


Technology Update

Development Work By AMT On Porous Ceramic Injection Molding

A photograph of a forest stream. The water flows over dark, moss-covered rocks. The banks are covered in vibrant green moss and ferns. A large, gnarled tree trunk lies across the upper part of the frame, its roots hanging down. The scene is dappled with sunlight filtering through the trees.

“In nature, porous materials are familiar natural substances...”



Front View: A few drops of blue ink were dripped on the porous ceramic injection molded part



Back View: The blue ink seeped through the pores of the ceramic part

Introduction

In nature, porous materials are familiar natural substances like plants, soils, rocks, and bones. Such natural materials have pores, acting like pathways, to allow liquids and gases to mix, migrate and flow.

Natural porous substances are often incorporated to build lightweight structures. Manufacturing has begun to emulate this superior natural structure by producing solid materials, most commonly metal or ceramics, incorporated with pores or interstices as the passage of gas or liquid.

Porous materials have widespread commercial applications. Porous ceramics finds its applications in filters, aerators, non-reactive permeable interface, moisture retention curves, etc. The areas of application for porous metals are equally wide: filters, fluid flow metering, flame and spark arrestor, gas distribution, etc.



Natural substances like corals have pores

Characterization of Porosity

Porosity is a complex multi-dimensional measure. Characterization of porous materials is most commonly done by mercury intrusion porosimetry¹. There are several important key parameters such as:

Total pore volume. This is the most direct determination of a physical property, usually done by mercury intrusion method. The total pore volume can be directly translated to porosity level. Porous materials with high porosity level (> 60 vol.%) are usually termed as 'sponges' or 'foams', whereas the lower ones (< 20 vol.%) are 'porous', although these terms are not mutually exclusive.

Pore size distribution. For most materials, porosity is composed of a network of interconnected voids of various sizes. Based on the specific pore models, analysis of pore volume and pore size distribution can be performed.

Open pore. An open pore structure permits a fluid to move from one surface to an opposing surface in the material through a convoluted pathway of interconnecting networked channels.

Closed pore. This is a structure in which the pathways or channels are blocked and do not provide the fluid with a continuous and interconnected network of channels to connect one surface of the material to an opposing surface. When a closed pore structure has a considerable level of porosity, it could float in water.



Porosity is a complex multi-dimensional measure. Characterization of porous materials is most commonly done by mercury intrusion porosimetry.



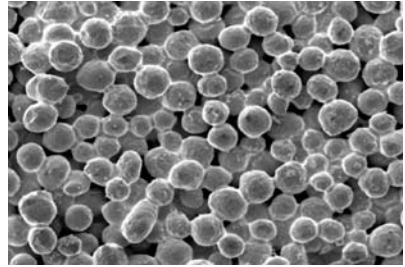
- ◀ Total Pore Volume
- ◀ Pore Size Distribution
- ◀ Open Pore
- ◀ Closed Pore

¹ Adapted from "An Introduction to the Physical Characterization of Materials by Mercury Intrusion Porosimetry", Paul A. Webb, Micromeritics Instrument Corp.

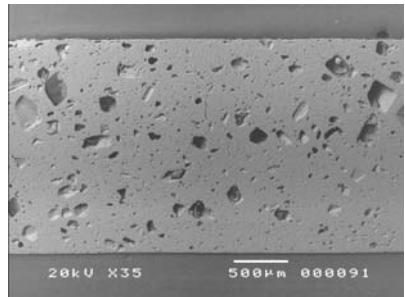
Porous PIM Material

The nature of PIM process has a couple of characteristics in favor of porosity. In fact, one of the challenges in PIM has been achieving the highest sintered density, closing the gap between PIM and bar-stock materials. The fact that PIM process starts from powder has made it possible to incorporate porosity without much alteration to the existing process.

The adjustment of powder particle size and sintering process will result in the presence of porosity in the sintered part. This way the level of porosity is controlled indirectly. The addition of pore filler is a more direct approach in controlling



Sintered Porous Copper



Porous ceramics manufactured by PIM



As with normal PIM parts, porous PIM parts have shape flexibility, an advantage that almost exclusively belongs to PIM.



the pore size distribution by controlling the particle size distribution of the pore filler. Such filler is partially extracted during thermal debinding and then completely burnt off during sintering, leaving behind pores.

As with normal PIM parts, porous PIM parts have shape flexibility, an advantage that almost exclusively belongs to PIM. The setback however, is the limit on the porosity level: sintering shrinkage that occurs during binder removal will take away part of the initial porosity. [AMT](#)