Public Abstract

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Title:LOW-TEMPERATURE SINTERING AND FABRICATION RESEARCH OF CERAMICS AND NUMERICAL SIMULATION ON ELASTIC, PRESSURE DROP AND HEAT TRANSFER PROPERTIES OF OPEN CELL FOAMS

Vanadium pentoxide (V2O5) was chosen as a sintering aid to lower the sintering temperature of the ZnO–TiO2 system. The advantage of V2O5 is that it has a lower melting point, around 680 ?. Solid V2O5 would become liquid phase during the sintering process, which can facilitate the densification of ceramics. The effect of V2O5 on the sintering behavior of ZnO–TiO2 ceramics and cermets was studied as a function of additive percentage and sintering temperature. Then porous alumina ceramics with different porosity were fabricated by two different methods. The first one combined the starch consolidation process with the gel-casting process using corn starch as the pore-forming agent and also as the binder. The other one used hollow microspheres as the pore-forming agent. For both of two methods, the bulk density, porosity, and microstructure of the obtained alumina ceramics were studied.
Open cell foams, as one type of porous materials, are nowadays commercially used in a broad range of applications. A method for the generation of random foam structures, based on Laguerre-Voronoi tessellations of randomly packed spheres with log-normal volume distribution, was proposed. This model could give the study of the variation coefficient effect on the geometric and topological properties of foams. To evaluate the generated model in this work, a series of parameters were discussed, such as the average number of faces per foam cell, porosity, and specific surface area, etc. Then a three dimensional random Laguerre-Voronoi foam model was developed to investigate the elastic properties of open cell ceramic foams. A size sensitivity study was first performed to determine the appropriate number of cells to be included in each foam specimen and the suitable number of specimens to be used in statistical analysis. This was followed by a finite element analysis to calculate the effective Young’s modulus, shear modulus, and Poisson ratio of the foams.
Finally, the pressure drop and heat transfer through open cell foams were investigated. A pressure drop correlation with a universal form was developed based on theoretical grounds and the tortuosity of open cell foams was taken into account for the pressure drop. The developed correlation was then validated using numerical simulations on pressure drop properties of aluminum foam structures of pore densities between 10 ppi and 50 ppi and porosities from 70% to 95%, with the commercial CFD analysis package: ANSYS Fluent. The numerical results for pressure drop were compared with the prediction by the theoretical correlation. The results showed that the pressure drop of foams increased with increasing pore density and decreasing porosity. The numerical results were consistent with the prediction of the theoretical correlation. Permeability and friction factor of foams were also evaluated. For the low Reynolds number range, friction factor scaled as 1/Re at lower Reynolds numbers, while at higher Reynolds numbers, the non-linear term began to dominate because of the inertial effects. Then the computed interstitial heat transfer coefficients were investigated. The heat transfer coefficient increased with the air velocity and the heat transfer coefficient increased when the porosity increases at constant pore density. At constant porosity the heat transfer coefficient increased when increasing the pore density. Furthermore, a correlation was given to derive the hydraulic diameter from the ppi number.