Process development for powder injection molding of short fiber reinforced ceramic-matrix-composites

Contents

- Motivation
- Objective
- Process Flow
- Results
- Discussion
Motivation
Transformation from conventional into potential

Conventional oxide Ceramics (monolithic)

- Excellent high temperature and corrosion resistance
- High stiffness (mechanical stability)
- Low creep rate
- Low fracture toughness (brittle)

Ceramic Fibers (chopped Nextel 610 Alumina Fibers)

- High strength & stiffness
- Fibres proved capable of increasing the resistance to cracks and ductility, breakage strength
- Sensitive to creep & grain growth

Ceramic Injection Molding

- Near-Net-Shaping
- Automation

Ceramic Matrix Composites (CMCs)

- All positive properties of conventional ceramics remain the same
- Ceramic composite parts with increased fracture toughness
- Precise parts can be produced fast & automated in large amounts
Objective

Development of a process chain for the injection molding of short fiber reinforced ceramic oxide-oxide composites with *increased fracture toughness* and *acceptable strength* *compared to non-reinforced material*
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Process Flow

- Powder characterization
  - BET
  - Particle size and particle size distribution
  - Density

- Feedstock production:
  - Oxide-Powder (Al2O3: TM-DAR)
  - Oxide-chopped-Fiber (Nextel 610 fibers: ~3.2 mm in length)
  - Binder System: PE, Paraffin-Wax, Stearic acid
  - Viscosity and granulate preparation

- [μ-] Injection Molding
  - Disc-form
  - Tensile specimens
  - Other forms

- Debinding
  - chemically
  - thermally

- Sintering

Kneader (or Extruder)
High Pressure Capillary Rheometer

Karelia-ark Karelia UAS
https://www.youtube.com/watch?v=PjKXbNuv1Ps
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Results
Kneader

Kneader – various fiber content from 0 to 20 [Vol%] - constant dispersant

- F71
- F53
- F35
- F17
- F4T

Increase Fiber content In [Vol%]

Kneader – various dispersant from 1.1 to 6.6 [mg] - constant fiber content

- F31
- F33
- F35
- F37
- F39
- F41

Increase Dispersant In [Vol%]
Results

Rheometer

Rheometer – various fiber content – constant dispersant

Rheometer - various dispersant - constant fiber content
Results
Injection Molding

Green Part

Sintered Part
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Discussion

- By this process flow fibers are found in the sintered parts from 150 to 800 µm in length.

- The effectivity of debinding process step required further developments to improve time/cost performance and processability at higher fiber contents. To achieve that new binding systems will be researched.