11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25
ICAM2009

Optimization by the Taguchi Method of fabrication parameters of cellular ceramic structures in alumina to be used as diesel soot filters

A. M. Montes(1)* and J. A. Escobar (1)

(1) Mechanical Engineering Department, Universidad de los Andes, Bogotá, Colombia. e-mail: maria-m@uniandes.edu.co
* Corresponding author.

Abstract – Cellular ceramic structures in alumina were produced by the replication method following a Taguchi experimental design. Parameters such as cell density, percentage of compression during the excess slurry removal stage, blowing pressure and time sustained at the sintering temperature were varied in order to determine the best combination to produce the most permeable and resistant structure, properties needed in the application of soot filtration.

Cellular alumina structures were fabricated by the replication method following a Taguchi experimental design. The replication method consists on the impregnation of a polymeric reticulated foam with a ceramic suspension. In this work commercial polyurethane foams were impregnated with a suspension made of 60%wt alumina, 5%wt acrylic binder, 1%wt ammonium polymethacrylate and 34%wt water. By controlled compression of the foam the excess suspension is then removed and the structure is left to dry. Afterwards it is heated in order to eliminate the polymer and consolidate the ceramic as a replica of the original structure. A slow heating rate of 0.5ºC/min was used in order to eliminate the polymer without creating residual stresses. This rate was maintained until 450ºC, since a thermo-gravimetric analysis showed that at this temperature the polymer has been completely removed. A rate of 10ºC/min was used afterwards until 1550ºC, temperature in which the highest resistance of the alumina structures is achieved [1]. By the replication method it is difficult to obtain structures with small pores (45-60 pores per inch) since the ceramic slurry tends to cover the windows generating clogged pores. However, soot filters must have small open pores in order to retain soot. For this reason a new stage was introduced in the process, which consists in blowing the structure once the excess slurry has been removed. This way the structures produced are highly reticulated (Fig. 1 and 2).

In order to determine the best combination of fabrication parameters a Taguchi experimental design was implemented. The parameters that were varied are: cell density (45 and 60ppi), percentage of compression (40, 50 and 60%), blowing pressure (5, 10 and 15psi) and time sustained at the sintering temperature (30, 60 and 90min). The Taguchi design proved to be useful in maximizing the mechanical resistance of the structures as well as in determining which parameters influence the most its permeability and resistance: percentage of compression and time sustained at the sintering temperature correspondingly. The optimized structure, fabricated with a 60ppi polymer, 40% compression, blowing pressure of 10psi and 90min sustained at the sintering temperature, presented a Darcyan permeability of 2.11 x 10^{-10} m^2, mechanical resistance of 1.10 MPa and 83% porosity, values that suit the range commonly reported in the soot filtration application [2].

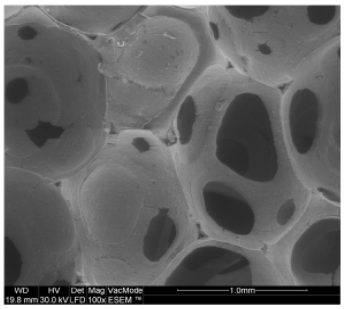

Figure 1: SEM 100x, alumina structure fabricated by the traditional replication method.

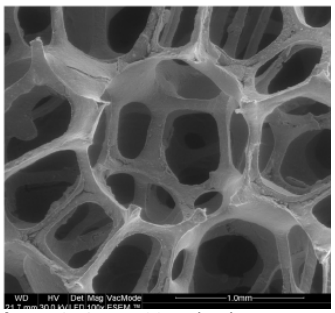

Figure 2: SEM 100x, alumina structure fabricated by the replica method with the implementation of a blowing stage.

References

[1] Y Han, J Li, Q Wei, and K Tang. Ceramics international (2002). The effect of sintering temperatures on alumina foam strength.
[2] M Scheffler and P Colombo. (2005). Cellular ceramics: structure, manufacturing, properties and applications. Wiley-VCH.