thermo scientific

APPLICATION NOTE

No. LR-56

Save production time and costs with powder injection molding manufacturing process

Author
Ansgar Frendel
Thermo Fisher Scientific, Karlsruhe, Germany

Abstract

Powder Injection Molding is a manufacturing process that helps save time and decrease overall costs. A large number of mechanically complex products can be produced within shorter production times. The best base material for this process is fine ceramics or metal powder blended with a binder to form a free flowing feedstock for the injection molding. To obtain a high quality end product it's important to achieve a homogeneous dispersion of the ceramic powder within the polymer matrix. In the below application note we'll show you how.

Introduction

In test runs with small laboratory compounders we can prove feasibility of binder-powder compound. Binder systems are based on waxes or polymers (e.g. LDPE, PP, POM). Compared to color-masterbatch compounds the focus is on highest degree of filling of the powder, still obtaining a feedstock which can be used in a molding process. After molding the „green" parts undergo a heat treatment (sintering). End products are e.g. catalyst beads, turbine blades.

Usually laboratory development will check for compatibility of the binder/powder system and the maximum degree of filling. Moreover molding trials for feedstock formulations can easily be performed in order to optimize the composition of the various components. The Thermo Scientific™ HAAKE™ MiniJet Pro enables quick tests on process ability of the CIM feedstock. The samples can be sintered and used for mechanical testing.

Materials and methods

A polyethylene wax based binder was blended with Zirconium oxide. For the Thermo Scientific™ HAAKE™ PolyLab™ OS a Thermo Scientific™ HAAKE™ RheoDrive 16 and a Thermo Scientific™ HAAKE™ PTW16/25 XL parallel twin screw extruder with two HAAKE metering feeder (binder, ceramic powder) was used (Fig. 1) to compound the raw materials:

Fig. 1: Instrument setup, RheoDrive 16, PTW16/25, split feed with two metering feeders, die plate and conveyor belt.

- Feed method: split feed with two feeders first zone.
- Strand die 2.5 mm and conveyor belt was for take off.

In case of air bubbles, atmospheric venting is advised. Product was cooled on the conveyor belt, and then easily cut to pellets and manually fed to the HAAKE MiniJet Pro.

Fig. 1 shows the split feed with two metering feeders coupled by an adaptor. Split feed is essential as wax (brittle flakes) and the ceramic (fine powder) segregates when fed through the same hopper.

To setup the system with the feed of the wax in the first zone and the powder via the secondary feed port is shown in Fig. 2. For powder compounds with polymer grades with high Tg (melting temperatures) this way of feeding is advised to prevent higher wear on the barrel. As the pellets have higher melting point the lubrication is decreased compared to waxes. Also when looking for high output, feeding with separate ports is advised.

Thermo Fisher SCIENTIFIC

Fig. 2: Separate feed of wax and powder.

Before starting the test with the volumetric feeders pretests for the output curve of the metering feeders were performed. Here the extruder was running the wax first, then subsequently adding the powder. Stable extrusion was achieved by the summarized set up:

Set values:
- Speed: 200 rpm
- TS1 (Feed): 30 °C
- TS2: 120 °C
- TS3: 160 °C
- TS4: 160 °C
- TS5: 160 °C
- T die: 160 °C

Measure values:
- Torque: 50 Nm
- Pressure die: 7 bar
- T (Melt): 170 °C

Fig. 3: The HAAKE MiniJet Pro.

For the MiniJet PRO (Fig. 3) the strand was broken to pellets and manually fed. The set values are as shown in table 1 resulting in e.g. a tensile bar (Fig. 4).

Table 1: Set values for HAAKE MiniJet Pro

Description	Values
Cylinder temperature	160 °C
Mold temperature	120 °C
Injection pressure	800 bar
Duration time	10 s
Post pressure	400 bar
Duration time	5 s

Fig. 4: Tensile bar in HAAKE MiniJet Pro mould.

Results and discussion

Compounding worked without problems all compounds produced showed excellent dispersion of the powders. The desired output of 6 kg/hr was reached with the given composition of powder and binder (85/15 % wt/wt). Neither the compounder nor feeding system was pushed to the limit. Fig. 5 shows the wax and powder, and the resulting compounds (disk, pellet, strand, tensile bar, sheet). Extruded strands were brittle and easy to break manually. Sheet extrusion was possible, but disks molded in the HAAKE MiniJet Pro showed higher surface quality, an indication of a very good dispersion. Injection molding by the HAAKE MiniJet Pro was easy with the parameters shown in the table 1.

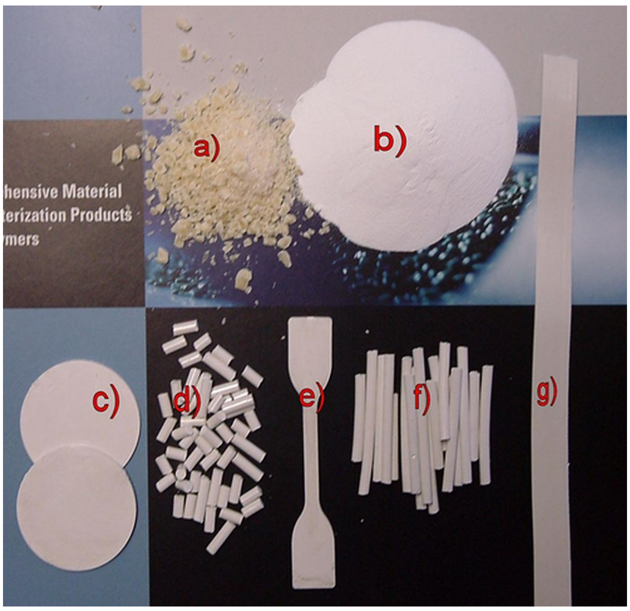

Fig. 5: Raw material (a, b) and product samples (c-g): a) wax (PE), b) ceramic powder (ZrO_2), c) disks, d) pellets, e) tensile bar, f) strands, g) sheet.

thermo scientific

Conclusion

The HAAKE PolyLab OS system and a parallel twin-screw extruder is the ideal instrument for quick development of CIM feedstock. The compounding itself could also be performed with the Eurolab 16XL stand-alone compounder with similar parameters.

The good mechanical properties of the specimen produced with the HAAKE MiniJet Pro gives a clear indication of the excellent dispersive mixing achieved with the above mentioned twin-screw setup used. The CIM feedstock can be directly used for time and cost efficient mass production of ceramic parts.

Further to the compounding tests with a small batch mixer could be performed e.g. to evaluate minimum binder ratio or using single screw extruders to measure the viscosity of the feedstock.

Find out more at thermofisher.com/extruders

ThermoFisher SCIENTIFIC

LR-56 1117