

Poroelastic properties on metal foams submitted to high pressure #687 Enrique Peña°, Elsa M. de la Calleja*, Ignacio Figueroa Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México °enriquepdp.fi@gmail.com, *elsama79@gmail.com

Abstract

The metallic foams are a novel possibility to impact significantly the design of materials taking into account the wide technological applications [1,2]. In this work the procedure to manufacture metallic foams with controlled porosity is presented. A high pressure cell is used to submit the metallic foams to reservoir conditions, which imply high pressures and high temperatures. The injection of the optimal fluid in metallic foams increase the pore pressure which induces a dilation of the foam [3]. These effects are described with poroelastic deformation quantities. The porous deformation is directly measured by image analysis and the well-known mechanical properties are calculated based in basic theoretical models. The aim of the present work is describe the poroelastic behavior of metallic foams [4] when they are submitted in reservoir conditions. The permeability and porosity are measured experimentally and the Carman-Kozeny [5] model is used to model our results. Our experimental results indicate

that metallic foams poses high structural stability even if they are mechanically perturbed. The nature of the process makes it possible to manufacture Mg foams to capture CO2 under certain humidity and temperature conditions (60 HR and 60 C).

c) Furnace





Experimental procedure to manufacture Metallic Foams [7]

The open-cell foams are manufactured by infiltration process, using a replication casting device in controlled conditions. The replication device, shown on the left side, consists of three parts: a cylindrical container made of stainless steel, a valve system and an electric furnace. a) Crucible Cylindrical pre-forms were produced by using amorphous NaCl particles, sieved and separated in two average sizes: (A) 0.7-1mm, and (B) 2-2.38mm. NaCl particles and Aluminum were deposited in the cylinder, subsequently sealed an connected with the valve system. Melting was carried out at 750 °C under a low (Ar) gas pressure of 0.1 MPa for 1 h while infiltration was at 0.4 MPa for 10 min.

When the formed Al–NaCl composite was completely solidified, this was extracted from the container and machined to obtain cylindrical samples of 38 mm of diameter and 50 mm of height. The NaCl particles were completely dissolved in H₂O. The porosity was characterized by image processing and calculated by means of the relative density ρ_{Rel} .







Permeability [3]

The structural stability of metallic foams under reservoir conditions has been measured by a chamber of high pressure. The physical conditions are 25000 PSI of pressure and 200°C on temperature. We found that, the permeability under reservoir conditions the metallic foams depends on the porosity. The Darcy's law is used to describe the behavior.

The permeability is calculated from experimental results by a high pressure chamber. We control the pressure, the geometrical parameters and the injection of the fluids. The Carman-Kozeny model is going to use to determine the relation between porosity and permeability based on experimental results







METALLIC FOAM POROSITY





 $\kappa A \Delta P$

Conclusion. The poroelasticity of metallic foams under reservoir conditions has been studied. By binary images we calculate the porosity after the metallic foams was pretreated. For first time the permeability of porous media (metallic foams) is analyzed and we found that permeability depends on porosity under reservoir conditions. The experimental results indicates that the porous media are more structural stable for extreme physical conditions.

References:

[1]G. A. Lara-Rodríguez, I.A. Figueroa, M. A. Suárez, O. Novelo-Peralta, I. Alfonso and R. Goodall. (2017). A replication-casting device for manufacturing open-cell Mg foams. Journal of Materials Processing Technology, 24, 16-22. [2] Banhart, J. (2001). Manufacture, Characterisation and Application of Cellular Metals and Metal Foams. Progress in Materials Science, 46, 559-63.

[3]Elsa de la Calleja, Ignacio Figueroa, Roberto Zenit. (2018). Structural stability in metal foams under high pressure, Journal of Structural Geology (To be submitted).

[4]J. O. Osorio-Hernández, M. A. Suárez, R. Goodall, G. A. Lara-Rodríguez, I. Alfonso and I. A. Figueroa. (2014). Manufacturing of open-cell Mg foams by replication process and mechanical properties. Materials and Design, 64, 136-141. [5] Dante Hernandez-Diaz, Oscar Chavez, Alberto Beltran, Armando Garcia, Baltasar Mena, and R. Zenit, Experimental study of the effect of wettability on the relative permeability for air-water flow through porous media (Submitted 2017) [6] Banhart, J. (2001). Manufacture, Characterisation and Application of Cellular Metals and Metal Foams. Progress in Materials Science, 46, 559-63.

[7] J. O. Osorio-Hernández, M. A. Suárez, R. Goodall, G. A. Lara-Rodríguez, I. Alfonso and I. A. Figueroa. (2014). Manufacturing of open-cell Mg foams by replication process and mechanical properties. Materials and Design, 64, 136-141.