Accuracy Examinations in Powder Injection Compression Moulding

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Contents

- PIM Accuracy: Powder loading
- Thickness variations: Demonstrator
- Minimum membrane thickness
- Accuracy investigations
- Outlook
Scheme of twin-piston tool

ejector side

dye side

inclined plane

injection gates

pistons

servomotor for piston movement
PIM Accuracy

First demonstrator:

**Cylinder** $\varnothing = 2.015\text{mm}$

- **Gate position:** dye side / middle
- **Piston pressure:** 5.8% / 19.5% of $P_{\text{max, motor}}$

Powder:

- **17-4PH Osprey 1.4542**
- $D_{50}$ ca. $4\mu\text{m}$

Feedstocks:

- **Powder**
- **Polyethylene**
- **Paraffine**
- **Stearic acid**
Green bodies

- Diameter [mm]
- Standard deviation
- Fit Curve 1

PIM Accuracy

Powder loading [Vol%]
PIM Accuracy

Sintered parts

![Graph showing the relationship between powder loading and diameter and standard deviation. The graph includes a line graph for diameter and a scatter plot for standard deviation. The x-axis represents powder loading (Vol%) ranging from 60 to 70, and the y-axis represents diameter in mm ranging from 1.60 to 2.05. The standard deviation is shown with red dots and a red line indicating the fit curve.]
Parts with considerable thickness variation

Creation of demonstrator:

Membrane carrier

bulk cylinder

membrane

z=0,8mm / 0,5mm

z=1,8mm / 1,3mm

z=2,8mm / 2,1mm

z=3,8mm / 2,9mm

z=4,8mm / 3,7mm

z=1,8mm / 0,5mm
Process conduct

Process 1: Unaltered powder injection moulding

- 63Vol% 17-4PH feedstock
- filling simulations
- constancy of cylinder diameter
Filling simulation

Evaluation of most suitable runner system

verified by short-shot studies
Filling simulation

determination of critical shear rates

→ acceptable shear rates
Accuracy of unaltered PIM

Variance of cylinder diameter

ca. ± 0.15%
Process conduct

Process 1: Unaltered powder injection moulding

- 63Vol% 17-4PH feedstock
- filling simulations
- constancy of cylinder diameter ca. ± 0.15%
- minimum membrane thickness ca. 400µm

Process 2: Powder injection moulding + embossing step

» pull back the pistons
» filling this cavity by injection of feedstock
» push the pistons forward up to final membrane thickness
sample, membrane section

movable dye piston

upper position

movable ejector piston

dye side

parting plane

ejector side

sample, bulk cylinder section

lower position
Minimum membrane thickness

Reduction of membrane thickness due to PIM + embossing process

Variation of main parameters: embossing force, gap width, and embossing delay time

Classification (from 1 to 5) of moulded membrane carriers

Class 1 sample: no visible failures

Class 5 sample: clearly visible voids
Thermal treatment

membrane carriers before debinding

class 1 sample after sintering

Porosity
1.6 – 2.1%

Pore sizes
1.7 – 2.1µm

Minimum membrane thickness
≤ 200µm

Constancy membrane thickness
± 0.4%
Further reduction of membrane thickness

200µm
150µm
100µm

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

PIM + embossing process

- hardening tests
- microstructure investigation
- increase powder loading $\rightarrow$ 67Vol%
- improve powder composition (bi-modal)
- improve piston movement
- avoid feedstock-wall adhesion
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