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

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Summary

Chopped (~3 mm) ceramic oxide fibers are added to Al_2O_3 monolithic ceramic as reinforcement and processed via injection molding.The effects of the fiber -content, -orientation, and the processing parameters like sintering temperature on the samples are investigated to optimize the processing chain of those CMC samples.

Motivation

(a) Fibers, **(b)** µ-PIM] parts, and **(c)** fiber reinforced µ-PIM part

Conventional oxide ceramics:

- *Excellent high-temperature and corrosion resistance,*
- *High stiffness and low creep rate.* But,
- They are ***brittle*** materials, which limits their applications

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chopped oxide **FIBERS**

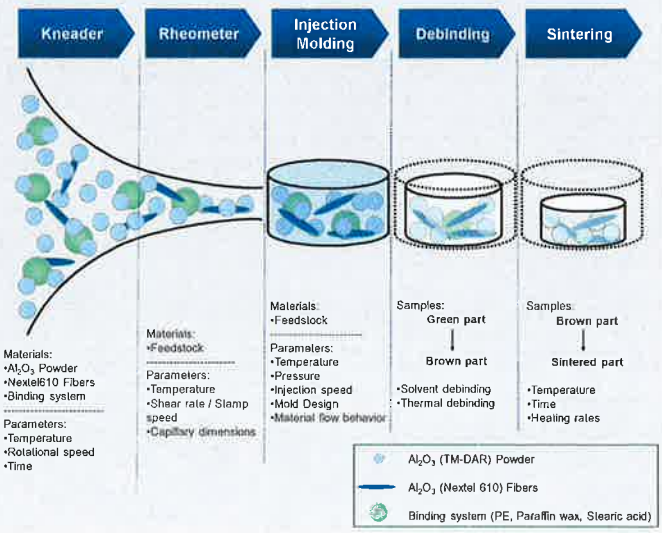
µ-Injection molding:

- Near-net shaping
- Fast and automated production
- Cost advantages after certain amount of pieces

Ceramic matrix composites (CMCs):

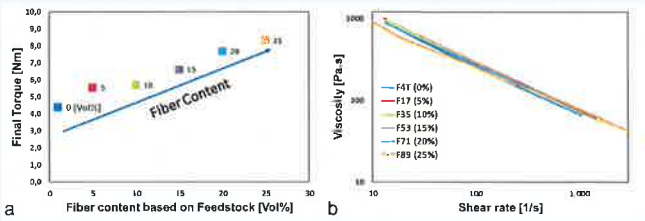
- ***Higher fracture toughness***
- *Save positive properties of conventional ceramic*
- *Adding advantages of µ-injection molding*

Process chain



Experimental Results

Effect of fiber content on Kneader and Rheometer

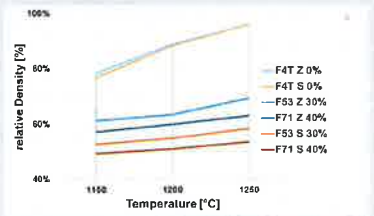


In both figures the feedstocks has the same loading at 50 [Volume%], in which TM-DAR Al_2O_3 powder (d_{50} = 0,11 µm) & fibers (Ø=10 µm, L=) and binding system of PE, Paraffin wax and stearic acid (3,3 mg/m²) are compounded.

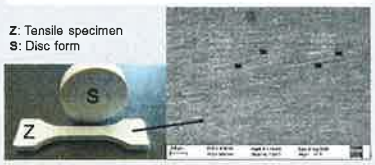
(a). Increasing fiber content cause increase in final torque because the fibers cannot be oriented and show no regular flow in the kneading chamber. (see picture I)

(b). On the other hand, in figure 2b almost no change is observed between feedstocks with different fiber contents on the viscosity/shear rate curves, because the fibers are well-oriented during the measurement in the direction of applied pressure in the high pressure capillary rheometer. (see picture II)

Sinter density: temperature, fiber-content & -orientation



Z: Tensile specimen
S: Disc form



There are several effecting factors on relative density, that are shown in this figure as: *fiber content, sintering temperature* and *sample geometry. Relative density (or shrinkage) of the samples increase* with decreasing fiber content and/or increasing temperature. Besides the rel. density of disc form wit random fiber orientation is lower than tensile specimens with relative oriented fibers.

Conclusions

Increasing fiber content complicated the filling step and compounding the feedstock in kneader. Furthermore the viscosity measurements show that there is almost no effect of the fiber content on the viscosity, but this cannot ensure the injection molding quality by itself. On the other hand, changes in fiber content, temperature and orientation cause substantial changes in sinter density & amount of shrinkage.

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