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ISO  
3252

Sixth edition  
2023-02

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**Powder metallurgy — Vocabulary**

*Métallurgie des poudres — Vocabulaire*

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Reference number  
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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](http://www.iso.org/directives)).

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

For an explanation of 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 [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 119, *Powder metallurgy*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/SS M11, *Powder metallurgy*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This sixth edition cancels and replaces the fifth edition (ISO 3252:2019), which has been technically revised.

The main changes are as follows:

- several new definitions and figures related to forming (3.2) have been added.

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](http://www.iso.org/members.html).

## Introduction

The terms are classified alphabetically under the following categories:

- 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.

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# Powder metallurgy — Vocabulary

## 1 Scope

This document defines terms related 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 <https://www.electropedia.org/>

### 3.1 Terms related to powders

#### 3.1.1

**acicular**, adj.  
needle-like particle form

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

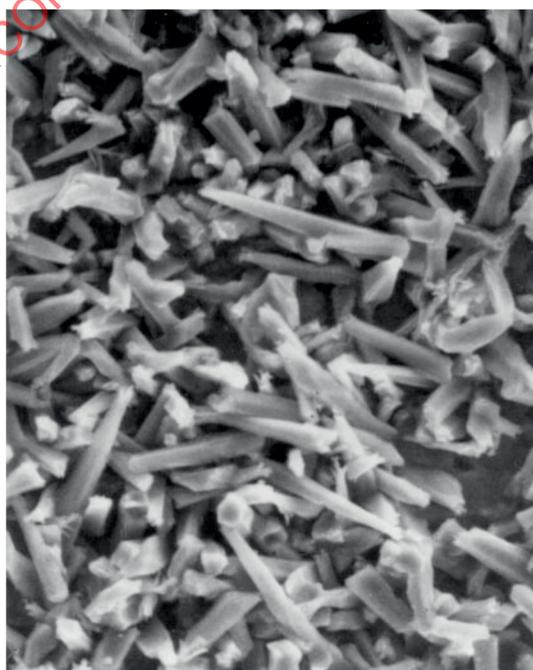


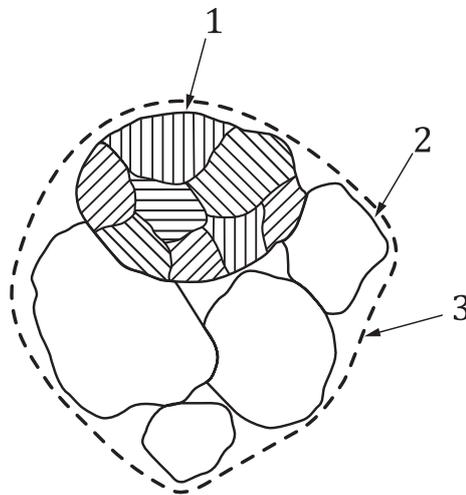
Figure 1 — Acicular

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**, adj.

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* ([3.2.48](#)) 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](#))

**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**

encompassing the powder characteristics of *compressibility* (3.1.24), *green strength* (3.2.48), edge retention, and lamination tendency, that relates to the ability of a powder to be consolidated into a usable *green compact* (3.2.11)

Note 1 to entry: Compactability is a conceptual term and 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****dehydrated powder**

powder made by removal of hydrogen from metal hydride

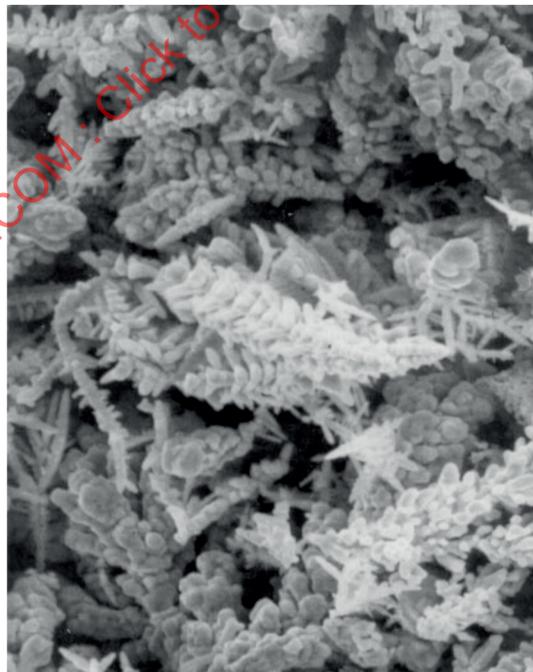
**3.1.28****demixing**

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

**3.1.29****dendritic, adj.**

branch-shaped

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 involving diffusion

**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**

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

**3.1.35**

**fibrous, adj.**

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**

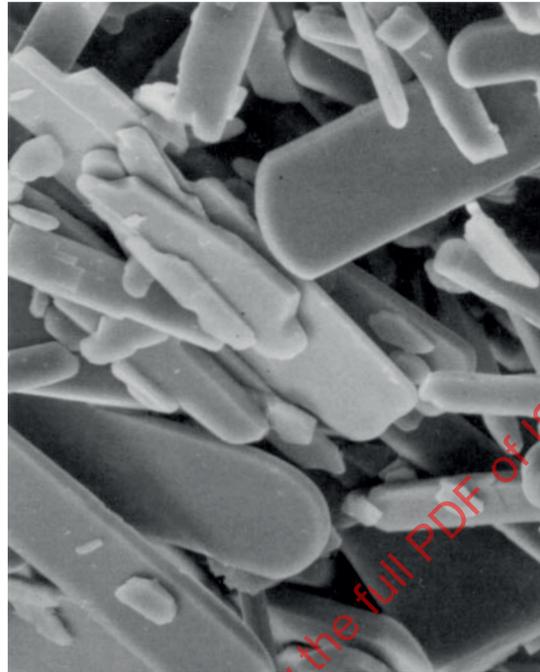
**fines**

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

**3.1.38**

**flaky**, adj.  
plate-like particle form

Note 1 to entry: See [Figure 6](#).



**Figure 6 — Flaky**

**3.1.39****flowability**

<qualitative term> 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**, adj.

approximately equidimensional non-spherical shape

Note 1 to entry: See [Figure 7](#).

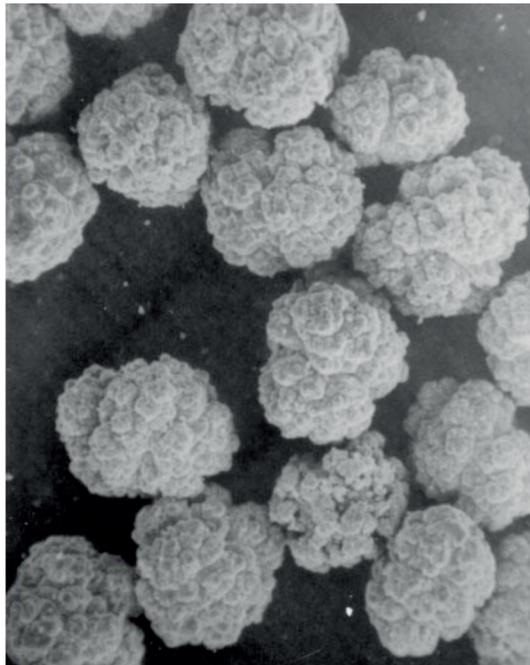


Figure 7 — Granular

**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](#).

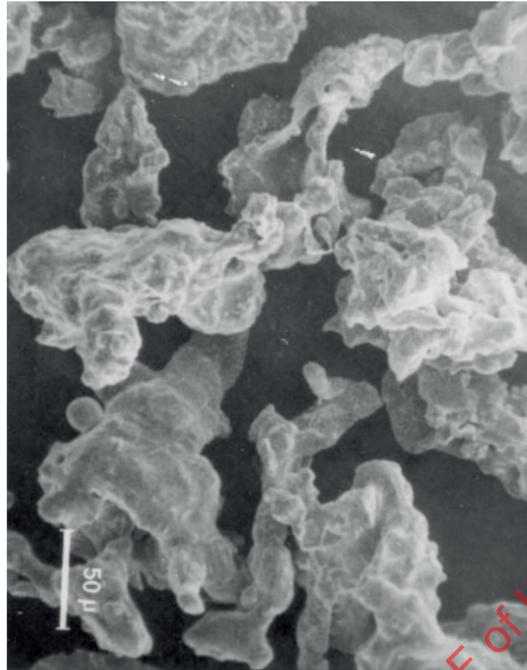


Figure 8 — Irregular

**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**

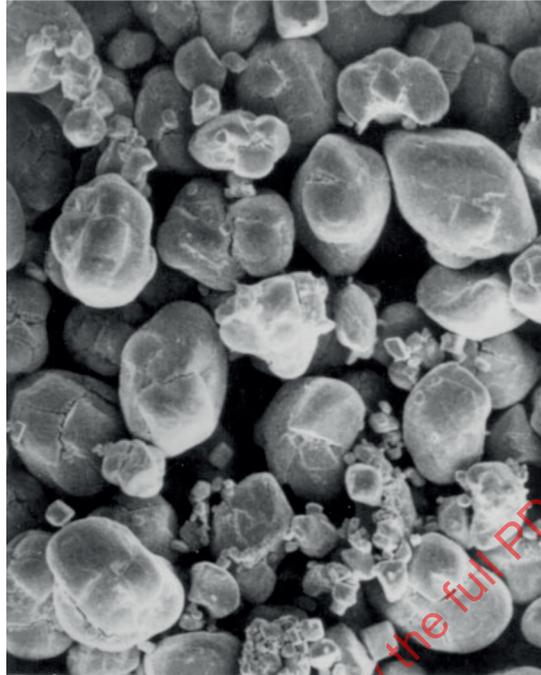
thorough intermingling of powders of two or more materials

**3.1.54**

**nodular**, adj.

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* (3.1.22) 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**, adj.

roughly spherical

Note 1 to entry: See [Figure 10](#).

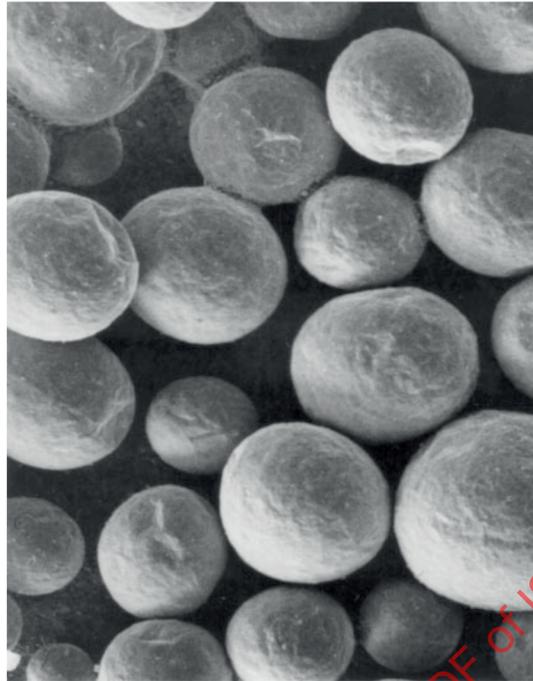


Figure 10 — Spheroidal

### 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 related to forming**

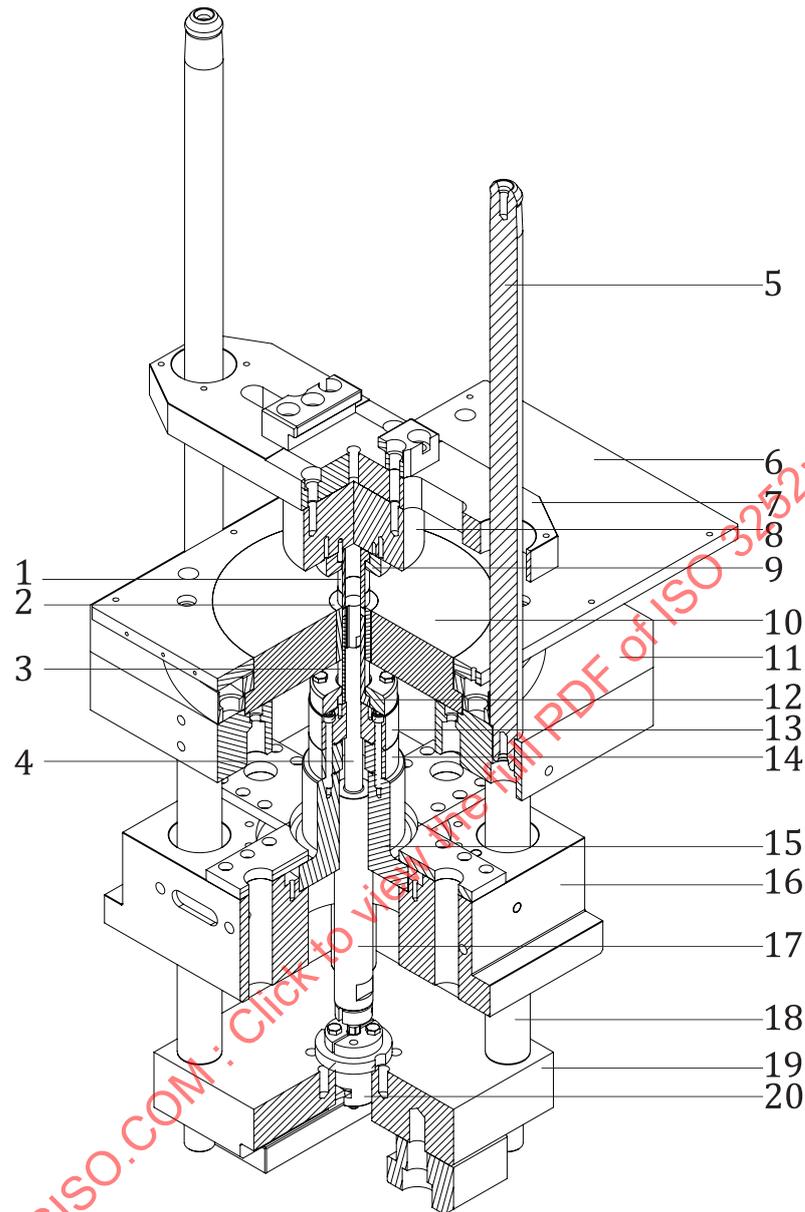
**3.2.1**

**adaptor**

device in which the press tools are mounted outside the press

Note 1 to entry: See [Figures 11](#) and [12](#).

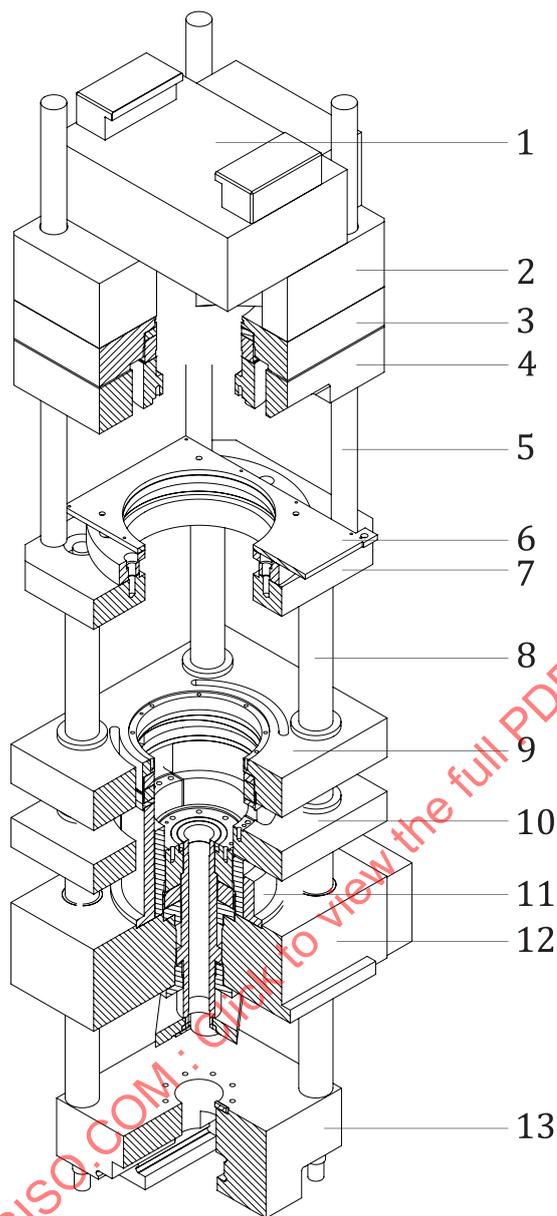
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**Key**

- |    |  |    |  |
|----|--|----|--|
| 1  | upper punch ( <a href="#">3.2.92</a> )         | 11 | die plate ( <a href="#">3.2.24</a> )           |
| 2  | die ( <a href="#">3.2.23</a> )                 | 12 | clamp ring ( <a href="#">3.2.8</a> )           |
| 3  | lower punch ( <a href="#">3.2.57</a> )         | 13 | punch plate ( <a href="#">3.2.73</a> )         |
| 4  | core rod ( <a href="#">3.2.18</a> )            | 14 | punch riser ( <a href="#">3.2.74</a> )         |
| 5  | guide rod ( <a href="#">3.2.49</a> )           | 15 | socket ( <a href="#">3.2.82</a> )              |
| 6  | filler plate ( <a href="#">3.2.41</a> )        | 16 | base plate ( <a href="#">3.2.4</a> )           |
| 7  | upper coupler plate ( <a href="#">3.2.90</a> ) | 17 | core rod extension ( <a href="#">3.2.20</a> )  |
| 8  | punch plate ( <a href="#">3.2.73</a> )         | 18 | tie rod ( <a href="#">3.2.85</a> )             |
| 9  | clamp ring ( <a href="#">3.2.8</a> )           | 19 | lower coupler plate ( <a href="#">3.2.55</a> ) |
| 10 | shrink ring ( <a href="#">3.2.79</a> )         | 20 | core rod connector ( <a href="#">3.2.19</a> )  |

NOTE Other types and arrangements exist.

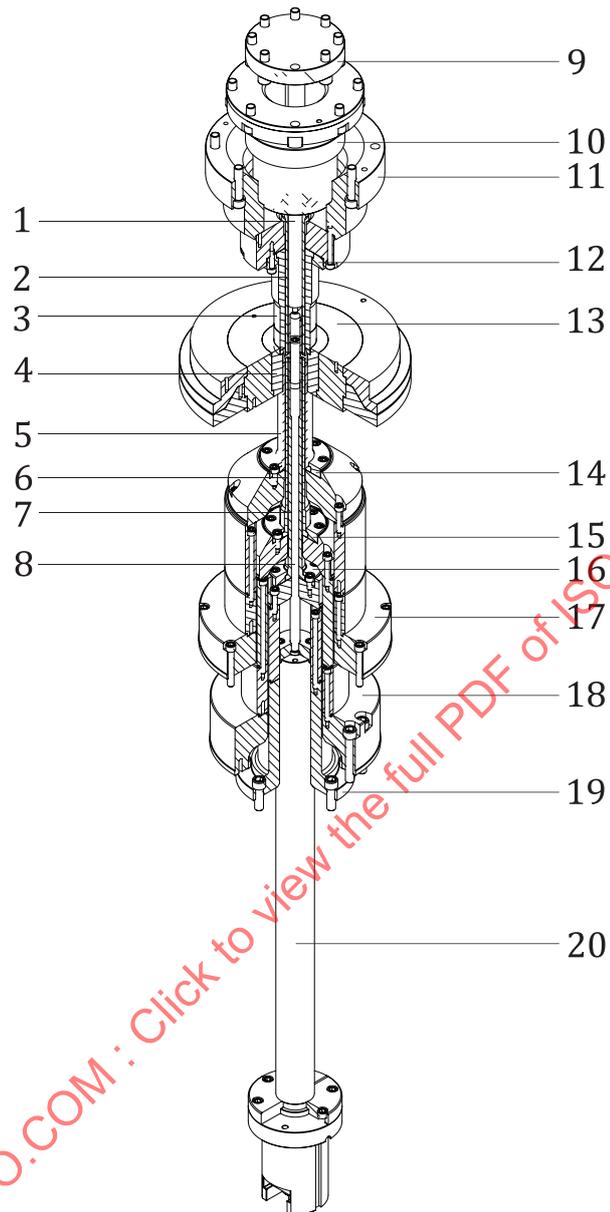
**Figure 11 — Tool set and adaptor for a mechanical press**



**Key**

- |   |  |    |  |
|---|--|----|--|
| 1 | upper coupler plate ( <a href="#">3.2.90</a> ) | 8  | tie rod ( <a href="#">3.2.85</a> )             |
| 2 | upper plate ( <a href="#">3.2.91</a> )         | 9  | lower plate ( <a href="#">3.2.56</a> )         |
| 3 | upper plate ( <a href="#">3.2.91</a> )         | 10 | lower plate ( <a href="#">3.2.56</a> )         |
| 4 | upper plate ( <a href="#">3.2.91</a> )         | 11 | lower plate ( <a href="#">3.2.56</a> )         |
| 5 | guide rod ( <a href="#">3.2.49</a> )           | 12 | base plate ( <a href="#">3.2.4</a> )           |
| 6 | filler plate ( <a href="#">3.2.41</a> )        | 13 | lower coupler plate ( <a href="#">3.2.55</a> ) |
| 7 | die plate ( <a href="#">3.2.24</a> )           |    |  |

**Figure 12 — Adaptor for multi-level hydraulic press**

**Key**

1	upper punch ( <a href="#">3.2.92</a> )	11	punch plate ( <a href="#">3.2.73</a> )
2	upper punch ( <a href="#">3.2.92</a> )	12	clamp ring ( <a href="#">3.2.8</a> )
3	upper punch ( <a href="#">3.2.92</a> )	13	shrink ring ( <a href="#">3.2.79</a> )
4	die ( <a href="#">3.2.23</a> )	14	clamp ring ( <a href="#">3.2.8</a> )
5	lower punch ( <a href="#">3.2.57</a> )	15	clamp ring ( <a href="#">3.2.8</a> )
6	lower punch ( <a href="#">3.2.57</a> )	16	clamp ring ( <a href="#">3.2.8</a> )
7	lower punch ( <a href="#">3.2.57</a> )	17	socket ( <a href="#">3.2.82</a> )
8	core rod ( <a href="#">3.2.18</a> )	18	socket ( <a href="#">3.2.82</a> )
9	punch plate ( <a href="#">3.2.73</a> )	19	clamp ring ( <a href="#">3.2.8</a> )
10	punch plate ( <a href="#">3.2.73</a> )	20	core rod extension ( <a href="#">3.2.20</a> )

**Figure 13 — Tool set for a multi-level hydraulic press**

**3.2.2****adaptor table**

member of the tool set designed to hold the *bolster* ([3.2.79](#))

**3.2.3**

**back relief**

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

**3.2.4**

**base plate**

part of the tool set adaptor, transferring the force onto the bottom punch(es) into the machine-body and providing the guide for the lower platens and die

Note 1 to entry: See [Figures 11](#) and [12](#).

**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**

**brown body**

<MIM terminology> debinded body ready to be sintered

**3.2.7**

**canning**

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

**3.2.8**

**clamp ring**

member of the tool set ring designed to clamp a *die* (3.2.23), *punch* (3.2.72) or a *core rod* (3.2.18)

Note 1 to entry: See [Figures 11](#) and [13](#).

**3.2.9**

**cold isostatic pressing**

**CIP**

isostatic pressing at ambient temperature

Note 1 to entry: The pressure-transmitting medium is normally a liquid.

**3.2.10**

**cold pressing**

**cold compacting**

pressing metal powder using either compacting tools or CIP mould at ambient temperature

**3.2.11**

**compact**

**green compact**

object prepared from powder by cold-pressing or by injection-moulding

**3.2.12**

**compacting**

process of making a *compact* (3.2.11)

**3.2.13**

**compacting pressure**

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

**3.2.14**

**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

**3.2.15****compound  
feedstock**

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

**3.2.16****consolidation**

process in which a powder or compact is densified

**3.2.17****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

**3.2.18****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 [Figures 11](#) and [13](#).

**3.2.19****core rod connector**

part of the tool set adaptor transmitting the movement of the machine for the *core rod* (3.2.18) to the tool set

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

**3.2.20****core rod extension**

part of the tool set adaptation between the *core rod connector* (3.2.19) and the *core rod* (3.2.18)

Note 1 to entry: See [Figures 11](#) and [13](#).

**3.2.21****counter-pressure****top-punch hold-down pressure**

pressure at which a compact is held between an upper and a *lower punch* (3.2.57) during a withdrawal or *ejection process* (3.2.32)

**3.2.22****debinding**

<MIM terminology> removal of *binder* (3.1.9) 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 [Figures 11](#) and [13](#).

**3.2.24****die plate**

upper plate of the tool set adaptor holding the *clamp ring* (3.2.8), *bolster* (3.2.79) and *die* (3.2.23)

Note 1 to entry: See [Figures 11](#) and [12](#).

**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* (3.2.9) 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* (3.2.11) 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* (3.2.11) 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* (3.2.12) 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 14](#).

**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****filler plate**

plate positioned over the die upon which the feed shoe rests

Note 1 to entry: See [Figures 11](#) and [12](#).

**3.2.42****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.

**3.2.43****fork**

part of the tool set pressing adaptor, used in connection with the *wedge* ([3.2.100](#)) for the compaction and uncovering of multi-sectional objects

**3.2.44****forming**

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

**3.2.45****green**

pressed or injection-moulded but unsintered

**3.2.46****green density**

mass per unit volume of an unsintered compact

**3.2.47****green machining**

machining of a unsintered compact to a predetermined shape

**3.2.48****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).

**3.2.49****guide rod****column**

part of the tool set adaptor guiding the moving parts of the upper part of the tool set with the die plate in the compacting direction

Note 1 to entry: See [Figure 11](#) and [12](#).

**3.2.50**

**hot isostatic pressing**

**HIP**

*isostatic pressing* ([3.2.52](#)) at elevated temperature activating the phenomena of diffusion and creep

Note 1 to entry: The pressure-transmitting medium is normally a gas.

**3.2.51**

**hot pressing**

pressing of a powder or compact, normally uniaxially, at elevated temperatures thus activating the phenomena of diffusion and creep

**3.2.52**

**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

**3.2.53**

**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.

**3.2.54**

**lifting rod**

member of the tool set bringing the *lower punch* ([3.2.57](#)) into the filling position

**3.2.55**

**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 [Figures 11](#) and [12](#).

**3.2.56**

**lower plate**

movable plate of the adaptor for connecting a *lower punch* ([3.2.57](#))

Note 1 to entry: See [Figure 12](#).

**3.2.57**

**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 [Figures 11](#) and [13](#).

**3.2.58**

**lower ram**

ram of a press acting on the pressing tool from below

**3.2.59**

**metal injection moulding**

**MIM**

method of *forming* ([3.2.44](#)) by the injection of a plasticized mixture of metallic powder(s) and *binder(s)* ([3.1.9](#)) into a mould

**3.2.60**

**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* ([3.2.45](#))

### 3.2.61 mould

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

### 3.2.62 multiple-cavity tool

tool set that produces two or more compacts in each pressing cycle

### 3.2.63 multiple pressing

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

### 3.2.64 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

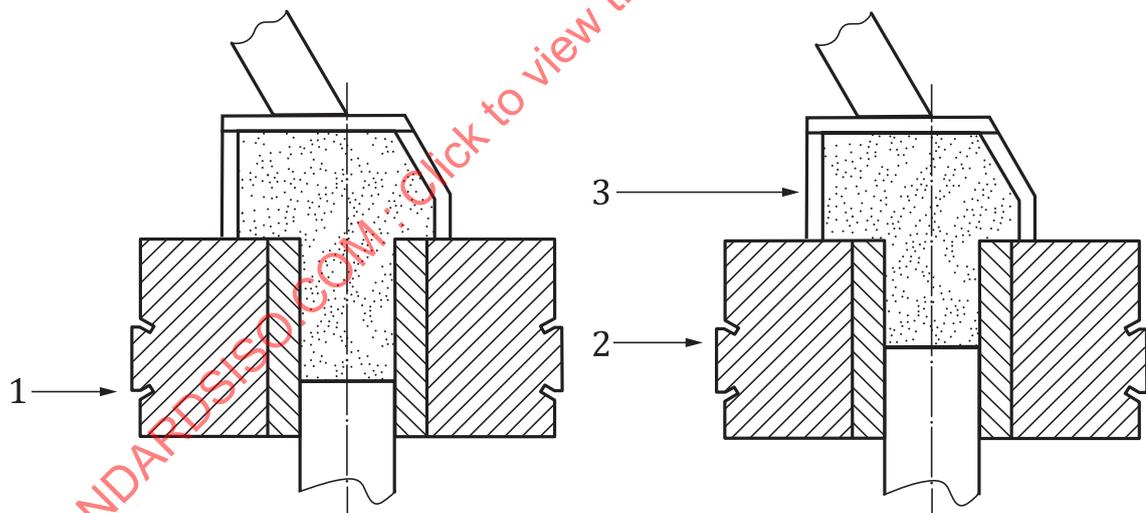
### 3.2.65 neutral zone

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

### 3.2.66 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 14](#).



#### Key

- 1 step 1
- 2 step 2
- 3 feed shoe

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

**Figure 14 — Overfill**

### 3.2.67 plasticized-powder extrusion

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

**3.2.68**

**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

**3.2.69**

**preform**

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

**3.2.70**

**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

**3.2.71**

**pressing crack**

crack formed in a compact during the pressing cycle

**3.2.72**

**punch**

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

**3.2.73**

**punch plate**

part of the tool set adaptor supporting a *punch* (3.2.72)

Note 1 to entry: See [Figures 11](#) and [13](#).

**3.2.74**

**punch riser**

part of the tool set adaptation connecting a *punch plate* (3.2.73) to a socket in order to increase the height of the assembly for a *punch* (3.2.72)

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

**3.2.75**

**sandwich die**

*split die* (3.2.83) consisting of discs perpendicular to the pressing direction

**3.2.76**

**segmented die**

*die* (3.2.23) fabricated by the assembly of several die segments within a retaining *shrink ring* (3.2.79)

**3.2.77**

**segmented punch**

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

**3.2.78**

**shaping**

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

**3.2.79**

**shrink ring**

**bolster**

member of the tool set designed to hold the die

Note 1 to entry: See [Figures 11](#) and [13](#).

**3.2.80**

**single-action pressing**

method by which a powder is pressed in a stationary die between one moving and one fixed punch

**3.2.81  
skeleton**

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

**3.2.82  
socket**

part of the tool set adaptation connecting the assembly for a *punch* (3.2.72) to the plate of the adaptor

Note 1 to entry: See [Figures 11](#) and [13](#).

**3.2.83  
split die**

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

**3.2.84  
spring back**

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

Note 1 to entry: See also ISO 4492.

**3.2.85  
tie rod**

part of the tool set adaptor connecting and transferring the motion of the lower coupling plate to the die plate

Note 1 to entry: See [Figure 11](#) and [12](#).

**3.2.86  
tool set**

assembly of tooling items used for the production of a specific powder product by the process of *compacting* (3.2.12) or *re-pressing* (3.4.7)

Note 1 to entry: The tool set may include dies, punches and *core rods* (3.2.18) but excludes press fittings common to more than one product.

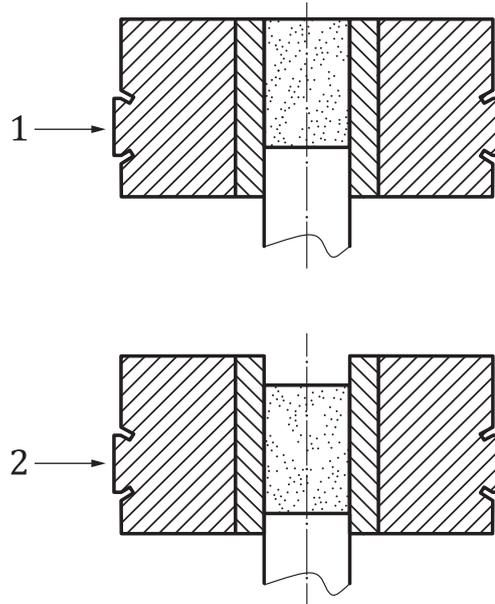
**3.2.87  
undercut forming**

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

**3.2.88  
underfill**

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

Note 1 to entry: See [Figure 15](#).



**Key**

- 1 step 1
- 2 step 2

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

**Figure 15 — Underfill**

**3.2.89 uniaxial pressing**

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

**3.2.90 upper coupler plate**

part of the tool set adaptor transmitting the movement of the machine upper ram to the tool set

Note 1 to entry: See [Figures 11](#) and [12](#).

**3.2.91 upper plate**

movable plate of the adaptor for connecting an *upper punch* ([3.2.92](#))

Note 1 to entry: See [Figure 12](#).

**3.2.92 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 [Figures 11](#) and [13](#).

**3.2.93 upper ram**

ram of a press acting on the pressing tool from above

**3.2.94 vibration-assisted compaction**

compaction of a powder using an oscillating *punch* ([3.2.72](#)) or punches

**3.2.95****vibration-assisted filling**

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

**3.2.96****volume filling**

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

**3.2.97****warm compaction**

*consolidation* (3.2.16) of a pre-heated powder in a pre-heated die

**3.2.98****warm pressing****warm compacting**

pressing metal powder using heated powder and heated compaction tools to get higher density than obtained by *cold pressing* (3.2.10)

**3.2.99****warm-die compaction**

*consolidation* (3.2.16) of an unheated powder in a pre-heated die

**3.2.100****wedge**

part of the tool set pressing adaptor, in connection with the *fork* (3.2.43), enabling the compaction and the ejection of multi-sectional objects

**3.2.101****weight filling**

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

**3.2.102****wet-bag isostatic pressing**

method of *cold isostatic pressing* (3.2.9) whereby the flexible mould containing the powder or compact is immersed in the pressure transmitting medium

**3.2.103****withdrawal position**

position of the tool set at the end of the *withdrawal process* (3.2.104)

**3.2.104****withdrawal process**

operation by which a *die* (3.2.23) descends over a fixed *lower punch* (3.2.57) to free the compact

**3.3 Terms related 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-pore**

<hardmetals> pore 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-pore**

<hardmetals> pore 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

Note 1 to entry: See also 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 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 from a compact by heating

Note 1 to entry: Binders and lubricants are examples of organic additives.

**3.3.22****diffusion porosity**

porosity created by diffusion of one constituent material into another

Note 1 to entry: For example, the Kirkendall effect.

**3.3.23****dimensional change**

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

**3.3.24****discoloring**

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

**frosting**

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* (3.2.50) 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

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

Note 1 to entry: See also ISO 2738.

**3.3.39****open pore**

pore communicating with the surface

**3.3.40****open porosity**

ratio of the volume of the *open pores* (3.3.39) to the total volume of a porous object

Note 1 to entry: See also ISO 2738.

**3.3.41****oversintering**

sintering at too high a temperature and/or for too long a time such that deterioration of the final properties results

**3.3.42****oxide network**

continuous or discontinuous oxides that follow prior particle boundaries

**3.3.43****packing material**

any material in which compacts are embedded in order to separate and protect them during *presintering* (3.3.50) or sintering

**3.3.44****pore**

inherent or induced cavity within a particle or within an object

**3.3.45****pore-forming material**

substance included in a powder mixture which volatilizes during sintering and thereby produces a desired kind and degree of porosity in the finished compact

**3.3.46****pore size**

linear dimension of an individual pore, determined by geometric analysis or physical tests

**3.3.47****pore size distribution**

percentage by numbers or by volume of each classified pore size which exists in a material

**3.3.48****porosity**

ratio of the volume of all the pores to the total volume of a porous object

**3.3.49****porosity structure**

pattern of the pores in a material, characterized by the shape, size and distribution of the pores

**3.3.50**

**presintering**

heating of a compact at a temperature below the required final *sintering temperature* (3.3.63)

**3.3.51**

**pressure sintering**

sintering with simultaneous application of normally uniaxial pressure

**3.3.52**

**pusher furnace**

furnace in which the components, packed into sinter trays, are transported through the furnace by a pushing system

**3.3.53**

**radial crushing strength**

breaking strength, determined by the application of a diametral compressive force, of a sintered hollow cylinder

Note 1 to entry: See also ISO 2739.

**3.3.54**

**rapid burn-off**

accelerated removal of organic additives in a separate zone of the sintering furnace, usually under an oxidizing atmosphere

**3.3.55**

**reaction sintering**

process wherein at least two constituents of a powder mixture react during sintering

**3.3.56**

**relative density**

ratio, usually expressed as a percentage, of the density of a porous object to the density of the same material in the pore-free state

**3.3.57**

**shrinkage**

decrease in dimensions of a compact as a result of sintering

Note 1 to entry: See also ISO 4492.

**3.3.58**

**sinter hardening**

thermal process in which a ferrous product is sintered and then cooled at a rate sufficient to produce a predominantly martensitic microstructure

[SOURCE: ASTM B243-17]

**3.3.59**

**sinter skin**

surface layer that may be formed on a sintered object during *sintering* (3.3.60) and has properties different from those of the inner parts of the object

**3.3.60**

**sintering**

thermal treatment of a powder or compact, at a temperature below the melting point of the main constituent, for the purpose of increasing its strength by the metallurgical bonding of its particles