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Metal Powders Used in Metallurgy

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Abstract
Metal powders used in metallurgy must be produced in great masses to satisfy the needs of industry. Conventional ball milling utilizes a random movement procedure that yields such powders but in low quantities. Planetary ball milling is examined as an alternative to conventional ball milling, and milling times, mass yield, and motion of the system are examined.

Metal powders are used in industry for advanced manufacturing techniques such as sintering, novel particulate volumes, and metal injection molding. (James, W.) Sintering is a process in which a mass of particulates is heated at extreme temperatures (often in excess of 700C) to form a uniform solid mass. Usually metal powder fills a mold from which a part is to be produced, and then heated. Upon retrieval from the furnace, the produced part is of uniform material. Figure 1 shows the transition of individual particles to solid material.

There are many ways of producing the metal powders needed for such manufacturing techniques, and they are usually grouped the following ways:

Mechanical – "machining, milling and mechanical alloying"

Chemical – "electrolytic deposition, decomposition of a solid by gas, thermal decomposition, precipitation from a liquid, precipitation from a gas, solid-solid reactive synthesis"

Physical – "atomization techniques" (James, W.)

This work features mechanical processes, namely mechanical alloying and milling.

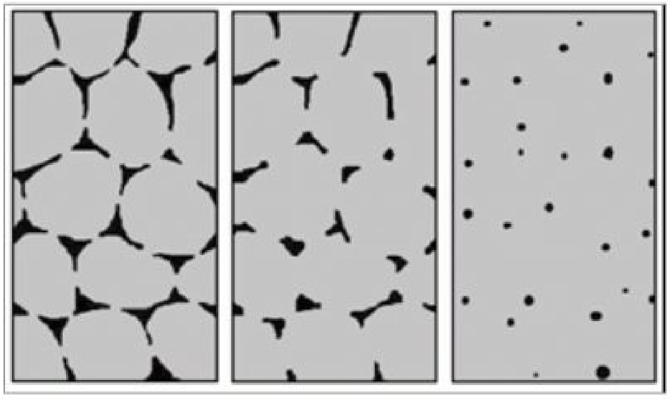


Figure 1: Sintered particles at different points in the process (Powder Metallurgy Review)

Ball milling is an attrition-based process in which metal powders are ground by the use of ball bearings in a cup-like vial. This vial is agitated violently, and is subjected to a seemingly randomized motion. Inside the vial, the ball bearings impact upon the sides of the vial and one another, milling and alloying the metal powder between such surfaces. Figure 2 shows just this. In order to impart such high energy to the vial and by extending the ball bearings, the vial itself needs to be manipulated. Also called high energy ball milling, the vial is moved in a jerking motion at high speeds by an external motor. To impart such energies, however, the vial's size directly influences the size of the motor needed.

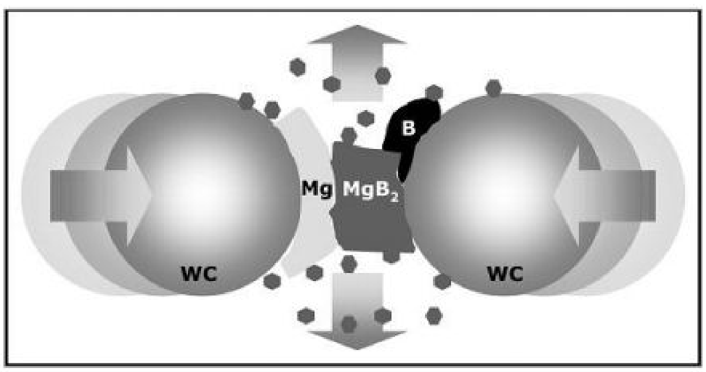


Figure 2: Mechanical alloying. (Student Scientific Society of Surface Engineering)

Planetary bill milling retains the ball bearings from conventional ball milling, but replaces the random shaking motion with a concentric anti-rotating platform. This purely mechanical addition reduces the need for high-energy violent motion, and resembles a kind of "teacup ride" motion. The energy imparted to ball bearings from the vial motion comes from the slingshot effect of the concentric anti-rotating motion. As the larger platform rotates, two smaller platforms move in the opposite rotation. This motion is outlined in Figure 3.

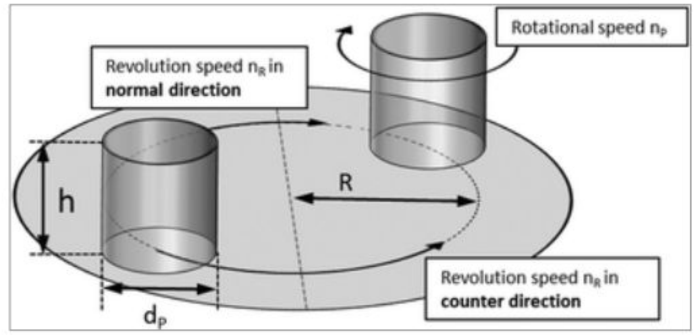
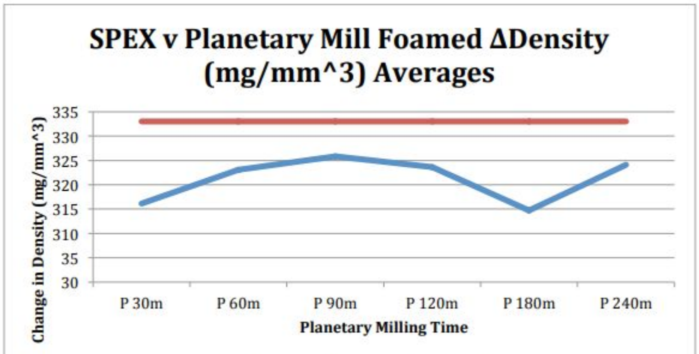


Figure 3: Planetary mill motion (Burmeister)

Transitioning between conventional ball milling to planetary millings carries with it several concerns. First, the volume conversion from a conventional ball mill vial to a planetary ball mill must be taken into account. In addition, the ratio of ball bearings and metal powder may be adjusted when considering the different shapes of the vials. Also, the motion of the planetary mill is substantially less energetic, and the milling time for planetary milling can be expected to be longer than conventional ball milling. Should stearic acid (or some other surfactant) be used to ensure the metal particles do not group together and amass, the ratio of stearic to metal powder can be adjusted. Since so many variables are changing, it may be difficult to compare the two.

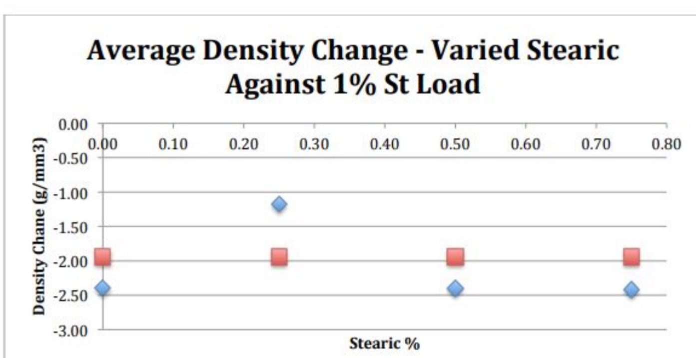
To begin the translation from conventional to planetary ball milling, the ratio of ball bearing mass to metal powder mass was conserved. Spherical copper and copper oxide powders were utilized to examine the efficacy of the planetary mill in alloying copper with 1.5% copper oxide by mass. Milling times for these powders were varied in an attempt to match the conventional ball mill powder. In addition, stearic acid was used in varying amounts after observing stearic acid flakes unused after the milling process. Graph 1 below shows the comparison of milling times with foam density.



Graph 1: Varying planetary milling durations.

The topmost straight bar represents the SPEX (conventional) ball mill run for 90 minutes, while the bottom curved line represents the planetary milled foams. The data was taken with respect to foamed metal solids due to their similar end-state. The foam is formed when annealed at 600C, as the oxygen leaves the alloyed particles and creates a metal foam structure. As the milling time was varied for the planetary mill, the 90 minute run in the center of the x-axis poses an interesting peak. This was used for further variations, as using a less energy intensive method to create the same end product is favorable.

The amount of stearic acid used in the mechanical alloying process was varied second, noting the presence of excess stearic at the end of the milling process. Graph 2 shows this variation.

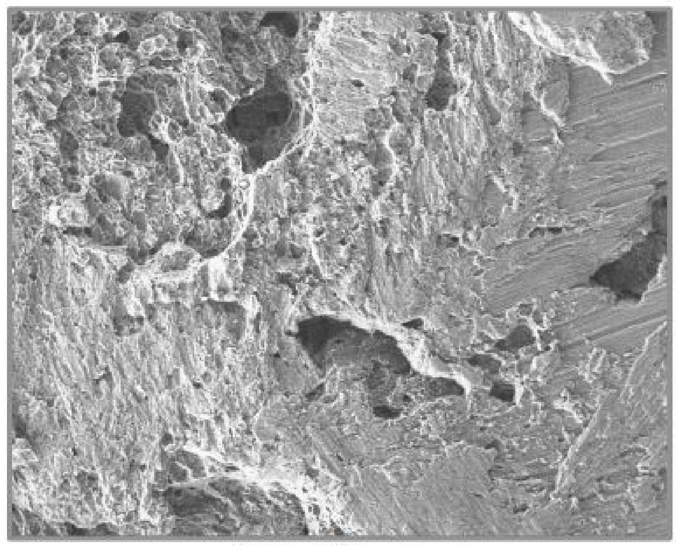


Graph 2:Varying stearic load

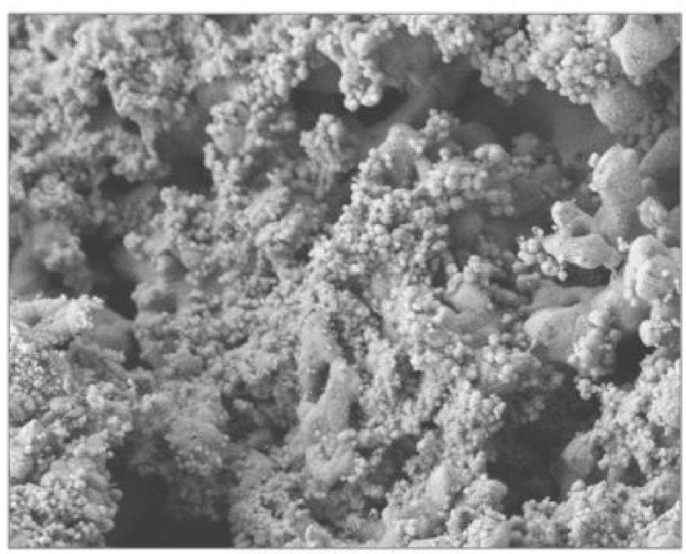
Stearic acid was reduced from the 1% by mass standard used in conventional ball milling to quantities of 0%, .25%, .5% and .75%. The diamonds represent varied stearic loads, while the squares are the normal density change for 1% load.

A better comparison can perhaps be made from examining scanning electron micrographs for the surfaces of 0% and .5% sintered/foamed stearic load variations.

Examining these micrographs lends insight into the foaming ability of such value variations, and it can be seen qualitatively



SEM 1: 0% Stearic load



SEM 2: .5% Stearic Load

that the .5% stearic acid load foams a greater amount than the 0% load, which was not revealed by the density change alone. Variation was also performed in the reduction of ball bearing used, from 114 to 75 and 50. This was performed to minimize the required materials. Further work can be performed in relating the conventional ball mill to the planetary mill, namely in the variation of longterm milling runs (in excess of 240 minutes). Overall, the translation can be seen can be seen as successful, as the manufactured powder foams to an extent.

References

Burmeister, C. F., Kwade, A. Chemical Society Reviews Issue 18. Process Engineering with Planetary Ball Mills. 2013. Retrieved March 5 2018. http://pubs.rsc.org/-/content/articlelanding/2013/cs/c3cs35455e/unauth#!divAbstract.

James, W. B. ASM Handbook, Volume 7. Powder Metallurgy Methods and Applications. 2015. Retrieved March 5 2018. https://www.asminternational.org/documents/10192/1849770/05438G_Sample.pdf/01410f1b-4bb2-4caf-874c-ebbd9360cd58.

Powder Metallurgy Review. Sintering in the Powder Metallurgy Process. Retreived March 5 2018. http://www.pm-review.com/introduction-to-powder-metallurgy/sinteringin-the-powder-metallurgy-process/.

Student Scientific Society of Surface Engineering/Student Scientific Association of Metallurgists. Nanomaterials.http://zasoby.open.agh.edu.pl/~11sashot/stronae7b9.html?t=tw&h=ma&v=.

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