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## Standard Terminology of Powder Metallurgy<sup>1</sup>

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### 1. Scope

1.1 This terminology includes definitions of terms that are specific to the powder metallurgy industry. These definitions are helpful in the interpretation and application of powder metallurgy terms.

### 2. Referenced Documents

#### 2.1 ASTM Standards:

B 331 Test Method for Compressibility of Metal Powders in Uniaxial Compaction<sup>2</sup>

### 3. Terminology

3.1 *Powder*—Terms associated with production, characterization, use, and testing of metal powders.

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##### 3.1.2 General:

**1001 agglomerate, n**—several particles adhering together.

**1002 particulate matter, n**—see **powder**.

**1003 P/M, n**—the acronym representing powder metallurgy. Used as **P/M Part**, **P/M Product**, **P/M Process**, and so forth.

**1004 powder metallurgy, n**—the production and utilization of metal powders.

**1005 powder, n**—particles that are usually less than 1000  $\mu\text{m}$  (1 mm) in size.

**1006 metal powder, n**—particles of elemental metals or alloys, normally less than 1000  $\mu\text{m}$  (1 mm) in size.

##### 3.1.3 Processes to Produce Powder:

**1101 atomization, n**—the dispersion of a molten metal into particles by a rapidly moving gas or liquid stream or by mechanical means.

**1102 granulation, n**—the production of coarse metal particles by pouring the molten metal through a screen into water (shotting) or by violent agitation of the molten metal while solidifying.

**1103 classification, n**—separation of a powder into fractions according to particle size.

**1104 air classification, n**—the separation of powder into particle size fractions by means of an air stream of controlled velocity.

**1105 gas classification, n**—the separation of powder into particle size fractions by means of a gas stream of controlled velocity.

**1106 chemical deposition, n**—the precipitation of one metal from a solution of its salts by the addition of another metal or reagent to the solution.

**1107 chemically precipitated metal powder, n**—powder produced by the reduction of a metal from a solution of its salts either by the addition of another metal higher in the electro-motive series or by other reducing agent.

<sup>1</sup> This terminology is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.01 on Nomenclature and Technical Data.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 02.05.



**1108 reduced metal powder, n**—metal powder produced, without melting, by the chemical reduction of metal oxides or other compounds.

**1109 disintegration, n**—the reduction of massive material to powder.

**1110 milling, n**—the mechanical treatment of metal powder, or metal powder mixtures, as in a ball mill, to alter the size or shape of the individual particles or to coat one component of the mixture with another.

**1111 pulverization, n**—the reduction in particle size of metal powder by mechanical means, a specific type of disintegration.

#### 3.1.4 *Types of Powder:*

**1201 atomized metal powder, n**—metal powder produced by the dispersion of a molten metal by a rapidly moving gas, or liquid stream, or by mechanical dispersion.

**1202 electrolytic powder, n**—powder produced by electrolytic deposition or by the pulverization of an electrodeposit.

**1203 dendritic powder, n**—particles, usually of electrolytic origin, having the typical pine tree structure.

**1204 carbonyl powder, n**—a metal powder prepared by the thermal decomposition of a metal carbonyl.

**1205 master-alloy powder, n**—a powder with high alloy concentration, designed to be diluted when mixed with a base powder to produce the desired composition.

**1206 pre-alloyed powder, n**—powder composed of two or more elements that are alloyed in the powder manufacturing process in which the particles are of the same nominal composition throughout. Synonymous with **completely alloyed powder**.

**1207 completely alloyed powder, n**—see **pre-alloyed powder**.

**1208 partially alloyed powder, n**—a powder in which the alloy addition or additions are metallurgically bonded to an elemental or pre-alloyed powder.

**1209 diffusion-alloyed powder, n**—a partially alloyed powder produced by means of a diffusion anneal.

**1210 mechanically alloyed powder, n**—a composite powder produced by mechanically incorporating other constituents which are generally insoluble within the deformable particles of the matrix metal.

**1211 matrix metal, n**—the continuous phase of a polyphase alloy or mechanical mixture; the physically continuous metallic constituent in which separate particles of another constituent are embedded.

**1212 composite powder, n**—a powder in which each particle consists of two or more distinct constituents.

**1213 spongy, n**—a porous condition in metal powder particles usually observed in reduced oxides.

**1214 sponge iron, n**—a coherent, porous mass of substantially pure iron produced by solid-state reduction of iron oxide (for example, iron ore or mill scale).

**1215 sponge iron powder, n**—ground and sized sponge iron, which may have been purified or annealed or both.

**1216 mixed powder, n**—a powder made by mixing two or more powders as uniformly as possible. The constituent powders will differ in chemical composition or in particle size or shape, or a combination thereof.

**1217 premix, n**—a uniform mixture of ingredients to a prescribed analysis, prepared by the powder producer, for direct use in compacting powder metallurgy products.

#### 3.1.5 *Shapes of Powder Particles:*

**1301 acicular powder, n**—needle-shaped particles.

**1302 needles, n**—elongated rod-like particles.

**1303 granular powder, n**—particles having approximately equidimensional nonspherical shapes.

**1304 nodular powder, n**—irregular particles having knotted, rounded, or similar shapes.

**1305 irregular powder, n**—particles lacking symmetry.

**1306 spherical powder, n**—globular-shaped particles.

**1307 flake powder, n**—flat or scale-like particles whose thickness is small compared with the other dimensions.

**1308 plates, n**—flat particles of metal powder having considerable thickness.

#### 3.1.6 *Additives to Powder:*

**1401 binder, n**—a cementing medium; either a material added to the powder to increase the green strength of the compact, and which is expelled during sintering; or a material (usually of relatively lower melting point) added to a powder mixture for the specific purpose of cementing together powder particles which alone would not sinter into a strong body.

**1402 feedstock, n**—*in metal injection molding (MIM)*, a moldable mixture of metal powder and binder.

**1403 powder lubricant, n**—an agent mixed with or incorporated in a powder to facilitate the pressing and ejecting of the compact.

**1404 dispersion-strengthened material, n**—a material consisting of a metal and finely dispersed, substantially insoluble, metallic or nonmetallic phase.

**1405 pore-forming material, n**—a substance included in a powder mixture that volatilizes during sintering and thereby produces a desired kind and degree of porosity in the finished compact.

#### 3.1.7 *Treatment of Powder:*

**1501 blending, n**—the thorough intermingling of powders of the same nominal composition (not to be confused with mixing).

**1502 equalizing, n**—see blending.

**1503 mixing, n**—the thorough intermingling of powders of two or more materials.

**1504 cross-product contamination, n**—the unintentional mixing of powders with distinct differences in either physical characteristics or chemical composition or both.

**1505 lubricating, n**—mixing with, or incorporating in, a powder, some agent to facilitate pressing and ejecting the compact from the die body; applying a lubricant to the die walls and punch surfaces.

#### 3.1.8 *Properties of Powder:*

**1601 apparent density, n**—the mass of a unit volume of powder, usually expressed as grams per cubic centimetre, determined by a specified method.

**1602 bulk density, n**—the mass per unit volume of a powder under nonstandard conditions, for example, in a shipping container (not to be confused with apparent density).

**1603 tap density, n**—the apparent density of the powder in a container that has been tapped under specified conditions.

**1604 flow rate, n**—the time required for a powder sample of standard weight to flow through an orifice in a standard instrument according to a specified procedure.

**1605 specific surface, n**—the surface area of one gram of powder, usually expressed in square centimetres.

**1606 compactibility, n**—a conceptual term, encompassing the powder characteristics of compressibility, green strength, edge retention, and lamination tendency, that relates to the ability of a powder to be consolidated into a usable green compact.

**1607 compressibility, n**—the capacity of a metal powder to be densified under a uniaxially applied pressure in a closed die.

DISCUSSION—Compressibility is measured in accordance with Test Method B 331 and may be expressed numerically as the pressure to reach a specified density, or alternatively the density at a given pressure.<sup>3</sup>

**1608 compression ratio, n**—the ratio of the volume of the loose powder to the volume of the compact made from it. Synonymous with **fill ratio**.

**1609 fill ratio, n**—see **compression ratio**.

**1610 oversize powder, n**—particles coarser than the maximum permitted by a given particle size specification.

**1611 plus sieve, n**—the portion of a powder sample retained on a standard sieve of specified number. (See **minus sieve**.)

**1612 minus sieve, n**—the portion of a powder sample which passes through a standard sieve of specified number. (See **plus sieve**.)

**1613 fines, n**—the portion of a powder composed of particles which are smaller than a specified size, currently less than 44  $\mu\text{m}$ . See also **superfines**.

**1614 superfines, n**—the portion of a powder composed of particles that are smaller than a specified size, currently less than 10  $\mu\text{m}$ .

**1615 fraction, n**—that portion of a powder sample that lies between two stated particle sizes. Synonymous with **cut**.

**1616 cut, n**—see **fraction**.

**1617 subsieve fraction, n**—particles all of which will pass through a 44- $\mu\text{m}$  (No. 325) standard sieve.

**1618 sieve fraction, n**—that portion of a powder sample that passes through a standard sieve of specified number and is retained by some finer sieve of specified number.

**1619 particle size, n**—the controlling lineal dimension of an individual particle as determined by analysis with sieves or other suitable means.

**1620 particle size distribution, n**—the percentage by weight, or by number, of each fraction into which a powder sample has been classified with respect to sieve number or microns. (Preferred usage: “particle size distribution by frequency.”)

**1621 hydrogen loss, n**—the loss in weight of metal powder or of a compact caused by heating a representative sample for a specified time and temperature in a purified hydrogen atmosphere—broadly, a measure of the oxygen content of the sample when applied to materials containing only such oxides as are reducible with hydrogen and no hydride-forming element.

### 3.1.9 Procedures to Evaluate Powder:

**1701 sieve analysis, n**—particle size distribution; usually expressed as the weight percentage retained upon each of a series of standard sieves of decreasing size and the percentage passed by the sieve of finest size. Synonymous with **screen analysis**.

**1702 screen analysis, n**—see **sieve analysis**.

**1703 sieve classification, n**—the separation of powder into particle size ranges by the use of a series of graded sieves.

### 3.1.10 Equipment to Evaluate Powder:

**1801 powder flow meter, n**—an instrument for measuring the rate of flow of a powder according to a specified procedure.

**3.2 Forming**—Terms associated with consolidation of metal powders and mixes, including tooling, equipment, and characterization of sintered compacts.

#### 3.2.1 General:

**2001 green**—unsintered (not sintered); for example, green compact, green density, green strength.

**2002 preforming**—the initial pressing of a metal powder to form a compact that is subjected to a subsequent pressing operation other than coining or sizing. Also, the preliminary shaping of a refractory metal compact after presintering and before the final sintering.

**2003 blank, n**—a pressed, presintered, or fully sintered compact, usually in the unfinished condition, requiring cutting, machining, or some other operation to give it its final shape.

**2004 briquet, n**—see **compact**.

**2005 compact, n**—an object produced by the compression of metal powder, generally while confined in a die, with or without the inclusion of nonmetallic constituents. Synonymous with **briquet**.

**2006 pressed bar, n**—a compact in the form of a bar; a green compact.

**2007 rolled compact, n**—a compact made by passing metal powder continuously through a rolling mill so as to form relatively long sheets of pressed material.

**2008 composite compact, n**—a metal powder compact consisting of two or more adhering layers, rings, or other shapes of different metals or alloys with each material retaining its original identity.

**2009 compound compact, n**—a metal powder compact consisting of mixed metals, the particles of which are joined by pressing or sintering or both, with each metal particle retaining substantially its original composition.

#### 3.2.2 Processes for Compacting:

**2101 molding, v**—the pressing of powder to form a compact.

**2102 press, v**—to apply force to a mass of powder, generally while confined in a die or container, to form a compact.

**2103 double press-double sinter, n**—to repress and sinter a previously presintered or sintered compact.

DISCUSSION—Used to describe a four-step manufacturing process.

**2104 single-action pressing, n**—a method by which a powder is pressed in a stationary die between one moving and one fixed punch.

DISCUSSION—Only during ejection does either the stationary die or punch move.

<sup>3</sup> See Test Method B 331.





**2105 double-action pressing, n**—a method by which a powder is pressed in a die between opposing moving punches.

**2106 withdrawal pressing, n**—a powder consolidation method in which the die moves downward in relation to the lower punch(es) during compaction. It further descends over the fixed lower punch(es) for ejection, so that the compact may then be pushed off the tooling at this point.

**2107 multiple pressing, n**—a method of pressing whereby two or more compacts are produced simultaneously in separate die cavities.

**2108 roll compacting, n**—the progressive compacting of metal powders by the use of a rolling mill. Synonymous with **powder rolling**.

**2109 powder rolling, n**—see **roll compacting**.

**2110 cold pressing, n**—the forming of a compact at room temperature.

### 3.2.3 Conditions for Compacting:

**2201 die lubricant, n**—a lubricant applied to the walls of the die and to the punches to facilitate the pressing and ejection of the compact.

DISCUSSION—Contrast with **powder lubricant**. Synonymous with **die-wall lubricant**.

**2202 die-wall lubricant, n**—synonymous with **die lubricant**.

### 3.2.4 Tools Used for Compacting:

**2301 compacting tool set, n**—see **die**.

**2302 die, n**—the part or parts making up the confining form in which a powder is pressed. The parts of the die may be some or all of the following: die body, punches, and core rods. Synonymous with **mold**.

**2303 mold, n**—see **die**.

**2304 die body, n**—the stationary or fixed part of a die.

**2305 die set, n**—the parts of a press that hold and locate the die in proper relation to the punches.

**2306 die insert, n**—a removable liner or part of a die body.

**2307 split die, n**—a die made of parts that can be separated for ready removal of the compact.

**2308 segment die, n**—a die fabricated by the assembly of several die sections within a retaining bolster or shrinkage ring.

**2309 punch, n**—part of a die or compacting tool set that is used to transmit pressure to the powder in the die cavity. See **upper punch** and **lower punch**.

**2310 upper punch, n**—the member of the compacting tool set or die that closes the die and forms the top of the part being produced.

**2311 lower punch, n**—the member of the compacting tool set or die that forms the bottom of the part being produced, and the position of which determines the volume of powder fill. Secondary or subdivided lower punches may be necessary to facilitate filling, forming, and ejecting of multiple level parts.

**2312 stripper punch, n**—a punch that, in addition to forming the top or bottom of the die cavity, later moves further into the die to eject the compact.

**2313 core rod, n**—a member of a die used to produce a hole in a compact.

**2314 rotary press, n**—a machine fitted with a rotating table carrying multiple dies in which a material is pressed.

**2315 compacting tool set, n**—an assembly of tooling items

in which powder is pressed.

DISCUSSION—May include a die, punches, and core rods.

**2316 die, n**—a member of the compacting tool set forming the cavity in which the powder is compacted or a P/M compact is repressed.

**2317 core rod, n**—a member of the compacting tool set that forms the inner profile of the P/M compact in the direction of pressing.

### 3.2.5 Phenomena Resulting from Compaction:

**2401 bridging, v**—the formation of arched cavities in a powder mass.

**2402 green, adj**—unsintered (not sintered); for example, green compact, green density, green strength.

**2406 springback, n**—see **green expansion**.

**2407 cold welding, n**—cohesion between two surfaces of metal, generally under the influence of externally applied pressure, at room temperature.

DISCUSSION—Often used to describe the mechanism by which powder particles develop initial bonds and a pressed compact develops green strength.

### 3.2.6 Properties of Compacts:

**2501 green density, n**—the mass per unit volume of an unsintered compact.

**2502 pressed density, n**—synonymous with **green density**.

**2503 green expansion, n**—the increase in dimensions of an ejected compact relative to the die dimensions, measured at right angles to the direction of pressing. Synonymous with **springback**.

### 3.2.7 Forging:

**2601 powder forging, v**—hot densification by forging of an unsintered, presintered, or sintered preform made from powder. Also referred to by the acronyms **P/F**, **P/M forging**, or **P/M hot forming**. There are two basic forms of powder forging: **hot upset powder forging** and **hot repress powder forging**.

DISCUSSION—In the case in which the preform has been sintered, the process is often referred to as “sinter forging.”

**2602 P/F, v**—the acronym for powder forging. See **powder forging**.

**2603 P/M forging, v**—see **powder forging**.

**2604 P/M hot forming, v**—see **powder forging**.

**2605 forging preform, n**—an unsintered, presintered, or fully sintered compact intended to be subjected to hot or cold forming and densification.

**2606 sinter forging, v**—see **powder forging**.

**2607 hot coining, v**—see **powder forging**.

**2608 hot forging, v**—see **powder forging**.

**2609 hot restriking, v**—see **powder forging**.

**2610 hot upset powder forging, v**—hot densification of a P/M preform by forging in which there is a significant amount of lateral material flow.

**2611 hot repress powder forging, v**—hot densification of a P/M preform by forging in which material flow is mainly in the direction of pressing. Also referred to as *hot restriking* or *hot coining*.

### 3.2.8 Metal Injection Molding:

**2705 metal injection molding (MIM), n**—a process in which a mixture of metal powders and a binder system is

forced under pressure into a mold. See also **powder injection molding**.

**2706 MIM**—see **metal injection molding**.

**2707 powder injection molding (PIM), n**—a process in which a mixture of powders and a binder system is forced under pressure into a mold. See also **metal injection molding**.

**2708 PIM**—see **powder injection molding**.

**3.3 Sintering**—Terms associated with forming a metallic bond among particles including processes, equipment, and characterization of sintered compacts.

**3.3.1 Processes for Sintering:**

**3101 sinter, v**—the bonding of adjacent surfaces of particles in a mass of powder, or a compact, by heating.

**3102 solid-state sintering, v**—sintering of a powder or compact without formation of a liquid phase.

**3103 presintering, v**—the heating of a compact at a temperature below the normal final sintering temperature, usually to increase the ease of handling or shaping the compact, or to remove a lubricant or binder before sintering.

**3104 activated sintering, v**—a sintering process during which the rate of sintering is increased, for example, by addition of a substance to the powder or by changing sintering conditions.

**3105 continuous sintering, v**—presintering, or sintering, in such manner that the objects are advanced through the furnace at a fixed rate by manual or mechanical means. Synonymous with **stoking**.

**3106 stoking, v**—see **continuous sintering**.

**3107 liquid phase sintering, v**—sintering of a compact, or loose powder aggregate, under conditions in which a liquid phase is present during part of the sintering cycle.

**3108 sintering time, n**—that time period during which the P/M powder or compact is held within the specified sintering temperature range.

**3109 infiltration, n**—a process of filling the pores of a sintered, or unsintered, compact with a metal or alloy of lower melting point.

**3110 nitrogen alloying, n**—the transfer of nitrogen from a furnace atmosphere to powder or a P/M part, in such a way as to increase the nitrogen content of the material within controlled limits.

**3111 cored bar, n**—a compact of bar shape heated by its own electrical resistance to a temperature high enough to melt its interior.

**3.3.2 Conditions During Sintering:**

**3201 packing material, n**—any material in which compacts are embedded during the presintering or sintering operation.

**3.3.3 Phenomena Resulting from Sintering:**

**3301 powder metallurgy part, n**—a shaped object that has been formed from metal powders and bonded by heating below the melting point of the major constituent. A structural or mechanical component, bearing, or bushing made by the powder metallurgy process. Synonymous with **P/M part**.

**3302 P/M part, n**—see **powder metallurgy part**.

**3303 fully dense material, n**—a material completely free of porosity and voids.

**DISCUSSION**—This is a conceptual term. In practice, complete densification is difficult to achieve and some microporosity will generally be

present. The measured density of a material depends on its specific chemistry, thermomechanical condition, and microstructure.

**3304 cake, n**—a bonded mass of unpressed metal powder.

**DISCUSSION**—Often refers to the form of powder as it exits a furnace.

**3305 closed pore, n**—a pore not communicating or connected with an exterior surface.

**3306 open pore, n**—a pore communicating with an exterior surface.

**3307 communicating pores, n**—see **interconnected porosity**.

**3308 interconnected porosity, n**—a network of pores in and extending to the surface of a sintered compact. Usually applied to powder metallurgy materials in which the interconnected porosity is determined by impregnating the specimens with oil. Synonymous with **communicating pores**.

**3309 exudation, n**—the action by which all or a portion of the low melting constituent of a compact is forced to the surface during sintering. Sometimes referred to as “bleed out.” Synonymous with **sweating**.

**3310 sweating, n**—see **exudation**.

**3311 infiltration erosion, n**—the pitting, channeling, and coarsening of the surface porosity that results from the dissolution of the base metal by the liquid infiltrant, as the infiltrant flows into the matrix.

**3312 infiltration residue, n**—material that remains on the surface of the part after infiltration.

**3313 blistered compact, n**—a sintered object characterized by having blisters or eruptions on the surface.

**DISCUSSION**—In ferrous materials, this effect is often caused by in-situ gas decomposition and soot formation that forces particles apart and causes the compact to blister.

**3315 neck formation, n**—during sintering, the development of a neck-like bond between particles.

**3316 slumping, n**—the lack of shape retention of a molded part, during subsequent processing, because of the effect of gravity.

**3317 warpage, n**—distortion that may occur in a compact during sintering.

**3318 oxide network, n**—continuous or discontinuous oxides that follow prior particle boundaries.

**3319 surface finger oxide, n**—the oxide that follows prior particle boundaries into a part from the surface and cannot be removed by physical means, such as rotary tumbling.

**3320 pore, n**—an inherent or induced cavity within a particle or within an object.

**3.3.4 Properties of Sintered Parts:**

**3401 dimensional change of a compact, n**—the difference, at room temperature, between the size of the sintered specimen and the die size.

**DISCUSSION**—The difference in dimensions is usually reported as a percentage of the die size. It should include a (+) when the sintered part is larger than the die size and a (–) when the sintered part is smaller than the die size.

**3402 growth, n**—an increase in dimensions of a compact which may occur during sintering. (Converse of **shrinkage**.)

**3403 shrinkage, n**—a decrease in dimensions of a compact which may occur during sintering. (Converse of **growth**.)



**3404 infiltrant efficiency, n**—the ratio of the mass of infiltrant absorbed by the part to the mass of infiltrant originally used, expressed as a percentage.

**3405 infiltration loading density, n**—infiltrant weight per unit area of contact between infiltrant and part.

**3406 metal filter, n**—a metal structure having controlled interconnected porosity produced to meet filtration or permeability requirements.

**3407 porosity, n**—the amount of pores (voids) expressed as a percentage of the total volume of the powder metallurgy part.

**3408 apparent porosity, n**—in cemented carbides, microstructural features that appear to be pores in a properly prepared, unetched surface; these features may result from uncombined carbon or nonmetallic inclusions as well as actual porosity.

**3409 density (dry), n**—the mass per unit volume of an unimpregnated powder metallurgy part.

**3410 density (wet), n**—the mass per unit volume of a powder metallurgy part impregnated with oil or other nonmetallic materials.

**3411 density ratio, n**—the ratio, often expressed as a percentage, of the density of a porous material to the density of the same material completely free of porosity. Synonymous with **relative density**.

**3412 relative density, n**—see **density ratio**.

**3413 K factor**—the strength constant in the formula for **radial crushing strength** of a plain sleeve specimen of sintered metal. See also **radial crushing strength**.

**3414 radial crushing strength, n**—the relative capacity of a plain sleeve specimen of sintered metal to resist fracture induced by a load applied between flat parallel plates in a direction perpendicular to the axis of the specimen.

**3415 transverse rupture strength, n**—the stress calculated from the flexure formula, required to break a specimen supported near the ends as a simple beam; the load is applied midway between the center lines of the supports.

**3416 permeability, n**—a property measured as the rate of passage of a liquid or gas through a compact; measured under specified condition.

**3417 oil content, n**—the measured amount of oil contained in an oil-impregnated object, for example, a self-lubricating bearing.

**3418 apparent hardness, n**—the hardness, including the effects of porosity, of a P/M material measured under specified conditions, using standard macro-indentation hardness equipment.<sup>4</sup>

DISCUSSION—The reading is a composite of pores and solid material. It usually is lower than that which would be measured for a pore-free material of the same composition and condition; not to be confused with particle hardness.

### 3.3.5 Procedure to Evaluate Sintered Parts:

<sup>4</sup> For a discussion of apparent hardness, see the section on Density in General Description of Production, Properties, and Uses of Metal Powder Sintered Bearings, and Sintered Metal Powder Structural Parts, which appears in the *Annual Book of ASTM Standards*, Vol 02.05.

**3501 rate-of-oil flow, n**—the rate at which a specified oil will pass through a sintered porous compact under specified test conditions.

#### 3.3.6 Removal of Binders:

**3601 binder removal, n**—the chemical or thermal extraction of binder from a compact. Synonymous with **debinding**.

**3602 debinding, n**—see **binder removal**.

3.4 *Postsinter Treatments*—Terms associated with secondary operations including repressing, machining, and heat treatment that are performed on sintered compacts.

#### 3.4.1 Processes:

**4102 impregnation, n**—a process of filling the pores of a sintered compact, with a nonmetallic material such as oil, wax, or resin.

**4105 repress, v**—to apply pressure to a previously pressed and either sintered or presintered compact. It includes **restrike**, **coin**, and **size**.

**4106 restrike, v**—to repress for the purpose of increasing the density of a sintered compact (not to be confused with **coin** or **size**).

**4107 coin, v**—to repress a sintered compact to obtain a definite surface configuration. Synonymous with **emboss** (not to be confused with **restrike** or **size**).

**4108 size, v**—to repress a sintered compact to decrease the dimensional variation (not to be confused with **coin** or **restrike**).

3.5 *Miscellaneous*—Terms that do not belong under any other category.

#### 3.5.1 Definitions:

**5101 RSM**—Rapidly Solidified Materials.

**5102 RSP**—Rapid Solidification Processing or Rapidly Solidified Powders.

**5103 RST**—Rapid Solidification Technology.

#### 3.5.2 Processes:

**5201 isostatic pressing, n**—the pressing of a powder, compact, or sintered object by subjecting it to a nominally equal pressure from every direction.

**5202 cold isostatic pressing, n**—the pressing of a powder, compact, or sintered object by subjecting it, at ambient temperature, to nominally equal pressure from every direction.

**5203 hot isostatic pressing, n**—the pressing of a powder, compact or sintered object by subjecting it, at elevated temperature, to nominally equal pressure from every direction.

**5204 hot densification, n**—the consolidation, at elevated temperature and pressure, of an unsintered, presintered, or sintered powder preform, or encapsulated or loose powder, to reduce porosity.

**5205 hot pressing, v**—pressure-assisted, low strain rate uniaxial densification of a powder preform, compact, or encapsulated or loose powder at a temperature sufficient to induce diffusion or creep.

#### 3.5.3 Materials:

**5301 hardmetal, cemented carbide, n**—sintered material characterized by high strength and wear resistance and comprising one or more carbides of refractory metals as the main component bonded by metallic binder phase.

**APPENDIX****XI. ALPHABETICAL INDEX****XI.1 Index Numbers correspond to numbers assigned to terms within the standard.****A**

acicular powder 1301  
activated sintering 3104  
agglomerate 1001  
air classification 1104  
apparent density 1601  
apparent hardness 3418  
apparent porosity 3408  
atomization 1101  
atomized metal powder 1201

**B**

binder 1401  
binder removal 3601  
blank 2003  
blending 1501  
blistered compact 3313  
bridging 2401  
briquet 2004  
bulk density 1602

**C**

cake 3304  
carbonyl powder 1204  
chemical deposition 1106  
chemically precipitated metal powder 1107  
classification 1103  
closed pore 3305  
coin 4107  
cold isostatic pressing 5202  
cold pressing 2110  
cold welding 2407  
communicating pores 3307  
compact 2005  
compactability 1606  
compacting tool set 2301  
completely alloyed powder 1207  
composite compact 2008  
composite powder 1212  
compound compact 2009  
compressibility 1607  
compression ratio 1608  
continuous sintering 3105  
core rod 2312  
cored bar 3111  
cross-product contamination 1504  
cut 1616

**D**

debinding 3602  
dendritic powder 1203  
density (dry) 3409  
density (wet) 3410

density ratio 3411  
die 2302  
die body 2304  
die insert 2306  
die lubricant 2201  
die set 2305  
die-wall lubricant 2202  
diffusion—alloyed powder 1209  
dimensional change of a compact 3401  
disintegration 1109  
dispersion-strengthened material 1404  
double-action pressing 2105  
double press-double sinter 2103

**E**

electrolytic powder 1202  
equalizing 1502  
exudation 3309

**F**

feedstock 1402  
fill ratio 1609  
fines 1613  
flake powder 1307  
flow rate 1604  
forging preform 2605  
fraction 1615  
fully dense material 3303

**G**

gas classification 1105  
granular powder 1303  
granulation 1102  
green 2402, 2001  
green density 2501  
green expansion 2503  
growth 3402

**H**

hardmetal, cemented carbide 5301  
hot densification 5204  
hot coining 2607  
hot forging 2608  
hot isostatic pressing 5203  
hot pressing 5205  
hot upset powder forging 2610  
hot repress powder forging 2611  
hot restriking 2609  
hydrogen loss 1621

**I**

impregnation 4102  
infiltrant efficiency 3404  
infiltration 3109  
infiltration erosion 3311  
infiltration loading density 3405  
infiltration residue 3312  
interconnected porosity 3308



irregular powder 1305  
isostatic pressing 5201

**K**

*K* factor 3413

**L**

liquid phase sintering 3107  
lower punch 3211  
lubricating 1505

**M**

master-alloy powder 1205  
matrix metal 1211  
mechanically alloyed powder 1210  
metal filter 3406  
metal injection molding (MIM) 2705  
metal powder 1006  
milling 1110  
MIM 2706  
minus sieve 1612  
mixed powder 1216  
mixing 1503  
mold 2303  
molding 2101  
multiple pressing 2107

**N**

neck formation 3315  
needles 1302  
nitrogen alloying 3110  
nodular powder 1304

**O**

oil content 3417  
open pore 3306  
oversize powder 1610  
oxide network 3318

**P**

packing material 3201  
partially alloyed powder 1208  
particle size 1619  
particle size distribution 1620  
particulate matter 1002  
permeability 3416  
P/F 2602  
PIM 2708  
plates 1308  
plus sieve 1611  
P/M 1003  
P/M forging 2603  
P/M hot forming 2604  
P/M part 3302  
pore 3320  
pore-forming material 1405  
porosity 3407  
powder 1005  
powder flow meter 1801  
powder forging 2601  
powder injection molding (PIM) 2707  
powder lubricant 1403

powder metallurgy 1004  
powder metallurgy part 3301  
powder rolling 2109  
pre-alloyed powder 1206  
preforming 2002  
premix 1217  
presintering 3103  
press 2102  
pressed bar 2006  
pressed density 2502  
pulverization 1111  
punch 2309

**R**

radial crushing strength 3414  
rate-of-oil flow 3501  
reduced metal powder 1108  
relative density 3412  
repressing 4103  
restrike 4106  
roll compacting 2108  
rolled compact 2007  
rotary press 2314  
RSM 5101  
RSP 5102  
RST 5103

**S**

screen analysis 1702  
segment die 2308  
shrinkage 3403  
sieve analysis 1701  
sieve classification 1703  
sieve fraction 1618  
single-action pressing 2104  
sinter 3101  
sinter forging 2606  
sintering time 3108  
size 4108  
slumping 3316  
solid-state sintering 3102  
specific surface 1605  
spherical powder 1306  
split die 2307  
sponge iron 1214  
sponge iron powder 1215  
spongy 1213  
springback 2406  
stoking 3106  
stripper punch 2312  
subsieve fraction 1617  
superfines 1614  
surface finger oxide 3319  
sweating 3310

**T**

tap density 1603  
transverse rupture strength 3415



**U**

upper punch 2310

**W**warpage 3317  
withdrawal pressing 2106

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