Determining precision of a high performance transfer press in micro metal forming

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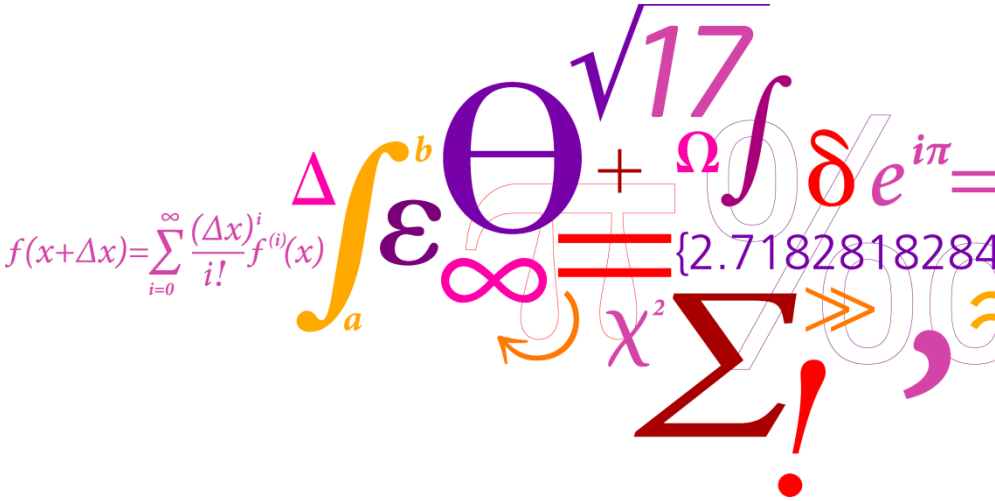

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Why micro forming is interesting?

- Remarkable accuracy

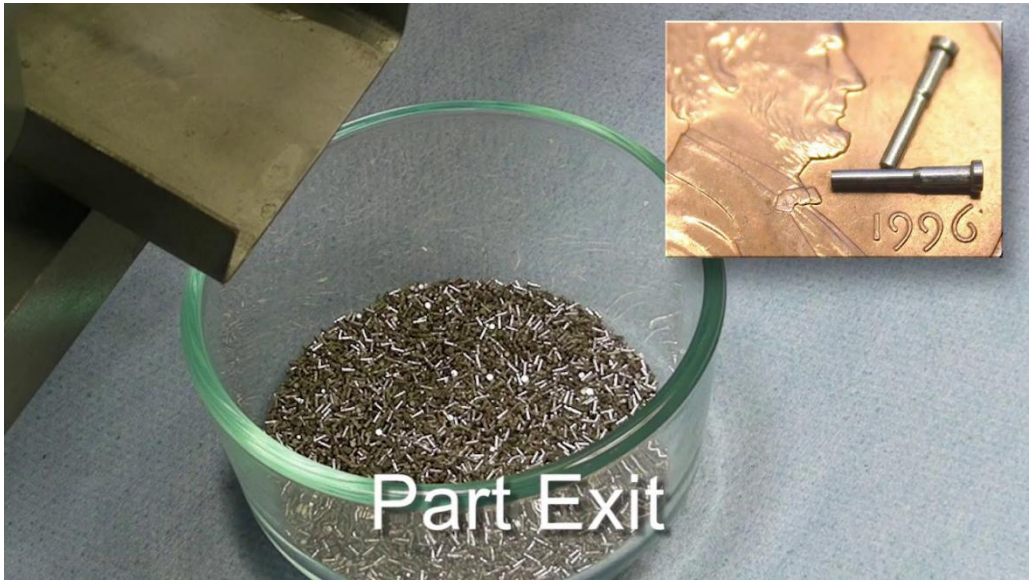
  - Diameters down to 0.15 mm (OD)
  - With wall thicknesses as low as 0.013mm
  - With the length about 60 mm
  - Length-to-diameter ratios greater than 55:1 are attainable
  - Finished part tolerances are as low as ±0.003mm

- Material saving

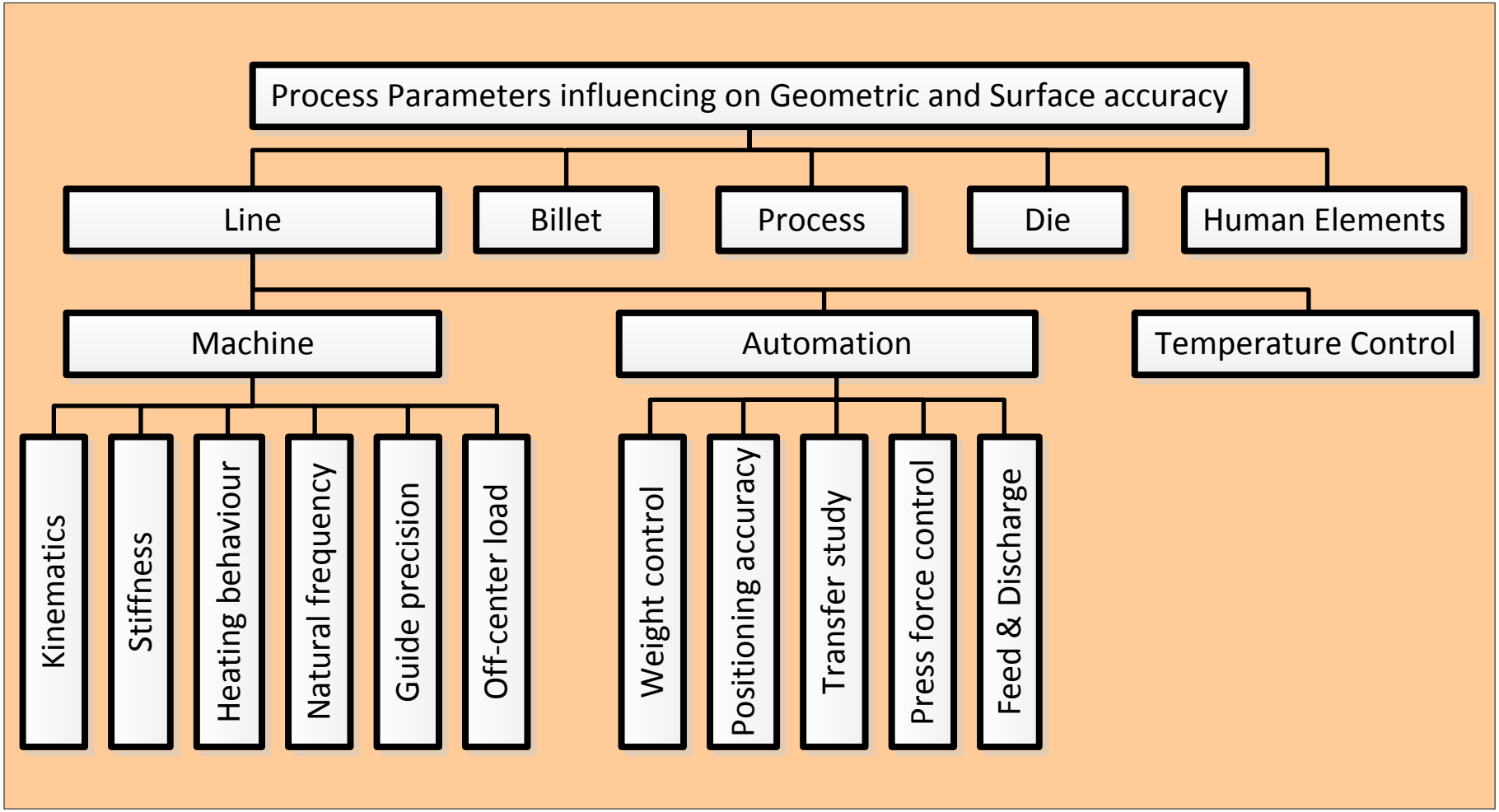
  - Material loss is usually 0-3%, while in machining, chip or grinding loss can be as much as 70% or more.

Why in forming process transferring is important?

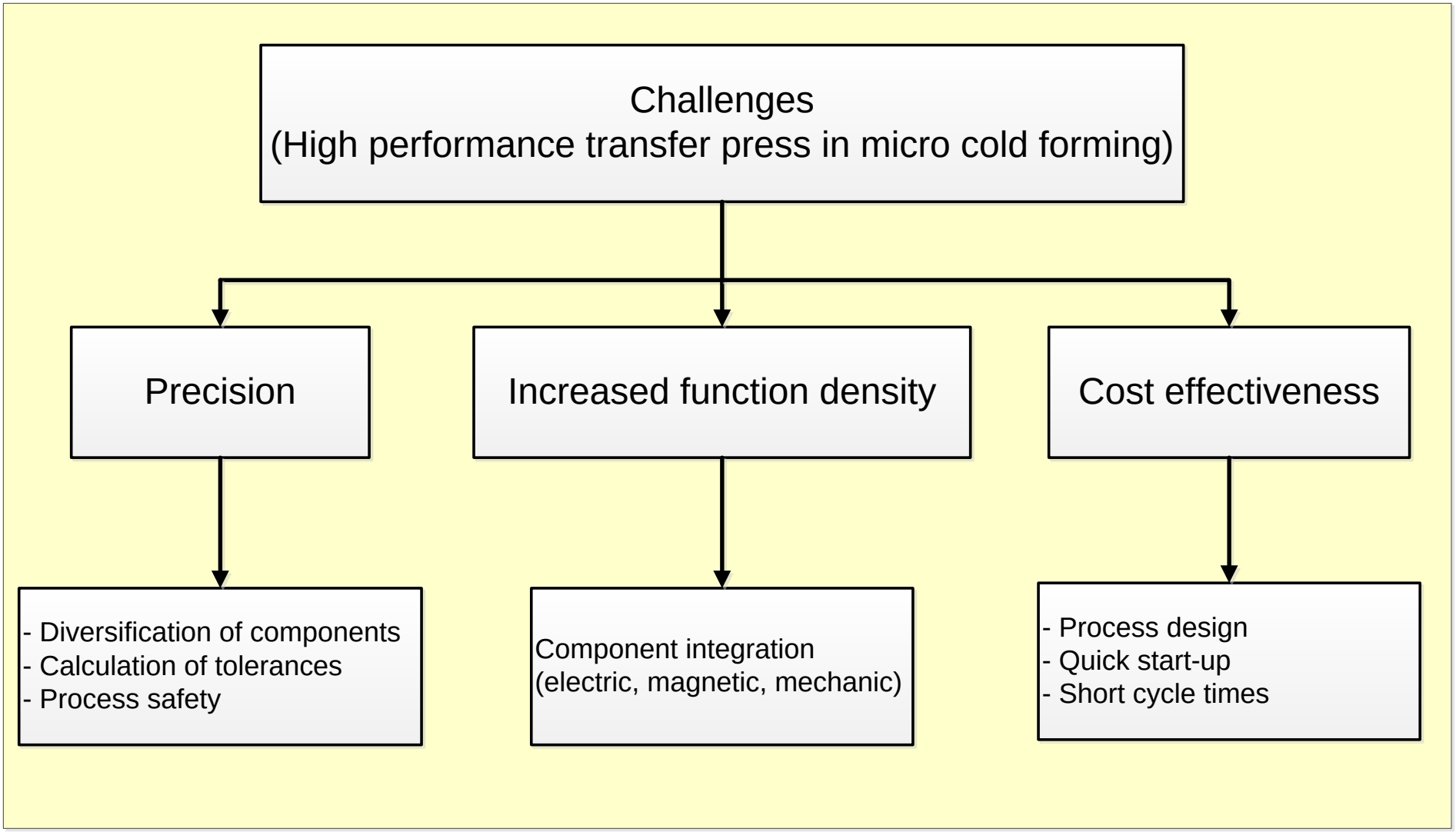
- High rate of production
  - Production speeds are 50-400 parts/minute, compared to 1-2 parts/minute in screw machining
  - Because of these super high production rates and material usage, cold formed part prices are often 40-60% of machined part prices



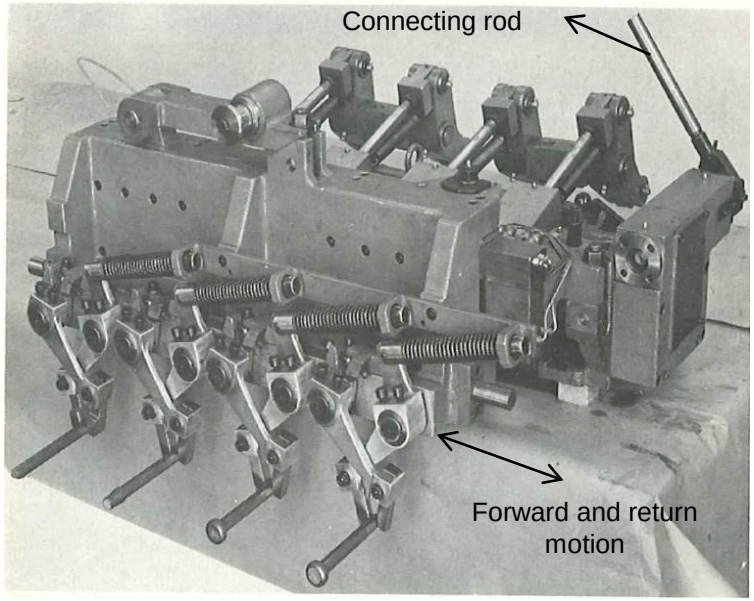
Process parameters



Challenges


Challenges
(High performance transfer press in micro cold forming)
Precision
Increased function density
Cost effectiveness
- Diversification of components
- Calculation of tolerances
- Process safety
Component integration
(electric, magnetic, mechanic)
- Process design
- Quick start-up
- Short cycle times

Conventional Transferring Tools

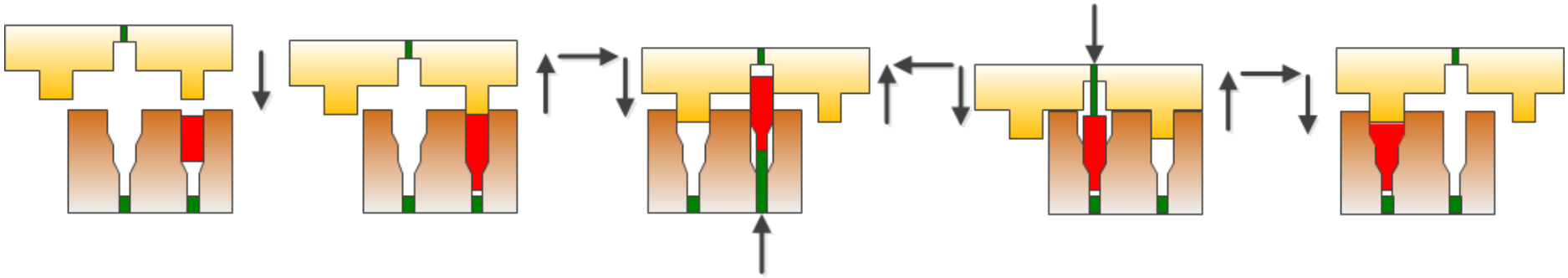


Tschätsch, H., 1977

NEDSCHROEF Machinery

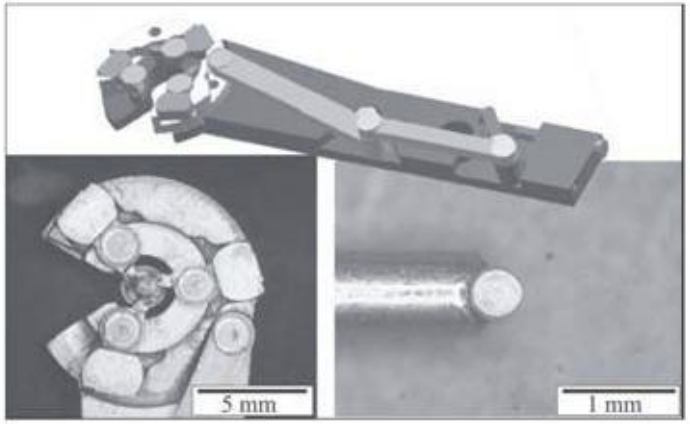
Transferring in micro forming

Miniature parts typically require smaller, more precise equipment



Courtesy of Deringer-Ney

Previous studies



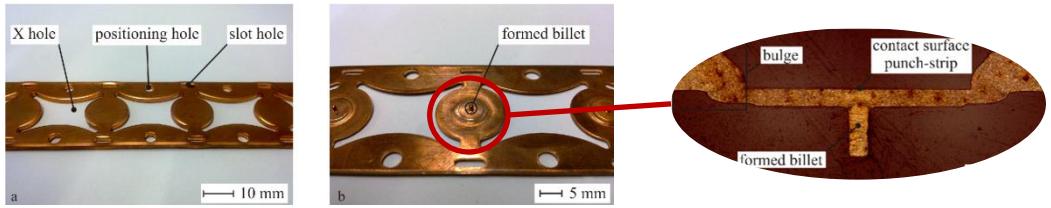
Geiger et al. 2001

- Principle: A mechanical gripper with a vacuum microgripper
- Repeating accuracy: between 5 µm and 15 µm
- The transfer length is 25 mm
- Wire: ø0.85 mm
- Speed: max. 260 strokes/min.

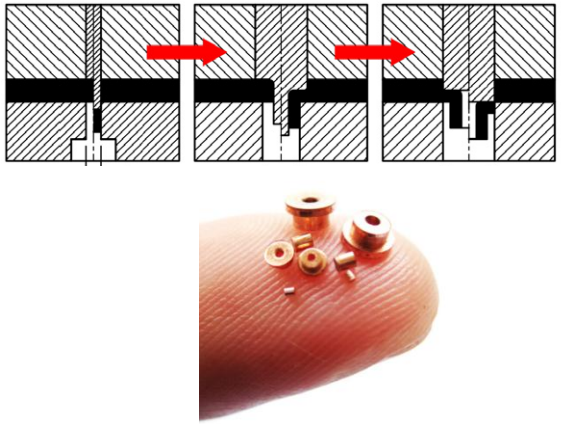
Wafios AG, 2007

- Principle: Horizontally mounted rotor with eight dies
- Wire: max. ø1.4 - 2.6 mm
- Feed length: max. 12 mm
- Speed: max. 400 strokes/min.

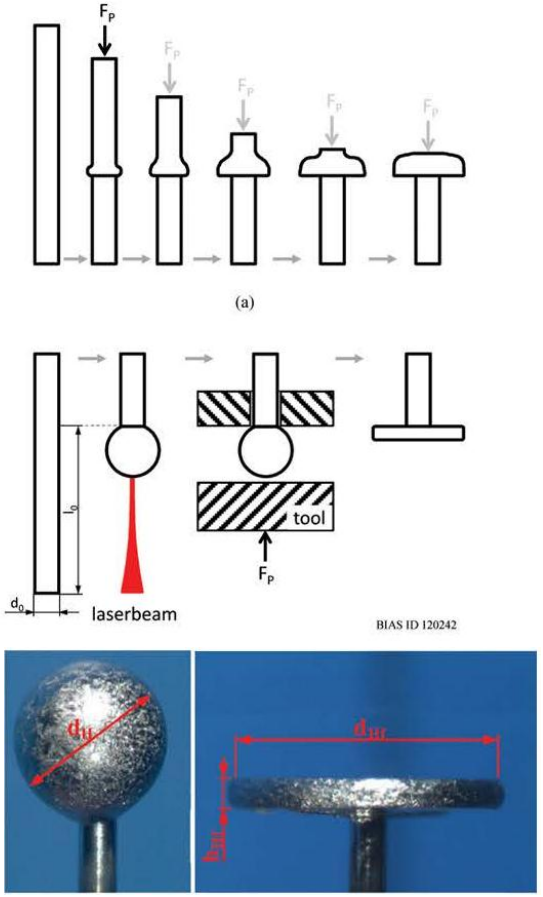
Recent studies



Experimental study of a full forward extrusion process from metal strip [Merklein, et al., 2012]

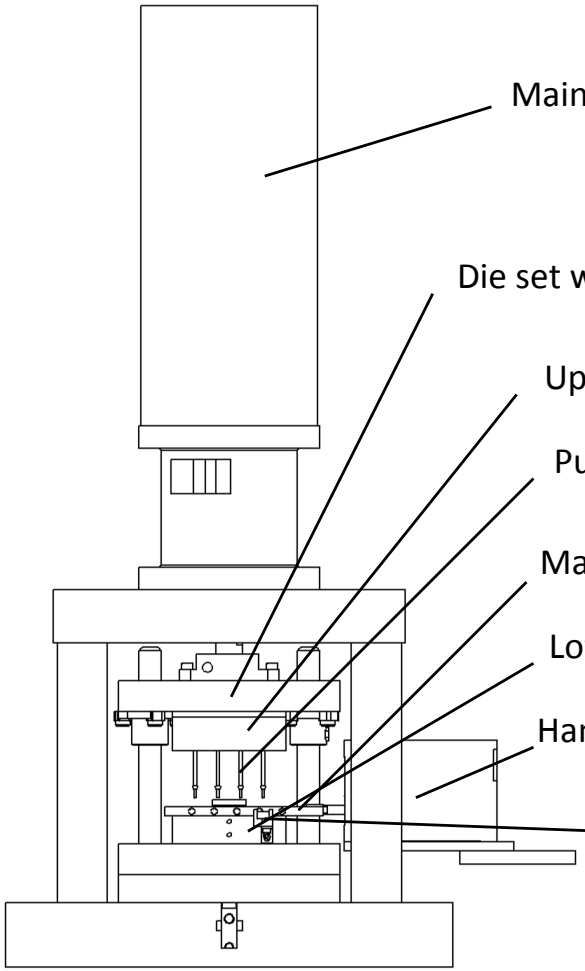


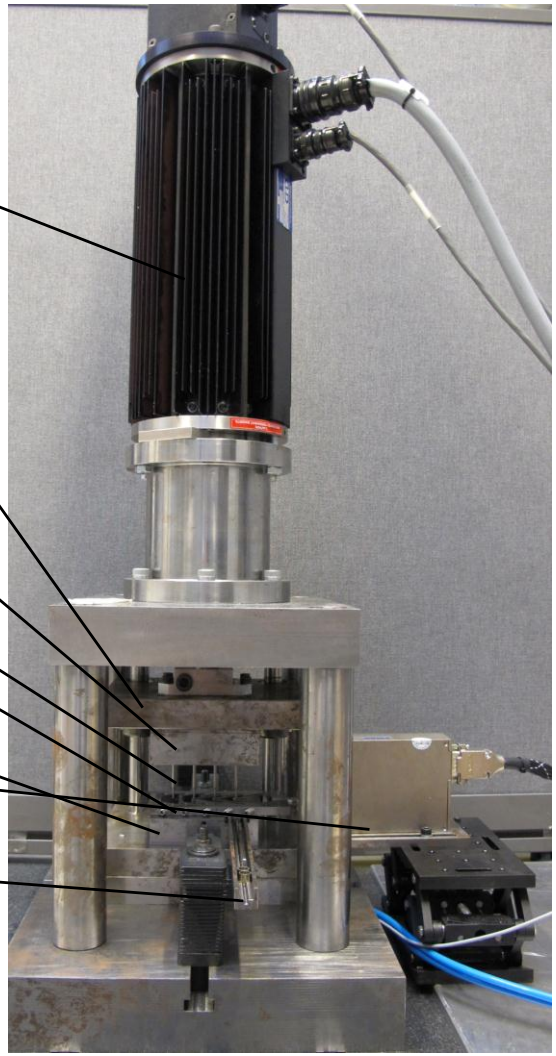
Micro-scaled progressive forming of bulk micropart from sheet metals [Fu, et al., 2013]



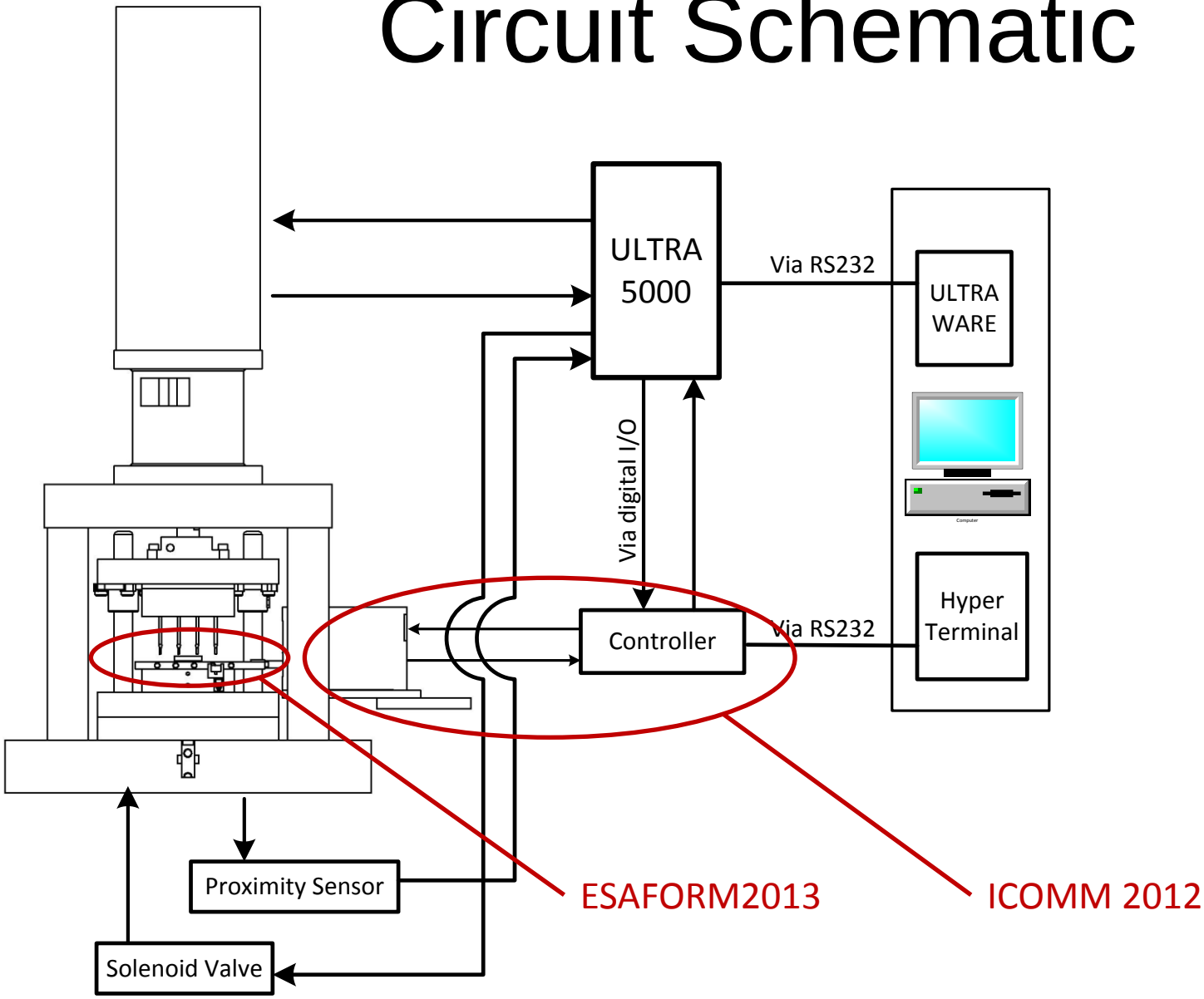
Investigation on Flow Stress Level of Spherical Preforms Generated by Laser Melting [Heiko Brüning & Frank Vollertsen, 2013]

Experimental setup

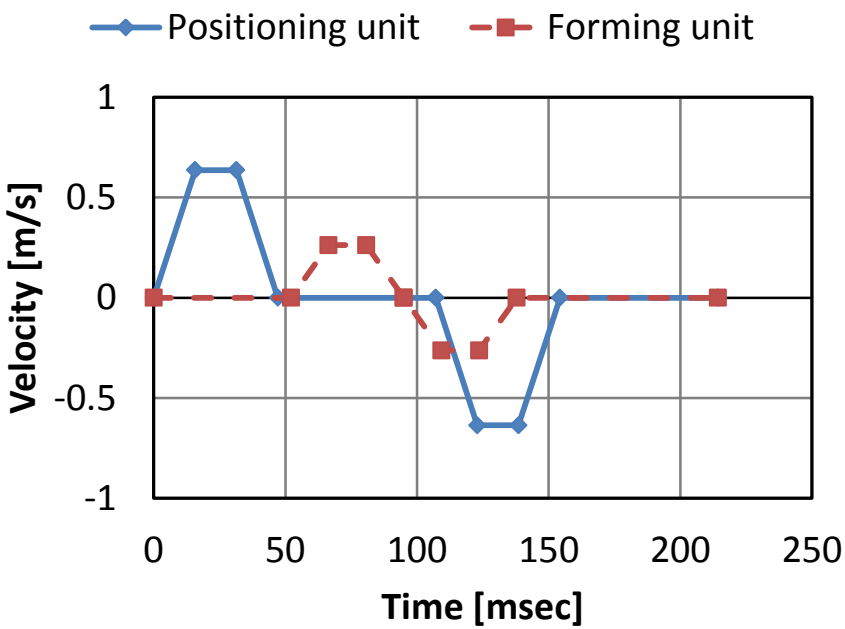


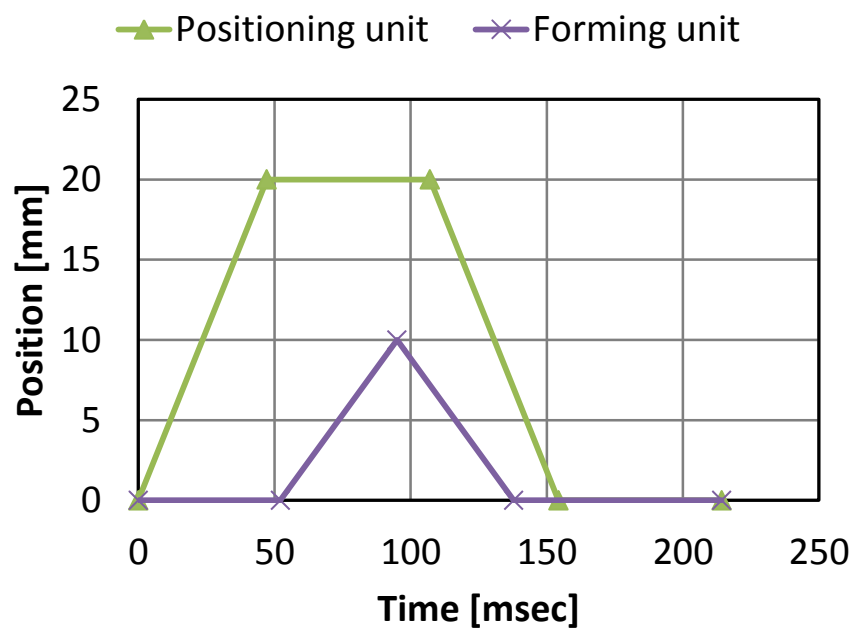


Circuit Schematic



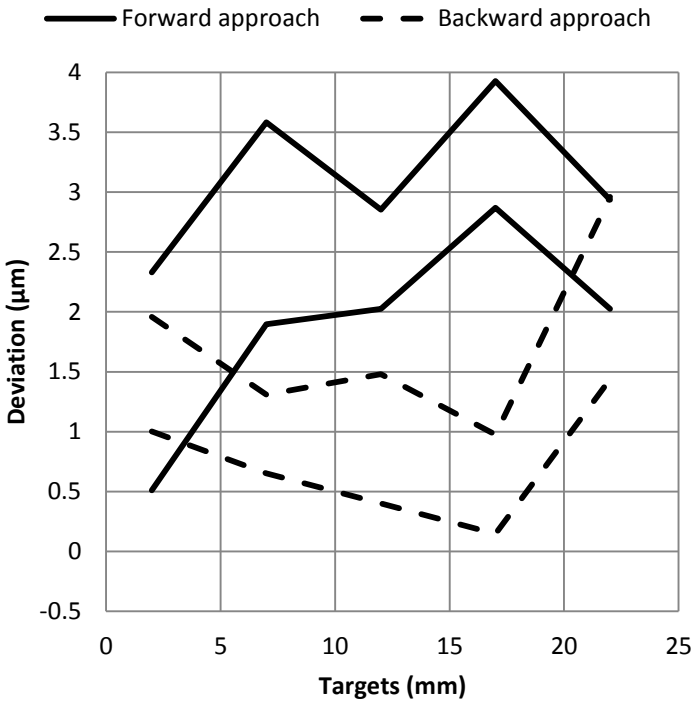
Dynamic parameters





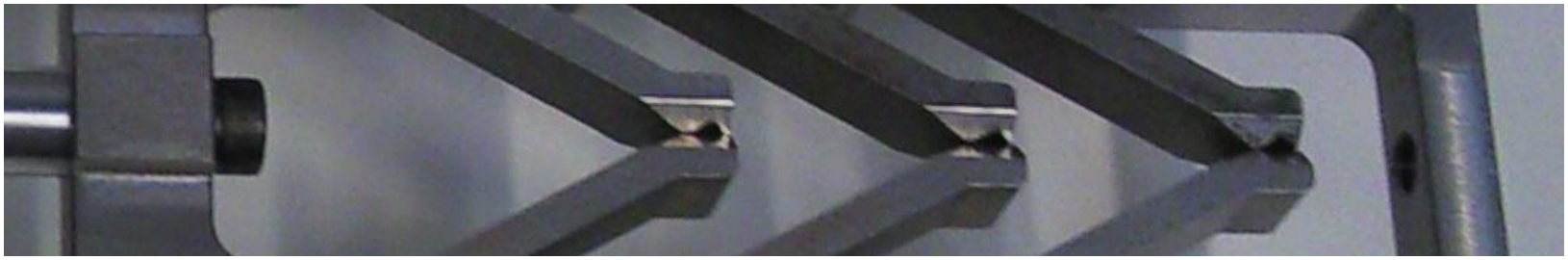
	Servo motor (Press)	Servo motor (Transport device)
Displacement (mm)	7.5	20
Half cycle time (ms)	60	120
Velocity (mm/s)	187.5	500
Acceleration (mm/s^2)	9400	40000
Dwell time (ms)	0	120
Moving mass (kg)	App. 15	App. 0.3

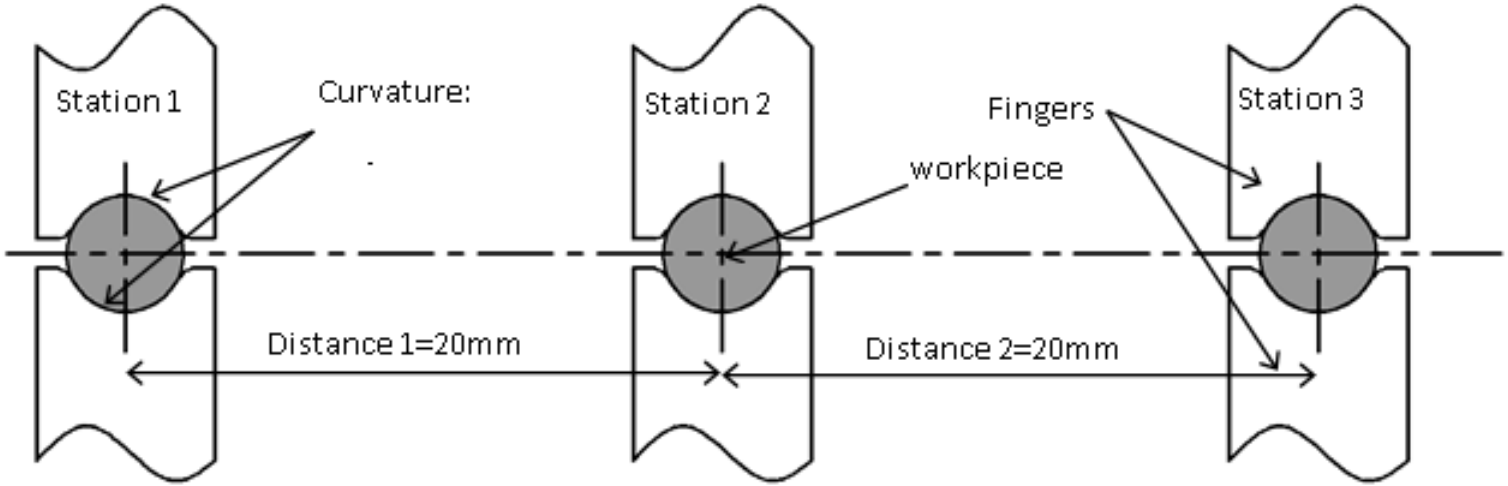
Error graph for single-axis error

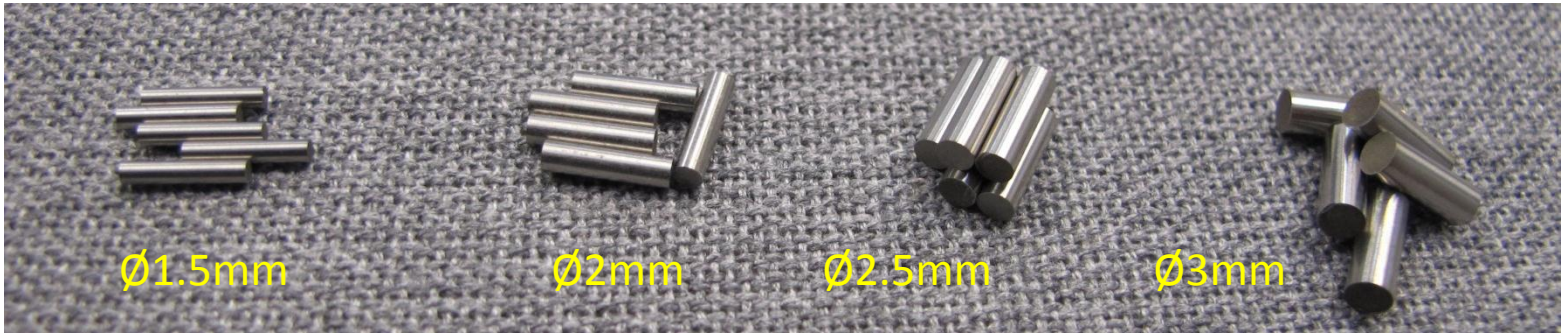


Accuracy and repeatability according to ISO 230-2

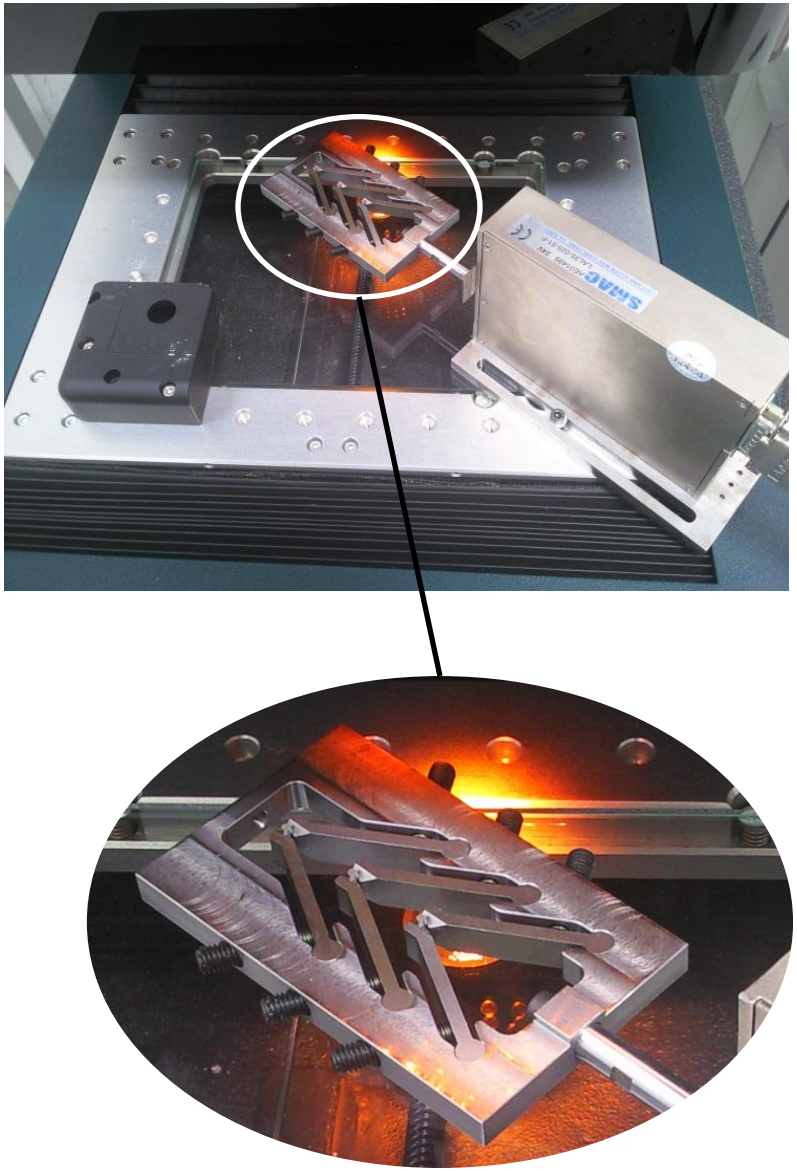
Gripping unit





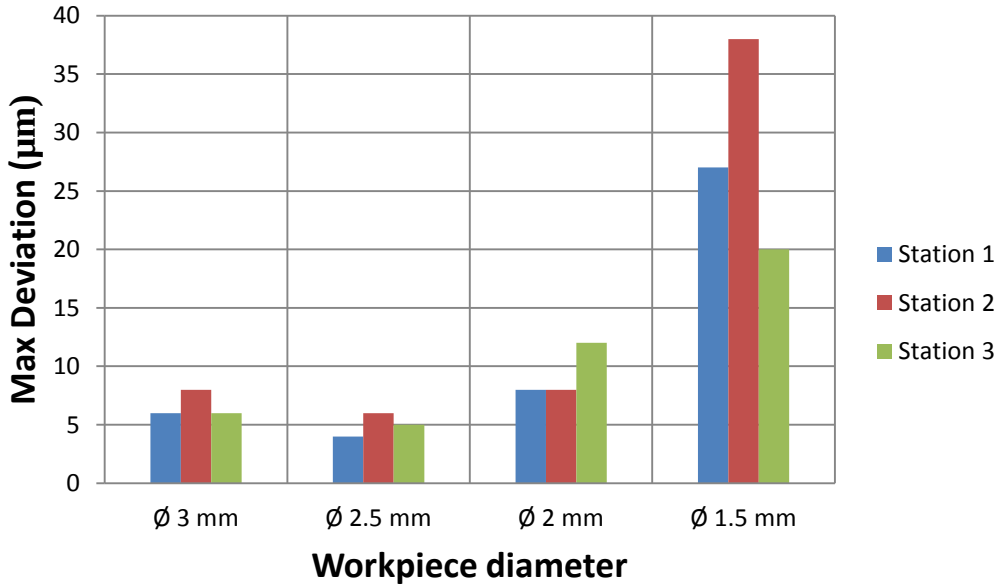


Experimental setup

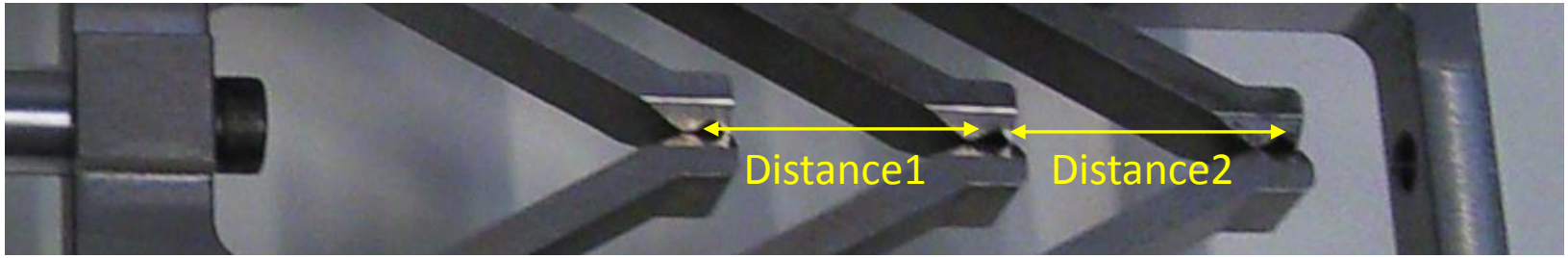


Accuracy and grippers' profile

Max. deviation [µm]	Station 1(dir.)	Station 2(dir.)	Station 3(dir.)
Ø 3 mm	6(x)	8(y)	6(y)
Ø 2.5 mm	4(x)	6(x)	5(x)
Ø 2 mm	8(y)	8(x)	12(x)
Ø 1.5 mm	27(y)	38(x)	20(y)

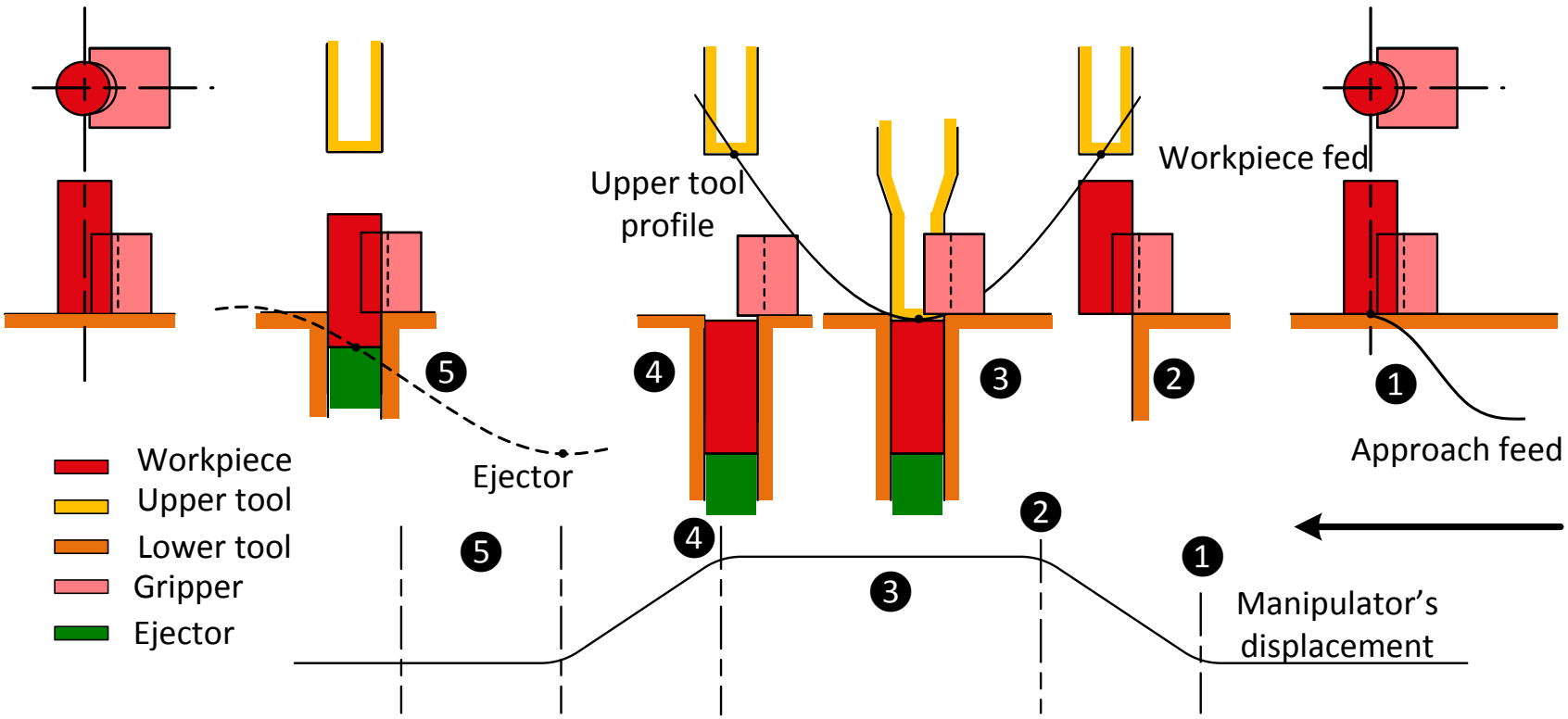


Reproducibility

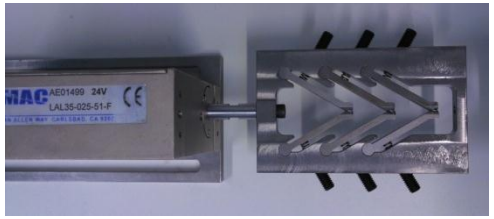


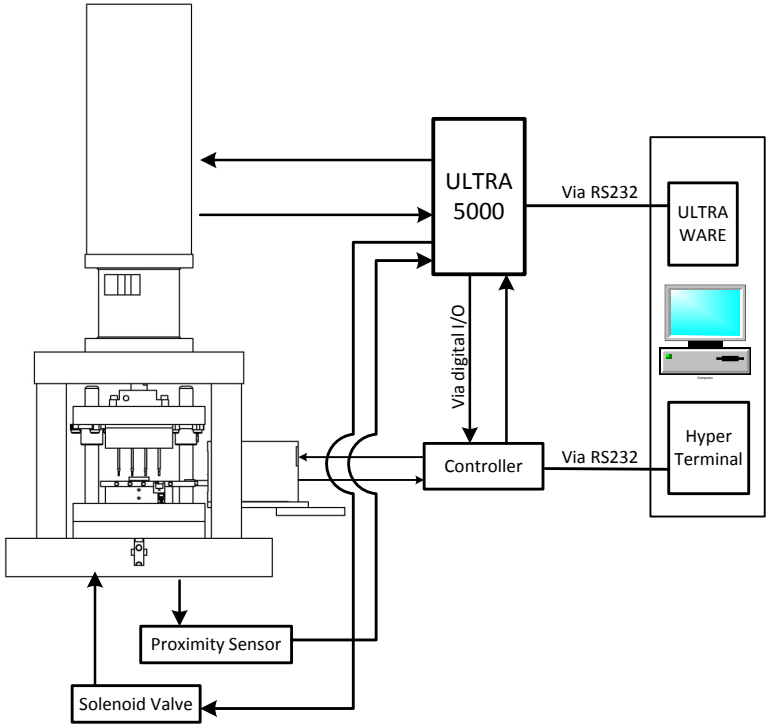
Ø 2.5 mm	Distance 1	Distance 2
Mean value	20.020 mm	19.985 mm
Standard deviation	0.002 mm	0.002 mm
Uncertainty	0.009 mm	0.009 mm

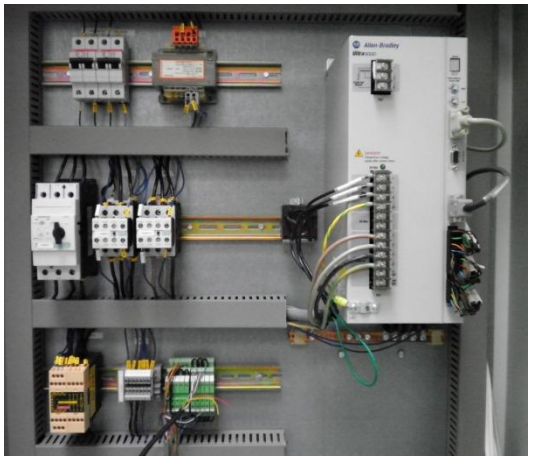
Two Dimensional Transfer Study

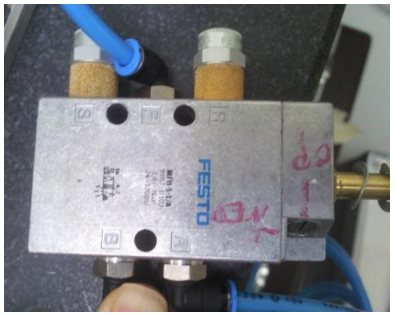


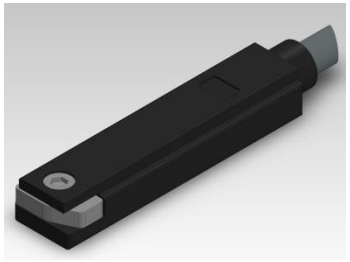
Circuit Diagram



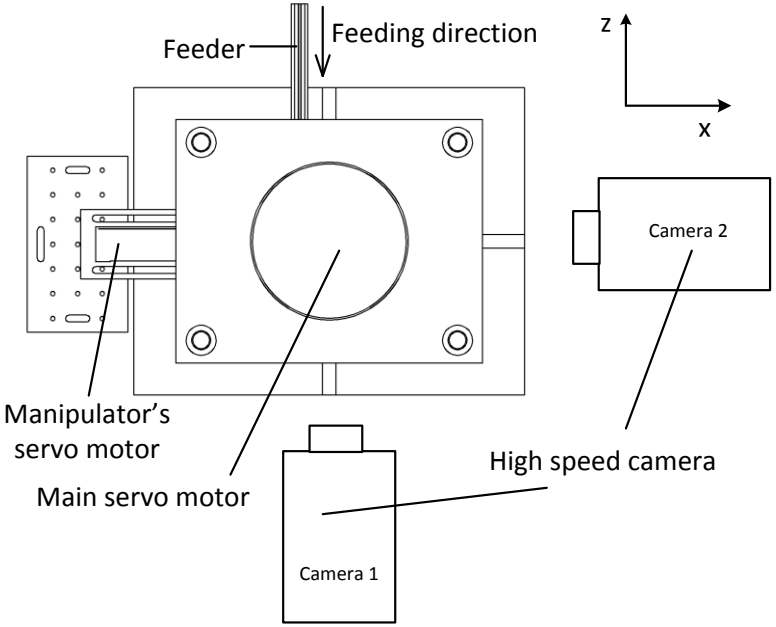






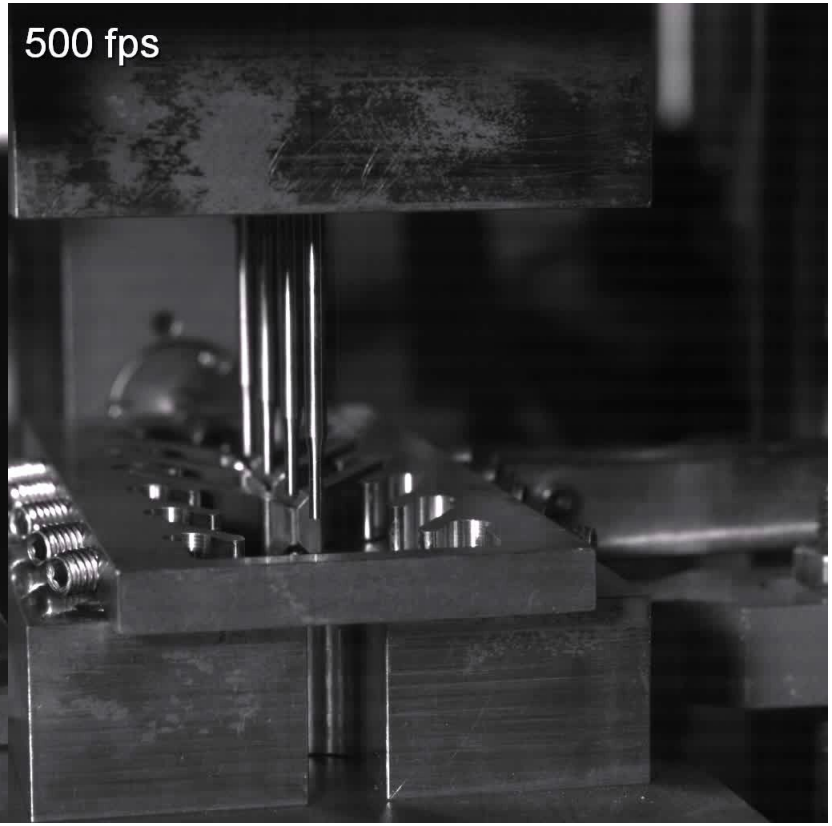


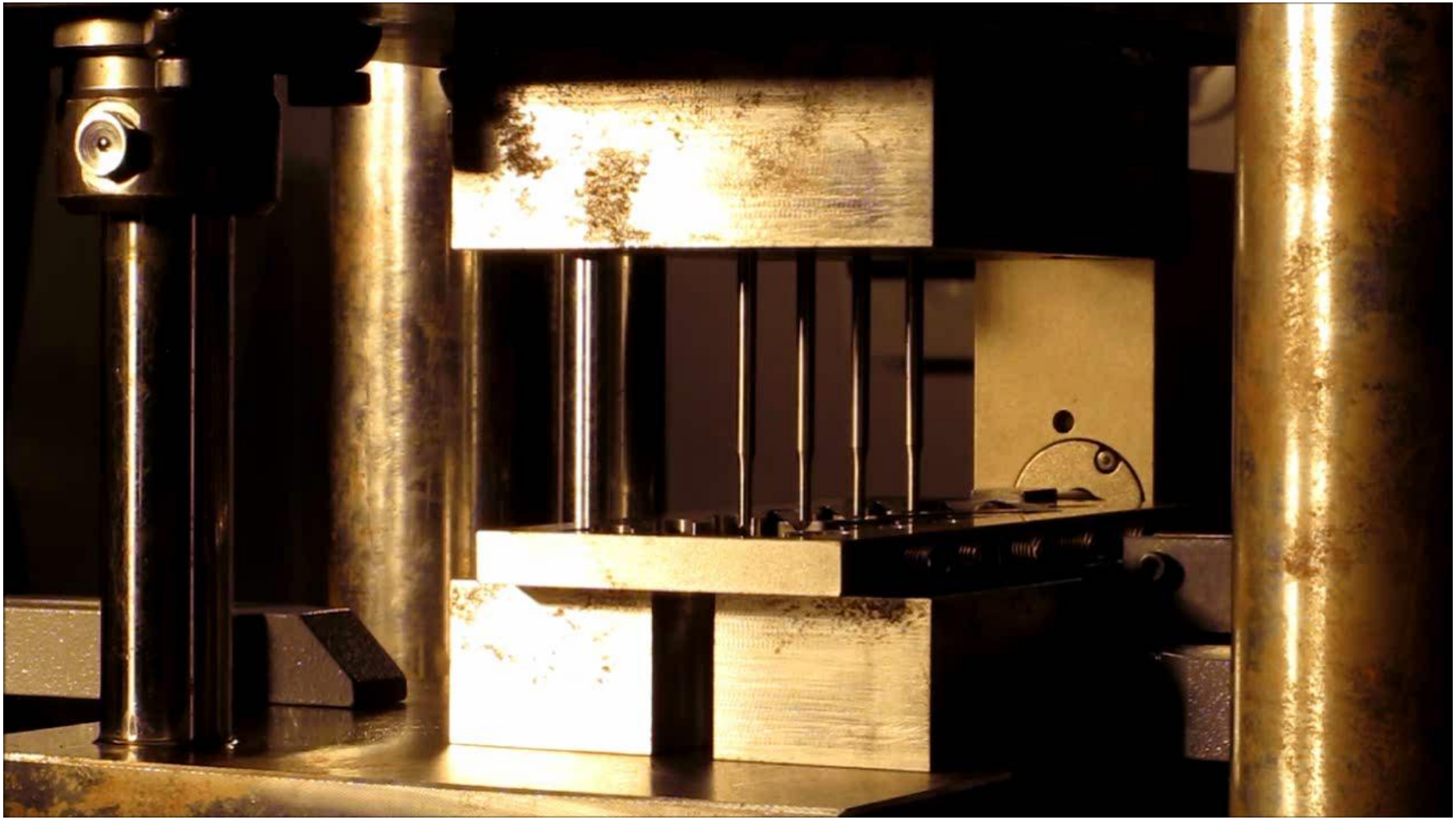
Setup of Cameras



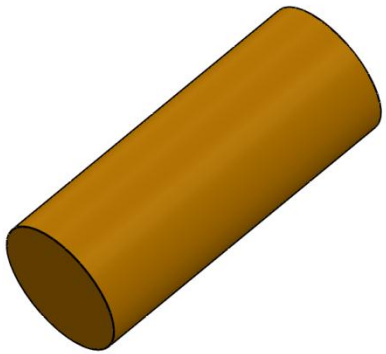
Direction of transferring: Right to left

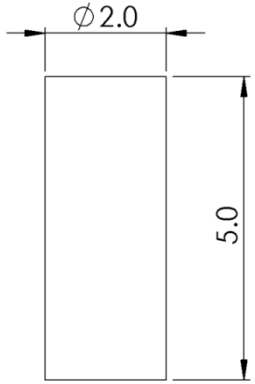

500 fps


500 fps

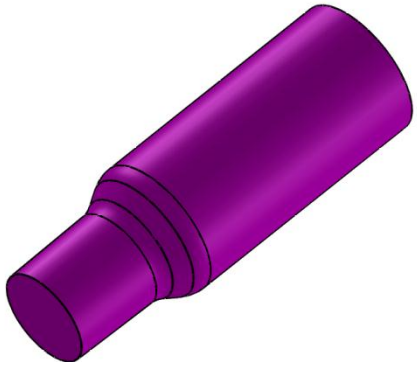


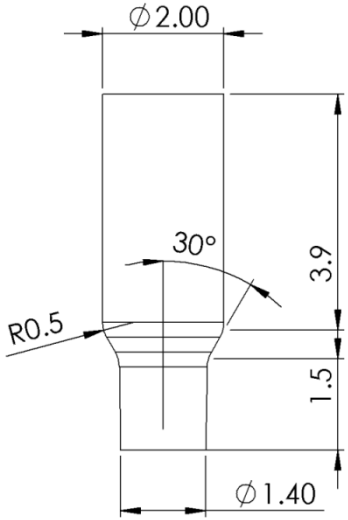
Processing sequence (Dimensions)



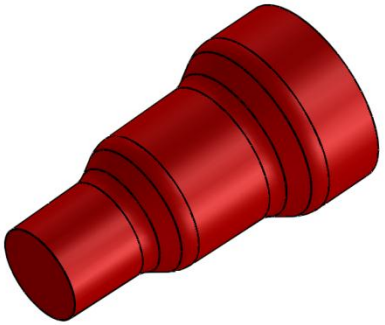


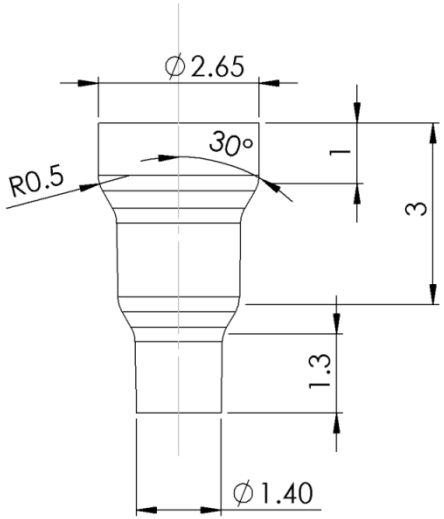
Billet





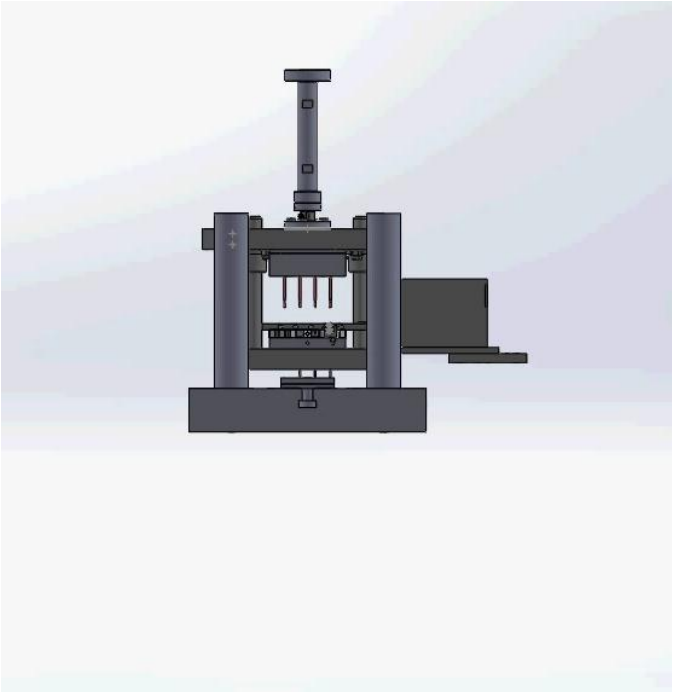
Forward Extrusion

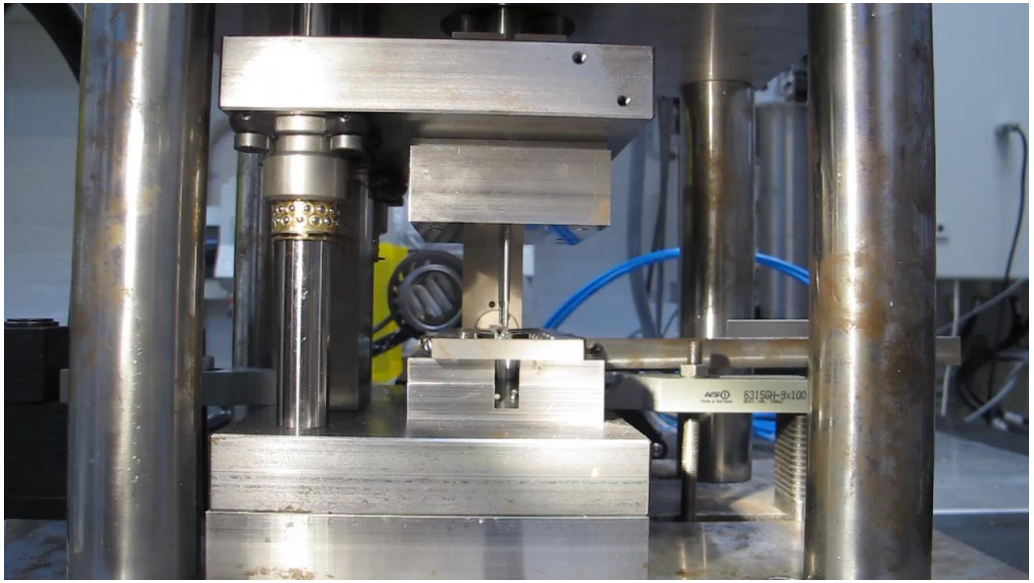


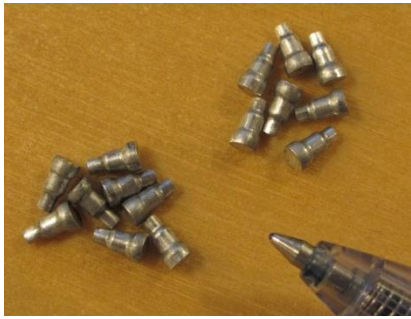


Upsetting

Initial production







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Questions ?