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Powder metallurgy — Vocabulary

Métallurgie des poudres — Vocabulaire

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 119, *Powder metallurgy*.

This fifth edition cancels and replaces the fourth edition (ISO 3252:1999), which has been technically revised.

The main changes compared to the previous edition are as follows:

— addition of the mandatory Clause 2 (Normative references);

— addition of terms in current use.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The terms are classified alphabetically under the following main headings:

— powders;

— forming;

— sintering and characteristics of sintered materials;

— post-sintering treatments;

— powder metallurgy materials.

NOTE Additional information on certain terms defined can be found in the standards given in Notes to entry. These are listed in the Bibliography.

Powder metallurgy — Vocabulary

1 Scope

This document defines terms relating to powder metallurgy. Powder metallurgy is the branch of metallurgy which relates to the manufacture of metallic powders, or of articles made from such powders with or without the addition of non-metallic powders, by the application of forming and sintering processes.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Terms relating to powders

3.1.1
acicular
needle-shaped

Note 1 to entry: See Figure 1.

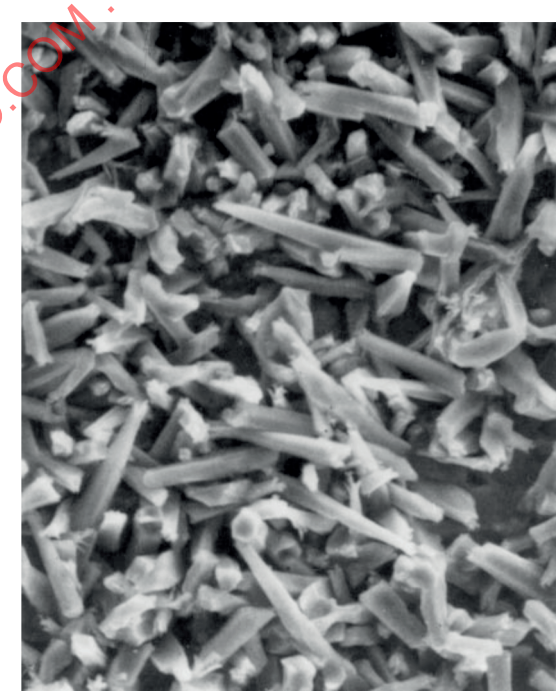
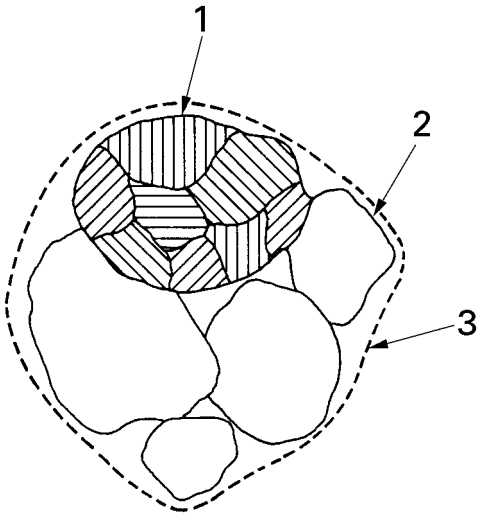


Figure 1 — Acicular

3.1.2
agglomerate
several particles adhering together

Note 1 to entry: See Figure 2.



Key
1 grain
2 particle
3 agglomerate

Figure 2 — Diagramatic representation of grain, particle and agglomerate

3.1.3
alloyed powder
metal powder consisting of at least two constituents that are partially or completely alloyed with each other

3.1.4
angle of repose
basal angle of a pile formed by a powder when freely poured under specified conditions on to a horizontal surface

3.1.5
angular
sharp-edged or roughly polyhedral

Note 1 to entry: See Figure 3.

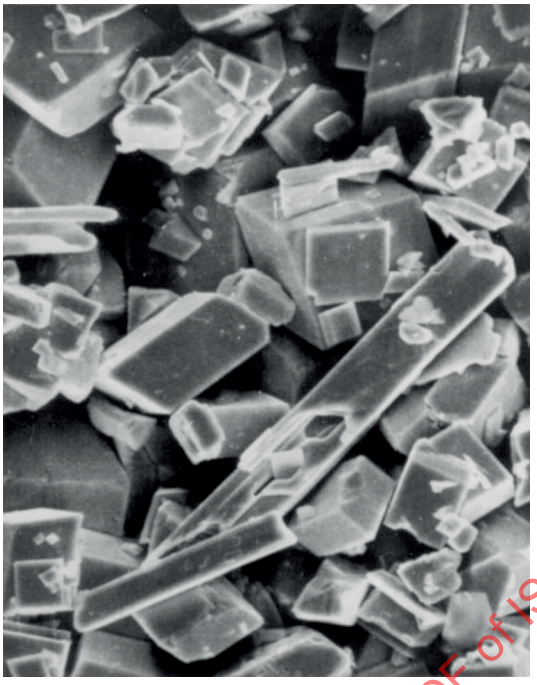


Figure 3 — Angular

3.1.6
apparent density
mass per unit volume of a powder obtained following specific methods

Note 1 to entry: For example, ISO 3923-1 related to free-flowing powders and ISO 3923-2 related to non-free-flowing powders.

3.1.7
atomization
dispersion of a molten metal into particles by a rapidly moving gas or liquid stream or by mechanical means

[SOURCE: ASTM B243-17]

3.1.8
atomized metal powder
metal powder produced by *atomization* (3.1.7)

3.1.9
binder
material added to the powder mix to increase the *green strength* (3.2.47) of the compact or to counteract dusting and *segregation* (3.1.75) of fine particulate mix constituents, and which is expelled during sintering

Note 1 to entry: In hard metals, it is also used for material (binder metal, usually of 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.

Note 2 to entry: Cementing medium is also used in the field of hard metals.

3.1.10
blended powder
powder made by *blending* (3.1.11) powders

3.1.11
blending
thorough intermingling of powders of the same nominal composition

Note 1 to entry: Not to be confused with *mixing* (3.1.53).

3.1.12
bridging
formation of arched cavities in a powder mass

3.1.13
bulk density
mass per unit volume of a powder under nonstandard conditions

3.1.14
cake
bonded mass of unpressed metal powder

EXAMPLE The condition of a powder mass as it exits an annealing furnace.

3.1.15
carbonyl powder
powder produced by the thermal decomposition of a metal carbonyl

3.1.16
chill-block cooling
process for producing rapidly solidified powders by cooling a thin layer of molten material on a solid substrate

3.1.17
chopped powder
powder produced by chopping material such as sheet, ribbon, fibre or filament

3.1.18
classification
separation of powder into fractions according to particle size

3.1.19
coated powder
powder consisting of particles having a surface layer of different composition

3.1.20
comminuted powder
powder produced by mechanical disintegration of solid metal

3.1.21
compactability
conceptual term, encompassing the powder characteristics of *compressibility* (3.1.24), *green strength* (3.2.47), edge retention, and lamination tendency, that relates to the ability of a powder to be consolidated into a usable *green compact* (3.2.13)

Note 1 to entry: Compactability may be a function of flowability, compressibility and green strength.

3.1.22
completely alloyed powder
alloyed powder (3.1.3) in which each powder particle has a homogeneous chemical composition being that of the entire powder

3.1.23
composite powder
powder in which each particle consists of two or more different constituents

3.1.24
compressibility
capacity of a powder to be densified under an uniaxially applied pressure

Note 1 to entry: The pressure applied is usually a uniaxial pressure in a closed die. Compressibility may be expressed as the pressure needed to reach a required density or as the density obtained at a given pressure.

Note 2 to entry: See ISO 3927.

3.1.25
compression ratio
ratio of the volume of the loose powder to the volume of the compact made from it

3.1.26
cut
fraction of a powder nominally within stated particle size limits

3.1.27
dehydrided powder
powder made by removal of hydrogen from metal hydride

3.1.28
demixing
loss of homogeneity of a powder mix due to excessive mixing time

3.1.29
dendritic
of branched shape

Note 1 to entry: See Figure 4.

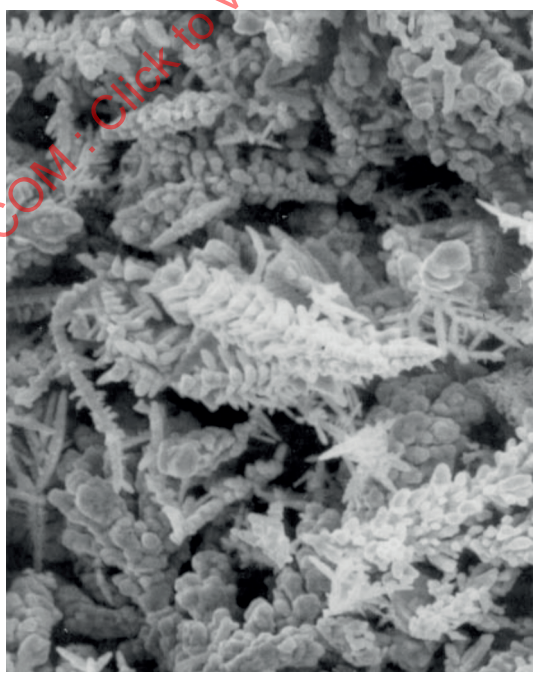


Figure 4 — Dendritic

3.1.30
diffusion-alloyed powder
partially *alloyed powder* (3.1.3) produced by means of a thermal process

3.1.31
dopant
substance added in small quantity to a metallic powder to prevent or control recrystallization or grain growth either during *sintering* (3.3.60) or during use of the resultant sintered object

Note 1 to entry: This term is especially used in the powder metallurgy of tungsten.

3.1.32
electrolytic powder
powder produced by an electrolytic process

3.1.33
elutriation
classification (3.1.18) of a powder through movement of the particles through a fluid medium

EXAMPLE Air classification and liquid classification.

3.1.34
feedstock
moldable mixture of metal powder and *binder* (3.1.9) used for injection moulding or powder extrusion

3.1.35
fibrous
having the appearance of regularly or irregularly shaped threads

Note 1 to entry: See Figure 5.

Figure 5 — Fibrous

3.1.36
fill factor
<uniaxial pressing> ratio of the height to which a powder fills a die to the height of the compact, measured after ejection from the die

3.1.37
fines
fraction of a powder that passes through the smallest sieve size used in the *sieve analysis* (3.1.76)

3.1.38
flaky
platelike shape

Note 1 to entry: See Figure 6.

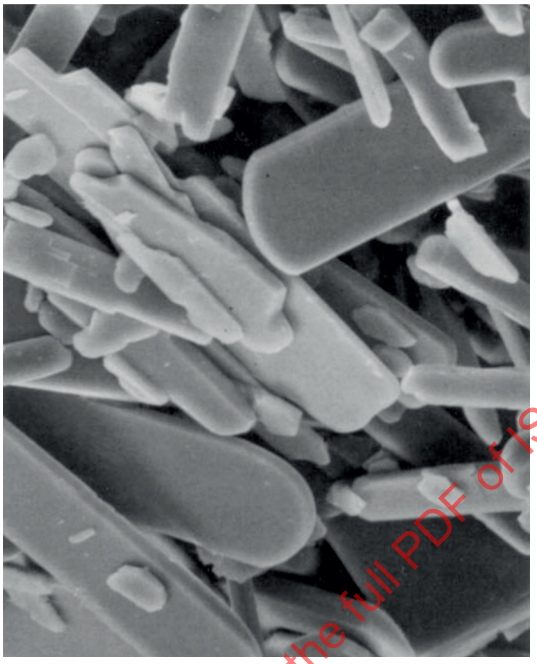


Figure 6 — Flaky

3.1.39
flowability
qualitative term describing the behaviour of a powder when flowing through a funnel of defined dimension

Note 1 to entry: See ISO 4490 and ISO 13517.

3.1.40
flowmeter
standardized funnel and cylindrical cup used for the determination of *apparent density* (3.1.6) and *flow rate* (3.1.41)

Note 1 to entry: For apparent density see ISO 3923-1 and ISO 3923-2.

Note 2 to entry: For flow rate see ISO 4490 and ISO 13517.

3.1.41
flow rate
time required for a powder sample of standard weight to flow through an orifice in a standard instrument according to a specified procedure

[SOURCE: ASTM B243-17]

3.1.42
granular
approximately equidimensional nonspherical shape

Note 1 to entry: See Figure 7.

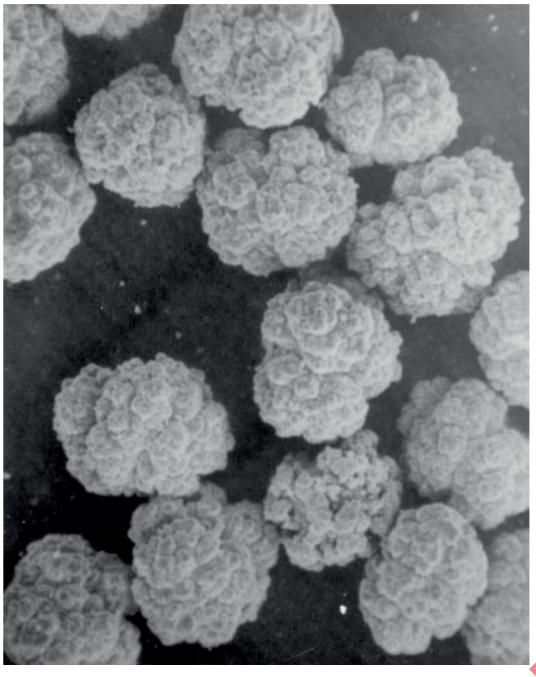


Figure 7 — Granular

3.1.43
granulation
agglomeration of fine particles to obtain a coarser powder with improved flowability

3.1.44
hydrogen loss
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

Note 1 to entry: 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. See also ISO 4491-2.

3.1.45
hydrogen-reducible oxygen
oxygen content of a powder emanating from oxygen-bearing constituents reduced by hydrogen under standardized conditions

Note 1 to entry: See also ISO 4491-3.

3.1.46
irregular
lacking any symmetry

Note 1 to entry: See Figure 8.

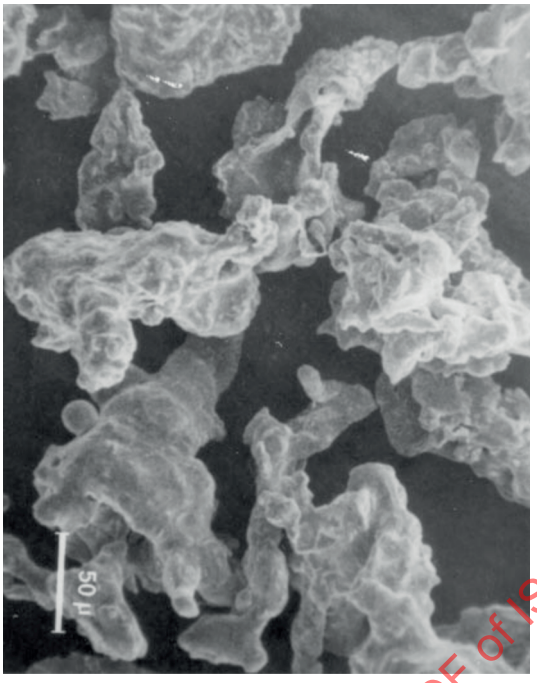


Figure 8 — Irregular

3.1.47
lubricant
material used to reduce inter-particle friction and the friction between the powder mass and the tooling

3.1.48
master alloy powder
alloyed powder (3.1.3) containing a relatively high concentration of one or more elements that may be difficult to introduce in their unalloyed states

Note 1 to entry: The master alloy powder is mixed with other powders to produce the required final composition.

3.1.49
mechanical alloying
process of alloying in the solid state by high-energy attritor or ball-mill

3.1.50
mechanically alloyed powder
composite powder (3.1.23) produced by mechanically incorporating other constituents which are generally insoluble within the deformable particles of the matrix metal

3.1.51
milling
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

3.1.52
mixed powder
powder made by mixing powders, where the constituent powders differing in composition

3.1.53
mixing
thorough intermingling of powders of two or more materials

3.1.54
nodular
of rounded irregular shape

Note 1 to entry: See Figure 9.

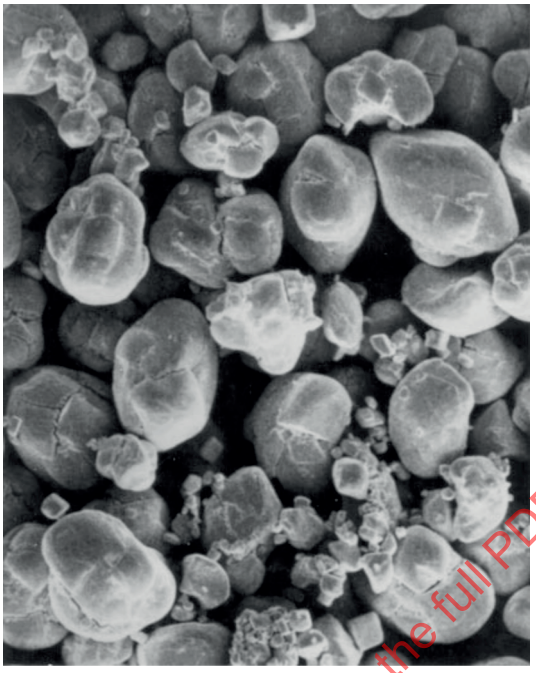


Figure 9 — Nodular

3.1.55
oversize
fraction of a powder sample with particle size larger than any specified upper limit

3.1.56
oversize particle
particle larger than any specified upper limit

3.1.57
partially alloyed powder
alloyed powder (3.1.3), the particles of which have not reached the completely alloyed state

3.1.58
particle
unit of powder that cannot readily be subdivided by the usual separation processes

Note 1 to entry: See Figure 2.

Note 2 to entry: The term "grain" is not synonymous with "particle" and should be used in its normal metallurgical sense.

3.1.59
particle shape
external geometric form of a powder particle

3.1.60
particle size
linear dimension of an individual particle as determined by analysis with sieves or other suitable means

3.1.61
particle size distribution
percentage by mass, by numbers or by volume, of each fraction into which a powder sample has been classified with respect to size

Note 1 to entry: See also ISO 4497.

3.1.62
plasticizer
thermoplastic material used as a *binder* (3.1.9) for improving formability of powders

3.1.63
powder
particles that are usually less than 1 mm in size

3.1.64
pre-alloyed powder
completely *alloyed powder* (3.1.3) usually made by *atomization* of melt (3.1.7)

3.1.65
precipitated powder
powder produced by chemical precipitation from solution

3.1.66
press-ready mix
premix
mixture of powders with other ingredients designed to make the mixture ready for compaction

3.1.67
pulverization
reduction in *particle size* (3.1.60) of metal powder by mechanical means, a specific type of disintegration

[SOURCE: ASTM B243-17]

3.1.68
pulverized powder
powder made by *pulverization* (3.1.67)

3.1.69
rapidly solidified powder
powder produced directly or in-directly at high solidification rates such that the particles have a modified or metastable microstructure

3.1.70
reaction milling
process of *mechanical alloying* (3.1.49) in which a reaction takes place between the metal and additives, the atmosphere or both

3.1.71
reduced powder
powder produced by chemical reduction of a metal compound without melting

3.1.72
sample splitter
device by means of which a previously obtained powder sample is split into representative portions

Note 1 to entry: See also ISO 3954.

3.1.73
sample thief
device used to draw a representative powder sample from a bulk quantity of powder

Note 1 to entry: See also ISO 3954.

3.1.74
sedimentation
settling of particles, suspended in a liquid, through the influence of an external force, such as gravity or centrifugal force

3.1.75
segregation
unintentional separation of one or more constituents of a powder, for example, by particle size or chemical composition

3.1.76
sieve analysis
screen analysis
screen classification
particle size distribution (3.1.61), 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

Note 1 to entry: See also ISO 4497.

3.1.77
sieve set
calibrated series of non-magnetic wire-cloth sieves

Note 1 to entry: See also ISO 4497.

3.1.78
slurry
pourable viscous dispersion of powder in a liquid

3.1.79
specific surface area
<of a powder> total surface area of the particles per unit mass of powder

3.1.80
spheroidal
roughly spherical

Note 1 to entry: See Figure 10.

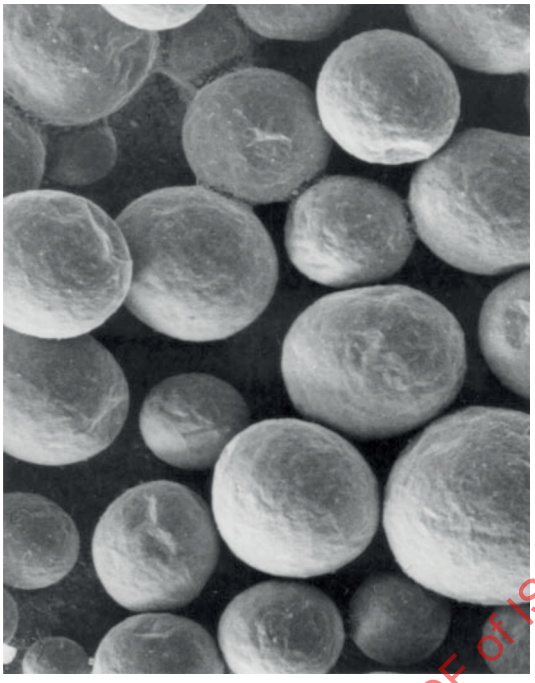


Figure 10 — Spheroidal

3.1.81
sponge powder
porous, *reduced powder* (3.1.71) produced by comminution of a metal sponge which is in itself a coherent, highly porous metal

3.1.82
spray drying
process for granulating powders by the rapid evaporation of the liquid from the droplets of a *slurry* (3.1.78)

3.1.83
tap density
mass per unit volume of a powder in a container that has been tapped under specified conditions

Note 1 to entry: See also ISO 3953.

3.1.84
tapping apparatus
device for the determination of *tap density* (3.1.83)

3.1.85
ultrasonically gas-atomized powder
powder produced by a gas *atomization* (3.1.7) process in which ultrasonic vibration is applied to the gas jet

3.1.86
ultrasonic gas-atomizing
atomization (3.1.7) process in which ultrasonic vibration is applied to the gas jet

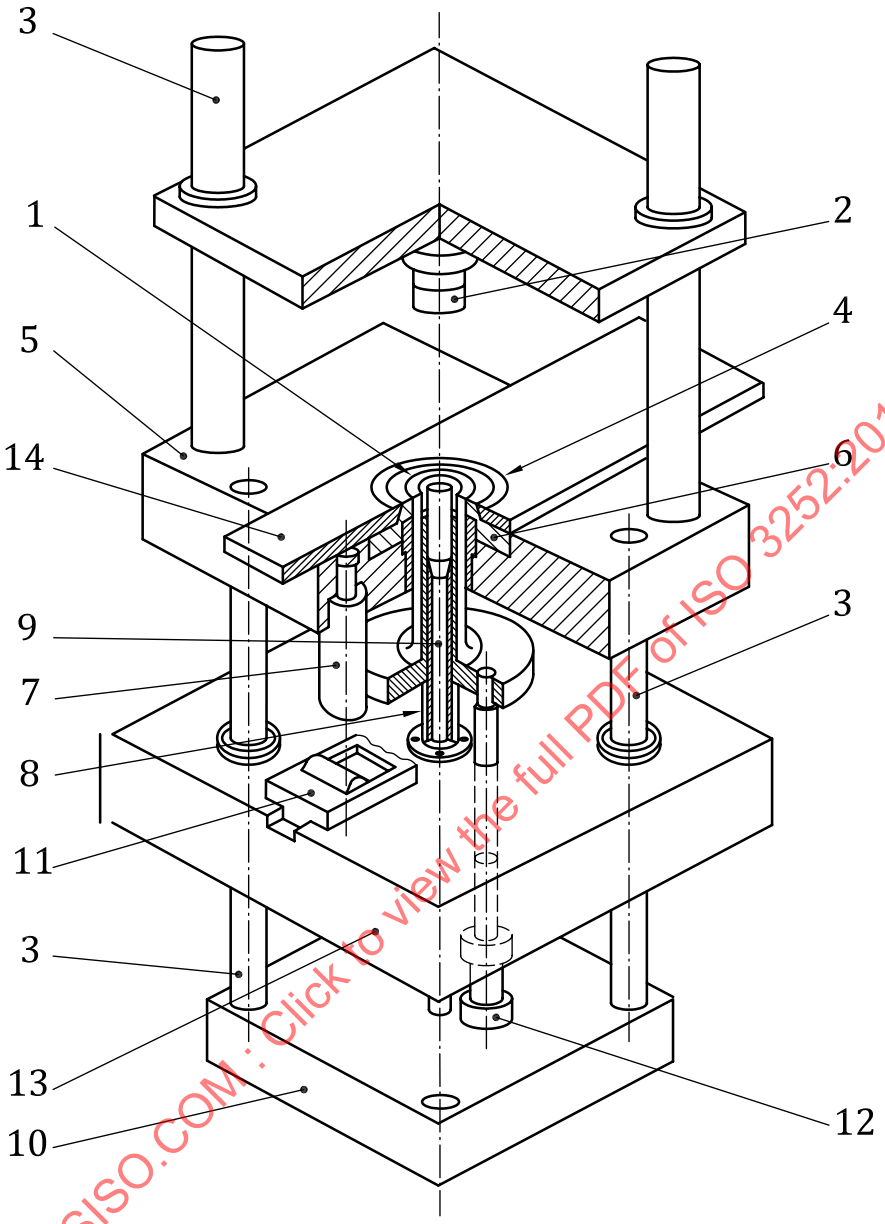
3.1.87
undersize
fraction of a powder sample with *particle size* (3.1.60) smaller than any specified lower limit

3.1.88
undersize particle
particle smaller than any specified lower limit

3.2 Terms relating to forming

3.2.1
adaptor
device in which the press tools are mounted outside the press

Note 1 to entry: See Figure 11.



Key

1	die	8	inner lower punch
2	upper punch	9	core rod
3	column	10	base plate (lower coupler plate)
4	bolster	11	fork
5	die plate	12	lifting rod
6	clamp ring	13	punch plate
7	wedge	14	adaptor table

NOTE Other types and arrangements exist.

Figure 11 — One type of withdrawal tool set (3.2.78) and press adaptor (3.2.1)

3.2.2
adaptor table
member of the tool set designed to hold the *bolster* (3.2.6)

Note 1 to entry: See Figure 11.

3.2.3
back relief
undesired dimensional reduction of the *die* (3.2.23) in the ejection direction

3.2.4
base plate
lower coupler plate
part of the tool set adaptor transmitting the movement of the machine lower ram to the tool set

Note 1 to entry: See Figure 11.

3.2.5
blank
pressed, presintered, or fully sintered compact, usually in the unfinished condition, requiring cutting, machining, or some other operation to give it its final shape

3.2.6
bolster
shrink ring
member of the tool set designed to hold the *die* (3.2.23)

Note 1 to entry: See Figure 11.

3.2.7
brown body
<MIM terminology> debinded body ready to be sintered

3.2.8
canning
encapsulation (3.2.34) in a metallic container which is usually evacuated prior to sealing

3.2.9
clamp ring
member of the tool set ring designed to clamp a *die* (3.2.23), punch or a *core rod* (3.2.20)

Note 1 to entry: See Figure 11.

3.2.10
cold isostatic pressing
CIP
isostatic pressing at ambient temperature, the pressure-transmitting medium normally being a liquid

3.2.11
cold pressing
cold compacting
pressing metal powder using either compacting tools or CIP mold at ambient temperature

3.2.12
column
part of the tool set adaptor guiding the moving parts of the tool set (*die plate* (3.2.24) and *base plate* (3.2.4)) in the compacting direction

Note 1 to entry: See Figure 11.

3.2.13
compact
green compact
object prepared from powder by cold-pressing or by injection-moulding

3.2.14
compacting
process of making a *compact* (3.2.13)

3.2.15
compacting pressure
specific compacting force related to the projected area of contact with the press punch(es)

3.2.16
composite compact
compound compact
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

3.2.17
compound
feed stock
<MIM terminology> mixture of metal powder, *binder* (3.1.9) and other additives

3.2.18
consolidation
process in which a powder or compact is densified

3.2.19
continuous-spray deposition
process for the production of a solid object by atomizing a molten or partially molten metallic stream which, before solidification, impinges on a substrate, where solidification subsequently occurs

3.2.20
core rod
member of the tool set or mould forming the inner profile of a compacted or sintered object in the compaction direction

Note 1 to entry: See Figure 11.

3.2.21
counter-pressure
top-punch hold-down pressure
pressure at which a compact is held between an upper and a *lower punch* (3.2.53) during a withdrawal or *ejection process* (3.2.32)

3.2.22
debinding
<MIM terminology> remove *binder* (3.1.7) from injection moulded body before *sintering* (3.3.60)

3.2.23
die
member of the tool set forming the cavity in which the powder is compacted or the sintered object is re-pressed

Note 1 to entry: See Figure 11.

3.2.24
die plate
upper plate of the tool set adaptor holding the *clamp ring* (3.2.9), *bolster* (3.2.6) and *die* (3.2.23)

Note 1 to entry: See Figure 11.

3.2.25
die wall lubrication
lubrication of die wall with solid or liquid *lubricant* (3.1.47) to eliminate and/or minimize the need for admixed lubricant to the powder

3.2.26
double-action pressing
method by which powder is pressed in a *die* (3.2.23) between two punches moving from opposite directions into the die cavity

3.2.27
dry-bag isostatic pressing
method of *cold isostatic pressing* (3.2.10) whereby the flexible mould in which the powder (or compact) is placed is rigidly mounted

3.2.28
dwell time
period during which constant pressure is applied to a compact

3.2.29
edge strength
ability of the edges of a compact to resist damage

3.2.30
ejection energy
total energy to eject a *green compact* (3.2.13) from *die* (3.2.23), obtained by integration of *ejection force* (3.2.31) and displacement curve

3.2.31
ejection force
maximum force necessary to eject *green compact* (3.2.13) from *die* (3.2.23)

3.2.32
ejection process
operation by which a compact is pushed out from a die after completion of pressing

3.2.33
ejector
component of a press tool used for the ejection of a compact from the *die* (3.2.23)

3.2.34
encapsulation
enclosing a powder or a compact in a thin-walled container

3.2.35
explosive compaction
high-energy consolidation by means of a detonation shock wave

3.2.36
feed shoe
part of the *compacting* (3.2.14) press that delivers powder to the die cavity, usually by sliding an open bottomed powder container over the open top of the *die* (3.2.23)

Note 1 to entry: See Figure 12.

3.2.37
fill
quantity of powder required to charge a *die* (3.2.23)

3.2.38
fill height
distance between the lower punch face and the top of the die body in the *fill position* (3.2.39) of the press tool set

3.2.39
fill position
position of the press tool set which allows the introduction of the desired amount of powder into the die cavity

3.2.40
fill volume
volume of the die cavity at the *fill position* (3.2.39)

3.2.41
floating die
die (3.2.23) that is able to move freely in the direction of pressing in order to create a *double-action pressing* (3.2.26) effect

Note 1 to entry: Generally, the die is supported by a spring.

3.2.42
fork
part of the tool set pressing adaptor, used in connection with the *wedge* (3.2.90) for the compaction and uncovering of multi-sectional objects

3.2.43
forming
process in which a powder is transformed into a coherent body of the required shape

3.2.44
green
pressed or injection-moulded but unsintered

3.2.45
green density
mass per unit volume of an unsintered compact

3.2.46
green machining
machining of a unsintered compact to a predetermined shape

3.2.47
green strength
mechanical strength of an unsintered compact

Note 1 to entry: This may be measured by radial crushing (see ISO 2739) or transverse rupture (see ISO 3995).

3.2.48
hot isostatic pressing
HIP
isostatic pressing (3.2.50) at elevated temperature, thus activating the phenomena of diffusion and creep, the pressure-transmitting medium normally being a gas

3.2.49
hot pressing
pressing of a powder or compact, normally uniaxially, at elevated temperatures thus activating the phenomena of diffusion and creep (*pressure sintering* (3.3.51))

3.2.50
isostatic pressing
pressing of a powder (or a compact) by subjecting its surface or the surface of the flexible part of the mould containing it, to nominally equal pressure from every direction

3.2.51
lamination crack
defect(s) roughly parallel to the punch faces of the part

Note 1 to entry: 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.

3.2.52
lifting rod
member of the tool set (pin) bringing the *lower punch* (3.2.53) into the filling position

Note 1 to entry: See Figure 11.

3.2.53
lower punch
member of the tool set closing the *die* (3.2.23) from below and transmitting the pressure to the powder or the sintered component

Note 1 to entry: See Figure 11.

3.2.54
lower ram
ram of a press acting on the pressing tool from below

3.2.55
metal injection moulding
MIM
method of *forming* (3.2.43) by the injection of a plasticized mixture of metallic powder(s) and *binder(s)* (3.1.7) into a mould

3.2.56
mould
<in metal or powder injection moulding> confining rigid form into which the powder and binder mixture is forced, and the configuration of which forms the surfaces of the *green* (3.2.44)

3.2.57
mould
<in isostatic compacting form> confining flexible form in which powder is isostatically compacted

3.2.58
multiple-cavity tool
tool set that produces two or more compacts in each pressing cycle

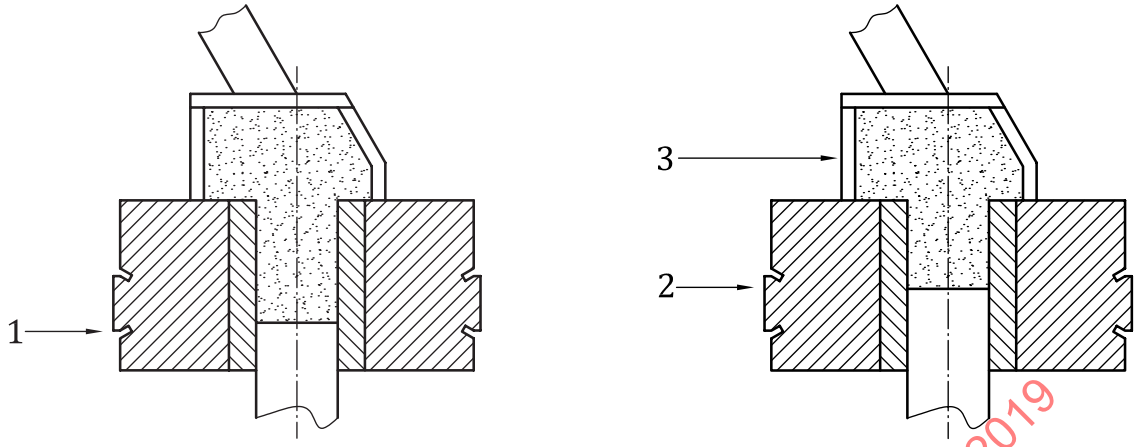
3.2.59
multiple pressing
method of pressing whereby two or more compacts are produced simultaneously in separate die cavities

3.2.60
multi-level tool adaptor
tool adaptor having several independently controllable plates, on the upper or lower side of the adaptor, each holding a separate punch

3.2.61
neutral zone
zone in a compact in which the stresses imposed by opposing punches are in equilibrium

3.2.62
overfill
powder filling sequence pushing the powder up into the *feed shoe* (3.2.36) to ensure proper filling

Note 1 to entry: see Figure 12.



Key

1 step 1

2 step 2

3 feedshoe

NOTE Before filling commences, the lower punch is positioned to allow excess powder to enter the die. Before removal of the feed shoe, the lower punch (and/or core rod) is moved to force excess powder back into the feed shoe, ensuring a good fill.

Figure 12 — Overfill

3.2.63
plasticized-powder extrusion
method of forming a plasticized mixture of powder and *binder* (3.1.9) by powder extrusion

3.2.64
powder rolling
process in which a powder is introduced between a pair of rotating rolls which cause the powder to be compacted into a continuous, coherent strip

3.2.65
preform
blank (3.2.5) intended to be subject to deformation and *densification* (3.4.2) involving change of shape

3.2.66
pressing
process in which a powder held in a *die* (3.2.23) or other container is subjected to an external force in order to densify the powder and produce a compact of prescribed shape and dimensions

3.2.67
pressing crack
crack formed in a compact during the pressing cycle

3.2.68
punch
item of a tool set used to apply pressure to the powder or object

3.2.69
punch plate
part of the tool set adaptor supporting a *punch* (3.2.68)

Note 1 to entry: See Figure 11.

3.2.70
sandwich die
split die (3.2.76) consisting of discs perpendicular to the pressing direction

3.2.71
segmented die
die (3.2.23) fabricated by the assembly of several die segments within a retaining *bolster* or *shrink ring* (3.2.6)

3.2.72
segmented punch
set of punches used to give various filling and compacting heights when producing two-stepped or multi-stepped compacts

3.2.73
shaping
<in hardmetal industry> achievement of a desired geometry before final sintering

3.2.74
single-action pressing
method by which a powder is pressed in a stationary die between one moving and one fixed punch

3.2.75
skeleton
porous compact or sintered object intended for *infiltration* (3.3.31)

3.2.76
split die
die (3.2.23) made in two or more sections that are separated to remove the compact

3.2.77
spring back
increase in dimensions of a compact after ejection from a *die* (3.2.23)

Note 1 to entry: See also ISO 4492.

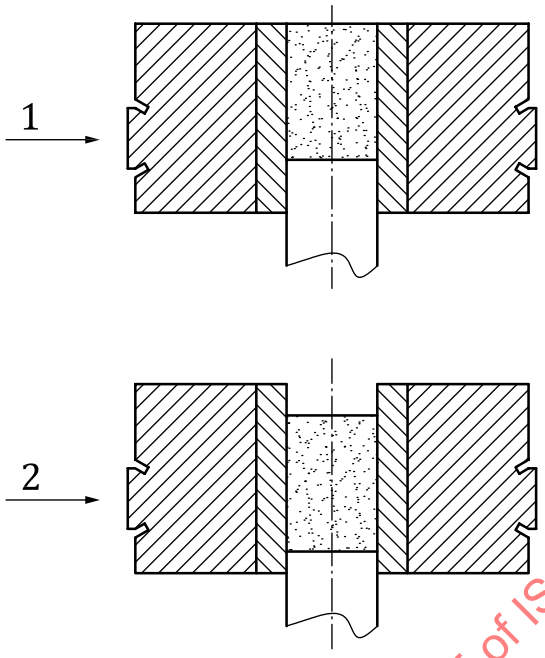
3.2.78
tool set
assembly of tooling items used for the production of a specific powder product by the process of *compacting* (3.2.14) or *re-pressing* (3.4.7)

Note 1 to entry: The tool set may include dies, punches and *core rods* (3.2.20) but excludes press fittings common to more than one product.

3.2.79
undercut forming
forming a compact of a shape which requires horizontal splitting of the tool die

3.2.80
underfill
powder filling sequence displacing the powder down into the die cavity after filling to minimize powder spillage

Note 1 to entry: See Figure 13.



Key

1 step 1

2 step 2

NOTE After filling the die and removing the feed shoe, the lower punch is retracted to transfer powder to a lower level in the die, thus avoiding spillage of powder when processing commences.

Figure 13 — Underfill

3.2.81
uniaxial pressing
pressing of a powder in such a manner that the applied force is along a single axis

3.2.82
upper punch
member of the tool set closing the *die* (3.2.23) from the top and transmitting the pressure to the powder or sintered component

Note 1 to entry: See Figure 11.

3.2.83
upper ram
ram of a press acting on the pressing tool from above

3.2.84
vibration-assisted compaction
compaction of a powder using an oscillating punch or punches

3.2.85
vibration-assisted filling
filling of a powder into a mould or *die* (3.2.23) which is subjected to vibration

3.2.86
volume filling
metering of a powder charge into a *die* (3.2.23) by setting the depth of *fill* (3.2.37)

3.2.87
warm compaction
consolidation (3.2.18) of a pre-heated powder in a pre-heated die

3.2.88
warm pressing
warm compacting
pressing metal powder using heated powder and heated compaction tools to get higher density than obtained by *cold pressing/cold compacting* (3.2.11)

3.2.89
warm-die compaction
consolidation (3.2.18) of an unheated powder in a pre-heated die

3.2.90
wedge
part of the tool set pressing adaptor, in connection with the *fork* (3.2.42), enabling the compaction and the ejection of multi-sectional objects

3.2.91
weight filling
metering of a powder charge into a *die* (3.2.23) by weighing the powder

3.2.92
wet-bag isostatic pressing
method of *cold isostatic pressing* (3.2.10) whereby the flexible mould containing the powder (or compact) is immersed in the pressure transmitting medium

3.2.93
withdrawal position
position of the tool set at the end of the *withdrawal process* (3.2.94)

3.2.94
withdrawal process
operation by which a *die* (3.2.23) descends over a fixed *lower punch* (3.2.53) to free the compact

3.3 Terms relating to sintering and characteristics of sintered materials

3.3.1
activated sintering
sintering process during which the rate of sintering is increased

EXAMPLE Addition of a substance to the powder or under the influence of the *sintering atmosphere* (3.3.61).

3.3.2
A-pores
<hardmetals> pores below 10 µm in size

Note 1 to entry: See also ISO 4499-4.

3.3.3
apparent hardness
hardness of a *sintered material* (3.5.10) measured under specified conditions so as to include the effects of porosity

Note 1 to entry: See also ISO 4498.

3.3.4
batch furnace
furnace designed to sinter separate batches without continuous transport

EXAMPLE A bell or box furnace.

3.3.5
batch sintering
sintering of a batch of parts in a furnace in which the batch is stationary and the temperature of which is controlled to give the required preheating, heating and cooling cycle

3.3.6
binder metal
<hardmetal industry> metallic *binder phase* (3.3.7) that has a lower melting point than the other phases of a heterogeneous *sintered material* (3.5.10)

3.3.7
binder phase
<hardmetal industry> phase in a heterogeneous *sintered material* (3.5.10) that binds together the other phases

3.3.8
binder removal
thermal or chemical process whereby the binder is removed from a metal injection moulded part

3.3.9
blistering
formation of blisters on the surface of a sintered object as a result of intensive evolution of gas or by the in-situ deposition of soot

3.3.10
B-pores
<hardmetals> pores from 10 µm to 25 µm in size

Note 1 to entry: See also ISO 4499-4.

3.3.11
bubble-point pressure
minimum pressure needed to force a gas to pass through a liquid-impregnated object to produce the first bubble

Note 1 to entry: See also ISO 4003.

Note 2 to entry: It is mainly a function of the maximum *pore size* (3.3.46) of the object.

3.3.12
carburizing
<hardmetal industry> production of a carbide due to a reaction between carbon and metal or carbon and metal oxide

3.3.13
closed pore
pore not communicating with the surface

3.3.14
closed porosity
ratio of the volume of the *closed pores* (3.3.13) to the total volume of a porous object (ISO 2738)

3.3.15
communicating pore
interconnected porosity
network of mutually connected pores that may or may not extend to an exterior surface

[SOURCE: ASTM B243-17]

3.3.16
continuous furnace
furnace permitting continuous transport of the compacts through the furnace

3.3.17
continuous sintering
sintering in a furnace with zones for *dewaxing* (3.3.21), preheating, heating and cooling through which the material to be sintered is made to pass continuously, either smoothly or stepwise

3.3.18
C-uncombined carbon pore
<hardmetals> clustered pores caused by the removal of carbon during the metallographic preparation of the material

Note 1 to entry: See also ISO 4499-4.

3.3.19
density
mass divided by volume, the volume also including the volume of the voids (pores) in the material

3.3.20
density distribution
quantification of any *density* (3.3.19) variation existing within a compact or sintered object

3.3.21
dewaxing
burn-off
removal of organic additives (binder or lubricant) from a compact by heating

3.3.22
diffusion porosity
porosity created by diffusion of one constituent material into another (such as Kirkendall effect)

3.3.23
dimensional change
change in dimensions of an object that occurs as a result of sintering

3.3.24
discolor(ing)
surface quality of sintered body, not showing metallic colour due to surface oxidation

3.3.25
fluid permeability
measure of the amount of liquid or gas flowing through a porous object per unit of time, as determined under specified conditions

Note 1 to entry: See also ISO 4022.

3.3.26
frost(ing)
defective surface quality of sintered body, looks like frosted due to reduction of oxidized surface during delubrication

3.3.27
gas pressure sintering
process for the production of powder metallurgy parts comprising sintering followed by *hot isostatic pressing* (3.2.48) in the same furnace chamber in order to eliminate residual porosity

3.3.28
getter
material used in a sintering process for the purpose of absorbing or chemically binding those substances from the *sintering atmosphere* (3.3.61) that are damaging to the final product

3.3.29
growth
increase in dimensions of a compact as a result of *sintering* (3.3.60)

Note 1 to entry: See also ISO 4492.

3.3.30
infiltrant
metal or alloy to be filled into the pores of an unsintered or sintered object

3.3.31
infiltration
process of filling the pores of an unsintered or sintered object with a metal or alloy of lower melting point than that of the object

Note 1 to entry: Infiltration can be carried out as a separate operation or in combination with sintering.

3.3.32
liquid-phase sintering
sintering (3.3.60) of a powder or compact containing at least two constituents, under conditions such that a liquid phase is formed

3.3.33
loose-powder sintering
gravity sintering
sintering of uncompacted powder

3.3.34
melt-off pore
pore appeared by melt-off of low melting point alloying constituent

3.3.35
mesh belt furnace
furnace through which the components are continuously transported by means of a mesh belt

3.3.36
mutually interconnected porosity
system of mutually accessible interconnecting pores

3.3.37
neck formation
development of a necklike bond between particles during sintering

3.3.38
oil content
amount of oil contained in an oil-impregnated object

Note 1 to entry: See also ISO 2738.

EXAMPLE An oil-retaining (self-lubricating) bearing.