Manufacturing and Investigation of Precision Powder Injection Moulded Parts

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- Precision and Micro Powder Injection Moulding - an Example
- Accuracy considerations on PIM
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Liquid Jet Nozzles for European X-ray Free Electron Laser

Collaborative project between DESY-CFEL and KIT-IAM

Current Design

- outer-Ø = 1.56 mm
- inner-Ø = 0.8 mm

- isometric view
- outer capillary
- fluid dye
- inner capillary
- axial/radial alignment
- gas channels
Simulation

First Results

Front view of ceramic capillary
Ø = 40 µm

CT cross section image
with internal guide bars

Current precision of CLM parts: ± 0.3%

Might be much better for a few particular dimensions
How to Improve PIM Accuracy

Creation of demonstrator:

Membrane carrier

bulk cylinder

membrane

z=4.8mm / 3.7mm
z=3.8mm / 2.9mm
z=2.0mm / 2.1mm
z=1.0mm / 1.3mm
z=0.0mm / 0.5mm

dye side

parting plane

upper position

movable dye piston

lower position

movable ejector piston

ejector side

sample, membrane section

sample, bulk cylinder section

Dr. V. Plotter 12.10.2016
Process conduct

2-step Process: **Feedstock injection + embossing**

» pull back the pistons

» filling this cavity by injection of feedstock

» push the pistons forward up to final membrane thickness

Variation of main parameters:

- embossing force
- opening width
- embossing delay time

Embossing Force

![Graph showing quality vs. embossing strength]
Sintered Specimen

membrane carriers before debinding

membran sample after sintering

Constancy density
< ± 0.2%

Constancy membrane thickness
± 0.4%

Minimum membrane thickness
≤ 200µm

Further reduction of membrane thickness

200µm

150µm

100µm

Sintered sample thickness ca. 90µm
feedstock sticks on piston top
Outlook

Accuracy of PIM
- investigation of bimodal powders
- reduced shear rates, variothermal temperization

Simulation of PIM
- jetting, powder-binder segregation etc.
- simulation of embossing step ↔ powder pressing

PIM Materials
- water soluble binder systems
  (PEG/PMMA or PVB/PMMA)

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Outlook

Sintered tensile specimen
10% Nextel fibers in Al₂O₃ matrix
(Source: M. Tülümen, IAM-WK)

New Materials for PIM
- Ceramic Matrix Composites (CMC)
- High Entropy Alloys (HEA)

sintered Co20Cr20Fe20Mn20Ni20 alloy
density approx. 7.65g/cm³
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