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Standard Terminology of Powder Metallurgy¹

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1. Scope

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

1.2 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

B331 Test Method for Compressibility of Metal Powders in Uniaxial Compaction

2.2 *ISO Standards:*³

ISO/ASTM 52900 Additive Manufacturing – General Principles – Fundamentals and Vocabulary

3. Terminology

3.1 *Definitions:*

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

activated sintering, *n*—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.

additive manufacturing (AM), *n*—the process of joining materials to make parts from three-dimensional (3-D) model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies.

DISCUSSION—Examples include **binder jetting (BJT)**, **directed energy deposition (DED)**, and **powder-bed fusion (PBF)**. Additional terms relating to additive manufacturing can be found in ISO/ASTM 52900.

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 02.05.⁴

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.

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

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.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandinnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

⁴ 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.

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 jetting (BJT), *n*—additive manufacturing process in which a liquid bonding agent is selectively deposited to join powder materials.

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

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 and made by the same production method.

DISCUSSION—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.

bridging, *n*—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

cavity (MIM), *n*—the hollow space of a mold that forms one part.

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 (CIP), *n*—isostatic pressing at ambient temperature.

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.