



ICHSF2012

**5th International Conference
on High Speed Forming,
ICHSF 2012**

**April 24th - 26th, 2012
Dortmund, Germany**



**Online measurement of the radial workpiece displacement in
electromagnetic forming subsequent to hot aluminum extrusion**

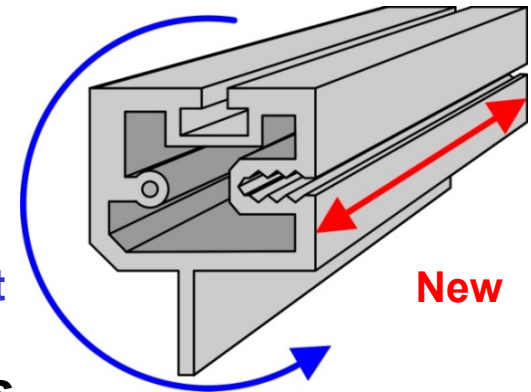
Andreas Jäger, A. Erman Tekkaya

- **Motivation and objective**
- **Processing of aluminum profiles subsequent to hot extrusion**
- **Online measurement of the radial workpiece displacement**
- **Summary and outlook**

- **Hot aluminum extrusion**

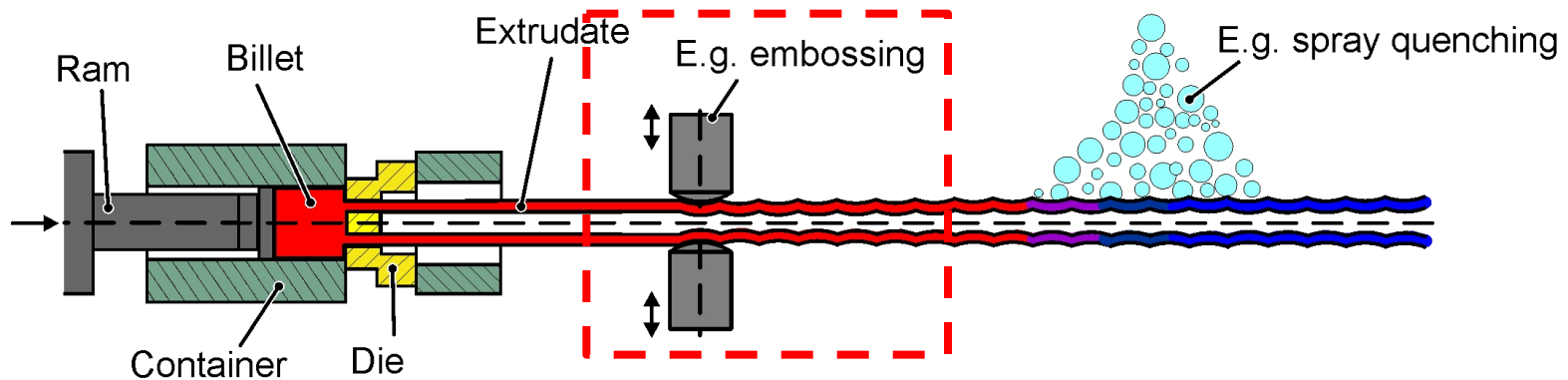
- + Straight, semi-finished products, mass production
- + Geometric complex cross sections possible
- + Integration of functionalities
- Homogeneous material properties
- Constant cross section

State of the art



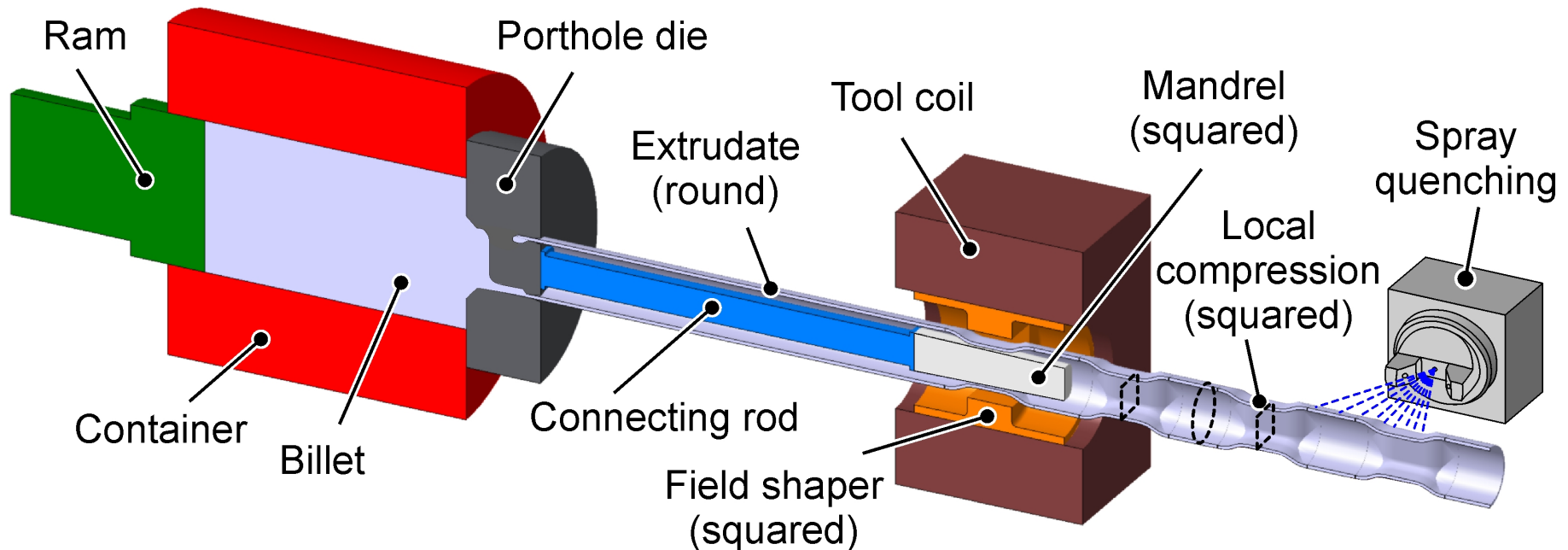
- **Integration of subsequent processing steps**

- **Manufacturing of function-adapted structural components**

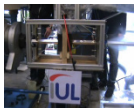
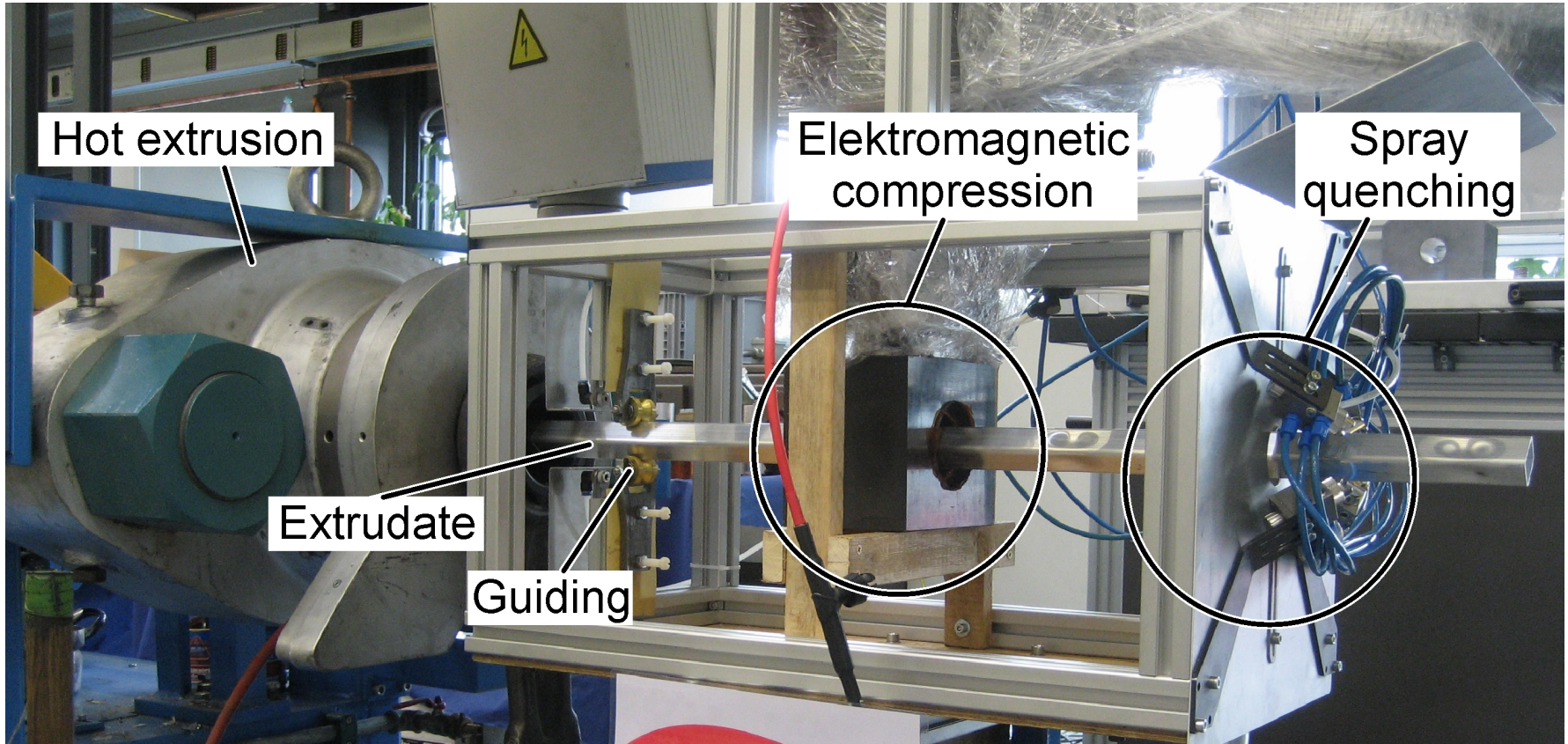


● Principle

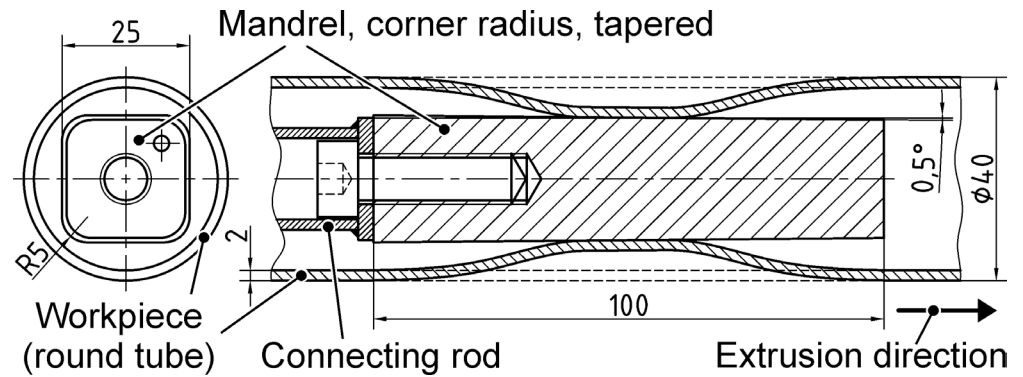
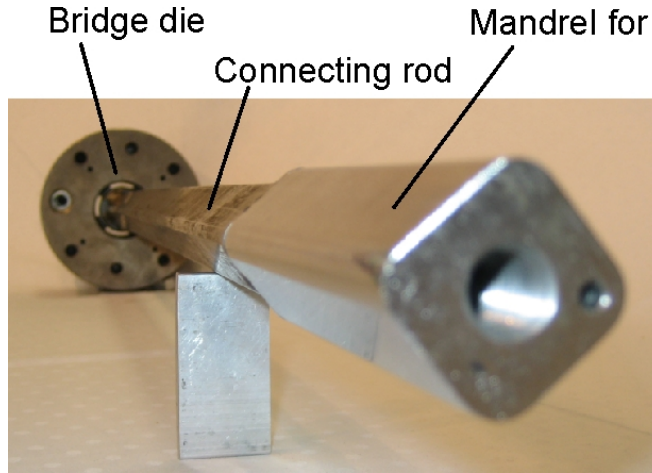
- Hot extrusion of aluminum tubes combined with subsequent (hot) electromagnetic compression
- Performing electromagnetic forming as a free forming operation or tool assisted



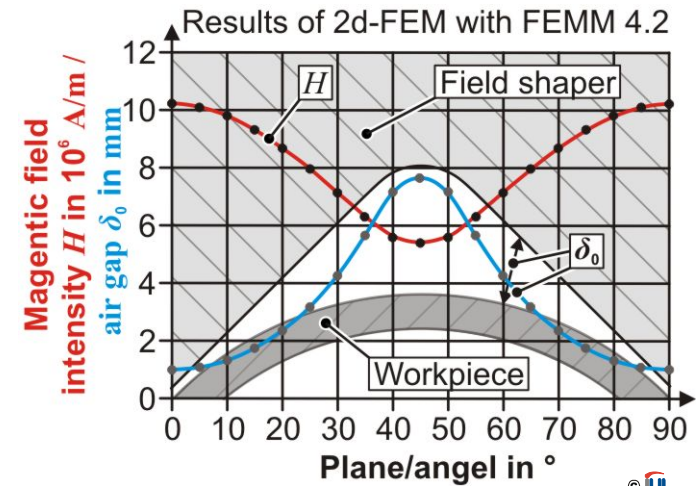
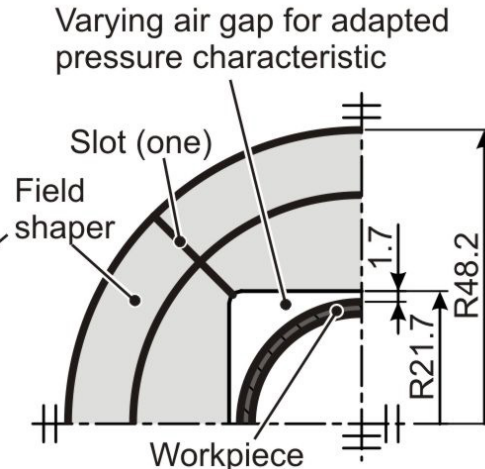
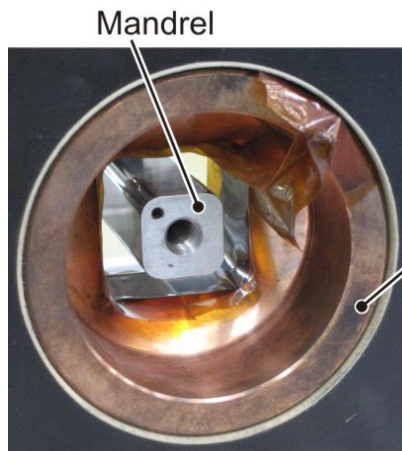
Patent application DE 10 2009 039 759 A1: Jäger, A., Risch, D., Tekkaya, A. E., 2009.



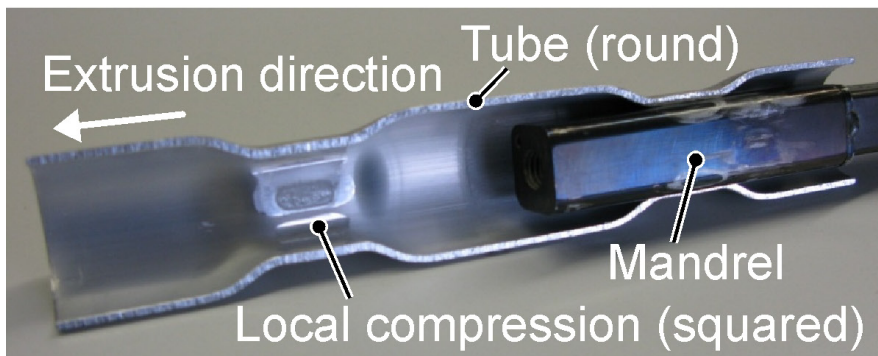
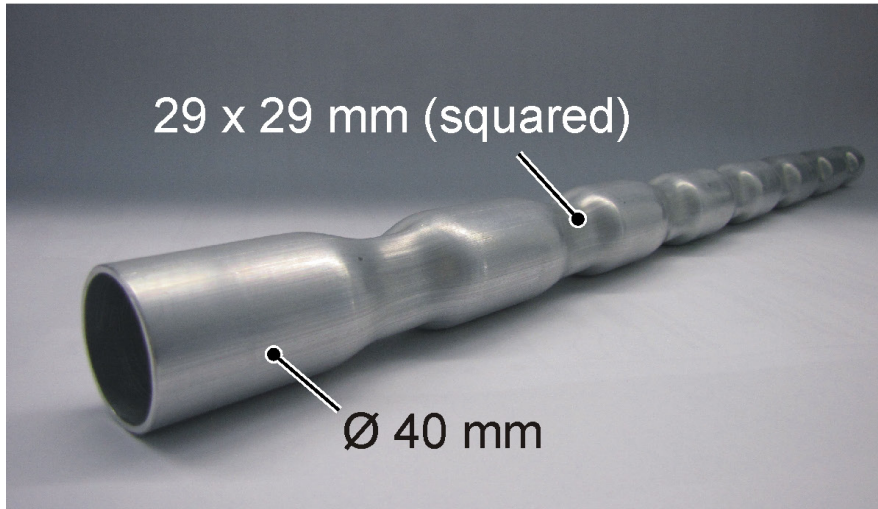
Die/mandrel assisted electromagnetic forming (EMF)



Varying air gap → varying pressure along the circumference



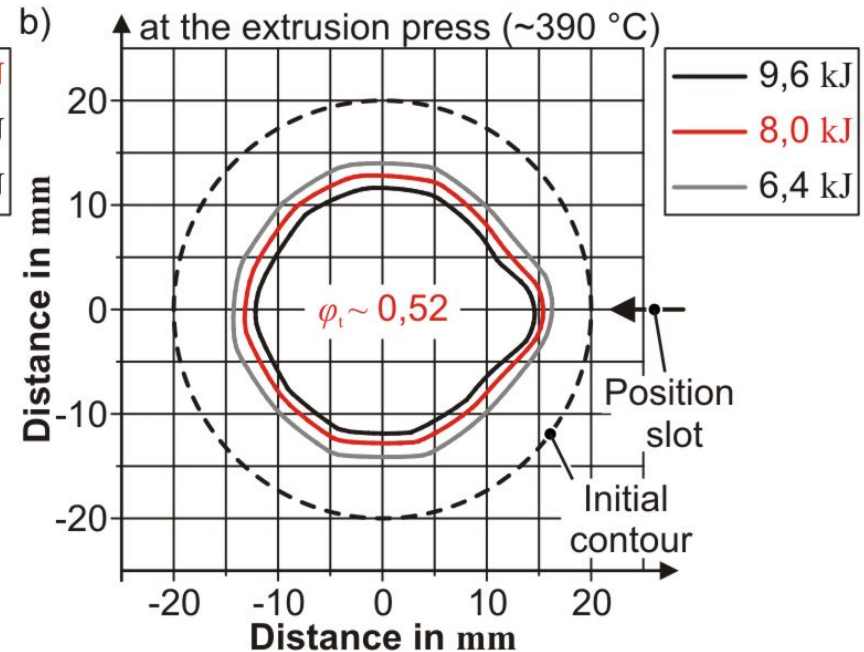
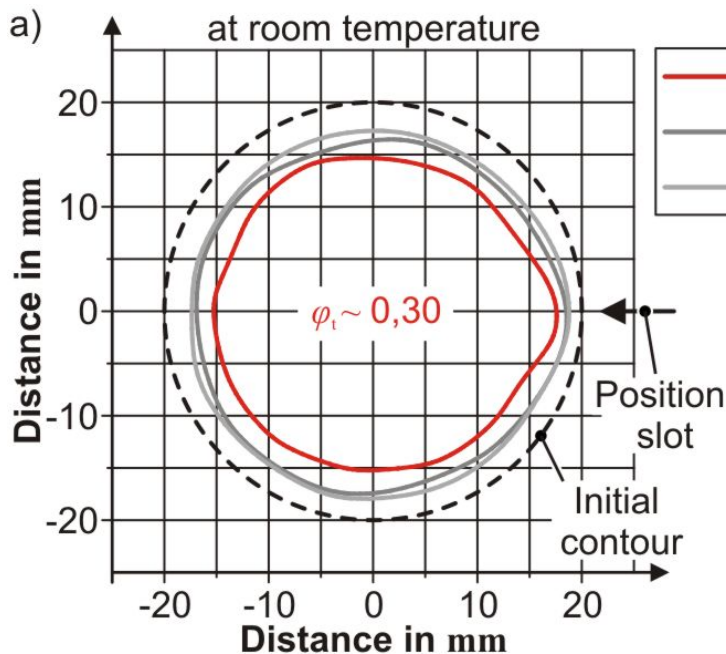
- **Result**



- **Application:**
Crashbox (inversion tube)

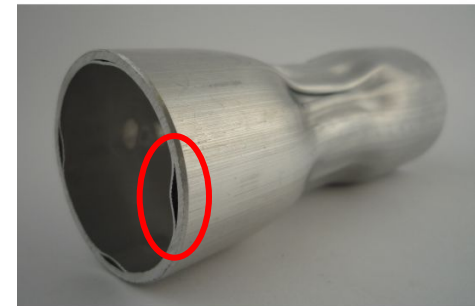
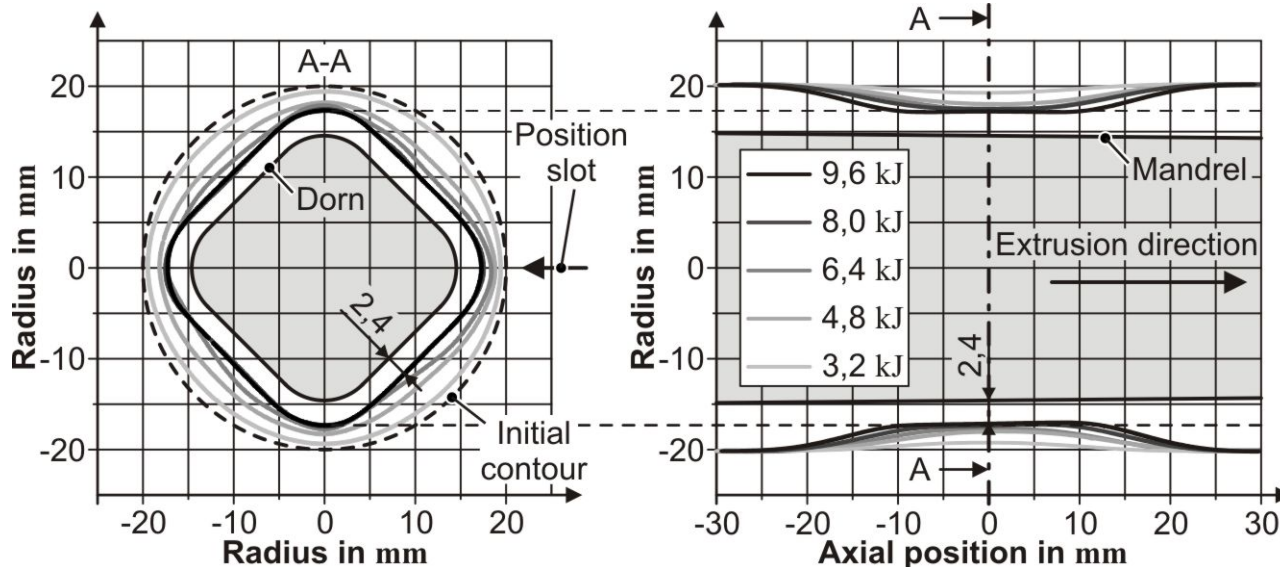


- Quasi continuous process
- Reduced handling (workpiece is guided and aligned)
- Using heat of extrusion for subsequent processing (forming, heat treatment)
- High temperature = higher formability



Hot extrusion and electromagnetic forming - Challenges and problems

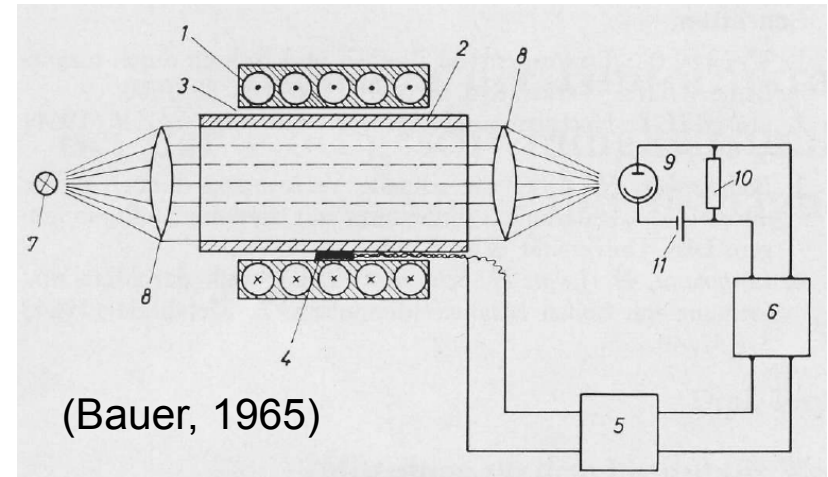
- **Pile-up of the extrudate caused by force fit between workpiece and mandrel**
- **Delamination and wrinkling in the area of the transverse extrusion weld**
- **Pickup**
- **Meeting geometrical tolerances**



- **→ Process control would be helpful**

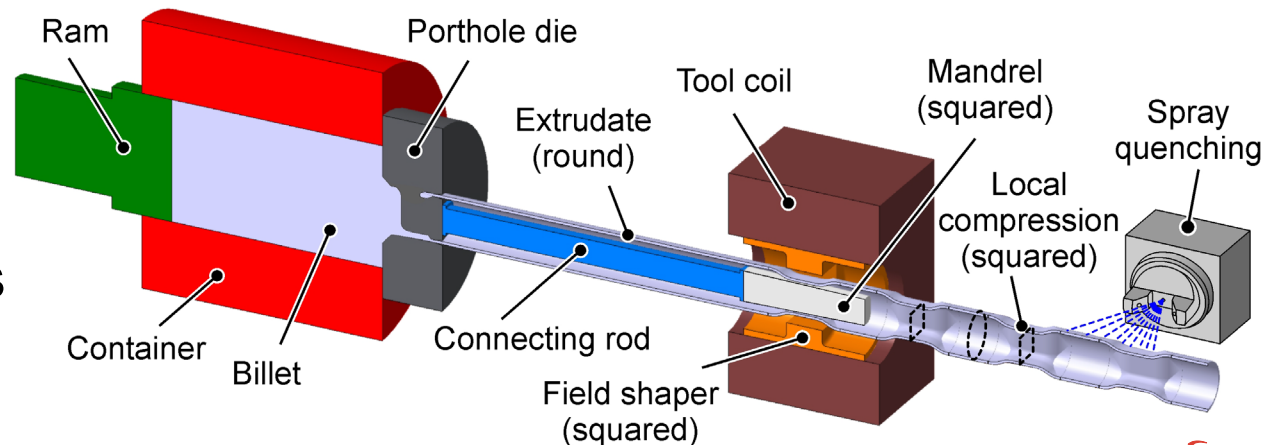
● State of the art:

- Shadowing effect (Bauer, 1965)
- Contact pin (Badelt et al., 2003)
- Photon Doppler Velocimetry (Fenton, 2010)

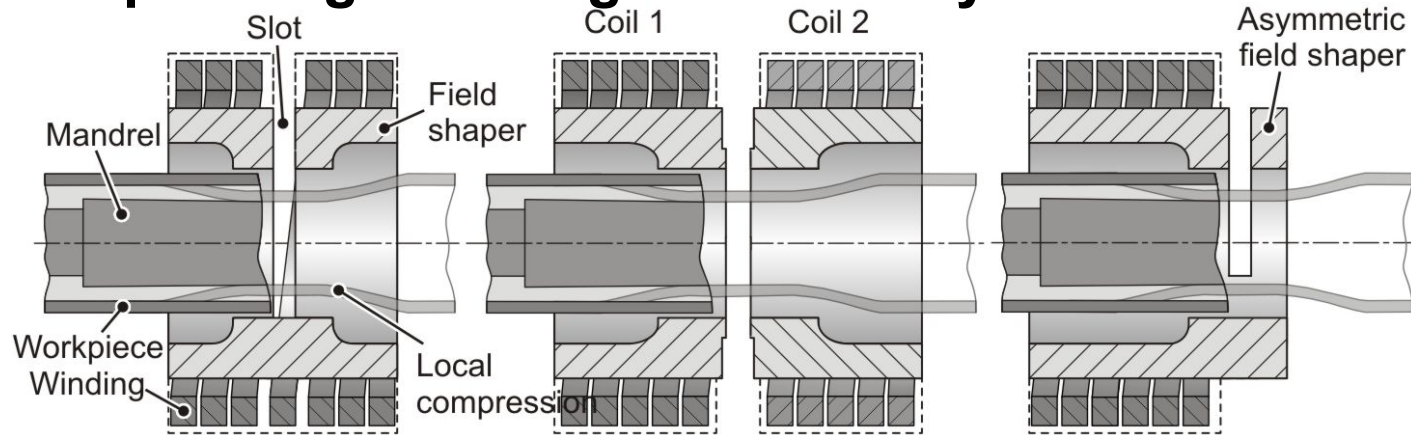


● Problems: High temperature and limited accessibility due to:

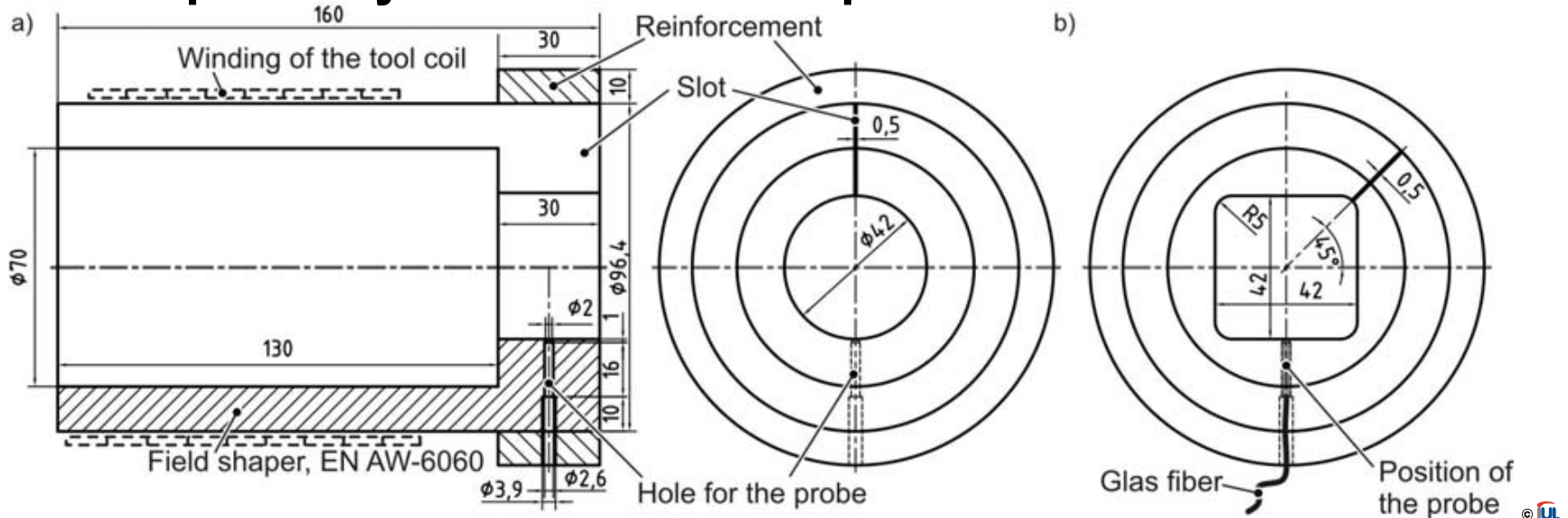
- Tool coil
- Field shaper
- Mandrel
- Extrusion press



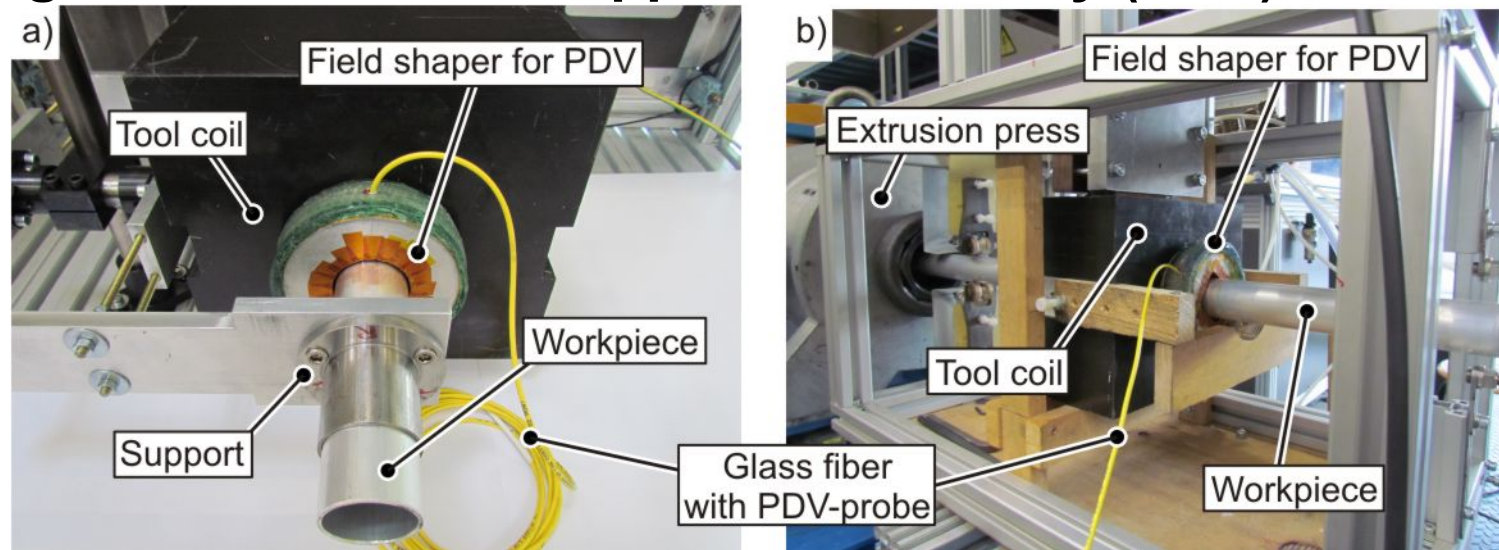
Concepts for generating accessibility



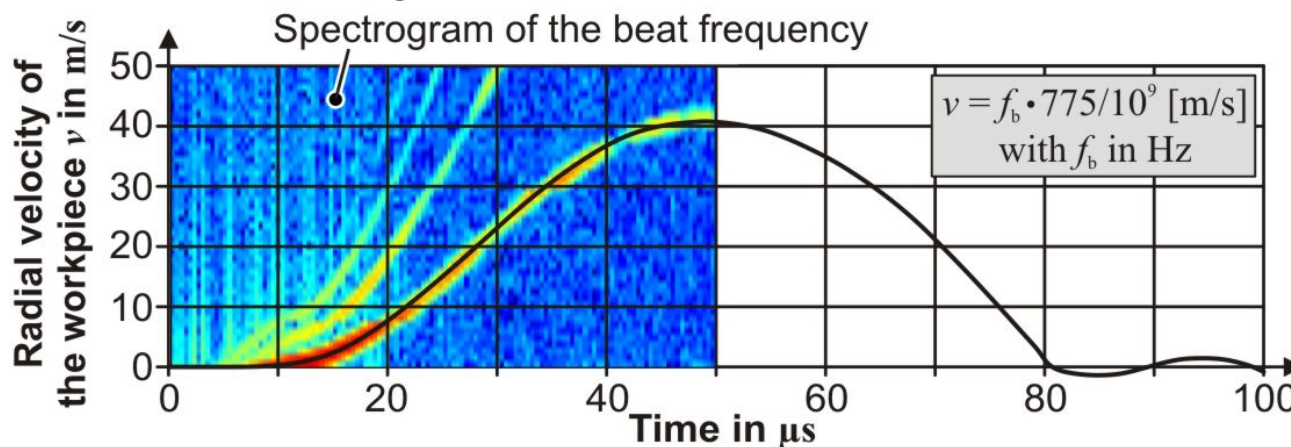
Concept of asymmetric field shaper was selected



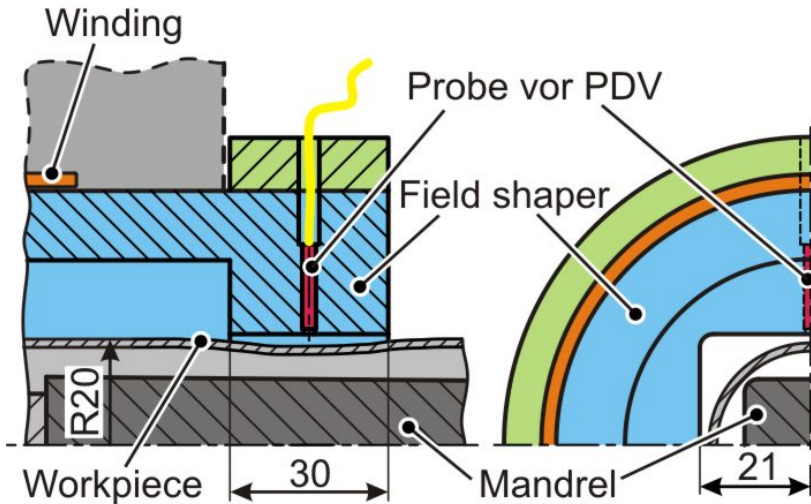
- **Integration of Photon Doppler Velocimetry (PDV) sensor**



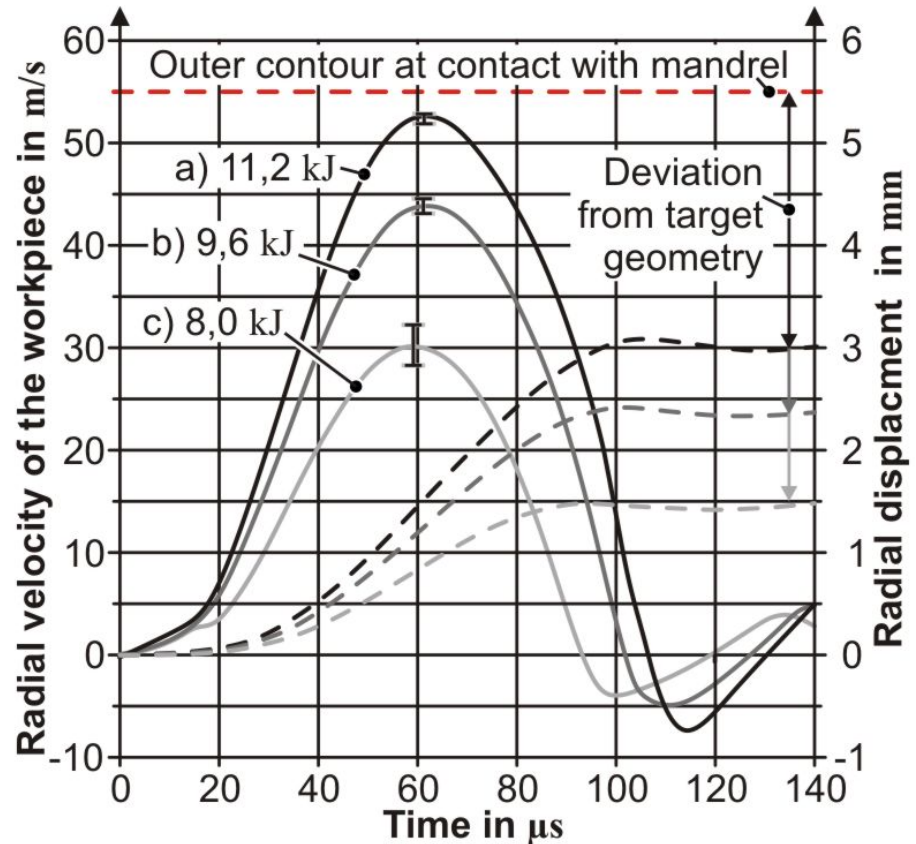
- **Example for the analysis of the PDV**



Results of the PDV-measurement within the process chain

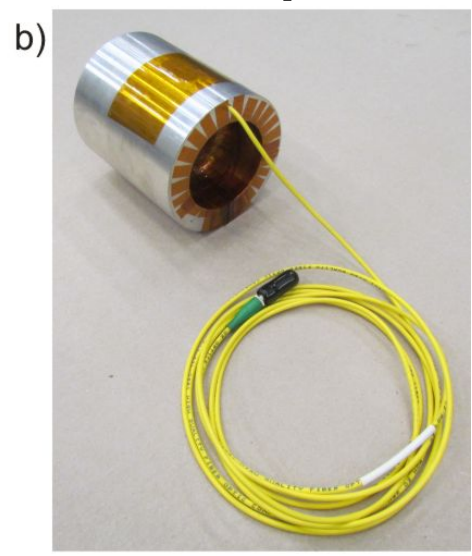
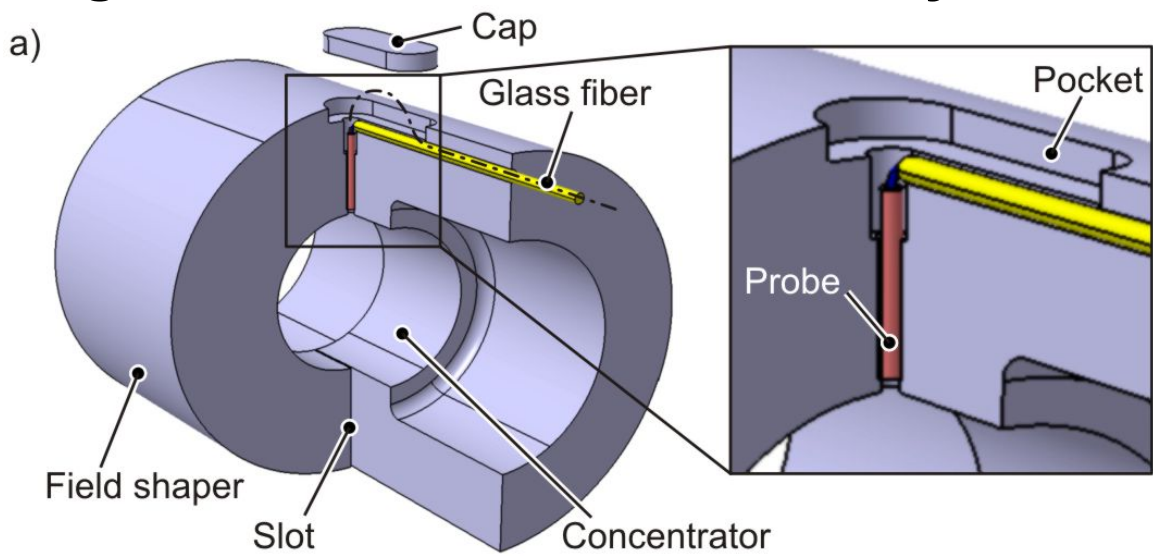


Workpiece: - Tube $\varnothing 40 \times 2$ mm - EN AW-6082 - ~ 400 °C (at the press)	Mandrel: - 25 x 25 mm - 1.2343, 54 HRC
Field shaper: - EN AW-6060 - 42 x 42 x 30 mm	Tool coil: - $\varnothing 97 \times 91.5$ mm - 8 windings

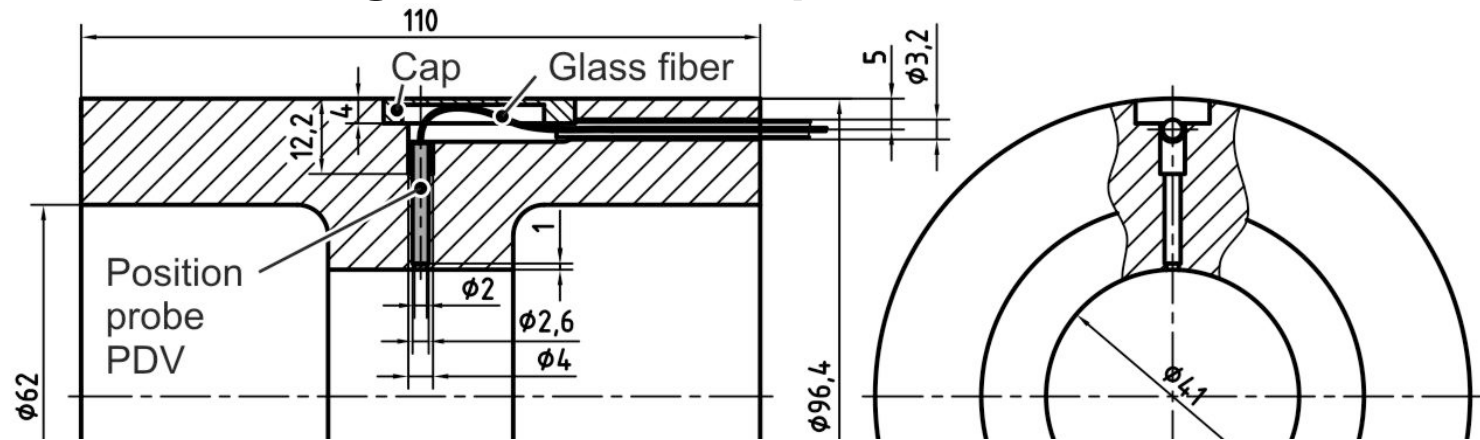


Problem: By using an asymmetric field shaper the efficiency/pressure is insufficient

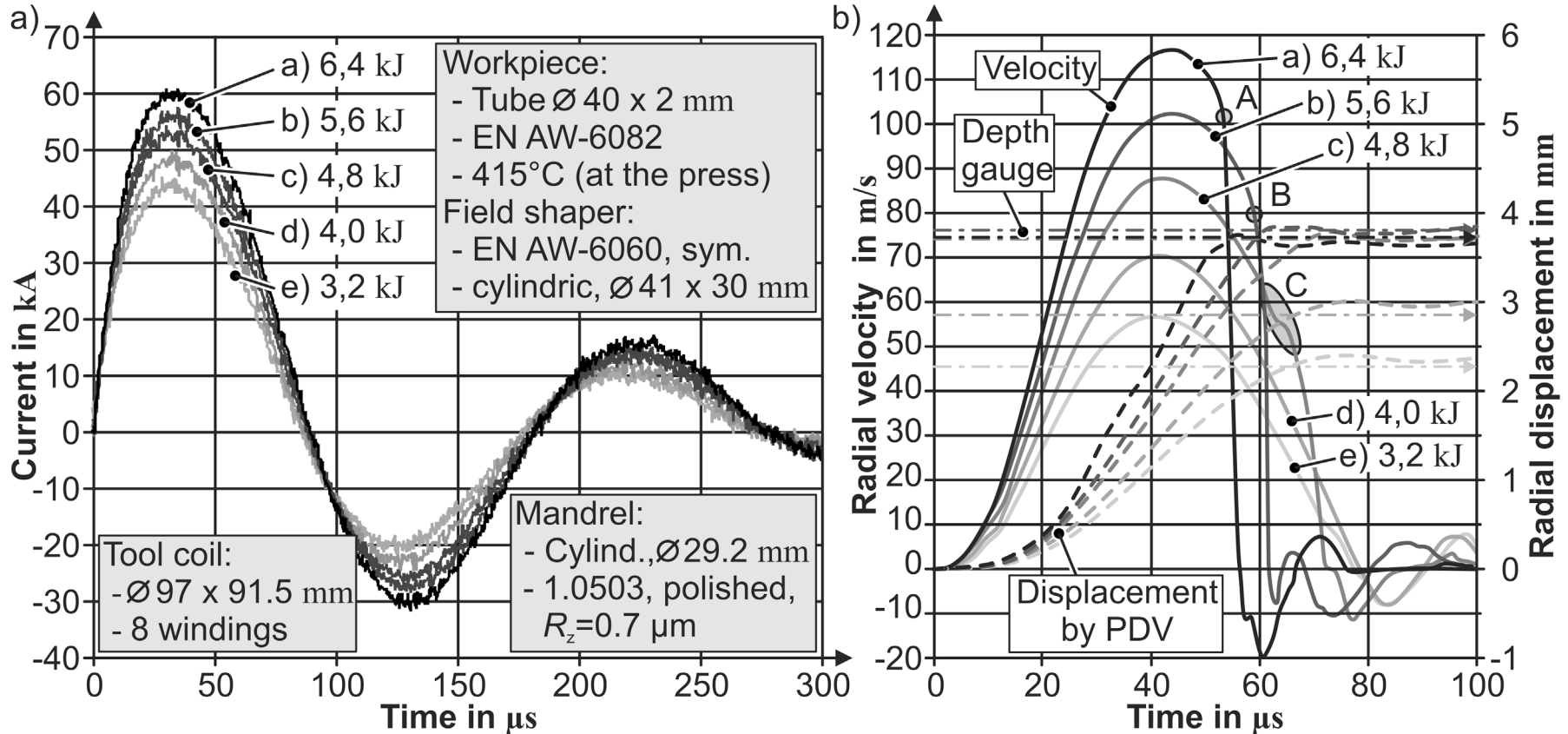
- **Integration of PDV-sensor into a symmetric field shaper**



- **Channel for the glass fiber and probe**



Results of the PDV-measurement within the process chain



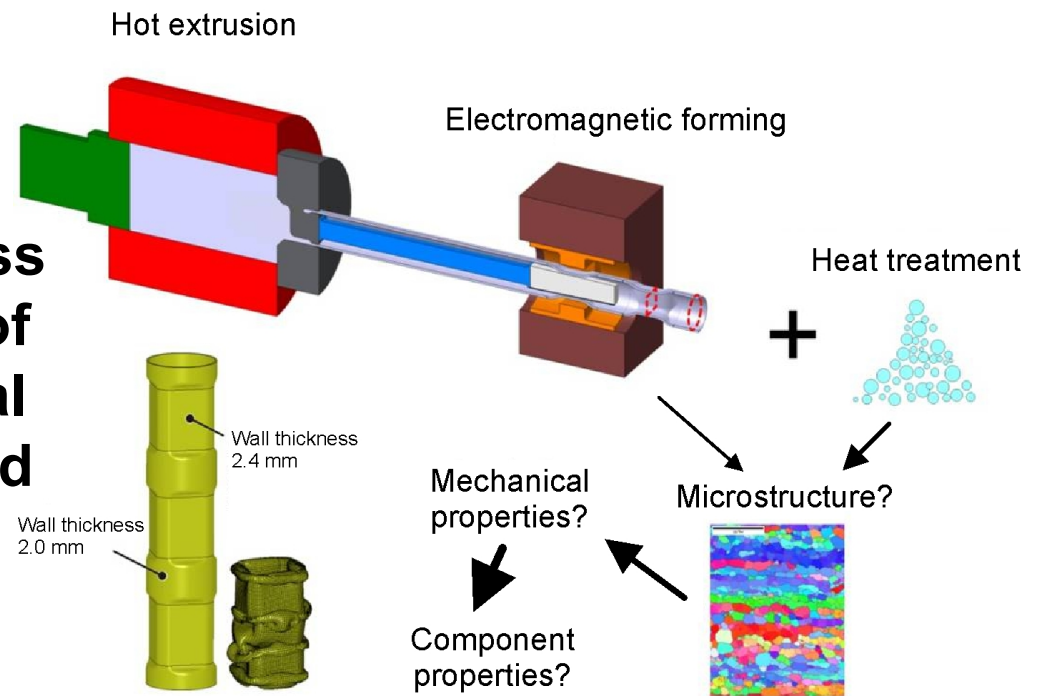
→ Tool for analyzing the workpiece displacement and the characterization of the material under the special conditions of the proposed process combination

- **Summary:**

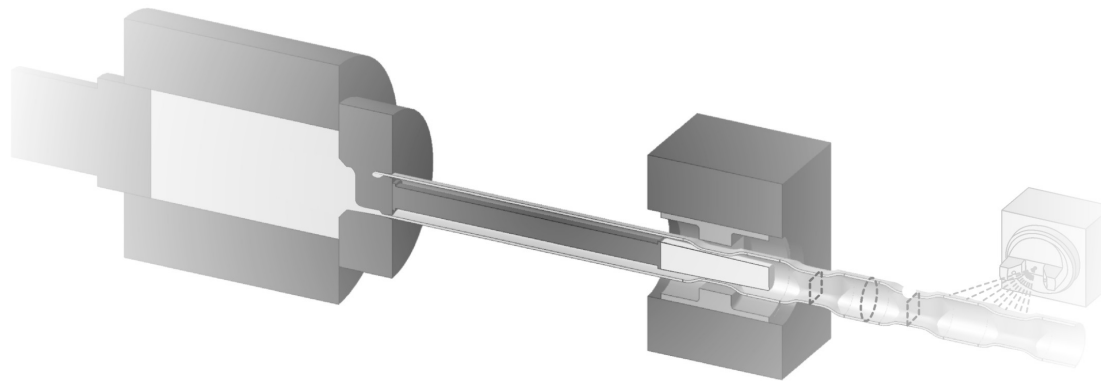
- **Concept for the integrated processing of aluminum profiles subsequent to hot extrusion**
- **Setup for the online measurement of the workpiece displacement in electromagnetic forming**

- **Outlook:**

- **Analysis of the process and characterization of the processed material at high strain rates and temperatures**



Thank you for your attention



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