
Powder metallurgy — Vocabulary

Métallurgie des poudres — Vocabulaire

STANDARDSISO.COM : Click to view the full PDF of ISO 3252:2019



STANDARDSISO.COM : Click to view the full PDF of ISO 3252:2019



COPYRIGHT PROTECTED DOCUMENT

© ISO 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
3.1 Terms relating to powders.....	1
3.2 Terms relating to forming.....	14
3.3 Terms relating to sintering and characteristics of sintered materials.....	24
3.4 Terms relating to post-sintering treatments.....	30
3.5 Terms relating to powder metallurgy materials.....	31
Bibliography	34

STANDARDSISO.COM : Click to view the full PDF of ISO 3252:2019

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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.

STANDARDSISO.COM : Click to view the full PDF of ISO 3252:2019

[STANDARDSISO.COM](https://standardsiso.com) : Click to view the full PDF of ISO 3252:2019

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](#).

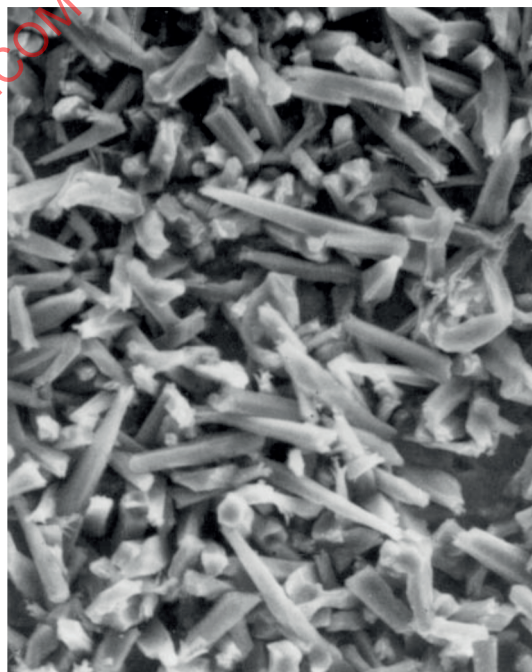


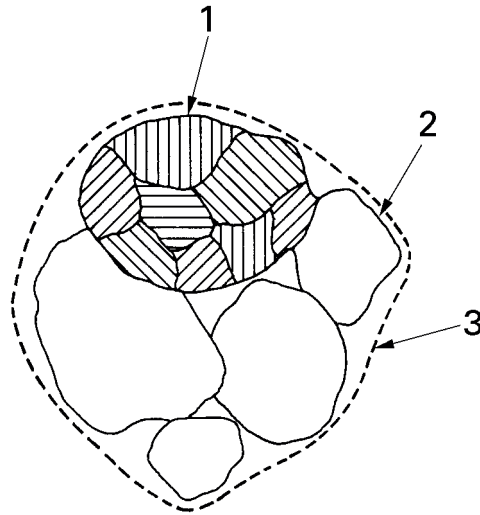
Figure 1 — Acicular

3.1.2

agglomerate

several particles adhering together

Note 1 to entry: See [Figure 2](#).



Key

- 1 grain
- 2 particle
- 3 agglomerate

Figure 2 — Diagrammatic 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](#).

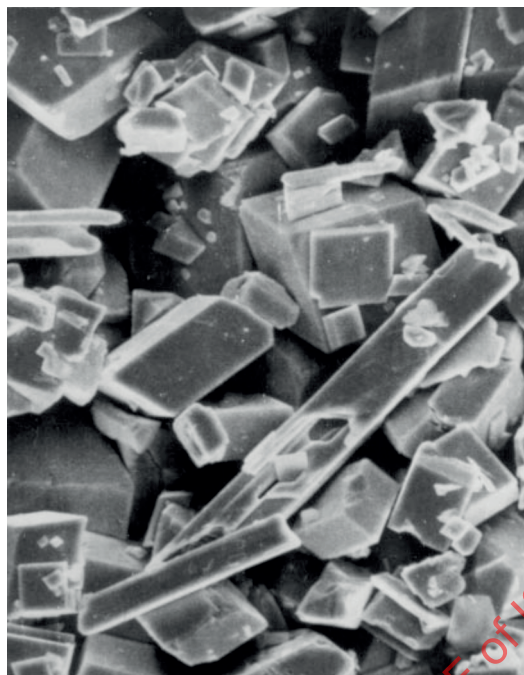


Figure 3 — Angular

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](#).

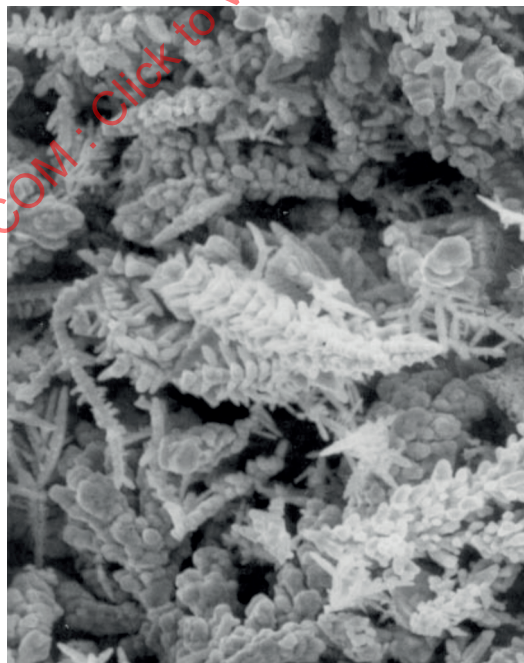


Figure 4 — Dendritic

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](#).

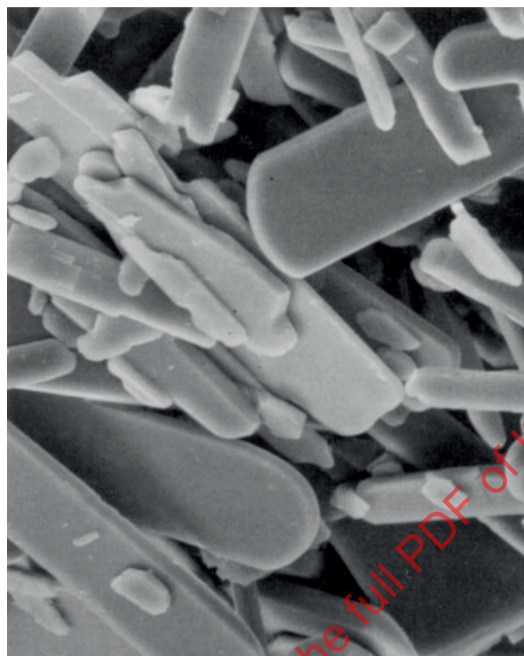


Figure 6 — Flaky

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](#).

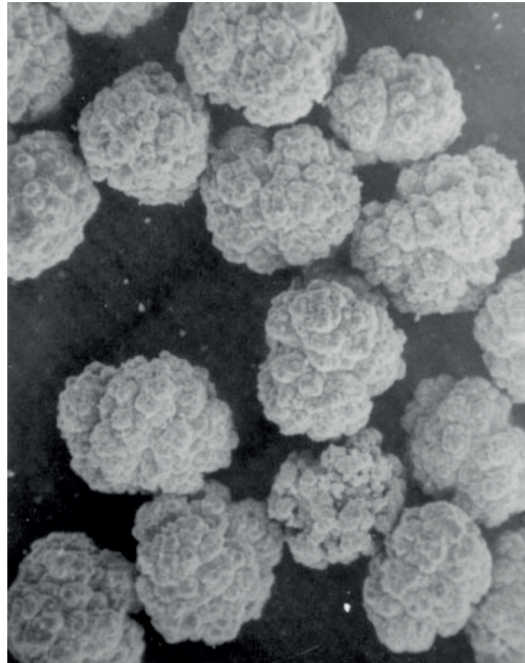


Figure 7 — Granular

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](#).

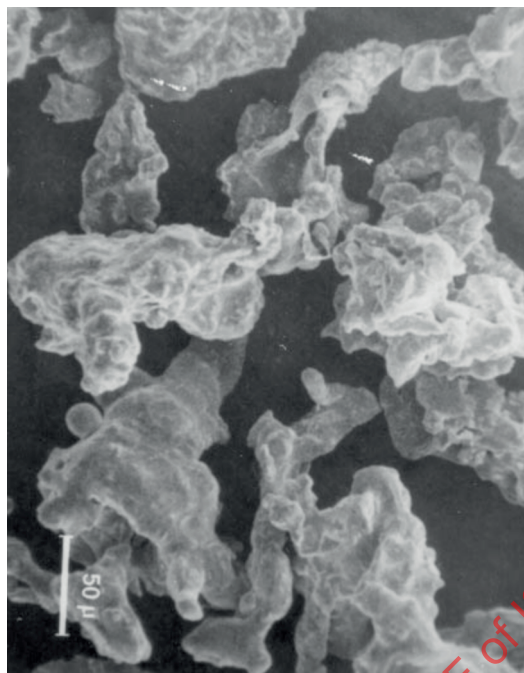


Figure 8 — Irregular

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](#).

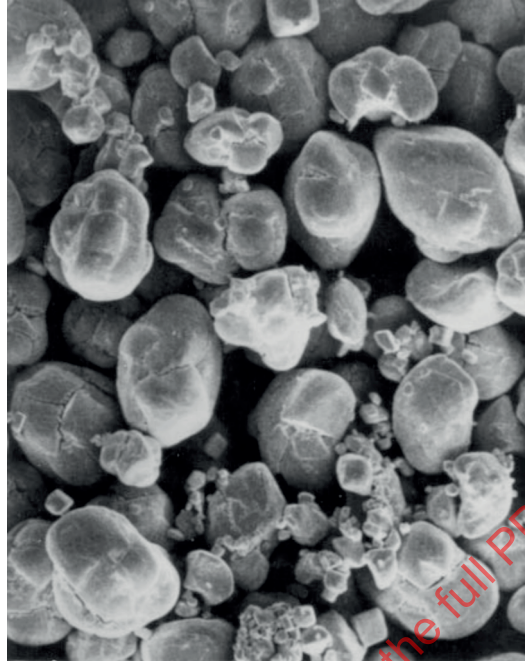


Figure 9 — Nodular

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](#).

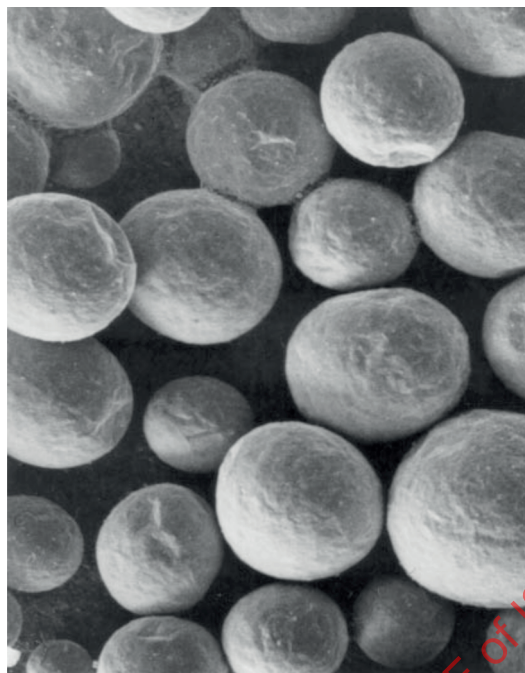


Figure 10 — Spheroidal

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

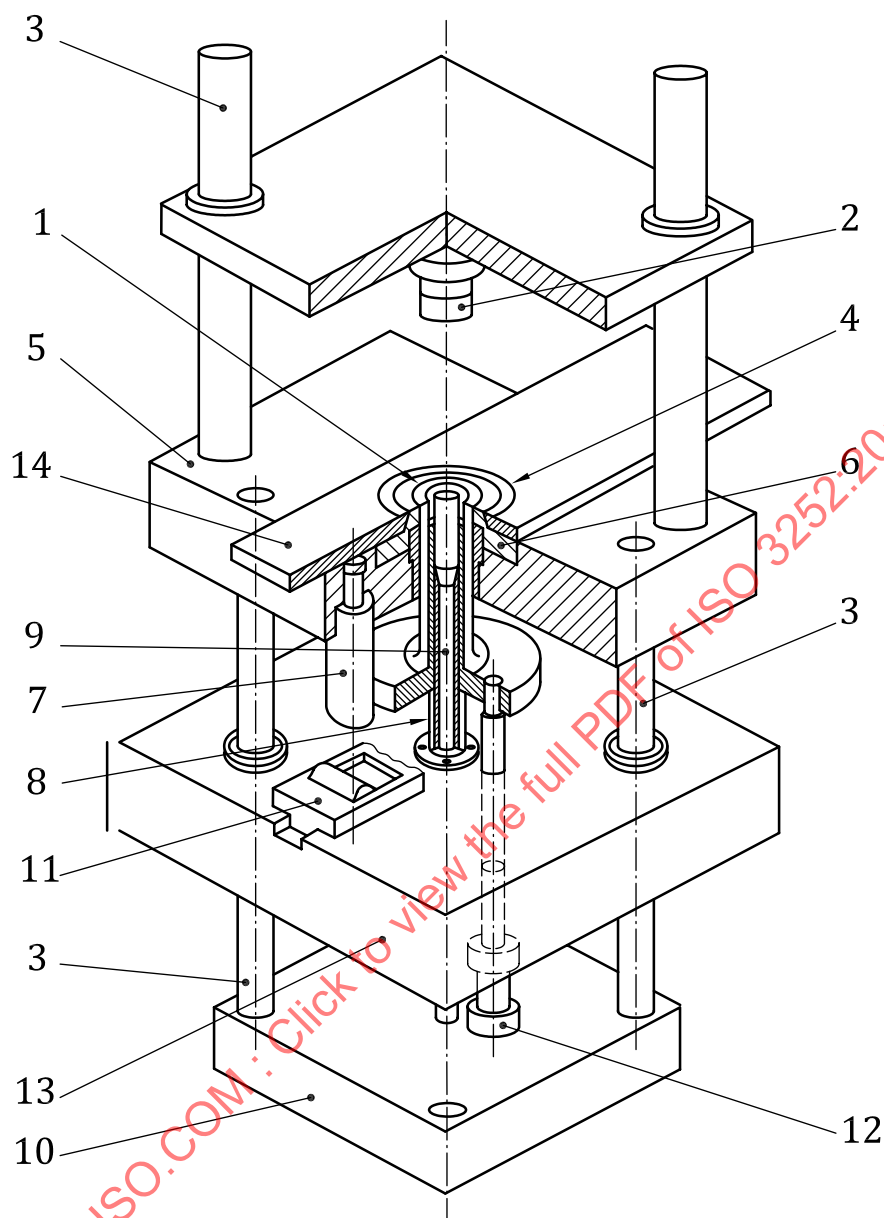
3.2.1

adaptor

device in which the press tools are mounted outside the press

Note 1 to entry: See [Figure 11](#).

STANDARDSISO.COM : Click to view the full PDF of ISO 3252:2019

**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

dwelt 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

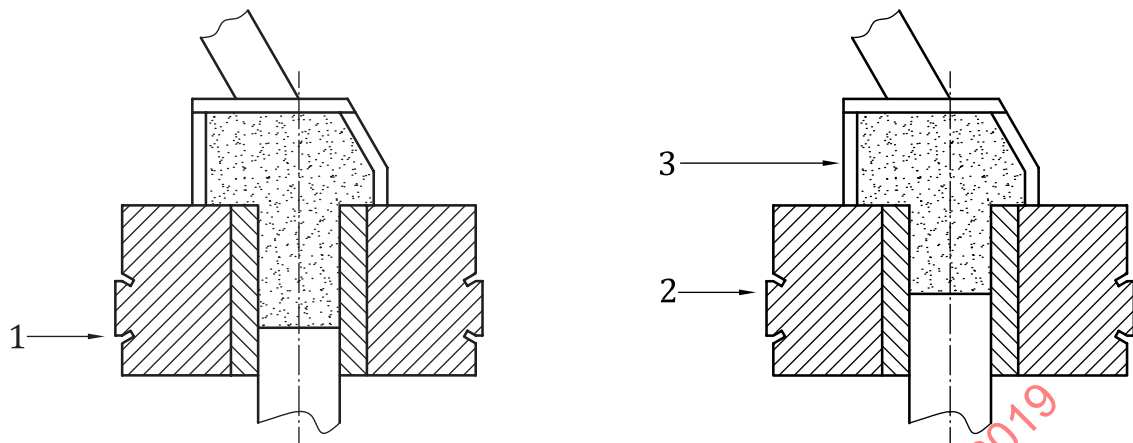
zone in a compact in which the stresses imposed by opposing punches are in equilibrium

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

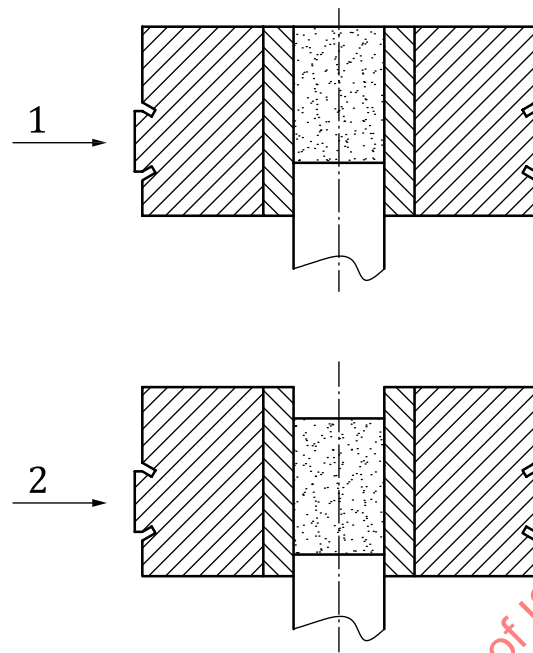
forming a compact of a shape which requires horizontal splitting of the tool die

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.