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

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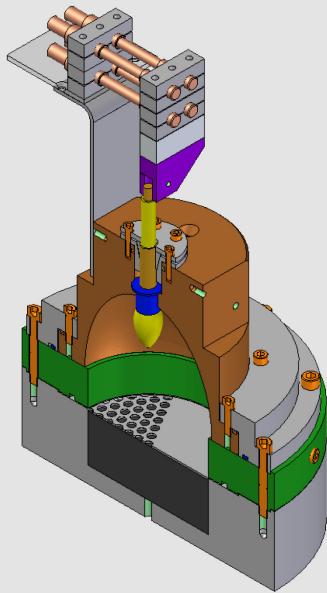
Research

- 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

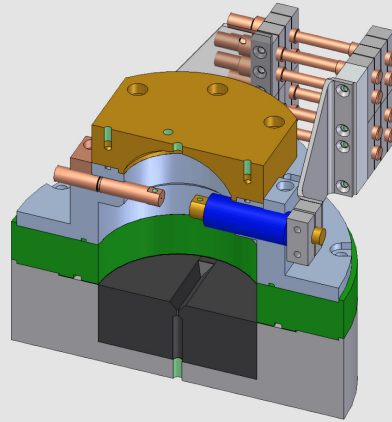
Economic Realization of Multifunctional Parts with Very Complex Geometries and Good Surface Quality

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

Electrohydraulic Setups

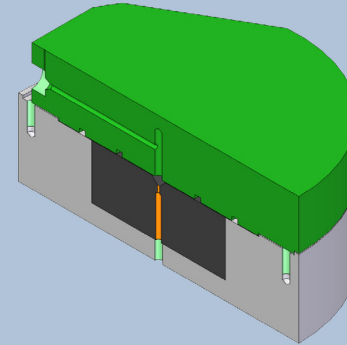


Spark gap setup 1
with Reflector

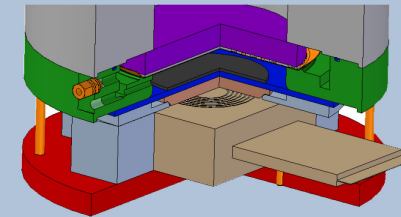


Spark Gap Setup 2
with a Wire

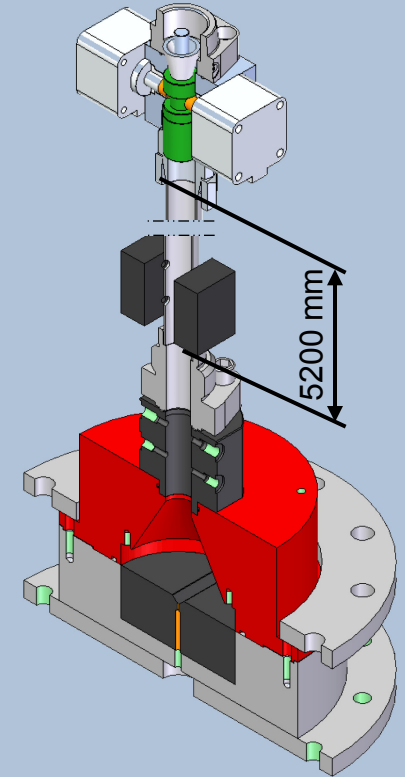
Reference Processes



Hydroforming
Setup

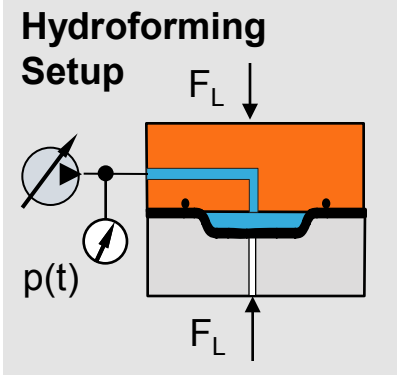


Electromechanical
Setup
with an
Electromagnetic
Accelerated Plunger

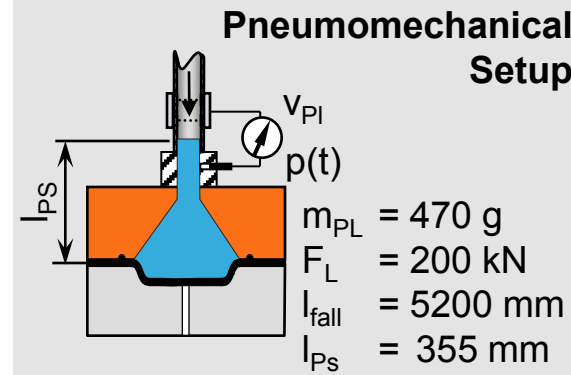


Pneumomechanical
setup
with Pneumatically
Accelerated Plunger

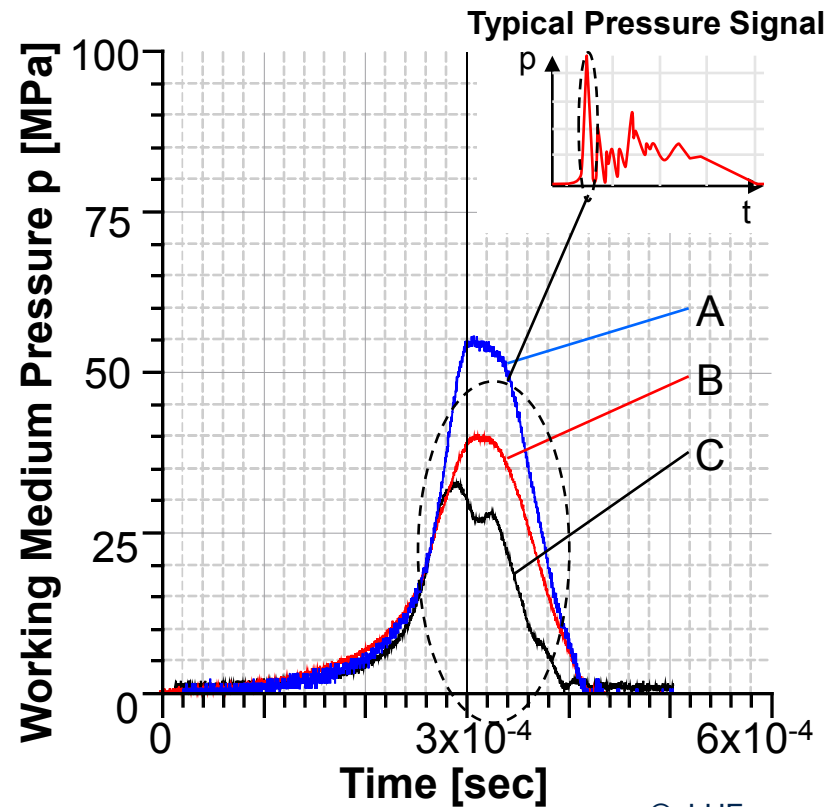
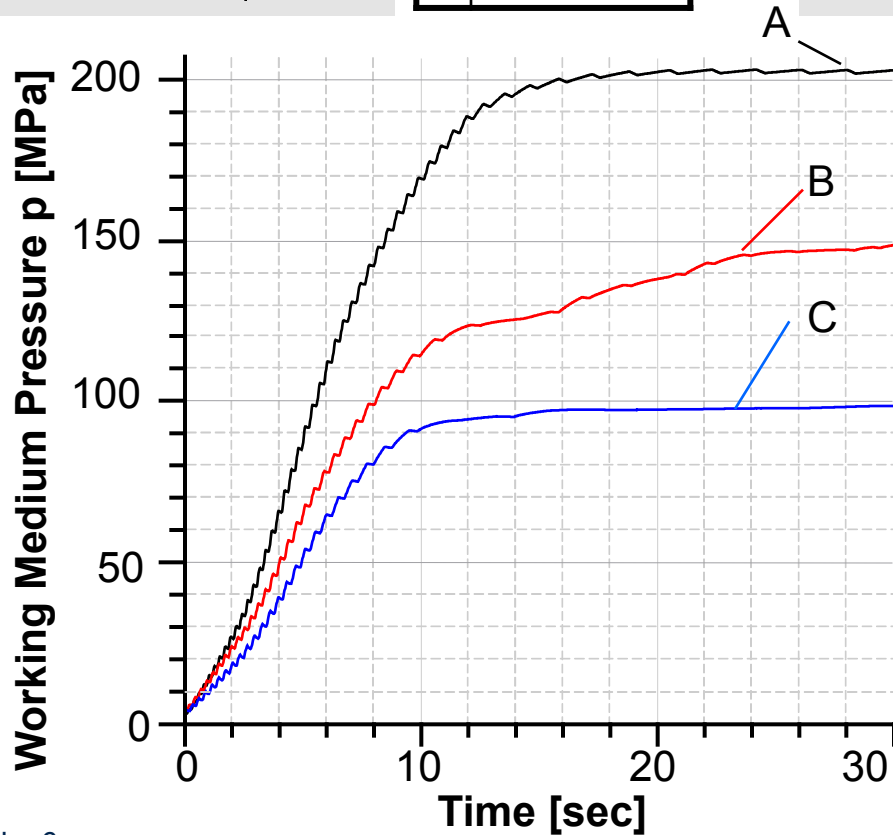
Characteristical Pressurization Behaviour



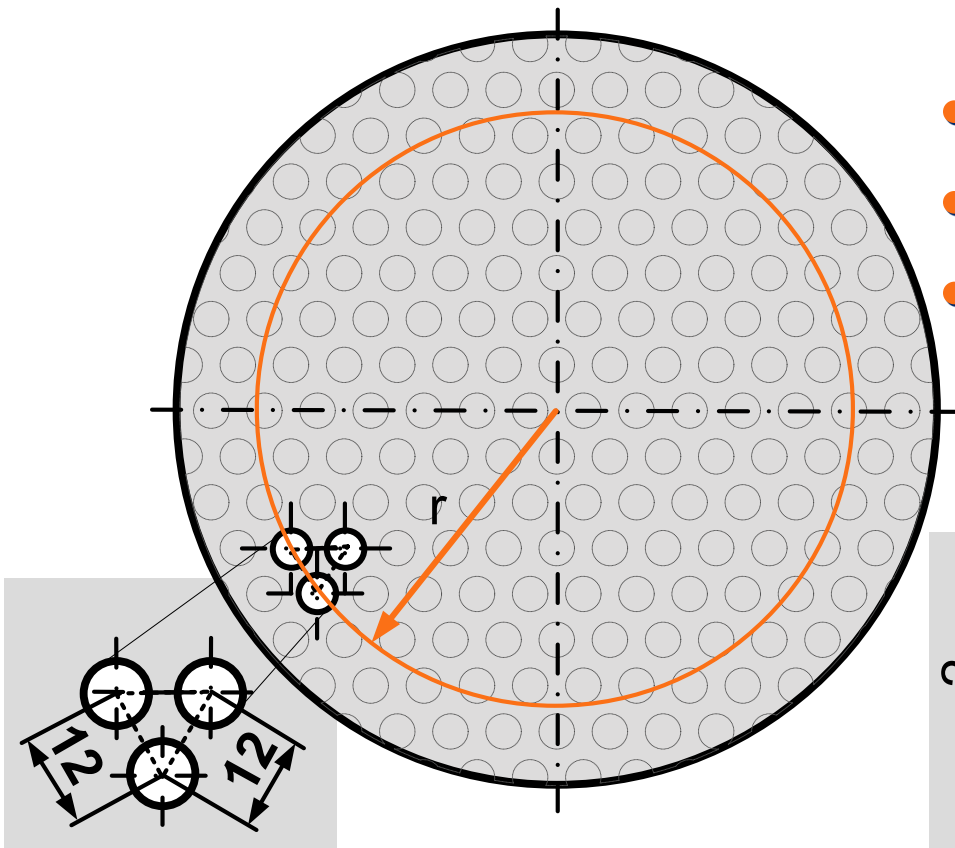
	Locking Force F_L [kN]
A	5700
B	4900
C	2500



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

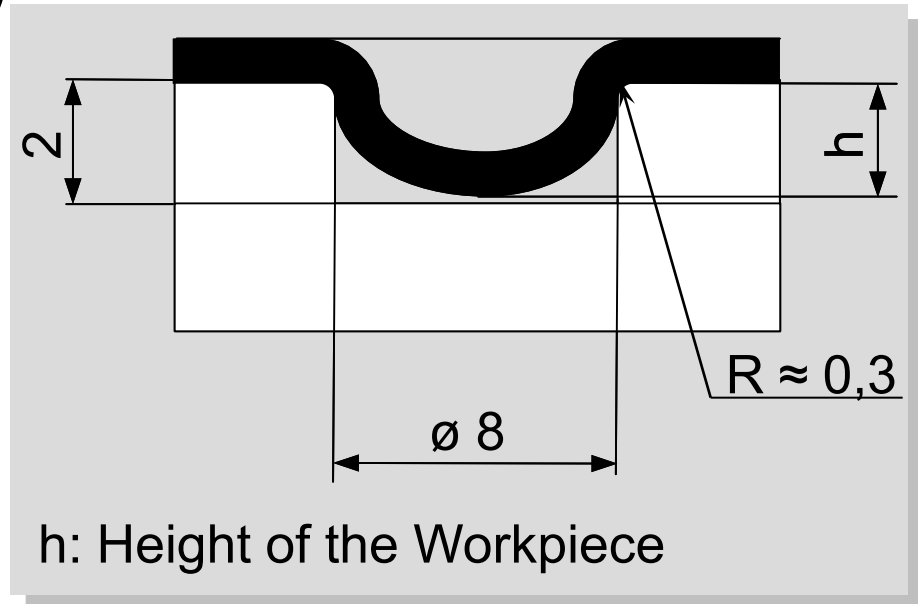


Qualitative Determination of the Pressure Distribution



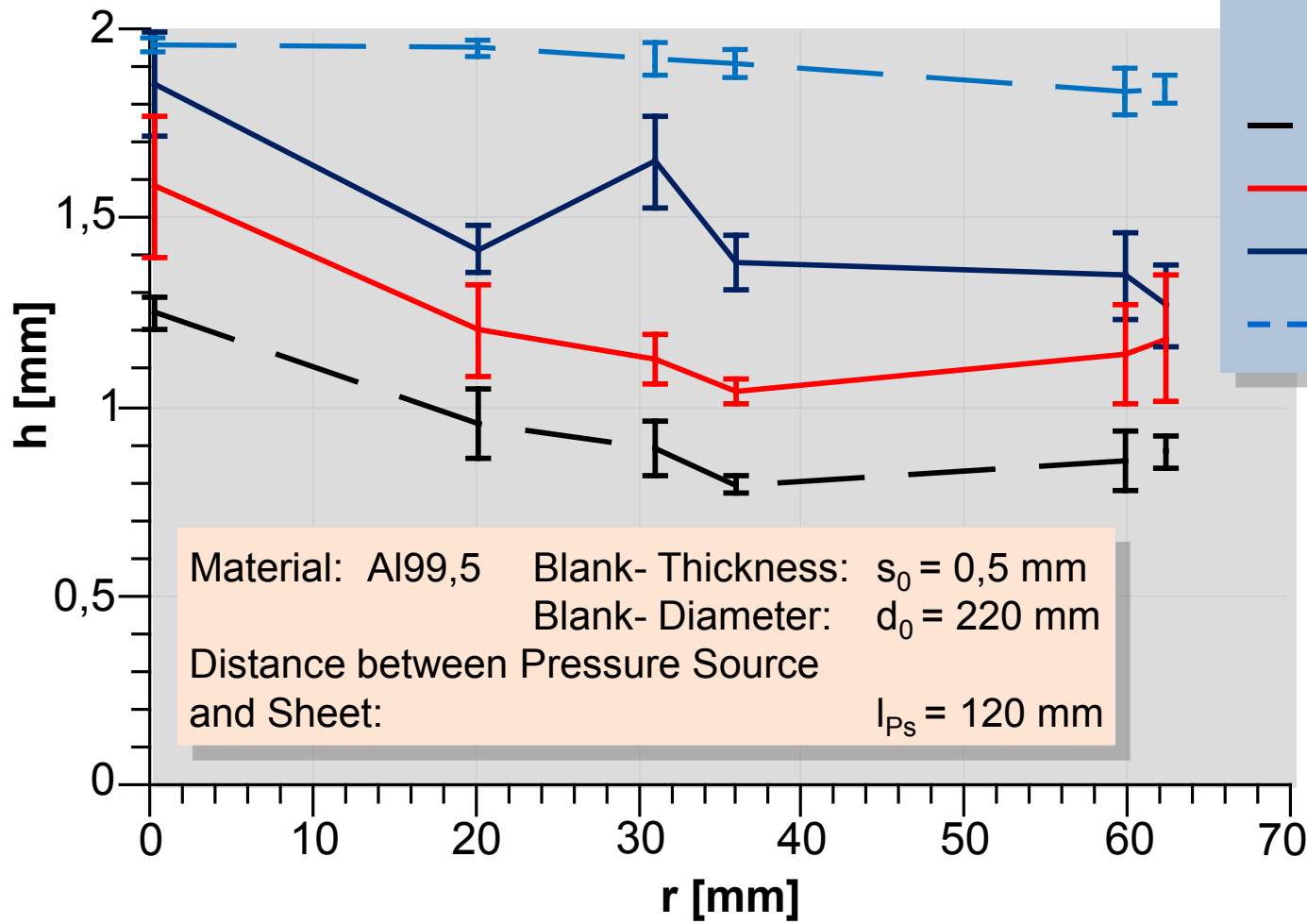
r : Radial Position of
the Measured Points

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



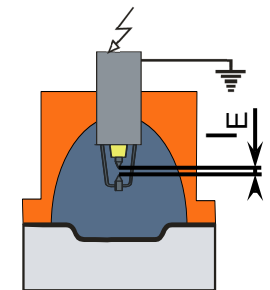
h : Height of the Workpiece

Influence of the Electrode-Distance on the Workpiece Height

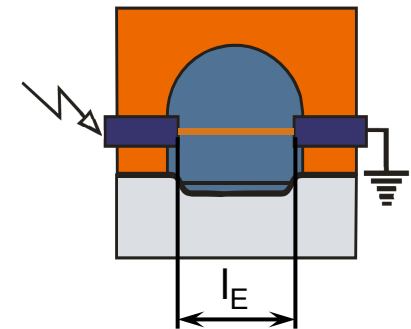
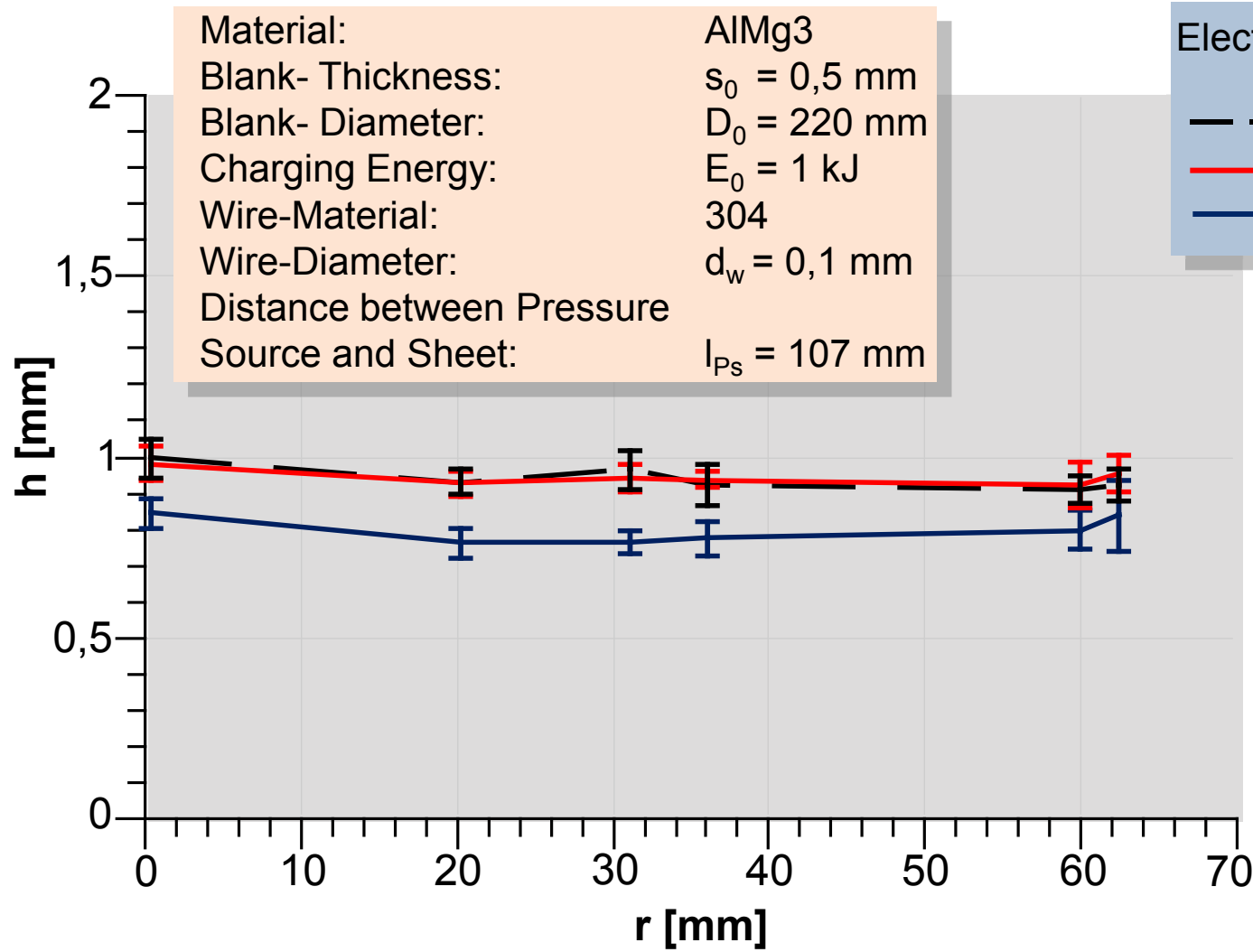


Material: Al99,5 Blank- Thickness: $s_0 = 0,5 \text{ mm}$
 Blank- Diameter: $d_0 = 220 \text{ mm}$
 Distance between Pressure Source
 and Sheet: $l_{PS} = 120 \text{ mm}$

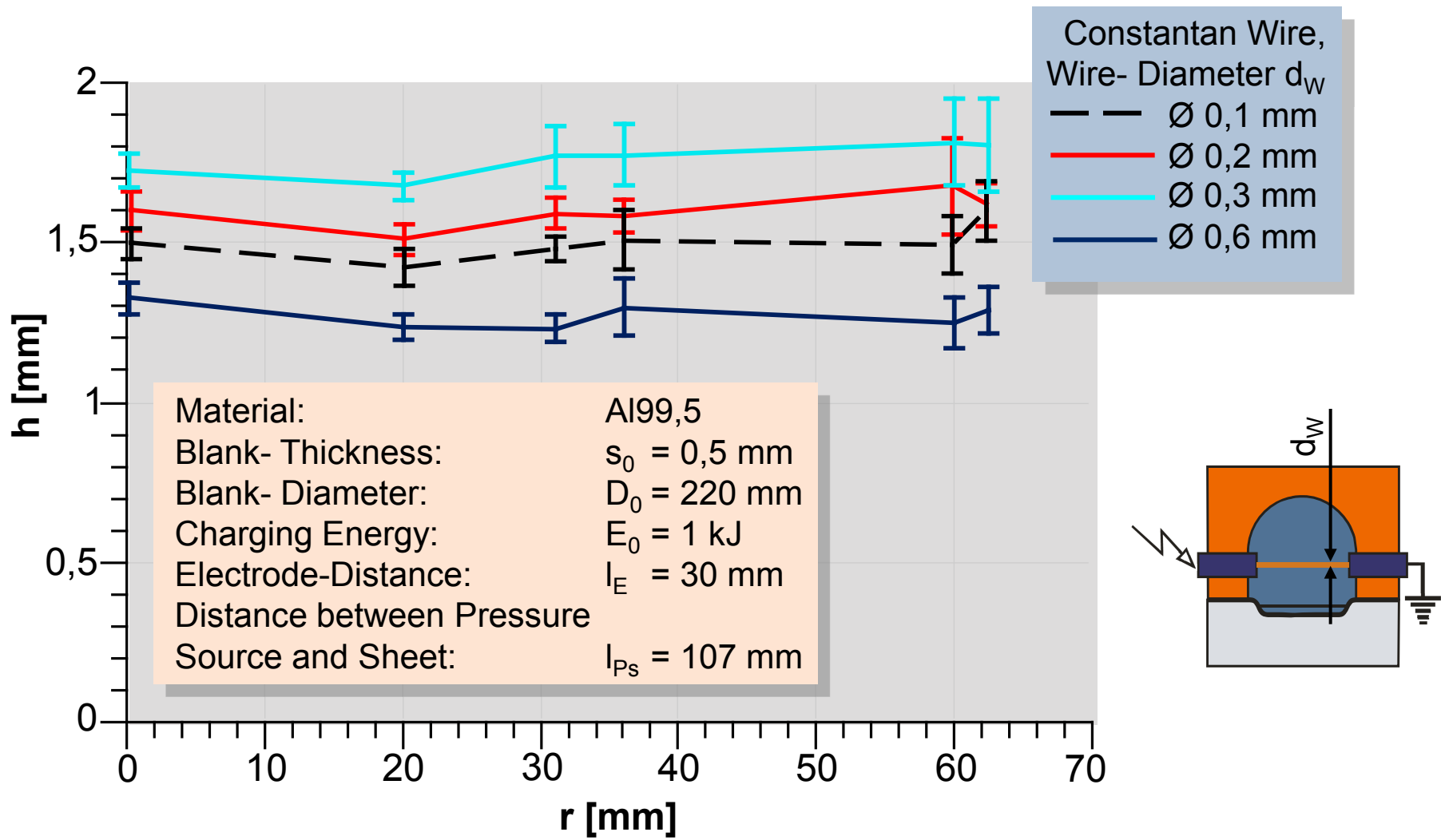
Electrode-Distance l_E in mm;	Charging Energie E_0
— — $l_E = 2$	$E_0 = 1 \text{ kJ}$
— $l_E = 6,6$	$E_0 = 1 \text{ kJ}$
— $l_E = 7$	$E_0 = 1 \text{ kJ}$
- - - $l_E = 6,6$	$E_0 = 2 \text{ kJ}$



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

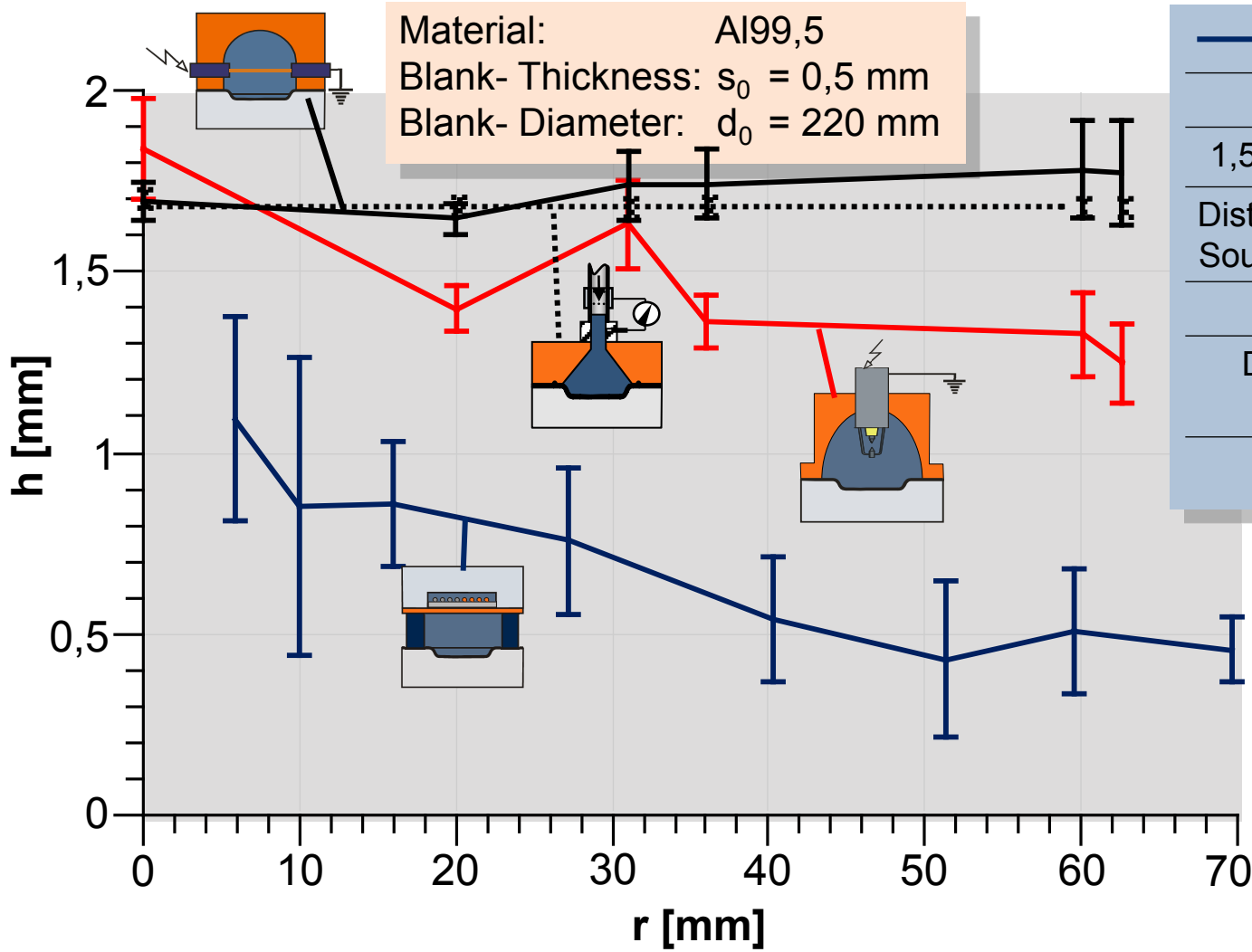


Influence of the Wire- Thickness Using a Constantan Wire



Workpiece Geometry – Comparison of High Speed Hydroforming Setups

Material: Al99,5
Blank- Thickness: $s_0 = 0,5$ mm
Blank- Diameter: $d_0 = 220$ mm



—	—	—
Energy in kJ			
1,5	1	1	0,6
Distance between Pressure Source and Sheet l_{Ps} in mm			
	120	110	335
Distance between the Electrodes l_E in mm			
	7	30	

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

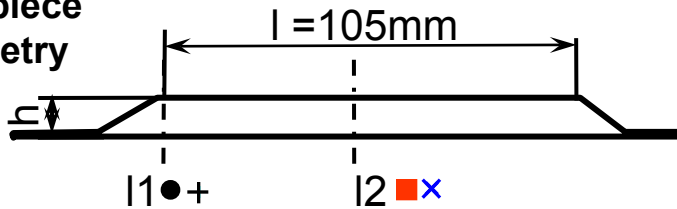
Blank- Material
 ASTM 304

Pneumomechanical Setup

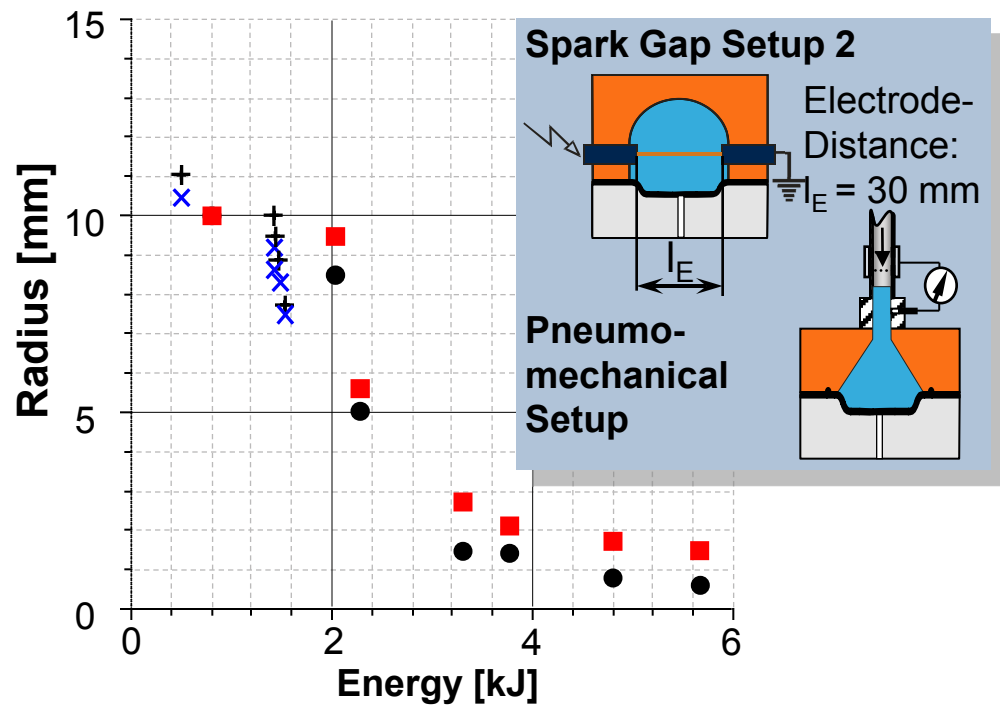
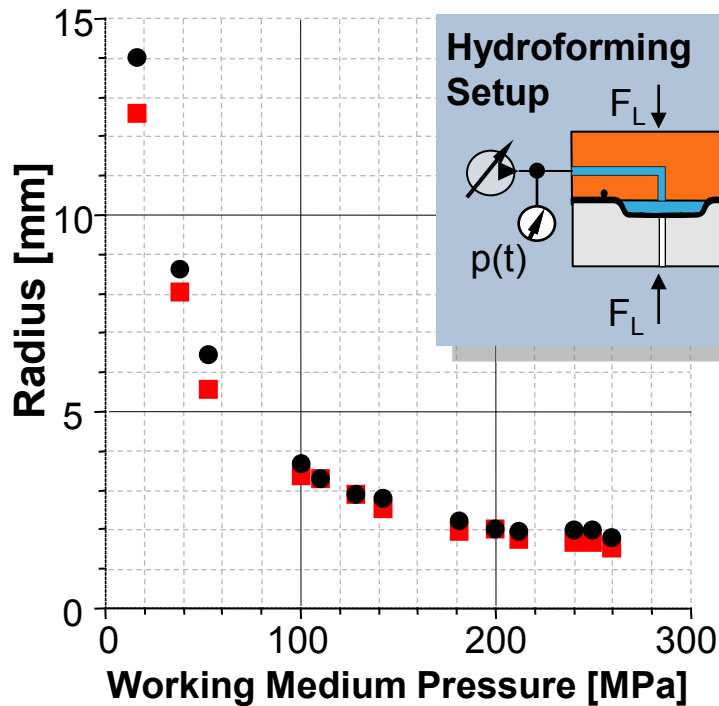
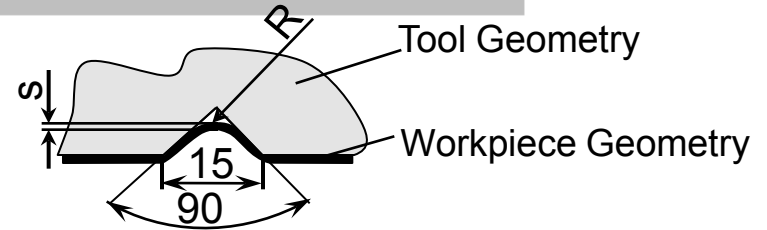
● ■

+ ×

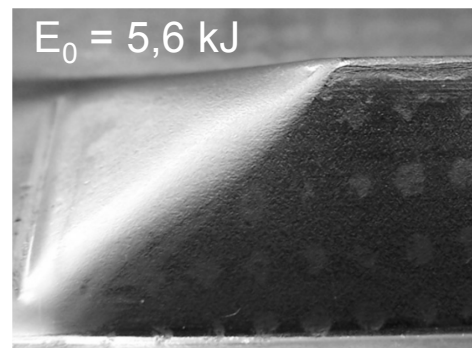
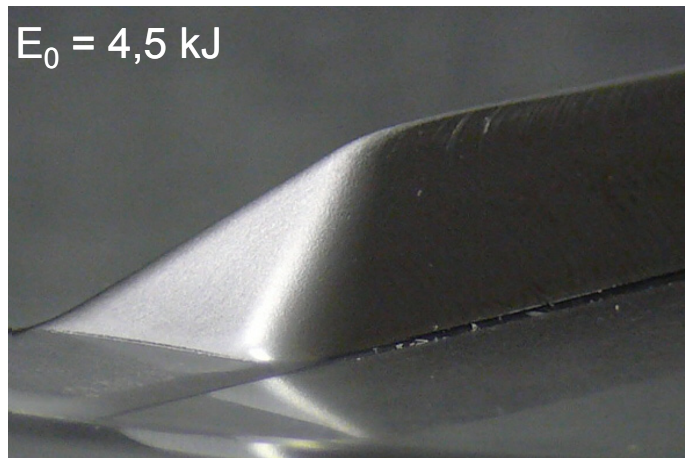
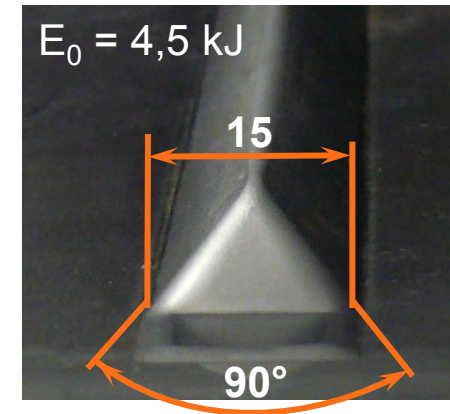
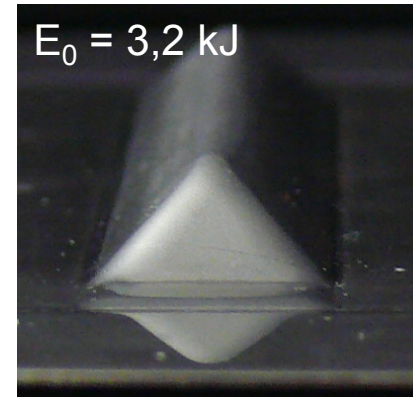
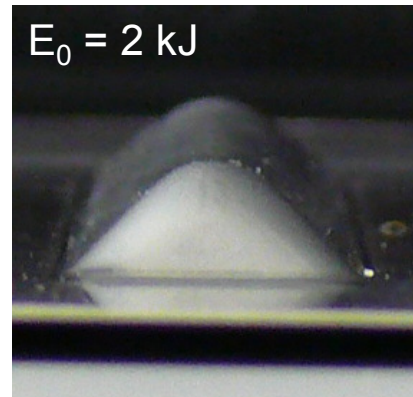
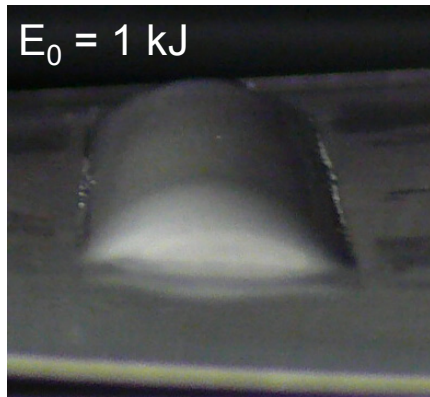
Workpiece Geometry



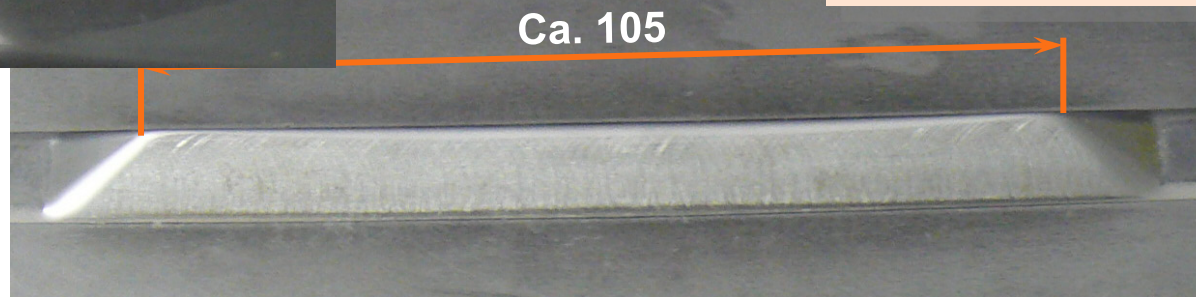
Section plane x-y(I)



Electrohydraulic Forming – Influence of the Charging Energy on the Geometry



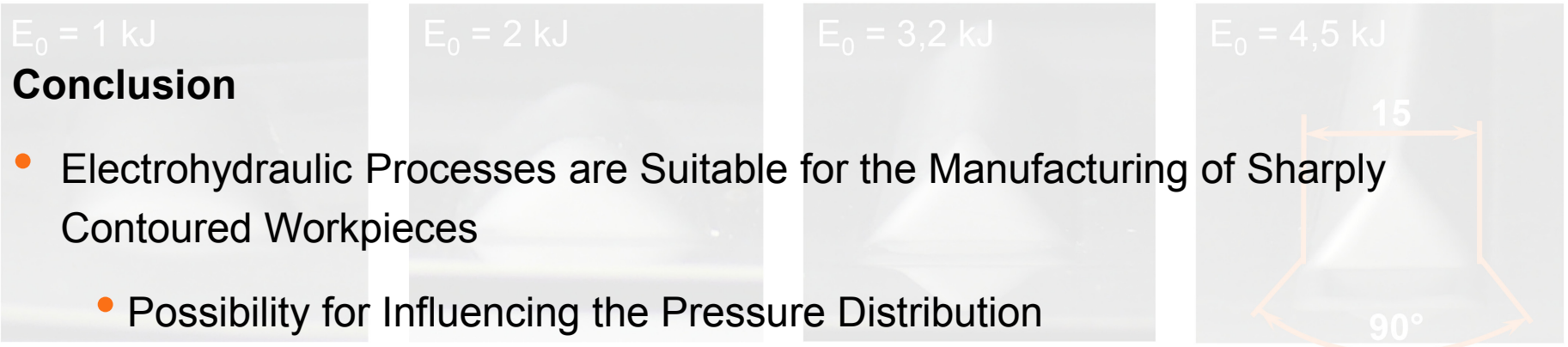
Material:	ASTM 304
Blank- Thickness:	$s_0 = 0,5 \text{ mm}$
Blank- Diameter:	$D_0 = 220 \text{ mm}$
Electrode- Distance:	$l_E = 30 \text{ mm}$
Wire- Material:	ASTM 304
Wire- Diameter:	$d_W = 0,1 \text{ mm}$



$E_0 = 1 \text{ kJ}$ $E_0 = 2 \text{ kJ}$ $E_0 = 3,2 \text{ kJ}$ $E_0 = 4,5 \text{ kJ}$

Conclusion

- Electrohydraulic Processes are Suitable for the Manufacturing of Sharply Contoured Workpieces
 - Possibility for Influencing the Pressure Distribution



$E_0 = 4,5 \text{ kJ}$ $E_0 = 5,6 \text{ kJ}$

Outlook

- Realization of Strong Local Deformation
- Lower Locking Forces
- Improvement of Geometrical Accuracy Necessary
- Forming of Semi Finished Parts

Material:	304
Thickness:	$s_0 = 0,5 \text{ mm}$
Diameter:	$D_0 = 220 \text{ mm}$
Spark gap:	$l_E = 30 \text{ mm}$
Wire- Material:	1.4301
Wire- Diameter:	0,1 mm

