Dough (Bulk) molding compound, DMC (BMC), polyester matrix

Description

Image

Caption

DMC molding for a toilet seat.

The material

Lay-up and filament winding methods of shaping composites are far too slow and labor-intensive to compete with steel pressings for car body panels and other enclosures. Sheet molding compounds (SMCs) and dough (or bulk) molding compounds (DMCs or BMCs) overcome this by allowing molding in a single operation between heated dies. To make SMC, polyester resin containing thickening agents and cheap particulates like calcium carbonate or silica dust is mixed with chopped fibers -- usually glass -- to form a sheet. The fibers lie more or less parallel to the plane of the sheet, but are randomly oriented in-plane, with a volume fraction between 15% and 40%. DMC is made in a similar way, but the mix has a higher concentration of filler and a lower volume fraction of chopped fiber (10% to 25%), which are randomly oriented in 3-dimensions. This makes a "pre-preg" with leather or dough-like consistency. When SMC sheet is pressed between hot dies it polymerizes, giving a strong, stiff sheet molding. DMC is molded in closed, heated dies to make more complex shapes: door handles, shaped levers, parts for washing machines and the like.

Composition (summary)

(OOC-C6H4-COO-C6H10)n + CaCO3 or SiO2 filler + 15 to 40% chopped glass strand.

General properties

Density	112	-	131	lb/ft^3
Price	* 2.05	-	2.26	USD/lb
Date first used	1962			

Mechanical properties

Young's modulus	1.74	-	2.03	10^6 psi
Shear modulus	* 0.566	-	0.87	10^6 psi
Bulk modulus	* 1.74	-	2.03	10^6 psi
Poisson's ratio	0.33	-	0.35	
Yield strength (elastic limit)	3.63	-	7.98	ksi
Tensile strength	4.93	-	10.2	ksi
Compressive strength	20.3	-	26.1	ksi
Elongation	1.4	-	1.9	% strain
Hardness - Vickers	* 7	-	16	HV
Fatigue strength at 10^7 cycles	* 1.74	-	3.92	ksi
Fracture toughness	* 2.73	-	5.46	ksi.in^0.5
Mechanical loss coefficient (tan delta)	* 0.005	-	0.008	

Thermal properties

Glass temperature	296	-	386	°F

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Maximum service temperature	284	-	410	°F
Minimum service temperature	-112			°F
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.156	-	0.289	BTU.ft/h.ft^2.F
Specific heat capacity	* 0.266	-	0.276	BTU/lb.°F
Thermal expansion coefficient	13.3	-	18.9	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	1e18	-	1e19	µohm.cm
Dielectric constant (relative permittivity)	4.2	-	5	
Dissipation factor (dielectric loss tangent)	0.002	-	0.008	
Dielectric strength (dielectric breakdown)	* 254	-	457	V/mil

Optical properties

Transparency	Opaque

Processability

Moldability	4	-	5	
Machinability	3	-	4	

Eco properties

Embodied energy, primary production	1.18e4	-	1.31e4	kcal/lb
CO2 footprint, primary production	7.59	-	8.38	lb/lb
Recycle	✗			

Supporting information

Design guidelines

The chopped fiber reinforcement makes SMC and DMC moldings stiffer, stronger and more abrasion resistant than straight resin castings or moldings. They are relatively cheap, but competitive with steel and aluminum pressings only when batch sizes are small ("small" means batch volumes below about 10,000) or the part itself is small. The in-mold curing time limits the rate at which parts can be molded -- the thicker the section, the longer this time becomes (because of the low thermal conductivity of the resin), and the greater the processing cost.

Technical notes

Considerably flow takes place when DMCs are molded. Flow leads to fiber alignment, something that can be exploited to improve part performance. The degree of alignment varies from place to place in the molding, something that is important to know if properties are to be predicted. Approximate estimates for the elastic constants of DMC parts, neglecting alignment, are Young's modulus = Fiber modulus x volume fraction /6Shear modulus = Fiber modulus x volume fraction /15Poisson's ratio = 1/4These are useful for first estimates but not adequate for detailed design.

Typical uses

Car battery cases; door handles and window winders; washing machine parts such as lids; automotive vents, distributor caps and other small moldings; casings for telephones, gas and electricity meters.

Tradenames

Celanex; Eastar; Glastic; Haysite; Hytrel; Plenco; Rynite; Synolite; Valox; Vybrex

Links

Reference

ProcessUniverse

Producers