Ceramic foam

Description

Image

Caption

Open-cell alumina foam sample. © Granta Design

The material

If you wanted to filter dross out of a molten metal at -- say -- 1800 C, how would you do it? The answer is to pour it through a ceramic foam. A range of such foams is now available with relative densities between 5% and 40% (the volume fraction of solid in the foam), with pore sizes between 0.05 and 2 mm. They are available in alumina, zirconia, and a number of other ceramics including the bio-ceramic hydroxyapatite. Their great merit is their stability at high temperatures: zirconia foams, for instance, can be use at up to 2000 Cathie data given here is for a medium-density alumina foam

Composition (summary)

Al2O3, ZrO2 and many other compositions.

General properties

Density	24.5	-	41.8	lb/ft^3
Price	* 15.9	-	24	USD/lb
Date first used	1970			

Mechanical properties

Young's modulus	0.276	-	0.551	10^6 psi
Shear modulus	* 0.087	-	0.203	10^6 psi
Bulk modulus	* 0.276	-	0.551	10^6 psi
Poisson's ratio	0.26	-	0.27	
Yield strength (elastic limit)	* 0.087	-	0.305	ksi
Tensile strength	* 0.087	-	0.305	ksi
Compressive strength	0.116	-	0.406	ksi
Elongation	0			% strain
Hardness - Vickers	0.08	-	0.3	HV
Fatigue strength at 10^7 cycles	* 0.0725	-	0.261	ksi
Fracture toughness	0.0273	-	0.091	ksi.in^0.5
Mechanical loss coefficient (tan delta)	* 0.003	-	0.01	

Thermal properties

Melting point	3.59e3	-	3.8e3	°F
Maximum service temperature	2.73e3	-	3.27e3	°F
Minimum service temperature	-459			°F
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.289	-	0.404	BTU.ft/h.ft^2.F

Specific heat capacity	0.186	-	0.229	BTU/lb.°F
Thermal expansion coefficient	3.86	-	4.94	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	1e20	-	1e23	µohm.cm
Dielectric constant (relative permittivity)	1.7	-	2.4	
Dissipation factor (dielectric loss tangent)	0.001	-	0.02	
Dielectric strength (dielectric breakdown)	254	-	432	V/mil

Optical properties

Transparency	Translucent

Processability

Machinability	3	-	4

Eco properties

Embodied energy, primary production	* 1.31e4	-	1.45e4	kcal/lb
CO2 footprint, primary production	* 6.53	-	7.22	lb/lb
Recycle	✗			

Supporting information

Design guidelines

Most ceramic foams are used as high-temperature filters for liquids and gasses (removing carbon particulates from diesel exhaust, for instance), and for high temperature thermal insulation, replacing materials like asbestos. They can be cut with saws, but this leaves an uneven surface. Better is the use of abrasive water-jet cutting. Interpenetrating composites ("3-3 composites") are made by infiltrating the ceramic with a polymer or a metal, giving a fully dense body. They have potential for wear-resistant parts and as armor to resist projectiles. Hydroxyapatite foams are biocompatible and have a pore size that encourages attachment and in-growth of cell.

Technical notes

Ceramic foams are made in a number of ways. Typical of them is co-foaming of a ceramic-polymer slurry. Fine ceramic powder is mixed with an acrylate monomer, a catalyst and a foaming agent. The concoction foams then polymerizes in much the same way that polymer foams are made, but the cell edges are full of ceramic powder. When this is sintered (heated at 1500 to 2000 C) the polymer burns off and the powder particles bond to give a consolidated ceramic foam.

Typical uses

High temperature filters for liquids and gases; catalyst carriers for chemical processing and catalytic converters; high temperature thermal insulation; as a first step in making 3-dimensionally interpenetrating composites; as a bioactive medium for cell attachment in implants.

Links

Reference

ProcessUniverse

Producers