STREAM – SBO Polyforce

Towards scientifically based screening criteria for laser sinterable polymers

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Introduction

Additive manufacturing

• produce parts directly from digital models
• building layer-by-layer
Introduction

Types of Additive Manufacturing
- Fused deposition modeling
- Stereolithography
- Laser sintering
Introduction

Types of Additive Manufacturing

- Fused deposition modeling
- Stereolithography
- Laser sintering
Introduction

Laser Sintering
  + wide possibilities part design, customized products
  + functional, high quality parts
  - limited range of sinterable polymers (PA12)

➡ What makes a polymer sinterable?
  ➡ screening criteria defined in Polyforce
Polyforce consortium

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machine development
polymers processing
material behaviour
What makes a polymer sinterable?

1) Powder flow
2) Sintering coalescence
3) Part solidification
What makes a polymer sinterable?

1) Powder flow

2) Sintering coalescence

3) Part solidification
Powder flow

Importance powder flow
  • smooth spreading
  • high packing density

How to measure powder flow?
  • angle of repose
  • film applicator setup
Powder flow

Film applicator setup
## Powder flow

<table>
<thead>
<tr>
<th></th>
<th><strong>PA12</strong></th>
<th><strong>PS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Layer packing density</strong></td>
<td>43%</td>
<td>59%</td>
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![PA12 powder image](image1)

![PS powder image](image2)

![PA12 layer image](image3)

![PS layer image](image4)
What makes a polymer sinterable?

1) Powder flow
2) Sintering coalescence
3) Part solidification
Sintering coalescence

Importance coalescence
  • part density
  • mechanical properties

How to analyze coalescence?
  • rheological data
  • direct visualization
Sintering coalescence

Rheological data

**PA12**

![Graph showing viscosity ($\eta_0$) vs. temperature ($T$) for PA12.](image)

**PS**

![Graph showing viscosity ($\eta_0$) vs. temperature ($T$) for PS.](image)

$T_m$ and $T_g$ are the melting and glass transition temperatures, respectively.
Sintering coalescence

Direct visualization
What makes a polymer sinterable?

1) Powder flow

2) Sintering coalescence

3) Part solidification
Part solidification

Problems during solidification
  • part warpage
  • crashing builds

How to analyze solidification behavior?
  • DSC / flash-DSC
  • NMR, WAXS/SAXS
  • measure shrinkage
Part solidification

Measure shrinkage
  • TMA adapter developed
Part solidification

1 Zoller et al., *Standard Pressure-Volume-Temperature Data for Polymers*, CRC Press, 1995
Part solidification

![Graph showing part solidification with percentages 2.2%, 8%, and 5% at specific temperatures.](image-url)
Conclusions

• Screening methodology for laser sintering materials
  1) Powder flow
  2) Sintering coalescence
  3) Part solidification

• Actual sintering tests have been conducted, but obtaining powders is often difficult

• Several candidates have been identified, and many more will be investigated in the near future
Thank you!

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