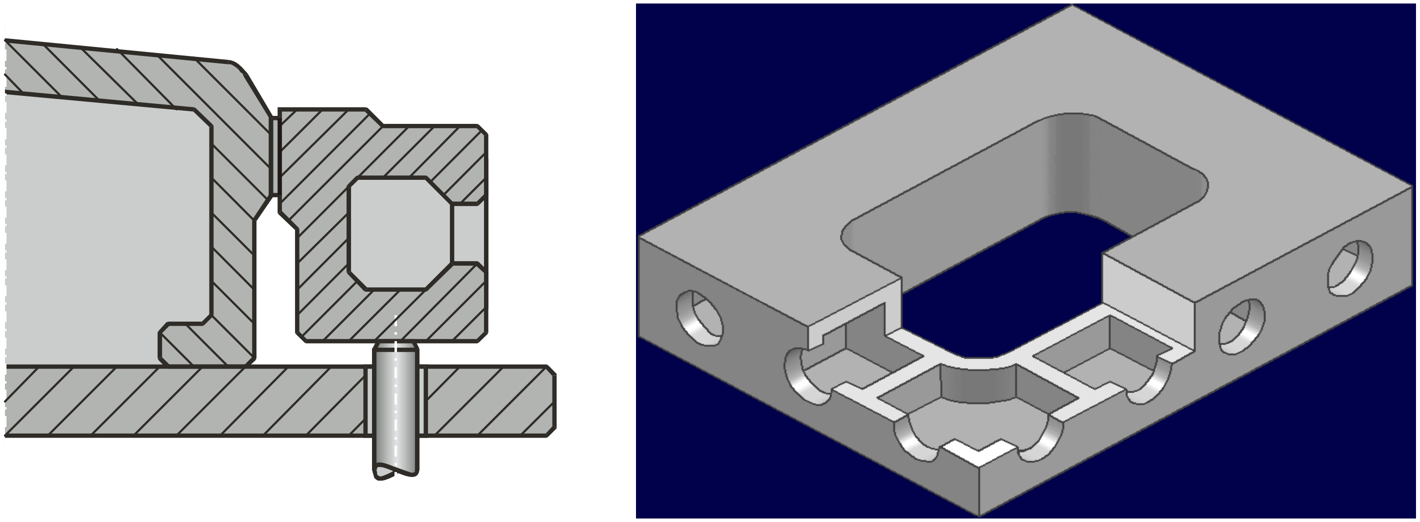
Sidewall of the Part, drawn with Controllable Drawbeads

Source: S. Beck, IFU

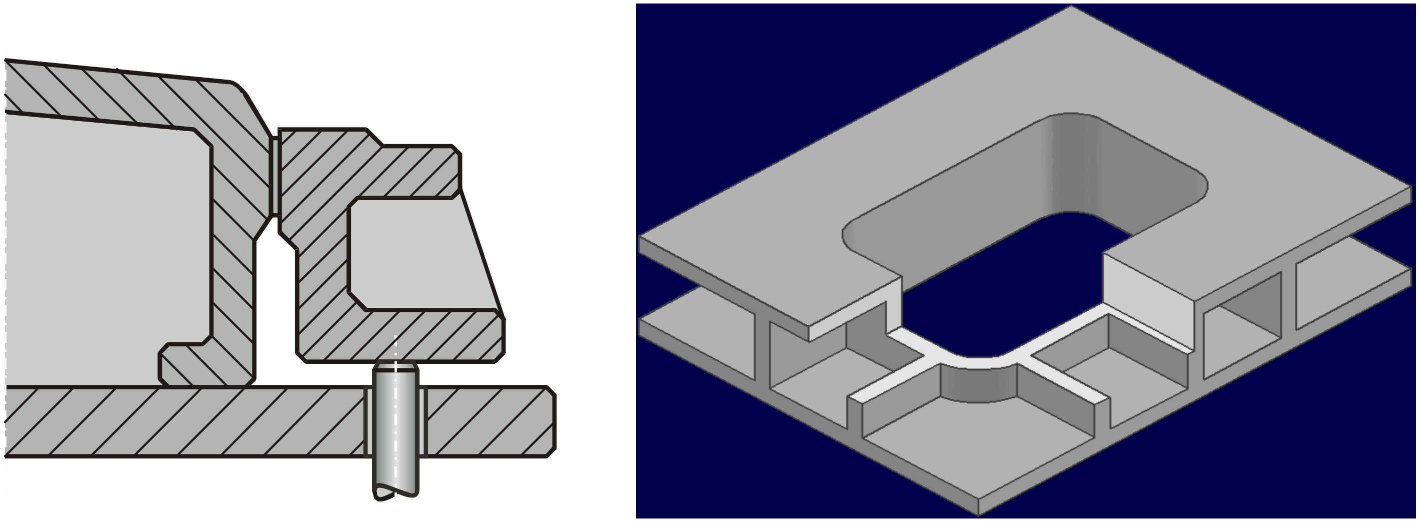
Surface Quality with and without Controllable Drawbeads (Measured with the System Diffracto)

- High Strength Steel Sheets
- Stretch Drawing of Flat Parts
- Controllable Draw Beads
- **Cushion Systems and Die Design**
- Summary

Box-Profile



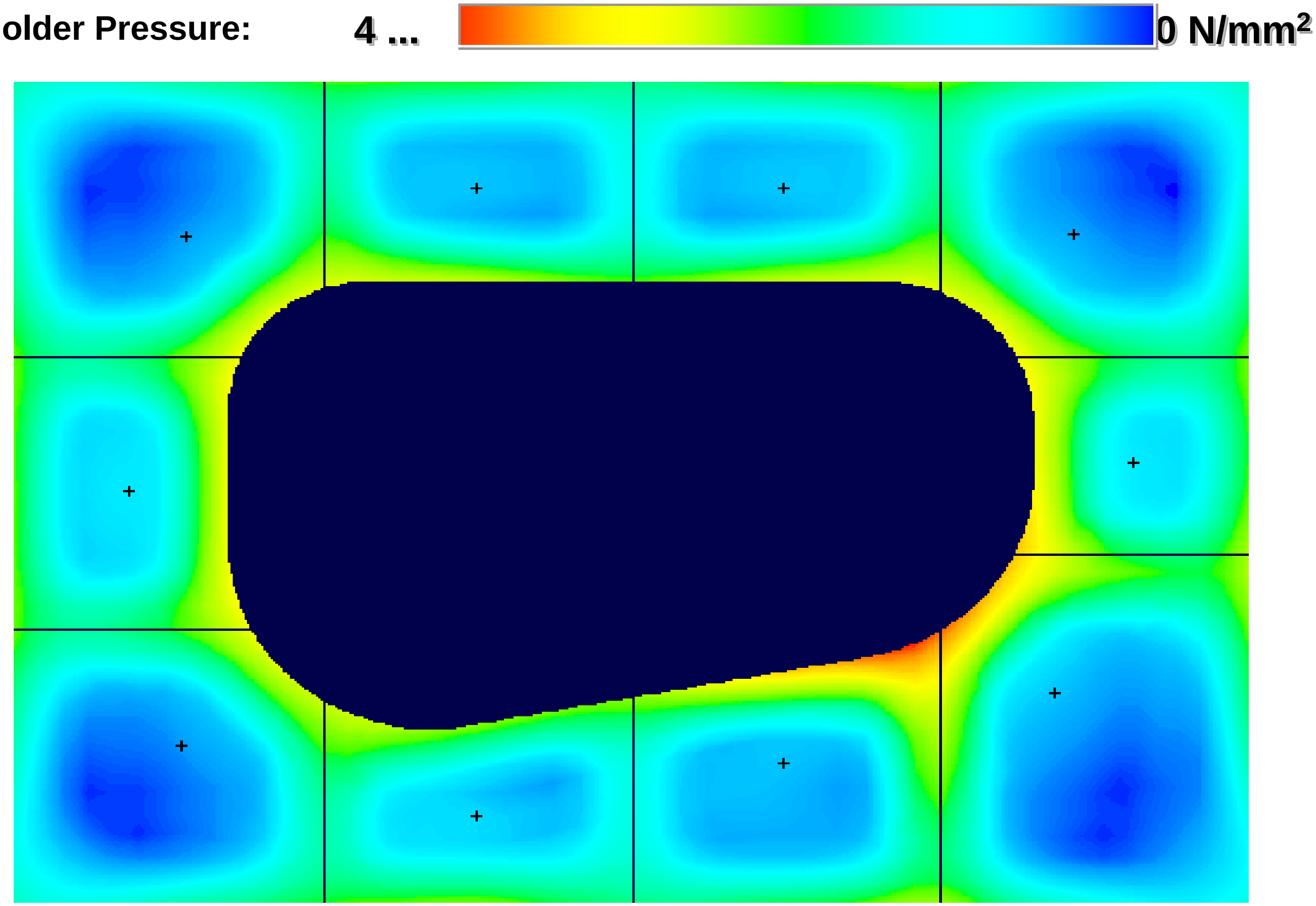
C-Profile



Source: M. Häussermann, IFU

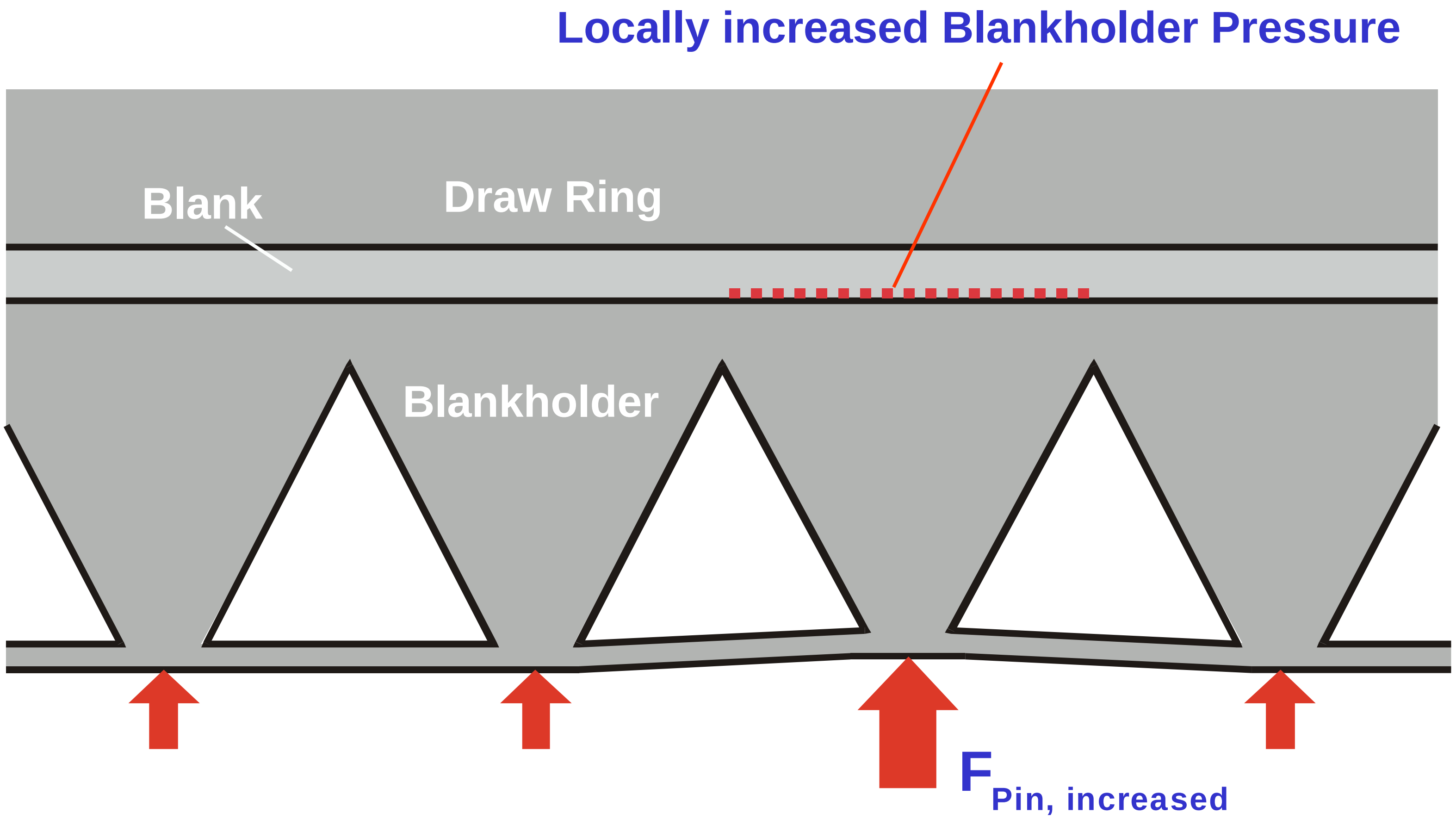
Design of Conventional Draw Dies

Blankholder Pressure: 4 ... 0 N/mm²



Source: M. Häussermann, IFU

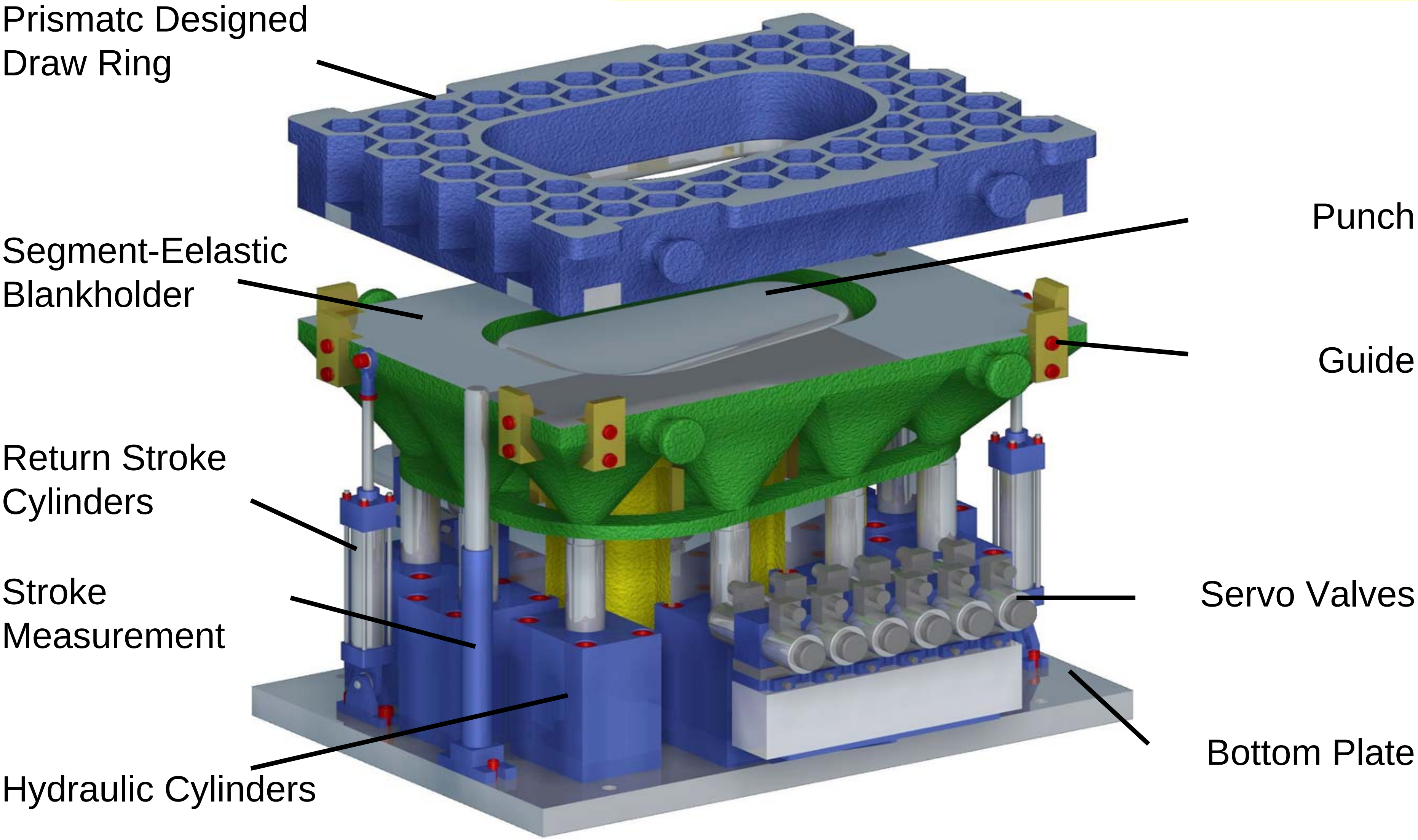
Blankholder Pressure by the Box-Profile



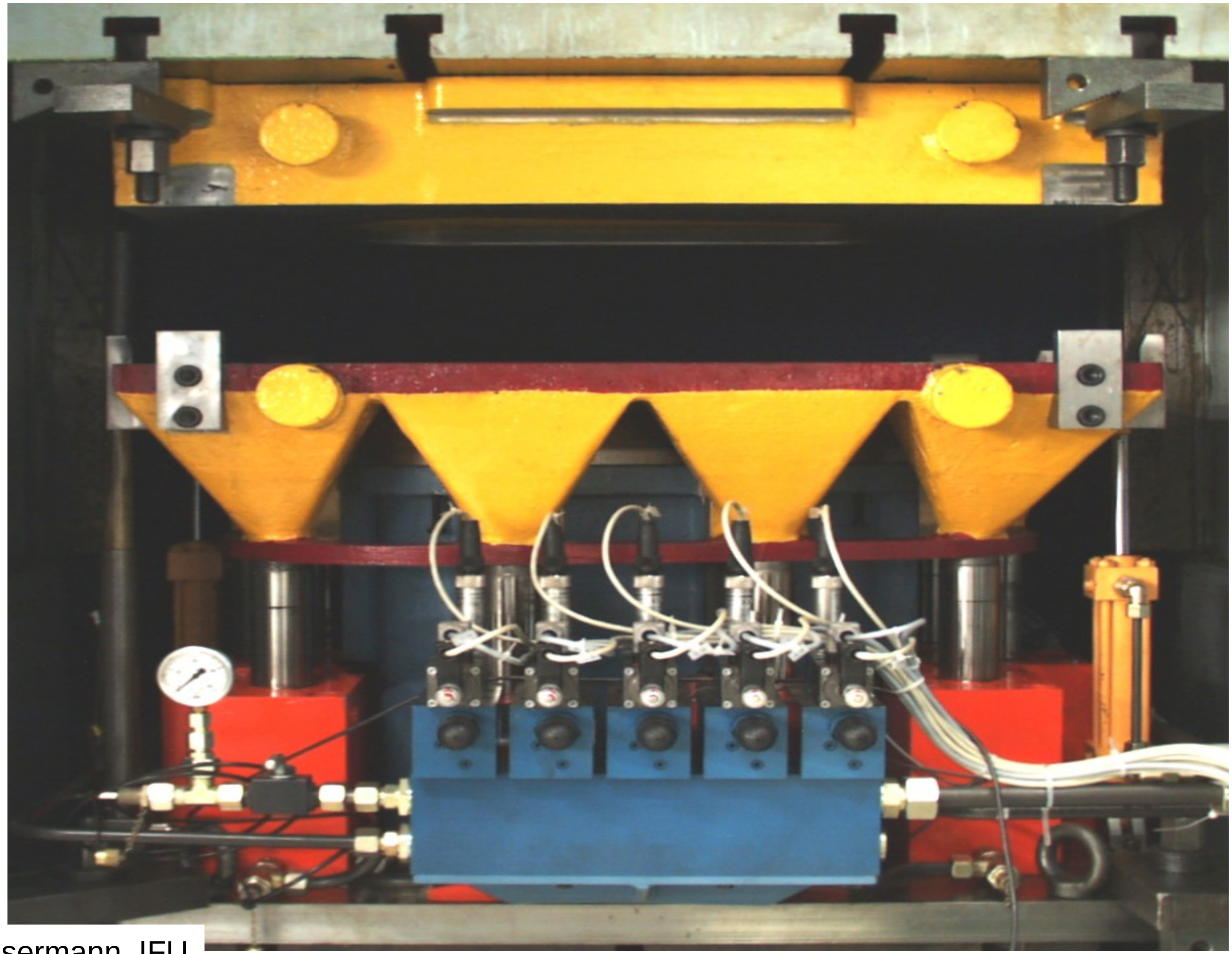
Source: M. Häussermann, IFU

Principle of the Segment-Elastic Blankholder

Draw Die with Segment-Elastic Blankholder, Prismatic Designed Draw Ring and 10-Point Cushion System Integrated into the Die



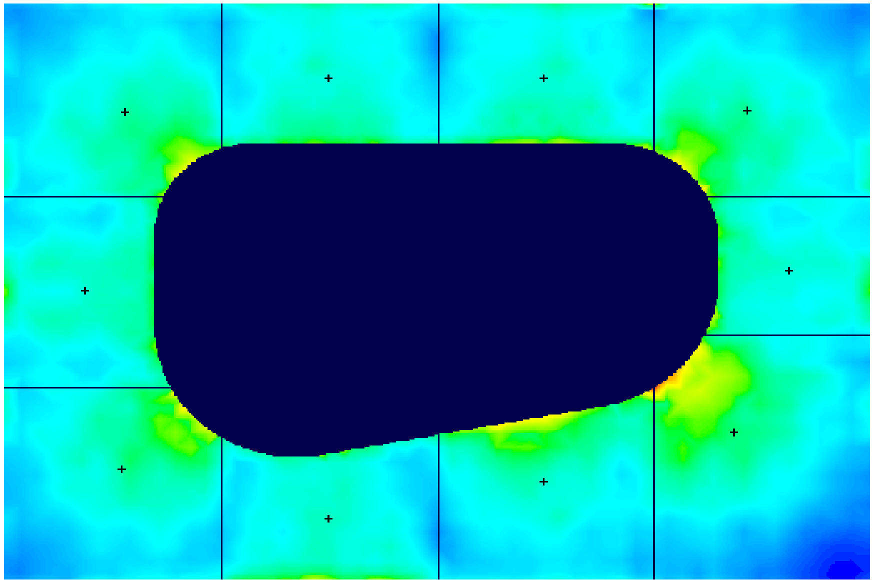
Source: M. Häussermann, IFU



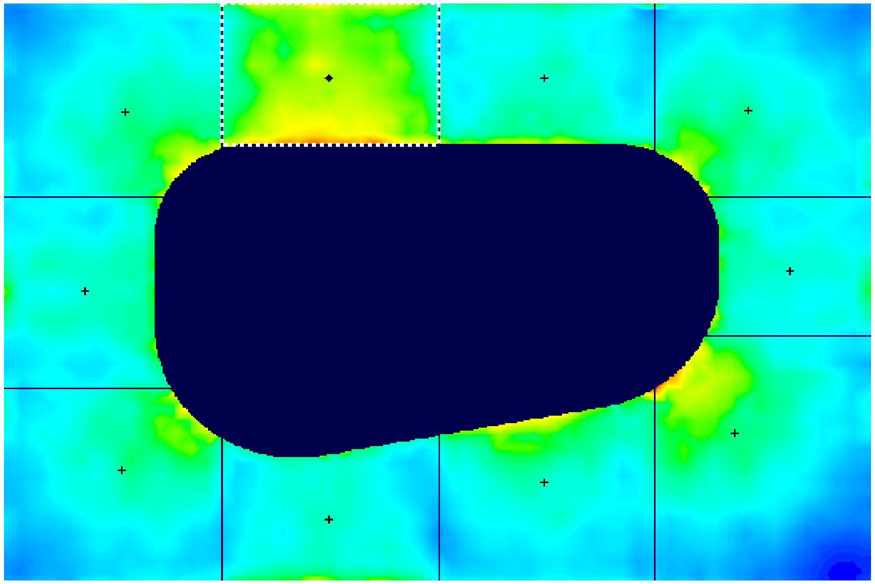
Source: M. Häussermann, IFU

Hydraulic Multipoint Cushion System in the Die

Normal Pressure: 4,5 ... ... 0 N/mm^2



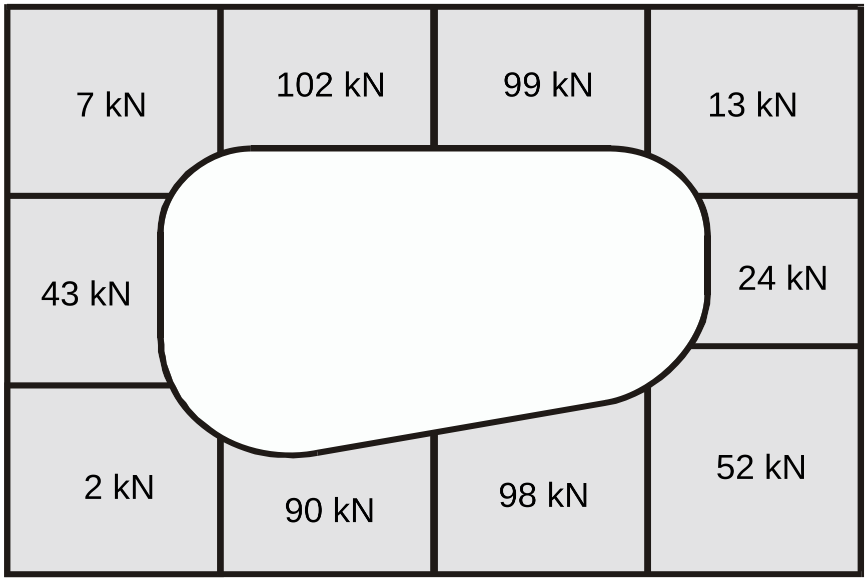
Equal Pin Forces



Increase of 100% in the Middle Area

Source: M. Häussermann, IFU

Total Blankholder Force 530kN

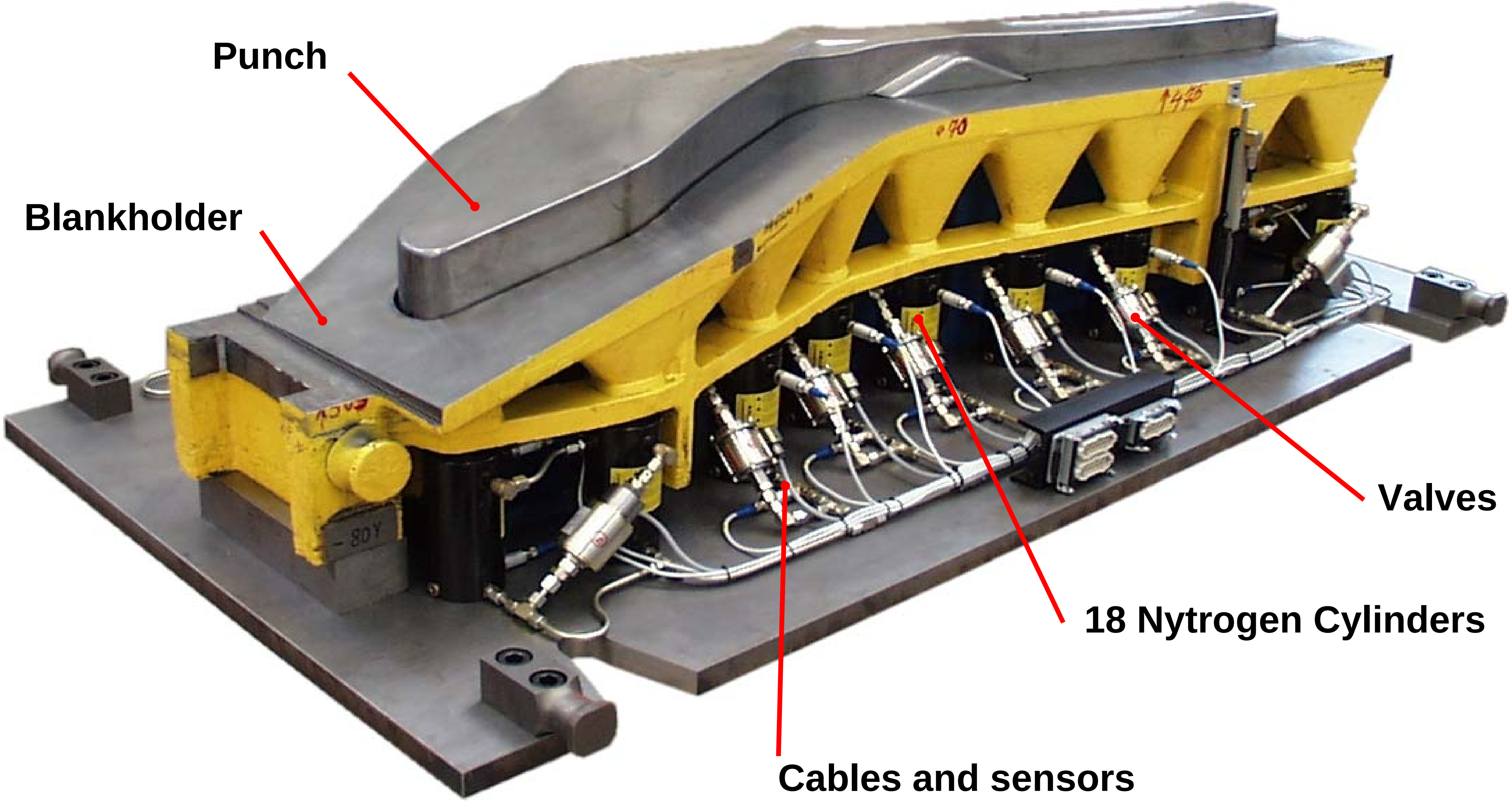


Good Part with 68 mm Draw Depth

Source: M. Häussermann, IFU

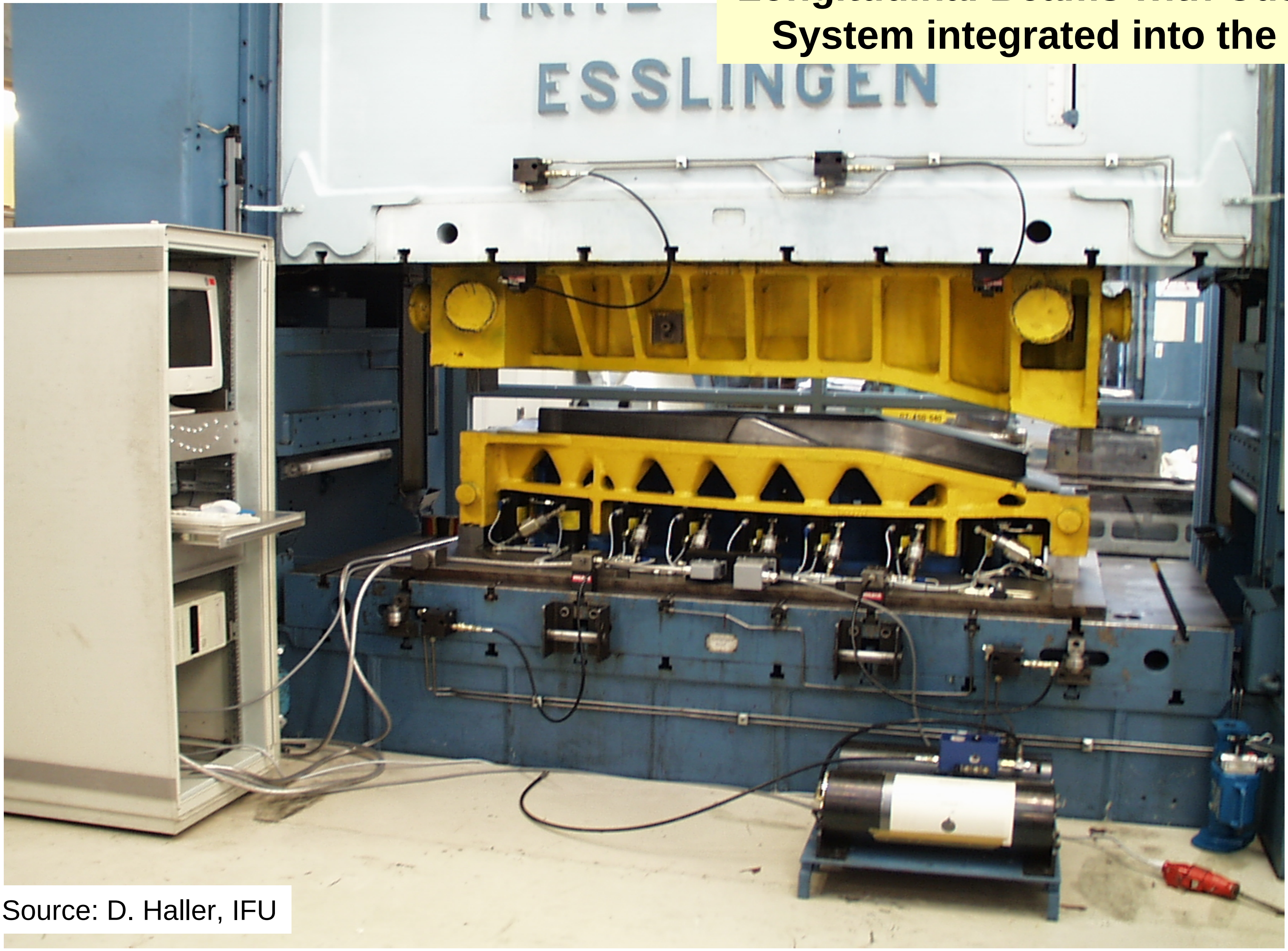
Optimization of the Cushion Pin Forces

Die for the Deep Drawing of Longitudinal Beams with Cushion System integrated into the Die



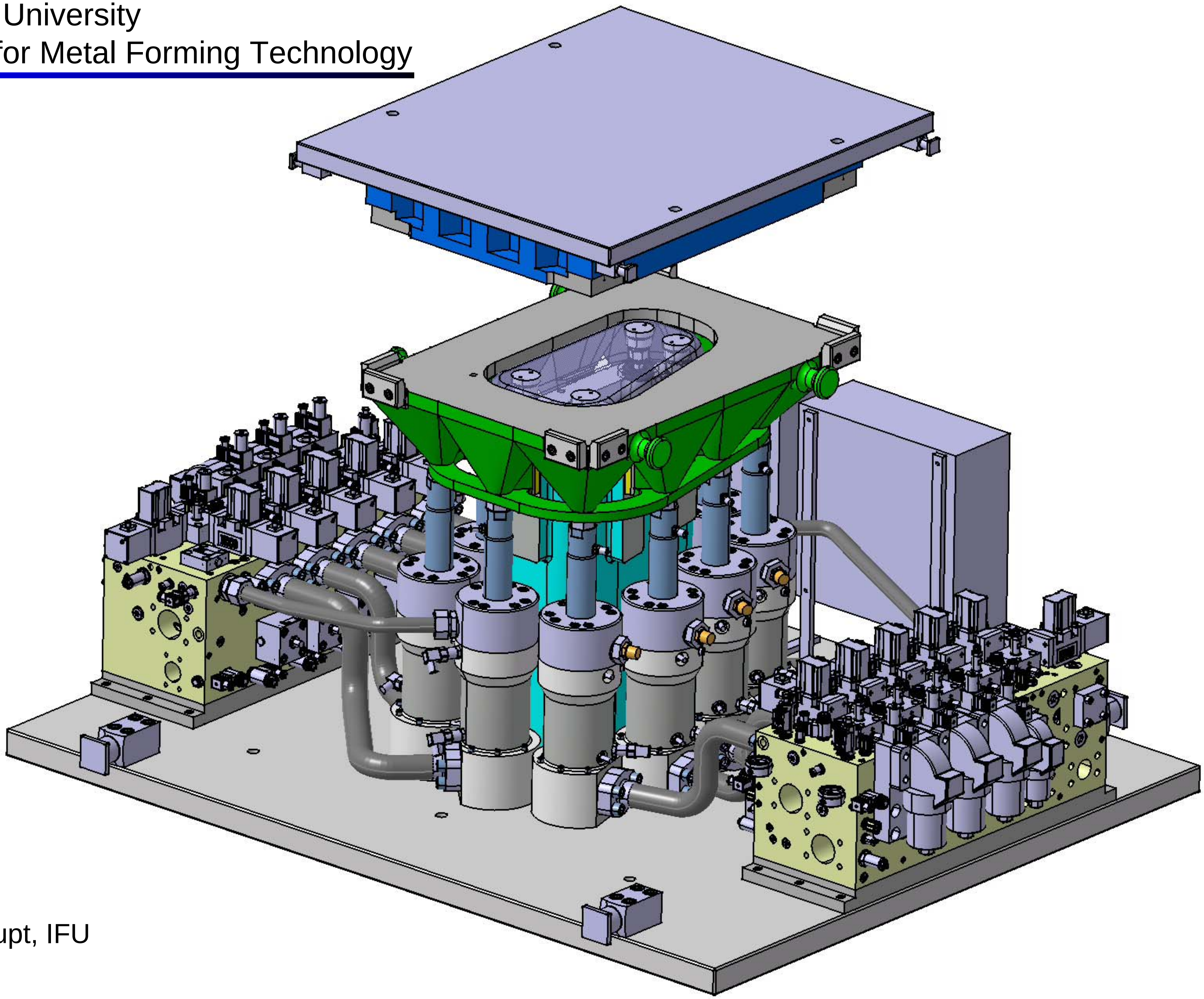
Source: D. Haller, IFU

Die for the Deep Drawing of Longitudinal Beams with Cushion System integrated into the Die



Source: D. Haller, IFU

Experimental Die



Source: J. Hengelhaupt, IFU

Hydraulic HMI

Main Mobile Hydraulic Unit

Press HMI

10 Point Flexible Binder Die

20.000 kN Hydraulic Press at the IFU

IFU HMI

MOOG Controller Units

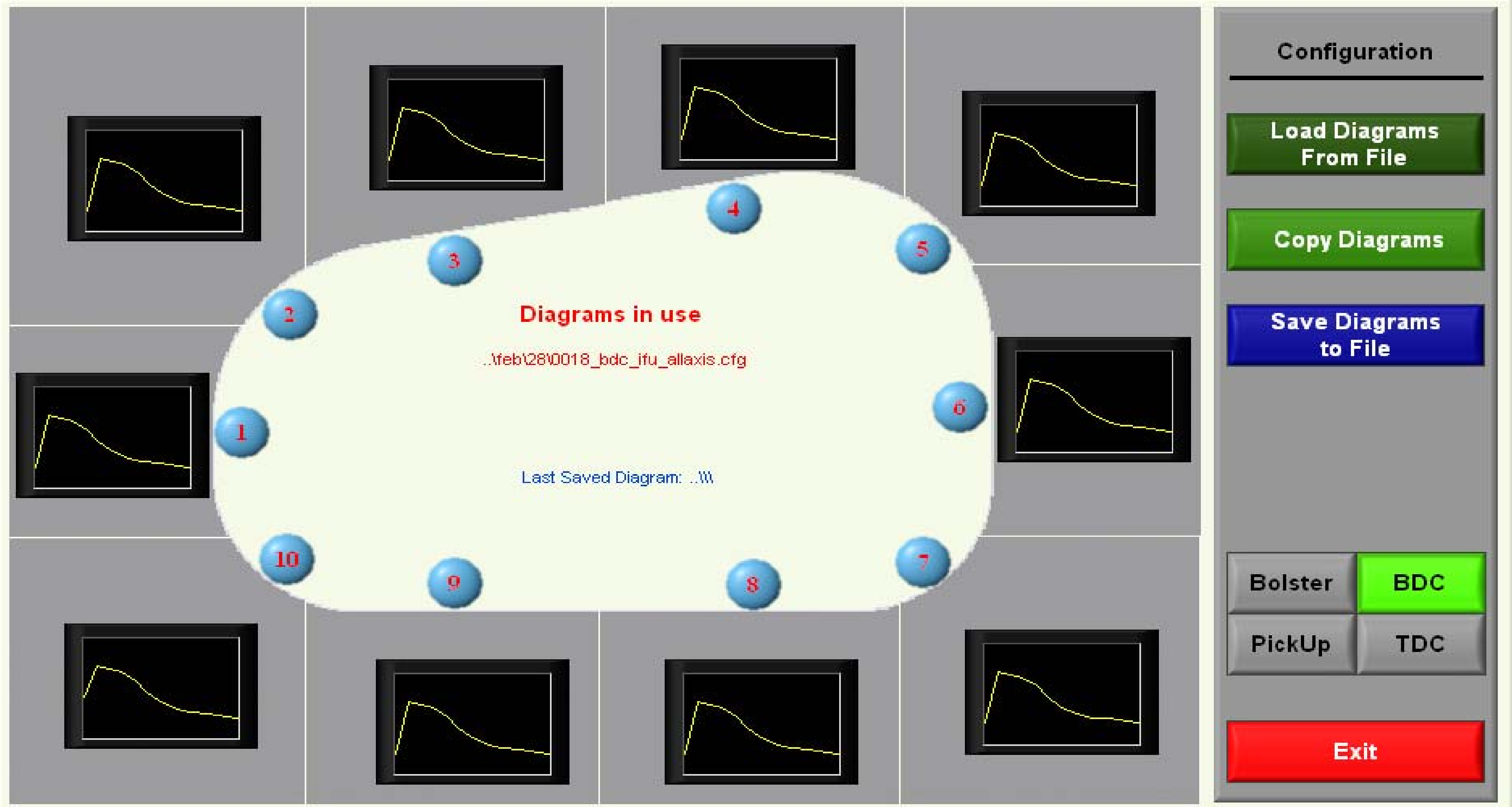
HYDAC Power Unit

Cooling System

2 x Return Tank Units

2 x Bladder Accumulators Station (each 1 x 60 bar and 2 x 10 bar)

Source: IFU



Diagrams in use

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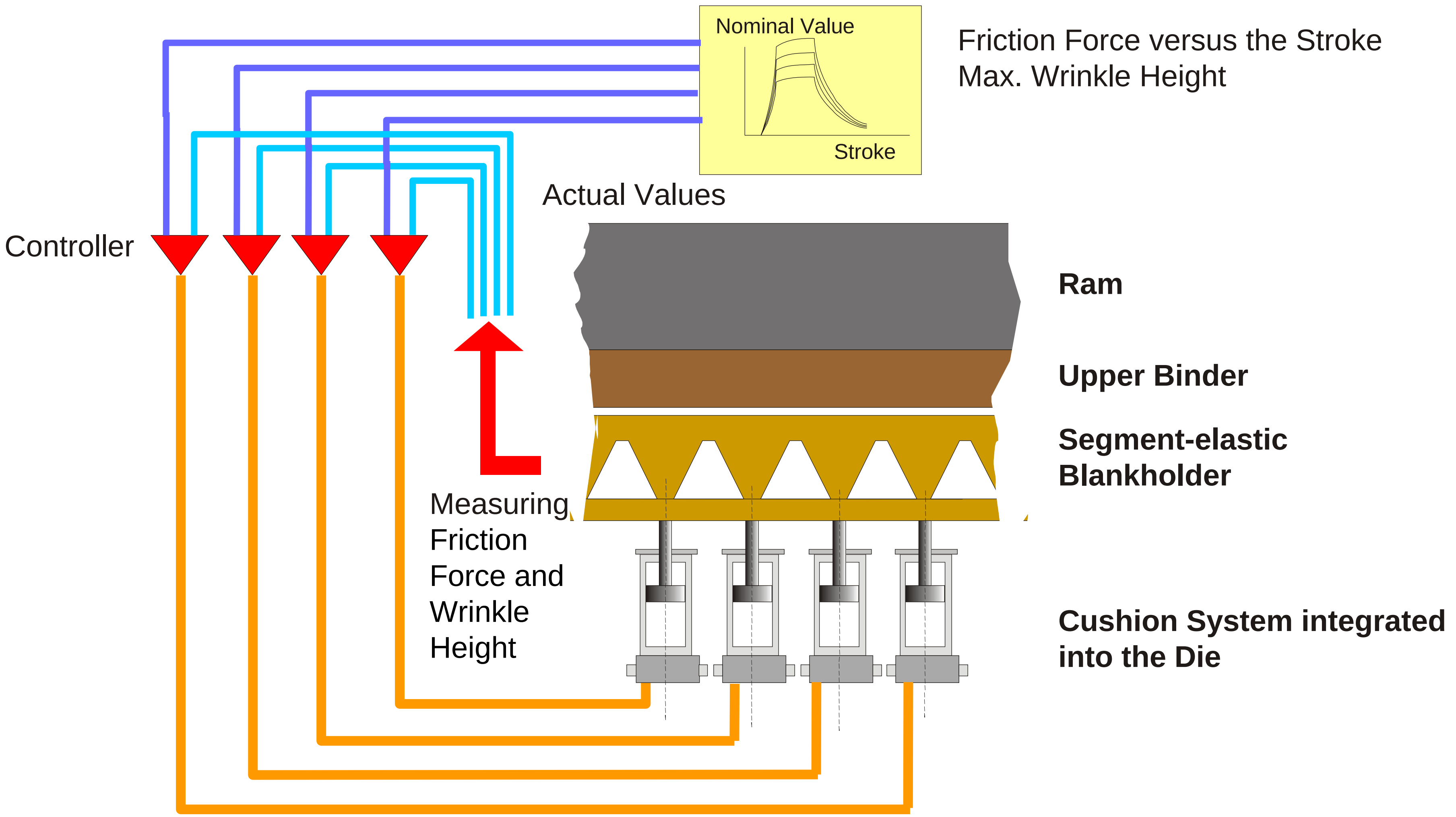
Last Saved Diagram: ..\\\

Source: M. Vulcan, IFU

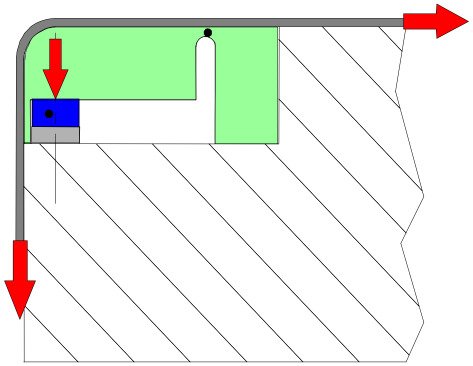
Control system with Touch Screen to Adjust the Blankholder Pressure Area by Area

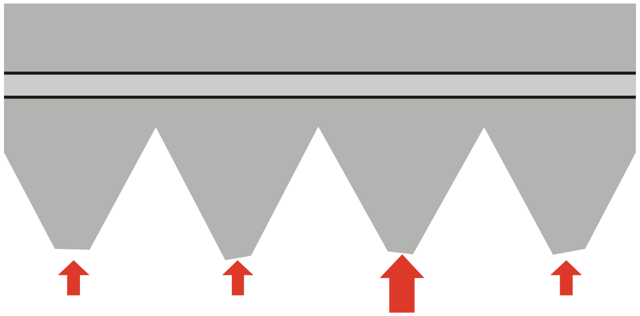


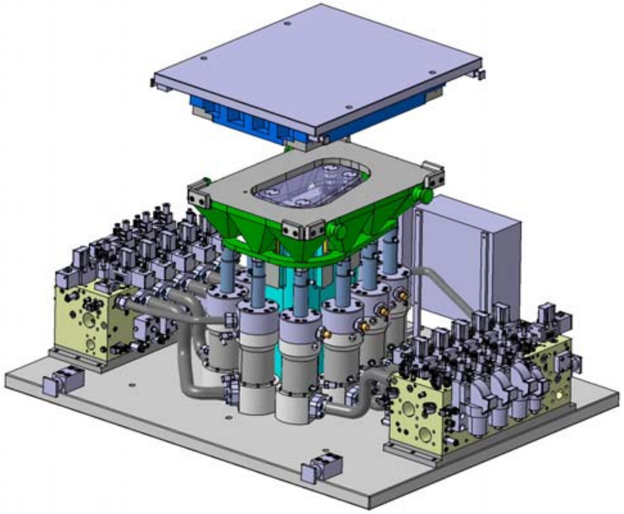
Source: IFU

Design of Closed Loop Control of the BHF

Tool and Die Design for Deep Drawing AHSS







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