İSTANBUL TECHNICAL UNIVERSITY
INSTUTUE OF SCIENCE AND TECHNOLOGY
DEPT. OF METALLURGY AND MATERIALS ENGINEERING
DEPT. OF MECHANICAL ENGINEERING

ITU
PARTICULATE MATERIALS
LABORATORIES
www.pmlab.itu.edu.tr

PRODUCTION OF SiC AND ZrO_2 CERAMIC FOAM FILTERS USING POLYURETHANE

Zeynep KECELI (*,), Tahsin BOYRAZ (*), Okan ADDEMIR (*)**

(*) Department of Metallurgical & Materials Engineering, Istanbul Technical University, Maslak 34469 TURKEY

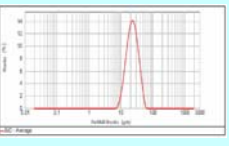
(**) Ford Otosan Otomotiv Sanayi A.S., Gebze Engineering, TUBITAK Technopark, Kocaeli, TURKEY

GENERAL ABSTRACT

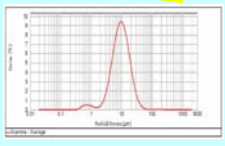
Ceramic foams are high porosity, low-density materials which possess unique three-dimensional skeleton structure. Cellular ceramics are comprised of various arrangement of space-filling polygons (cells) and can be classified into two broad groups: honeycombs and foams [1]. Ceramic foams can be characterized as linked networks of irregularly shaped open or closed cell polyhedrons, with a low fractional density ranging from 0.05 to 0.5 [2]. These materials have a wide range of applications due to their properties. They can be used as catalyst supports, filters for hot gases and molten metals [3]. Filtration is the process of seperating solid particles from the melt, with the solid particles being captured on the filter and the liquid phase passing through the filter [4]. Filtration improves the surface finish and pressure tightness of castings and improves mechanical properties of the castings. It reduces the rework on castings, increases machinability and improves casting yield. There are several established filter technologies presently on the market. These include strainer cores, woven cloth or mesh, and ceramic tile filters. Ceramic tile filters are generally considered to be the most effective [5]. The permeability of porous ceramics is determined by the manufacturing process and pore structure. The use of conventional gating systems even with generously dimensioned runner bars is not sufficient to retain enough slag and suspended reaction to meet the high quality standards of today's castings [6].

TECHNICAL ABSTRACT

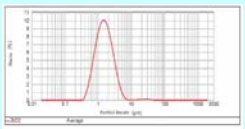
During the last decade there has been a growing interest in catalytic reactor engineering based on structured catalytic beds. Compared to traditional packed bed reactors,structured catalytic beds provide improved hydrodynamics and catalytic performance. In this context, silicon carbide (SiC) and zirconia (ZrO_2) foam materials seems to be a good candidate for use as catalyst support due to their high geometrical surface area (m^{-1}) and open porosity leading to low pressure drop. SiC and ZrO_2 foams are widely used as catalysis carriers, high temperature insulation materials and filters for hot gases and molten metals due to high strength in high temperature, well thermal shock resistance, and excellent oxidation resistance. Ceramic foam filters are produced by impregnating reticulated polyurethane foam with a ceramic slip, removing the excess slip by squeezing the foam, then drying and firing the body. Filter material properties necessary to attain temperature capability, chemical inertness, mechanical, physical properties and thermal properties. In this study, SiC and zirconia ceramic foam filters were produced seperately by using expanded polyurethane. Various ceramic slurries are then poured into the polyurethane cell and allowed to air dry. After the shaping operation, filters are subjected to sintering process under various conditions. The densities of the sintered samples, porosity of the foams, water absorption, bending strength and thermal shock properties were also investigated.



Particle Size and Particle Size Distribution of the SiC



Particle Size and Particle Size Distribution of the Alumina

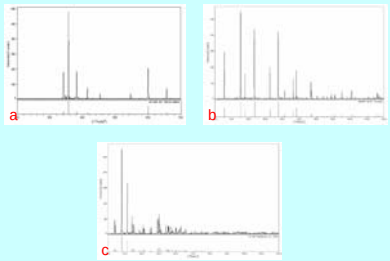


Particle Size and Particle Size Distribution of the Zirconia

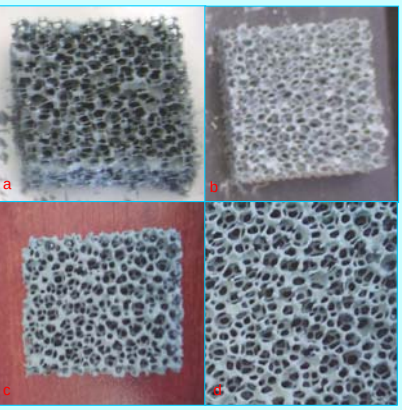
Al_2O_3 (20 wt %)	SiC (80 wt %)	ZrO_2 (90 wt %)	Al_2O_3 (10 wt %)
Milling Stage 4 hours, dry milling Ball to powder Ratio: 7:1 Milling Atmosphere: Air Planetary Ball Mill		**Milling Stage** 4 hours, dry milling Ball to powder Ratio: 7:1 Milling Atmosphere: Air Planetary Ball Mill	
Mixing Stage Homogenized powder batch, water and hydrolyzed liquor were proportionally mixed together to form a slurry.		**Mixing Stage** Homogenized powder batch, water and hydrolyzed liquor were proportionally mixed together to form a slurry.	
Solidifying Stage Polyurethane Sponge Drying at room temperature		**Solidifying Stage** Polyurethane Sponge Drying at room temperature	
Debinding Stage Heat at 1000^0C 2 hours heating rate 1^0 C/min		**Debinding Stage** Heat at 1000^0C 2 hours heating rate 1^0 C/min	
Sintering Stage Heat at 1400^0C 2 hours heating rate 1.5^0 C/min		**Sintering Stage** Heat at 1600^0C 2 hours heating rate 1.5^0 C/min	

Physical Properties of Polyurethane

PHYSICAL PROPERTIES	UNIT	STANDARD VALUE	RESULT
DENSITY	kg / m³	30 +/- 1	29,81
HARDNESS	N	130 +/- %15	142
TENSILE STRENGTH	Kpa	≥ 60	73
PORE PER INCH	PPM	7-13	10
AIR ABSORBITION	dm³/ sn	≥ 6	9,3
PRESSURE DECREASE	cm H_2O	≤ 0,3	0,08

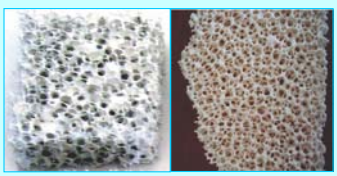


X-Ray Diffraction Patterns of a) SiC, b) alumina, c) zirconia



SiC Filter Shapes a) Polyurethane sponge with SiC slurry, b) SiC Foam after debinding, c) & d) Sintered SiC Foam

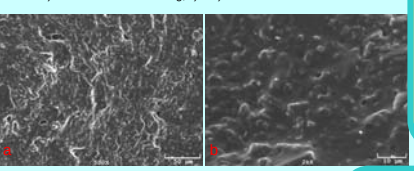
Tests	SiC Filter	ZrO_2 Filter
Thermal Shock Properties	6	7
Bending Strength (MPa)	0,73 ± 0,25	0,81 ± 0,15
Density (g/cm³)	1,92 ± 0,013	2,86 ± 0,016
Water Immersion	%3,69±0.08	%1,51 ± 0.06
Porosity	%6,6 ± 0.07	%4,51 ± 0,04

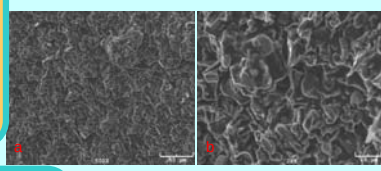


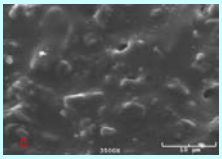
Zirconia Filter Shapes a) Polyurethane sponge with zirconia slurry, b) Sintered Zirconia Foam

CONCLUSIONS

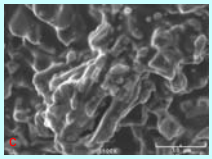
The preparation and performances of zirconia foam with high bending strength and well oxidation resistance were reported. Results show that zirconia filter has better bending strength and thermal shock properties than SiC filter. Porous SiC filter has lower density compared to zirconia. Filters produced using polyurethane cell have desired and predetermined surface versus transition areas. The filters can be used in two positions. In the first case, it has straight transitions and in the second case, it has crosswise path. The result of the water absorption test shows that the average value of the difference between filter weights is 6.25%. The filters can withstand temperatures of 1400 ◦C.







Sintered SiC Foams a) x500, b) x2000, c) x3500



Sintered Zirconia Foams a) x500, b) x2000, c) x3500

REFERENCES

[1] L. Montanaro, Y. Jorand, G. Fantozzi, A. Negro, Ceramics foams by powder processing, Journal of the European Ceramic Society 18 (1998) 1339–1350.
[2] D. Weaire, Foam physics, Advance Engineering Materials 4 (2002) 723–725.
[3] J. Saggio-Woyansky, C.E. Scott, W.P. Minnear, Processing of porous ceramics, American Ceramic Society Bulletin 71 (11) (1992) 1674–1682.
[4] N. Altinkok, R. Koker, Mixture and pore volume fraction estimation in Al2O3/SiC ceramic cake using artificial neural networks, Materials and Design 26 (2005) 305–311.
[5] E.A. Moreira, M.D.M. Innocentini, J.R. Coury, Permeability of ceramic foams to compressible and incompressible flow, Journal of the European Ceramic Society 24 (2004) 3209–3218.
[6] Hack, J. A., Clark, H. and Child, C., *The filtration of steel castings*. The Foundryman, April 1990, pp. 183–188.

Correspondence : Zeynep KEÇELİ
Ford Otosan Otomotiv Sanayi A.S., Gebze Engineering, TUBITAK Technopark, Kocaeli, TURKEY
Tel : +90(262)677-9470 e-mail: zkeceli@ford.com

Knowledge Based Materials
MARIE CURIE ACTIONS