



March 2010

# **Investigation of the Electrohydraulic Forming Process with Respect to the Design of Sharp Edged Contours**

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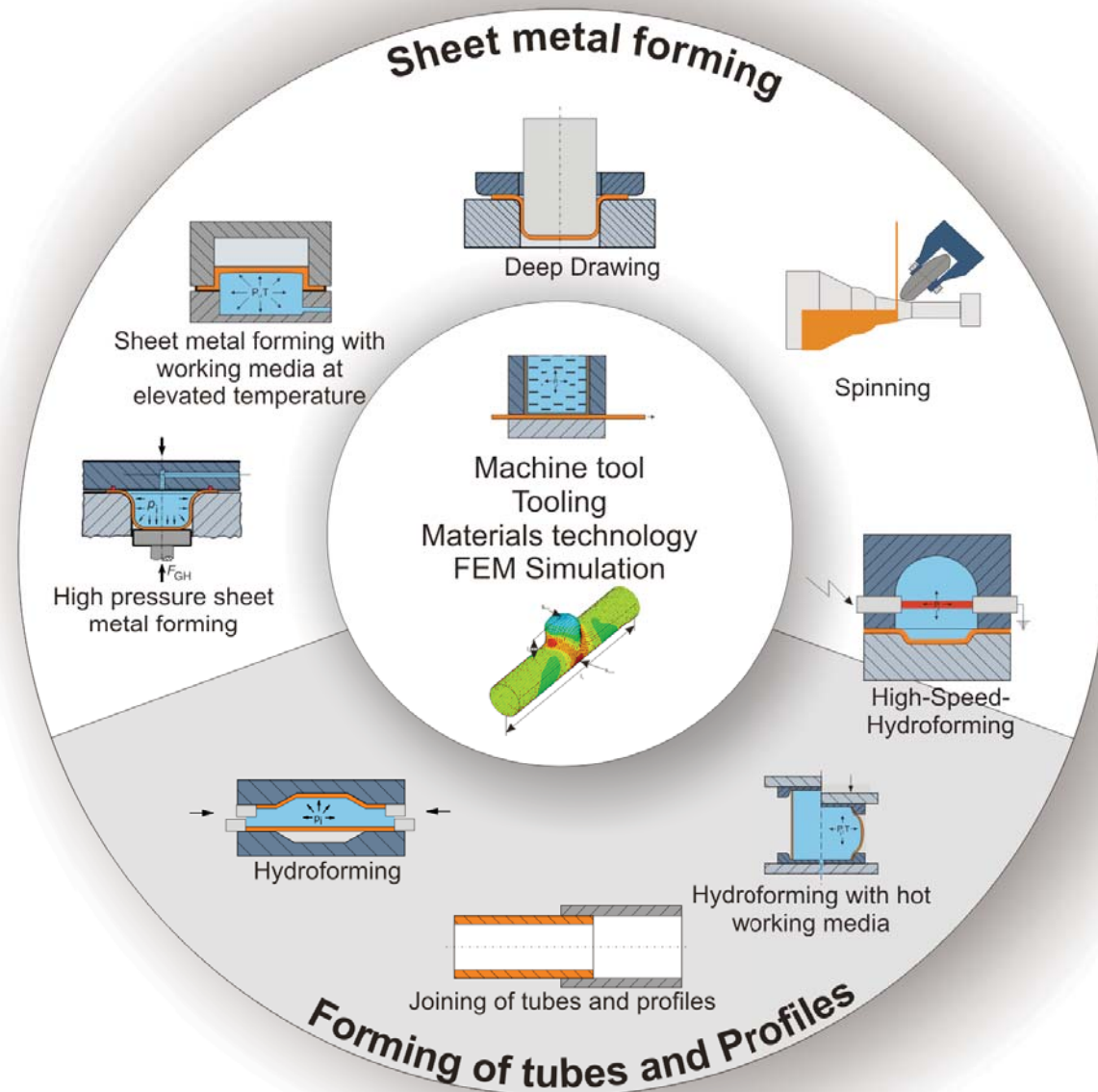
## **ICHSF 2010**

# Chair of Forming and Machining Technologies (LUF) in Paderborn



## Research

- Hydroforming of Tubes and Profiles
- High Pressure Sheet Metal Forming
- Forming of Hybrid-Materials
- Forming by Elevated Temperature
- Deep Drawing
- Closed- and Open-Loop-Control
- Tool-Systems
- Machine Tools
- Incremental Forming Processes
- Metal Spinning and Flow-Forming
- Flexible Manufacturing of small and medium Batch Sizes
- Rapid Tooling
- High-Speed-Forming
- Joining of Tubes and Profiles

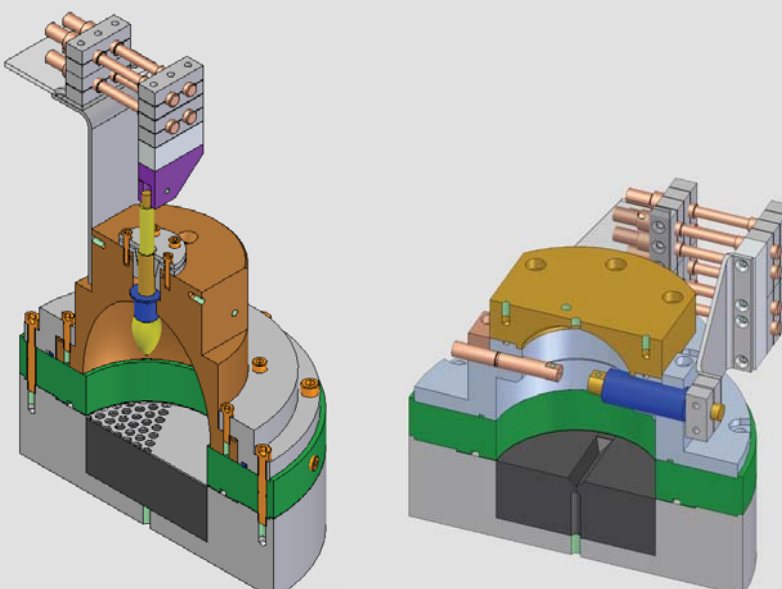


## **Economic Realization of Multifunctional Parts with Very Complex Geometries and Good Surface Quality**

- Promising Solution: Hydroforming, High Speed Hydroforming or a Combination of Both
- Identification of Process-Specific Advantages and Disadvantages is Necessary

# High-Speed Hydroforming Setups

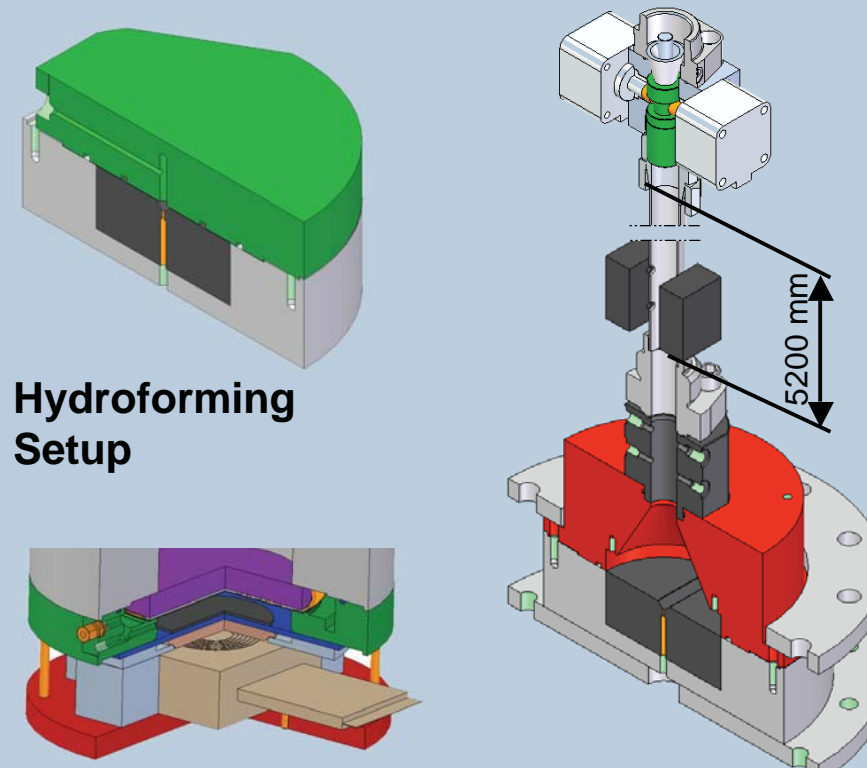
## Electrohydraulic Setups



**Spark gap setup 1 with Reflector**

**Spark Gap Setup 2 with a Wire**

## Reference Processes



**Hydroforming Setup**

**Electromechanical Setup with an Electromagnetic Accelerated Plunger**

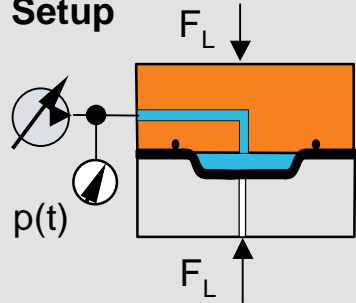
**Pneumomechanical setup with Pneumatically Accelerated Plunger**

5200 mm

# Characteristical Pressurization Behaviour

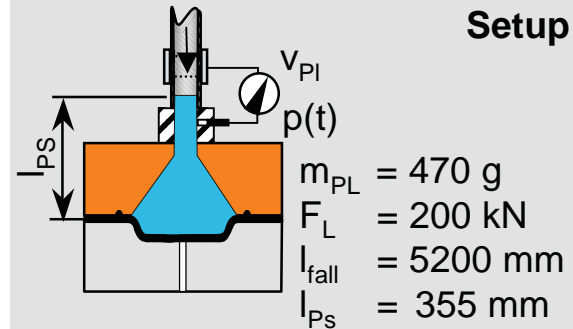


**Hydroforming Setup**

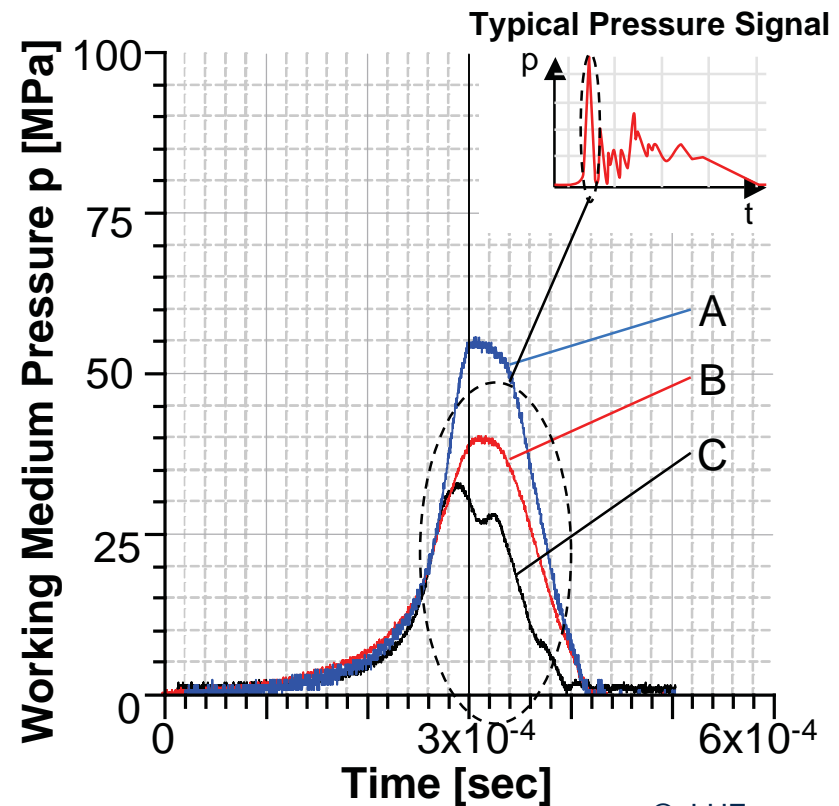
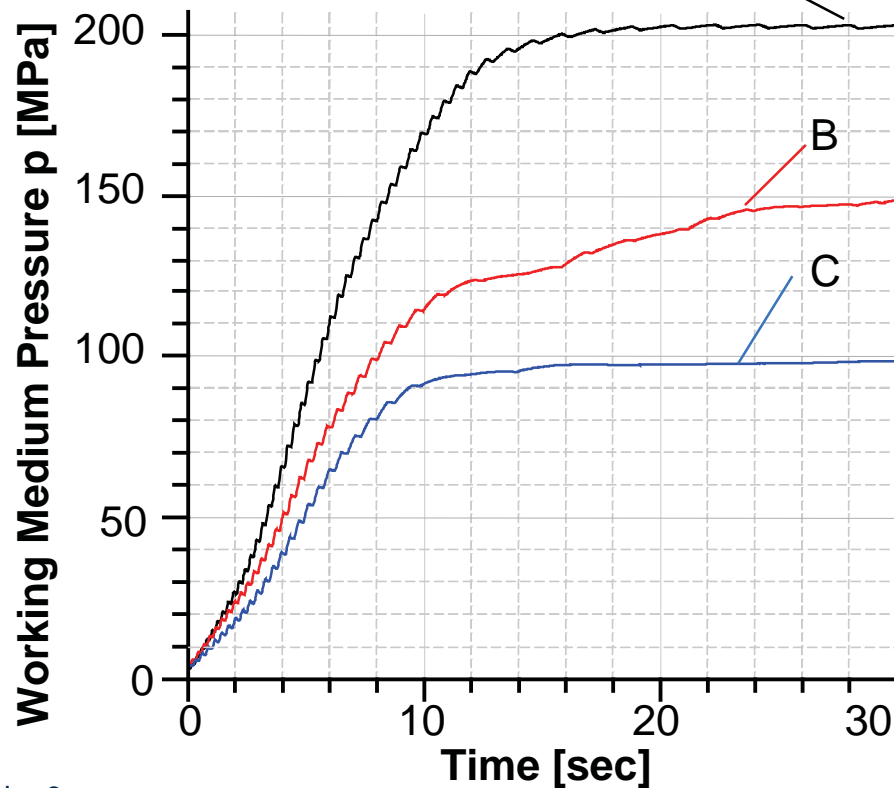


	Locking Force $F_L$ [kN]
A	5700
B	4900
C	2500

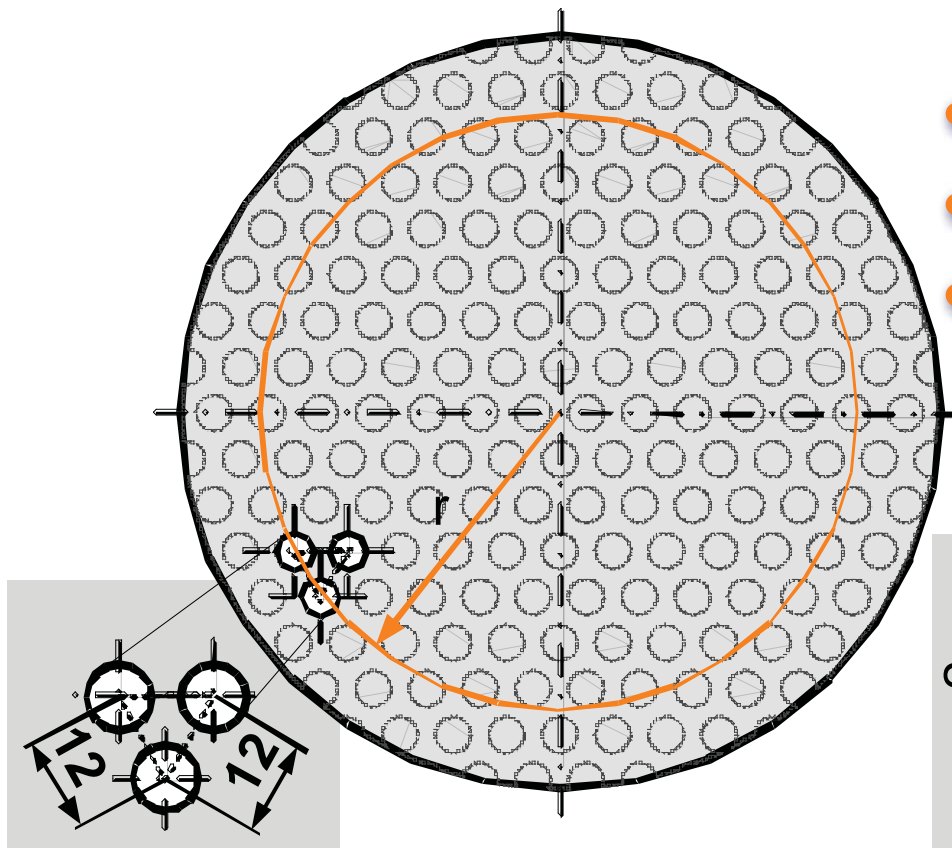
**Pneumomechanical Setup**



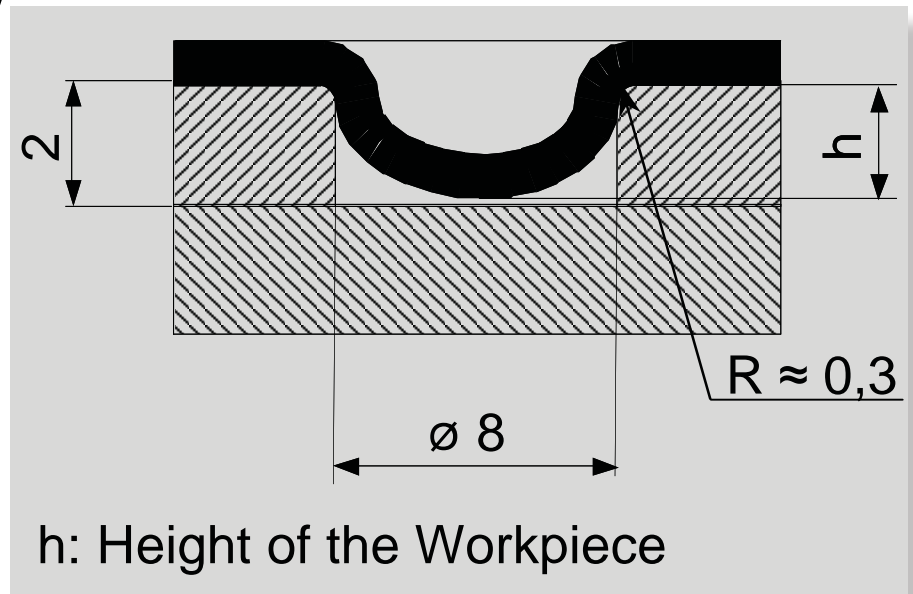
	Kinetic Energy E[J]	Plunger Velocity $v_{PL}$ [m/s]
A	1350	72
B	1100	65
C	450	41



# Qualitative Determination of the Pressure Distribution



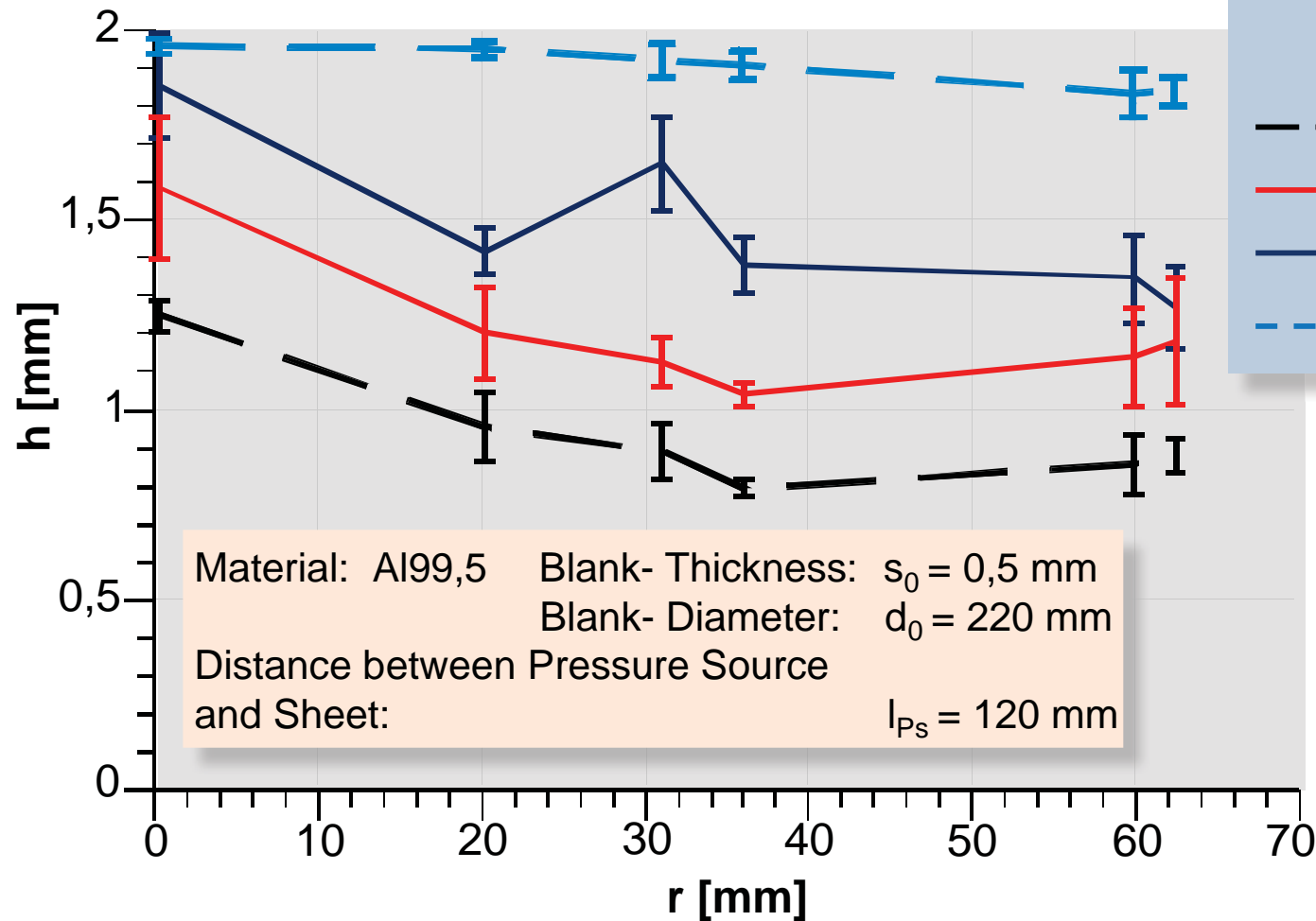
- Material: Al99,5 und AlMg3
- Blank- Diameter:  $D_0 = 220 \text{ mm}$
- Blank- Thickness:  $s_0 = 0,5 \text{ mm}$



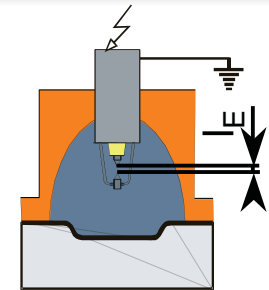
r: Radial Position of  
the Measured Points

h: Height of the Workpiece

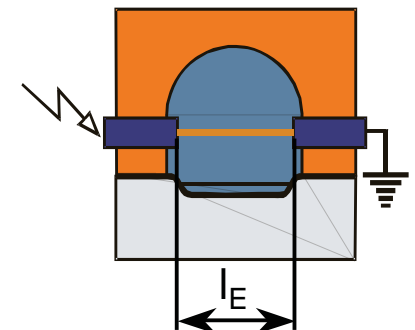
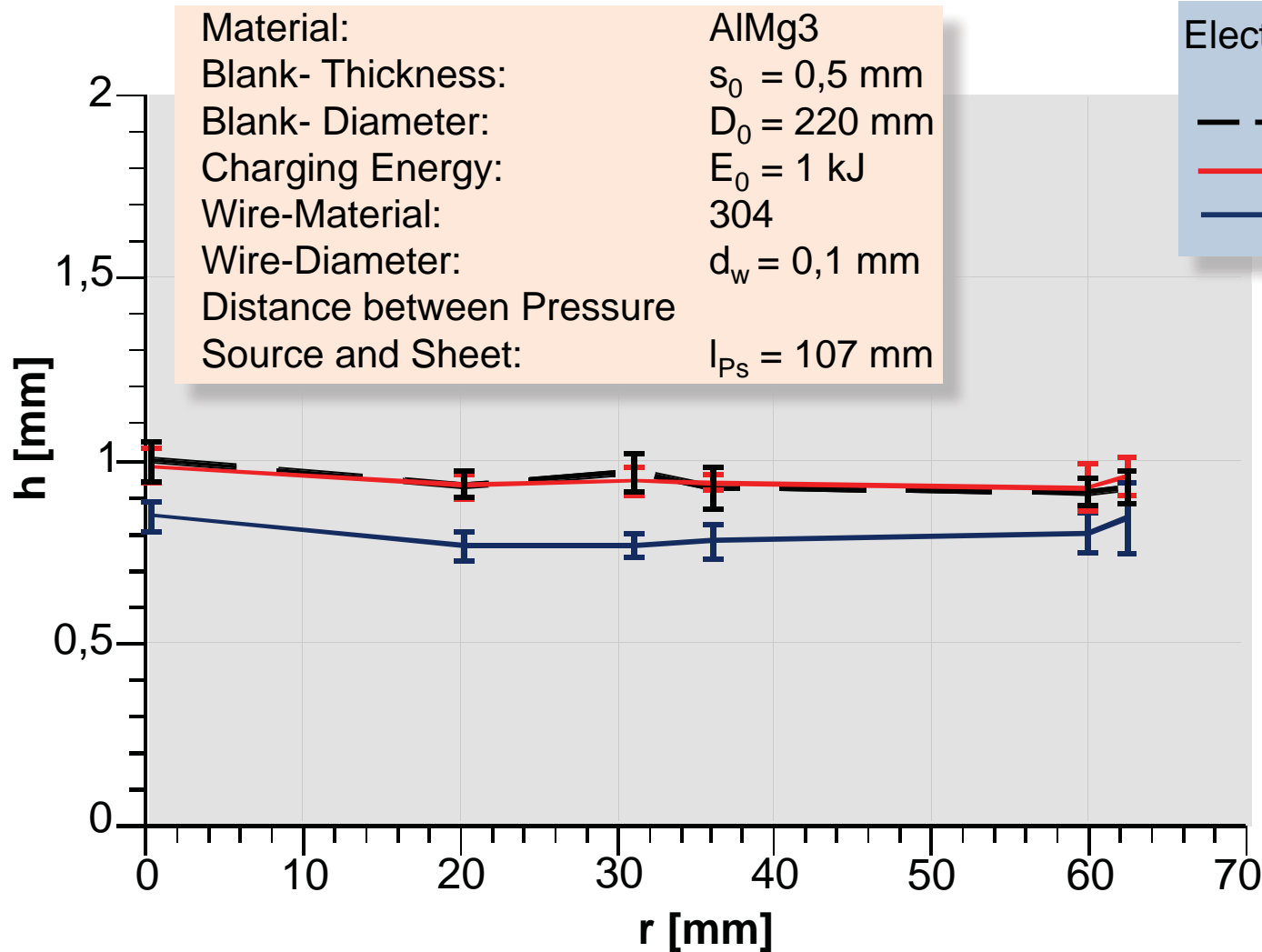
# Influence of the Electrode-Distance on the Workpiece Height



Electrode-Distance $l_E$ in mm;	Charging Energie $E_0$
--- $l_E = 2$	$E_0 = 1$ kJ
— $l_E = 6,6$	$E_0 = 1$ kJ
— $l_E = 7$	$E_0 = 1$ kJ
- - - $l_E = 6,6$	$E_0 = 2$ kJ

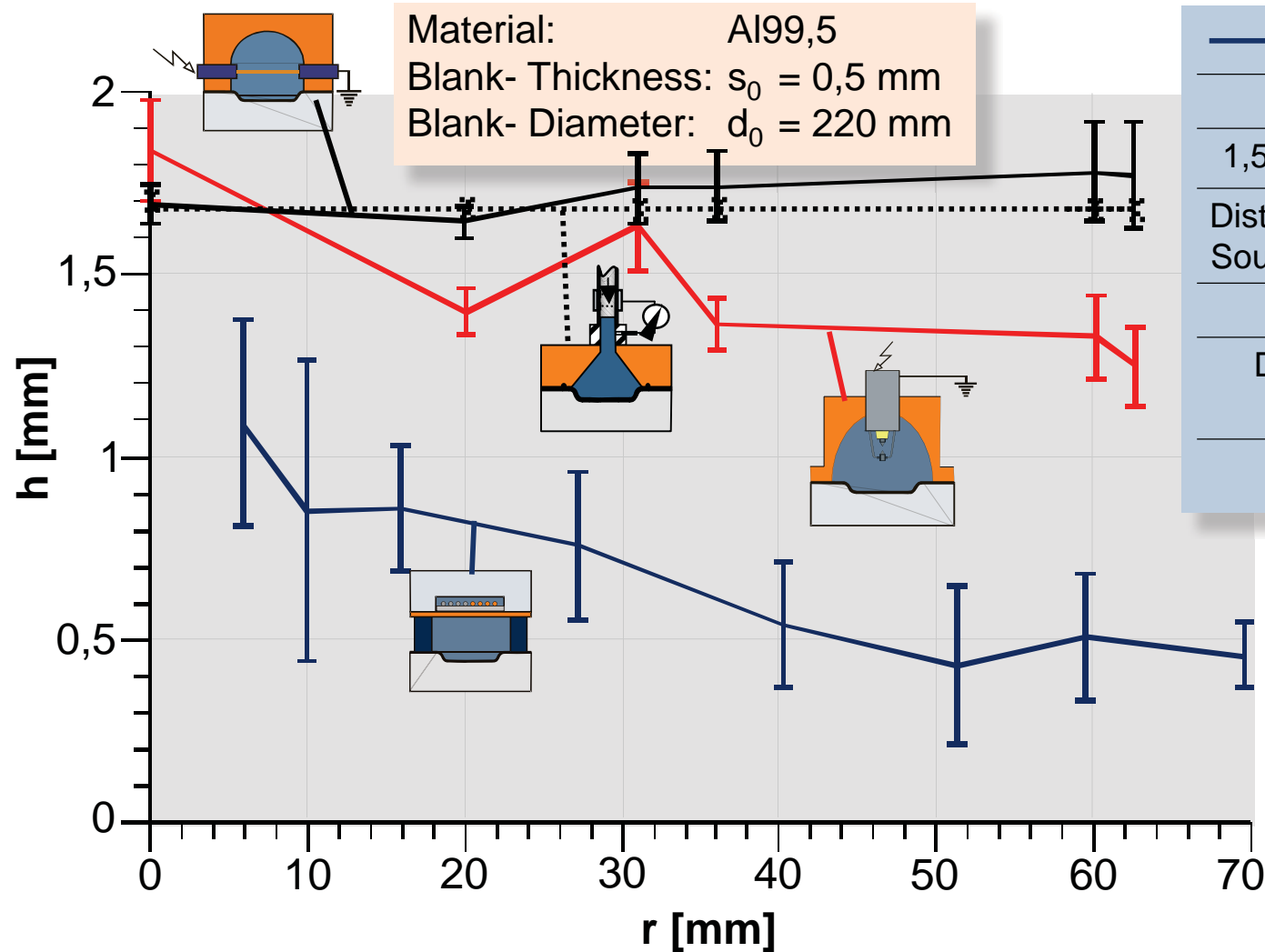


# Influence of the Electrode-Distance on the Workpiece Height (Spark Gap with Wire)





# Workpiece Geometry – Comparison of High Speed Hydroforming Setups



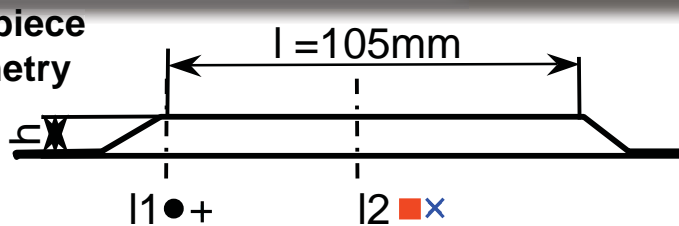
# Comparison between Hydroforming and High-Speed Hydroforming Processes

## Boundary Conditions

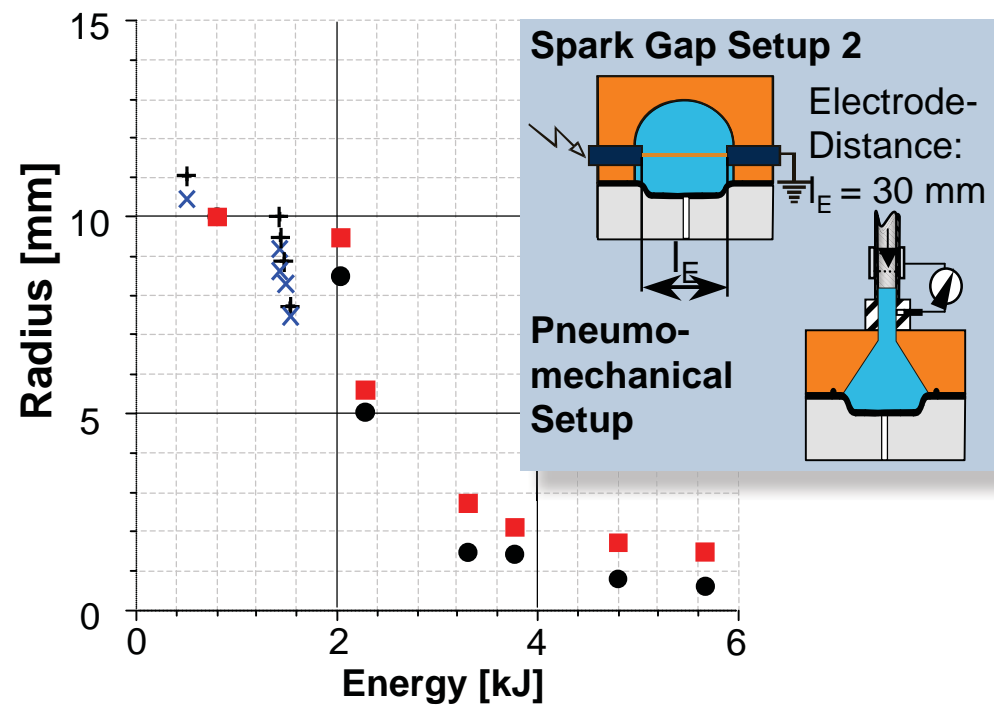
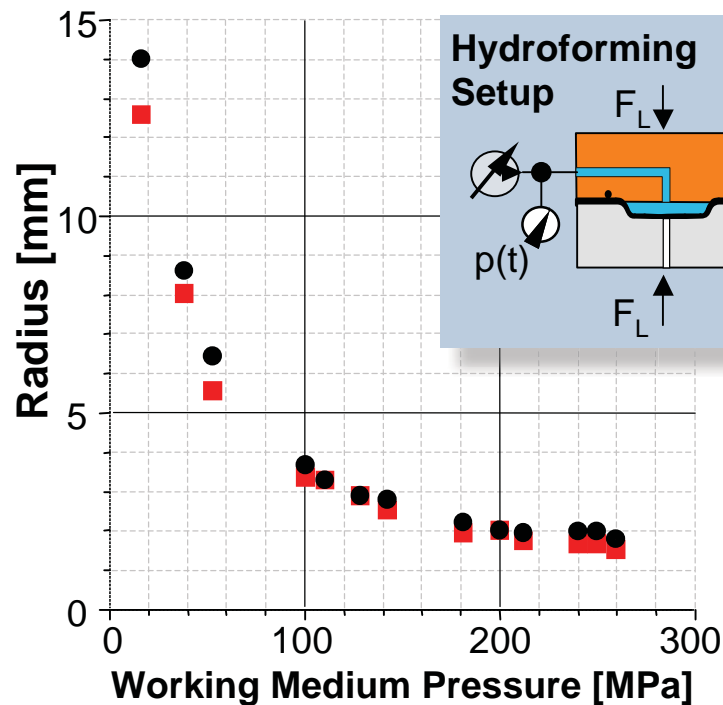
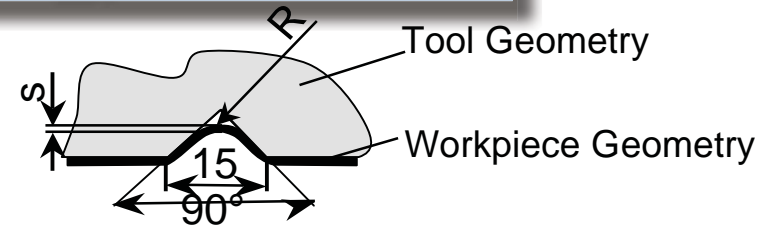
Blank- Thickness:  $s_0 = 0,5 \text{ mm}$   
Blank- Diameter:  $D_0 = 220 \text{ mm}$

Hydroforming and Electrohydraulic Setup	Blank-Material	Pneumomechanical Setup
● ■	ASTM 304	+ ×

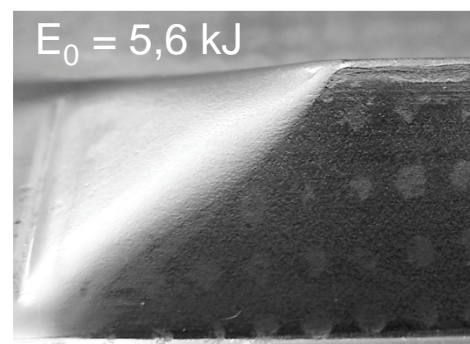
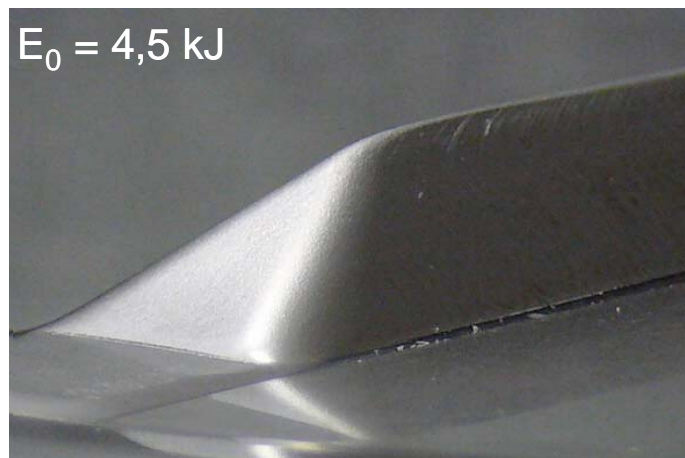
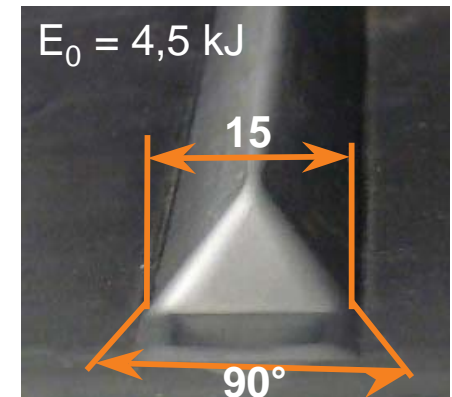
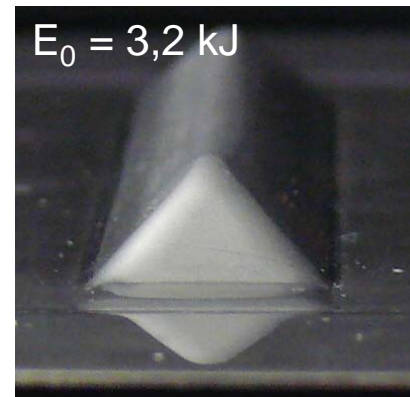
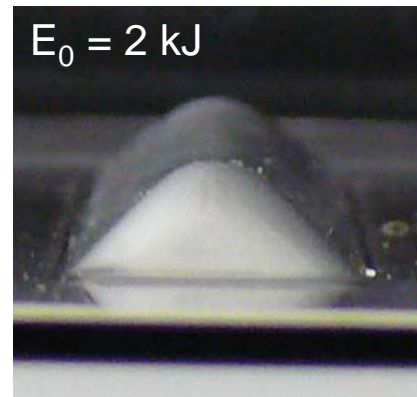
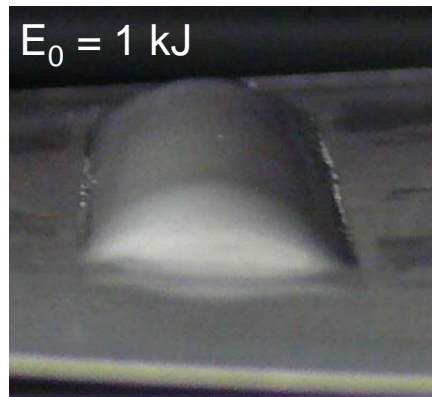
## Workpiece Geometry



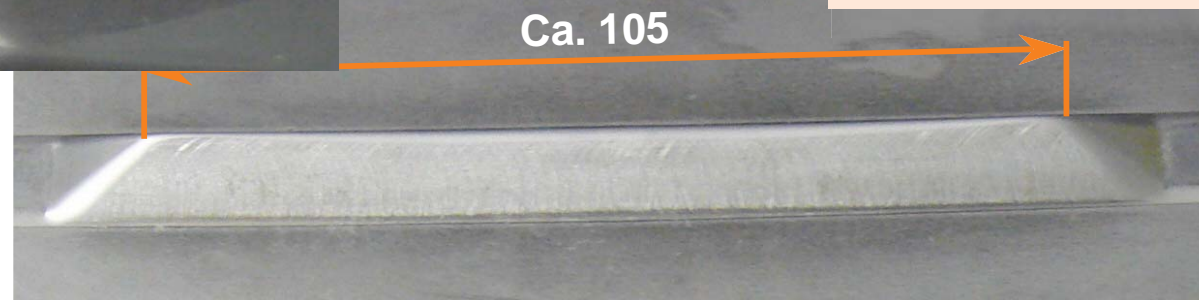
## Section plane x-y(I)



# Electrohydraulic Forming – Influence of the Charging Energy on the Geometry



Material: ASTM 304  
Blank- Thickness:  $s_0 = 0,5 \text{ mm}$   
Blank- Diameter:  $D_0 = 220 \text{ mm}$   
Electrode-  
Distance:  $l_E = 30 \text{ mm}$   
Wire- Material: ASTM 304  
Wire- Diameter:  $d_W = 0,1 \text{ mm}$



# Conclusion and Outlook

