Designation: B243 – 16a

Standard Terminology of Powder Metallurgy[1]

This standard is issued under the fixed designation B243; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This terminology standard includes definitions that are helpful in the interpretation and application of powder metallurgy terms.

2. Referenced Documents

2.1 *ASTM Standards:*

B331 Test Method for Compressibility of Metal Powders in Uniaxial Compaction

3. Terminology

3.1 *Definitions:*

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

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.

agglomerate, *n*—several particles adhering together.

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

angle of repose, *n*—the basal angle of a pile formed by powder when freely poured under specified conditions onto a horizontal surface.

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

apparent hardness, *n*—the hardness of a PM material (including the effects of porosity), measured using macroindentation hardness equipment.

DISCUSSION—See general description of production, properties, and uses of sintered metal powder bearings and structural parts, paragraph on density and mechanical properties, information on hardness measurement, Volume 02.05.[2]

apparent porosity, *n*—specific to 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.

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

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

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.

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

blister crack, *n*—typically small defects (star burst) over or around a bump or blister.

DISCUSSION—These may occur during sintering as a result of rapid outgassing of the lubricant. The rapid outgassing may be caused by the specified amount of lubricant being subjected to an excessive heating rate. The defects may also be caused by "concentrated balls" of lubricant, or moisture. During the sintering of the copper base PM parts, hydrogen gas from the furnace atmosphere can diffuse into the compact and react with residual oxygen, producing steam that can form blisters and cracks. In that industry, this is also called embrittlement, and is not to be confused with the hydrogen embrittlement of high strength steel.

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.

[1] 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.

Current edition approved Dec. 1, 2016. Published February 2017. Originally approved in 1949. Last previous edition approved in 2016 as B243 – 16. DOI: 10.1520/B0243-16A.

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

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.

binder (MIM), *n*—a mixture of polymers or other materials, or both, that when combined with metal powders enables the mixture to flow during the injection molding process. The binder imparts green strength to the MIM part and allows it to retain its molded shape.

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

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

briquet, *n*—see **compact.**

brown part, *n*—an MIM part that has had a majority of the binder (first stage) removed. Synonymous with **debound part**.

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).

burn-off, *n*—removal of organic additives (binder or lubricant) from a compact by heating.

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

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

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

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.

cermet, *n*—sintered material containing at least one metallic phase and at least one nonmetallic phase that is generally of a ceramic nature.

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.

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 electromotive series or by other reducing agent.

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

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

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

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.

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

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.

comminuted powder, *n*—a powder produced by mechanical attrition of solid metal or powder

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

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.**

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.

compacting, *n*—a process in which a powder held in a die or other container is subjected to an external force in order to densify the powder and produce a compact of prescribed shape and dimensions.

compacting pressure (uniaxial), *n*—applied force divided by the projected area of contact with the punch(es).

compacting tool set, *n*—an assembly of tooling items in which powder is pressed.

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

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

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.

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

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.

compounding (MIM), *n*—process whereby the metal powders and molten binder constituents are combined to produce a feedstock.

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 B331 and may be expressed numerically as the pressure to reach a specified density, or alternatively the density at a given pressure.[3]

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**.

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**.

cooling rate, *n*—the average temperature change per second between prescribed temperatures during the cooling phase of a thermal process.

core rod, *n*—a member of the compacting tool set that forms internal features such as splines, diameters, keyways, or other profiles in a PM compact.

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

crack (RD), *n*—generally a planar defect.

cracked ammonia, *n*—see **dissociated ammonia**.

cracks (rigid die system (RD)), *n*—the following names and definitions apply only to items produced in a rigid die system (RD) as opposed to those cracks produced by other systems, that is, metal injection molding, vacuum hot pressing, and so forth.[4]

cut, *n*—see **fraction**.

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

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

debound part, *n*—see **brown part**.

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

densification crack, *n*—a defect caused by differential stresses in a region of a part that has experienced large differences in shrinkage during sintering.

density (dry), *n*—see **sintered density**.

density (wet), *n*—see **impregnated density**.

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**.

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

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

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

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

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

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.

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

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

dissociated ammonia, *n*—a reducing gas produced by the thermal decomposition of anhydrous ammonia over a catalyst, resulting in a gas of 75 % hydrogen and 25 % nitrogen. Synonymous with cracked ammonia.

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

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

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

ejection crack, *n*—a defect that occurs during the removal of the compact from the tooling (usually occurs in multilevel parts that are not supported uniformly on all lower surfaces).

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

endothermic gas, *n*—a reducing gas atmosphere used in sintering, produced by the reaction of a hydrocarbon vapor and air over a catalyst with the use of an external heat source. It is low in carbon dioxide and water vapor while containing combustibles of about 60 atomic percent hydrogen and carbon monoxide combined.

equalizing, *n*—see blending.

exothermic atmosphere (gas), *n*—a reducing gas atmosphere used in sintering, produced by partial or complete combustion of hydrocarbon fuel gas and air with the associated generation of heat. The maximum combustible content is approximately 25 atomic percent.

explosive compaction, *n*—high-energy consolidation of powders by means of a detonation shock wave.

[3] See Test Method B331.

[4] There is detailed information on numerous cracks, their location, cause, and prevention in a handbook published by Metal Powder Industries Federation, Princeton, New Jersey, "The Common Cracks in PM Compacts" by D. Zenger and H. Cai.

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**.

feedshoe, *n*—a part of the compacting press that delivers powder to the die cavity, usually by sliding an open-bottomed powder container over the open top of the die.

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

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

fines, *n*— the portion of a powder composed of particles which are smaller than a specified size, currently less than 44 μm. See also **superfines**.

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

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.

fluid permeability, *n*—see **permeability**.

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

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.

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

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

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.

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

green crack, *n*—a defect that occurs prior to sintering.

green density, *n—(a)* the mass per unit volume of an unsintered PM part or test specimen.

(b) the mass per unit volume of an unsintered compact.

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**.

green strength, *n*—stress required to break an unsintered compact.

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

hardmetal, *n*—see **cemented carbide**.

heating rate, *n*—the average temperature change per unit time between prescribed temperatures during the heating phase of a thermal process.

hot densification, *n*—the consolidation, at an elevated pressure and at a temperature that often results in recrystallization, of an unsintered, presintered, or sintered powder preform, or of encapsulated or loose powder, to reduce porosity.

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

(b) subjecting a powder, compact, or sintered object to an elevated pressure, nominally equal from every direction, and an elevated temperature, the combination of which is sufficient to induce diffusion and creep, resulting in the densification of the material being processed.

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.

hot repress powder forging, *n*—hot densification of a PM preform by forging where the material flow is mainly in the direction of forging.

hot upset powder forging, *n*—hot densification of a PM preform by forging where there is a significant amount of lateral material flow.

hybrid-alloy powder, *n*—a pre-alloyed or diffusion-alloyed powder to which either elemental or master-alloy metal powders have been admixed.

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.

hydrogen-reduced powder, *n*—powder produced by the reduction of a metal oxide in an atmosphere containing hydrogen.

impregnated density, *n*—the mass per unit volume of a sintered PM part or test specimen, impregnated with oil or other lubricants. Synonymous with **density (wet)**.

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

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.

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

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.

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

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

interconnected porosity, *n*—a network of mutually connected pores that may or may not extend to an exterior surface. Synonymous with **communicating pores**.

irregular powder, *n*—particles lacking symmetry.

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

lamination crack, *n*—a defect(s) roughly parallel to the punch faces of the part (these defects usually occur when powder is compressed to high density and the relaxation forces during pressure release exceed the binding force between the particles).

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.

lot, *n*—a specified quantity of product manufactured under traceable, controlled conditions as agreed between producer and user.

lubricant, *n*—material used to reduce inter-particle friction and the friction between the powder mass and the tooling.

lubricant (admixed), *n*—a lubricant incorporated into a powder mixture.

lubricant (die-wall), *n*—a lubricant applied to the tooling surfaces to facilitate ease of movement of the tooling and the removal of the compact or part from the tooling.

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

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.

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.

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

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**.

metal powder, *n*—particles of elemental metals or alloys, normally less than 1000 μm (1 mm) in size.

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

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.

MIM, *n*—see **metal injection molding**.

mixed powder, *n*—see **powder mixture**.

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

mold, *n*—in metal or powder injection molding, the member of the tooling into which the powder and binder mixture is forced, and the configuration of which forms the surfaces of the green part. In isostatic compacting, a mold is also the confining form in which powder is isostatically compacted.

molding, *v*—see **compacting**.

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

nanopowder, *n*—a powder consisting of particles typically less than 100 nm in size.

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

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

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

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

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

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

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

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

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

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

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

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.")

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

permeability, *n*—the rate of passage of a liquid or a gas through a porous material; determined under specified conditions.

PF, *n*—the acronym for powder forging. See **powder forging**.

PIM, *n*— see **powder injection molding**.

platelet powder, *n*—a powder composed of flat particles having considerable thickness (as compared with flake powder).

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

PM, *n*—the acronym for powder metallurgy.

PM forging, *n*—see **powder forging**.

PM part, *n*—see **powder metallurgy part**.

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

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.

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

powder, *n*—particles that are usually less than 1000 μm (1 mm) in size.

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

powder forging, *n*—densification (generally hot) of a PM preform by forging.

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

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**.

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

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 **PM part**.

powder mixture, *n*—a powder made by mixing two or more powders of differing chemical composition, particle size distribution, particle shape, or a combination of these characteristics.

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

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**.

preform, *n*—a PM compact intended to be changed in shape through deformation and densification.

preforming, *n*— 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.

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

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.

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

pressing crack, *n*—a defect occurring as a result of the forming operation.

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

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

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

punch, *n*—a member of a compacting tool set used to close the die cavity and transmit the applied pressure to the powder or PM compact.

DISCUSSION—Multiple upper or lower punches may be needed to compact multilevel parts.

push-off crack, *n*—a defect or crushed surface caused by the action of the feed shoe or other mechanism removing the compact from the area above the lower punch.

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.

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

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

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

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

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

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

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.

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

RSM—Rapidly Solidified Materials.

RSP—Rapid Solidification Processing or Rapidly Solidified Powders.

RST—Rapid Solidification Technology.

runner (MIM), *n—(1)* the secondary feed channel in an injection mold that runs from the inner end of the sprue to the cavity gate.*(2)* the piece formed in a secondary feed channel or runner.

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

segregation, *n*—the separation of one or more constituents of a powder, for example, by particle size or chemical composition.

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

shot volume (MIM), *n*—the total hollow space of a mold including cavity or cavities, runner(s), and sprue.

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

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**.

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

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.

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.

sinter, *v*—to increase the bonding in a mass of powder or a compact by heating below the melting point of the main constituent.

sinter forging, *n*—see **powder forging**.

sinter hardening, *n*—a thermal process in which a ferrous product (material) is sintered and then cooled at a rate sufficient to produce a predominantly martensitic microstructure.

sintered density, *n*—the mass per unit volume of a sintered PM part or test specimen not impregnated with oil or other lubricant. Synonymous with **density (dry)**.

sintering crack, *n*—a defect that occurs during the sintering operation.

sintering time, *n*—the total elapsed time during which the PM part/specimen is within (±) a specified percentage of the stated sintering temperature.

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

slip casting, *n*—a method of forming metal or ceramic shapes by pouring a stabilized suspension of a powder in a fluid, usually water, into the shaped cavity of a fluid-absorbing mold, followed by debinding and sintering.

slip (rupture) crack, *n*—a defect that occurs typically at the junction between levels of a multilevel part (occurs during the pressing cycle while powder is transferring from one level (area) to another).

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

soft magnetic composite, *n*—a compacted PM product in which individual ferrous powder particles are separated by a dielectric material.

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

solids loading, *n*—the relative volume of metal powder in a feedstock designed for metal injection molding, expressed as a volume percent, e.g. 65 % solids loading.

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

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

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

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).

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

sponge metal, *n*—any porous metal produced by the reduction or decomposition of a compound at temperature below the melting point of the metal.

sponge metal powder, *n*—a powder produced from a sponge metal by mechanical methods of size reduction.

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

sprue (MIM), *n*—*(1)* the primary feed channel that runs from the outer face of a n injection mold to the runner.*(2)* the piece formed in a primary feed channel or sprue.

steam blackening, *n*—the superheated steam treatment of a ferrous PM component to form a thin, dark, oxide layer, primarily Fe_3O_4, on the outside surfaces of the component, and extending into the surfaces of the interconnecting porosity.

steam treatment, *n*—see **steam blackening**.

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

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.

subsieve fraction, *n*—the portion of powder passing through a 45-μm (no. 325) sieve.

superfines, *n*—the portion of a powder composed of particles that are smaller than a specified size, currently less than 10 μm.

surface-connected porosity, *n*—a network of interconnected pores or isolated pores that are connected to an exterior surface.

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.

sweating, *n*—see **exudation**.

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

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.

warm compaction, *n*—the consolidation of a pre-heated powder in a pre-heated die.

warm-die compaction, *n*—the consolidation of an unheated powder in a pre-heated die.

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

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.

APPENDIX

(Nonmandatory Information)

X1. ACRONYMS USED IN THE PM INDUSTRY, LITERATURE, AND STANDARDS

X1.1 Subcommittee B09.01 has collected the following acronyms, typically used within the Powder Metallurgy Industry, and has chosen to include this table as an aid to those using this Terminology who may be unfamiliar with some of the PM acronyms currently in use.

TABLE X1.1 PM Acronyms

Acronym	Meaning
A2LA	American Association of Laboratory Accreditation
ASTM	American Society for Testing and Materials
BET	Brunauer, Emmett and Teller Theory
CAD	computer aided design
CAE	computer aided engineering
CAM	computer aided manufacturing
CIP	cold isostatic pressing
CNC	computer numerical control
CTE	coefficient of thermal expansion
CYS	compressive yield strength
EDM	electro-discharge machining
FEA	finite element analysis
FGM	functionally graded materials
HIP	hot isostatic pressing
HSS	high-speed steel
HT	heat treated
HTS	high temperature sintering
ICP	inductively coupled plasma (spectrometer)
IGA	inert gas analysis
K	radial crushing strength
$K_{( )}$	fracture toughness (stress state defined by subscript)
LPS	liquid-phase sintering
MIM	metal injection molding
MMC	metal matrix composite
MPIF	Metal Powder Industries Federation
NDT	non-destructive testing, non-destructive techniques
PF	powder forging
PIM	powder injection molding
PM	powder metallurgy
PV	pressure/velocity factor
RBF	rotating beam fatigue
RBO	rapid burn off (sintering)
RCF	rolling contact fatigue
TRS	transverse rupture strength
tsi	tons/square inch (compacting)
UTS	ultimate tensile strength
YS	yield strength