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Pore Size Controlling in PM Alloy Parts

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Abstract

Pores are important characteristics in powder metallurgy alloy parts. The effect of processing parameters on pore size is discussed. If pore size can be controlled as small as several or tens of nanometers in PM alloy parts, the parts may gain special physical or mechanical properties. The challenge to obtain pores sizing in several or tens of nanometers in PM alloy parts is discussed.

Pores are formed in compaction process of green compacts, and then coalesce or shrink in sintering. Pores are main characteristics of PM (powder metallurgy) alloy parts. These parts gain certain kind of properties due to the presence of pores inside. Thus, materialists are trying to control the shape, the size and the distribution of pores in the PM parts [1-2].

Pore Size in Green Compacts

Green compacts are usually compacted from multiple powders, which include both hard particles to construct the skeleton and soft particles to bind the skeleton. In the cold compaction of the multiple powders mixture, the pore size in the green compacts is mainly affected by the size and the shape of the hard particles in these powder mixtures. The specific process to construct the pores in the compaction process of the green compacts can be illustrated schematically, as shown Figure1.

Here, hard particles are partially broken and rearranged to construct the shapes of pores in the green compacts. Soft particles are deformed and flow plastically, which act like a bridge to connect the adjacent hard particles. The size of pores is affected by the both of the size of hard particles and the compaction pressure in the cold densification process. However, the effects of compaction pressure on pore size in cold densification are very limited when the pressure reaches a threshold value [3]. Pore size in green compacts can be lowered by lowering the size of the hard particles in the multiple powder mixture [3].

Pore Size Evolution in Sintering of Green Compacts

Pores formed in cold compaction process would further evolve in sintering. Pores are Spheroidized and shrink by the diffusion of the atoms in the powders in sintering. Pore size in this stage is decided by the diffusion of chemical compositions with a lower melting point or elements with smaller atom diameter in the green compacts because they are easy to diffuse to the edges of these pores and partially fill the pores, which is illustrated in Figure 2 [4].

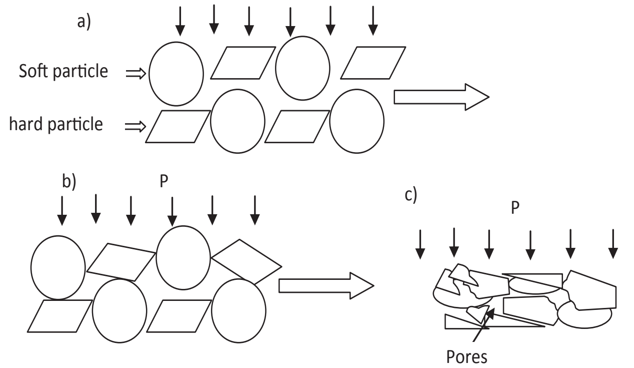

Figure 1: Schematic illustration of the formation of pores in compaction of multiple powders.

The pore size formed in sintering largely depends on the pore size in the green compacts and the holding time of them at a sintering temperature.

It may be of great interest to gain some special physical or mechanical properties of porous metals if the pore size in them can be controlled to as small as several or tens of nanometers [5,6].

Challenges in pore size controlling in P M alloy parts

It may be easy to control pore size to tens of nanometers on surfaces of metal membrane by lithography or etching techniques [5-7]. But the whole size of the porous parts fabricated by these techniques is very small. Pore size in inorganic materials, for instance in alumina can also be controlled as small as tens of nanometers by removal of water from between the crystal planes [8]. However, it is not easy to control the pore size in PM metals as small as several or tens of nanometers by traditional powder metallurgy process.

In traditional PM process, the particle size of the powder is usually a few or tens of microns, which construct the shape of pores.

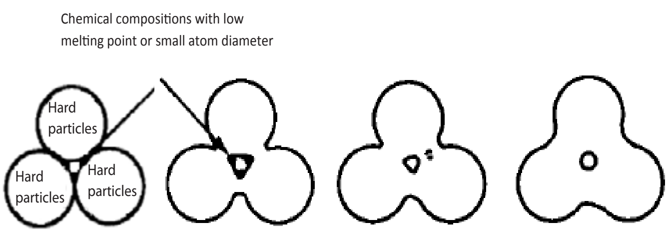

Figure 2: Schematic illustration of the evolution of pores in sintering.

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Even if there are many methods available to make particles as small as tens of nanometers, for instance, attrition milling. However, if the particle size is too small, for example, as small as several nanometers, they aggregate easily in sintering. Thus, the sinterability of the green compacts would be deteriorated, resulting in crack-like voids in the sintered parts. Moreover, some metals are highly oxidizable, such as Al, Cu. The smaller the powder particle size is, the more susceptibility the particle tends to be oxidized even at an ambient with very low oxygen partial pressure. A tenacious surface oxide film may form, which would hindered the further sintering process [9].

These kinds of difficulties must be overcome if the pore size in traditional PM alloy parts can be controlled to as small as tens of nanometers.

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