Zeeospheres™
ceramic microspheres

Reducing warpage, improving flow and enhancing processability in glass fiber reinforced polypropylene

Introduction

A number of articles have appeared in technical publications in recent years describing the advantages of combinations of fibers and spheres in polymer systems. In an attempt to quantify these advantages with Zeeospheres™ Ceramic Microspheres, a study was undertaken recently to evaluate combinations of Zeeospheres ceramic microspheres and glass fibers in injection molded polypropylene. The results of this study are detailed in the attached tables and charts.

The key finding of this study is that optimized combinations of Zeeospheres ceramic microspheres and glass fibers can reduce or eliminate the warpage problems normally encountered in glass fiber reinforced systems while maintaining an excellent balance of strength vs. stiffness and good heat deflection properties. Additionally, Zeeospheres ceramic microspheres /glass fiber combinations can improve mold flow, minimize "tear drop" fiber voids around mold inserts and reduce shrinkage.

Warpage

Polypropylene composites containing Zeeospheres™ Ceramic Microspheres alone or in combination with glass fiber reinforcement produce parts which exhibit less warpage than straight glass fiber reinforced polypropylene. The degree of warpage (as with other physical properties tested) varies with the ratio of ceramic microspheres to glass fiber, indicating that the system should be optimized by the user/customer for desired results in individual applications.

Systems 5 and 6 in the accompanying data indicate that an optimum system with this resin and mold completely eliminated warpage while still maintaining a good balance of other physical properties.

Shrinkage

Polypropylene filled with Zeeospheres ceramic microspheres exhibits substantially less shrinkage than unfilled polypropylene. It has also been shown in previous studies to exhibit less shrinkage than conventional mineral-filled PP. Glass fiber polypropylene has traditionally been shown to have the lowest shrinkage of any system; however, in this study, combinations of Zeeospheres ceramic microspheres and glass fiber were shown to exhibit shrinkage as low as that of straight glass fiber-reinforced polypropylene.

Heat Deflection Temperature (HDT)

Polypropylene filled with Zeeospheres ceramic microspheres gives higher HDTs than unfilled polypropylene. Higher levels of Zeeospheres ceramic microspheres produce even higher HDTs. Glass fiber increases HDT even more. Polypropylene composites containing Zeeospheres ceramic microspheres plus glass fiber yield HDTs that are on par with those reinforced at the same levels with glass fiber alone.

Specific Gravity

Zeeospheres ceramic microspheres are lower in specific gravity than glass fiber. Therefore, replacing some of the chopped glass with Zeeospheres ceramic microspheres lowers the specific gravity of the composite.

Flow

The attached chart of flow (in inches) through the different thickness fingers of a "finger flow" mold demonstrates that a system containing 30% glass fibers plus 10% Zeeospheres™ Ceramic Microspheres actually gives better flow than a system containing just 30% glass fiber. Zeeospheres ceramic microspheres' "ball bearing" effect enhances mold flow while glass fiber retards flow.

Flexural Modulus

The addition of Zeeospheres ceramic microspheres to unfilled or glass reinforced polypropylene consistently increases flexural modulus. (Systems 7,8 & 9 vs. 1; System 5 vs. 3).

Impact (Notched Izod)

Because they have little reinforcing effect, the addition of Zeeospheres ceramic microspheres to unfilled polypropylene has essentially no effect on notched Izod. Glass fibers, by contrast, will improve notched Izod impacts.

Summary

This work demonstrates that substituting Zeeospheres ceramic microspheres for a fraction of the glass fibers or resin in a glass reinforced composite can improve warpage and processability while maintaining a good balance of strength and stiffness properties in some applications. And since the volume cost of the displaced polypropylene resin and the added Zeeospheres ceramic microspheres is essentially the same, there should be no increase in cost over straight glass filled polypropylene.

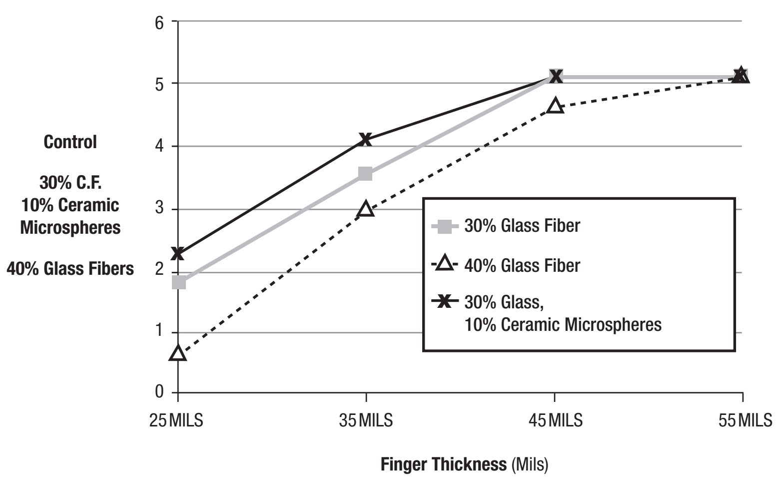
As with any unique material, however, optimum properties are obtained only when a user's/customer's system is properly balanced. Simply inserting Zeeospheres ceramic microspheres into an existing plastic formula can produce varied and not necessarily optimum results. Actual test data for the various systems and tests described here are attached.

Finger Flow Mold, Inches*

Fiber/Reinforcement	55 MILS	45 MILS	35 MILS	25 MILS
None	5.063	5.063	4.863	2.750
30% Glass Fiber	5.125	5.125	3.542	1.813
40% Glass Fiber	5.125	4.646	2.958	0.625
30% Glass, 10% G-600	5.125	5.125	4.083	2.250

G-600 = Zeeospheres Ceramic Microspheres G-600
*260°C/500°F Melt Temp., 1400PSI, 100F Mold Temp., 5.125 Inches Mold.

Flow of Filled/Reinforced PP (260°C/500°F Melt Temp. at 1400PSI)



Experimental Materials

Pro-fax® 6501 – 0.90gm/cc density, 4-5 Melt Index

Zeeospheres™ Ceramic Microspheres G-600 – 2.1 gm/cc density, Average Particle Size (microns) - 1.8 by population, 7.8 by volume

Fiberglas® OCF 457AA – 2.6 gm/cc density, Chop Length-3/16 inch, Diameter -13 microns, surface treated

Processing

The polypropylene and fillers were dry blended, extrusion compounded on a single screw extruder with a 1 inch barrel diameter, water quenched and pelletized. The pellets were dried for two hours at 170°F prior to injection molding on an Arburg screw injection molding machine.

Test Methods

Property	Method	Unit	Details
Tensile strength	ASTM D638	psi	Die cut microtensile bars
Elongation	ASTM D638	%	Die cut microtensile bars
Flexural Modulus	ASTM D790B	si	5" × 0.5' × 0.250" bars
Flexural Strength	ASTM D790B	si	5" × 0.5' × 0.250" bars
Notched Izod Impact	ASTM D256A	ft-lbs in at 23 °C	
Deflection Temp.	ASTM D648	°C at 66 si	
Mold Shrinkage	ASTM D955	in/in	5" × 0.5' × 0.250" bars
Warpage		in	2" × 2.5" × 60 mils

Properties of Reinforced Polyproylene Compounds

Filler Reinforcement	Warpage (mm)	Flexural Modulus (× 103 psi)	Flexural Strength (× 103 psi)	Notched Izod Impact (23°C ft. lbs/in)	Shrinkage (in./in.)	Heat Deflection Temperature (°C)	Tensile Yield Strength (× 103 psi)	Elongation Break (%)
1. Control	0.0	254	8.2	0.8	0.018	0.018	0.018	425
2. 20% GF	4.0	445	10..2	1.4	0.002	0.002	0.002	<10
3. 30% GF	3.2	636	11..2	1.5	0.001	0.001	0.001	<10
4. 40% GF	2.2	870	11.7	1.4	0.001	0.001	0.001	<10
5. 30% GF 15% G-600	0.0	680	9.7	1.1	0.001	0.001	0.001	<10
6. 25% GF 15% G-600	0.0	528	8.7	1.0	0.001	0.001	0.001	<10
7. 20% G-600	0.0	303	7.4	0.7	0.017	0.017	0.017	269
8. 30% G-600	0.0	308	7.0	.08	0.016	0.016	0.016	225
9. 40% G-600	0.0	366	7.1	.08	0.014	0.014	0.014	114

GF = Glass Fiber   G-600 = Zeeospheres Ceramic Microspheres G-600

129 Valentine Dr. • Lockport, Louisiana 70374
985.532.2541 • www.zeeospheres.com