International Standard

ISO/ASTM 52948

Additive manufacturing of metals — Powder bed fusion — Classification of imperfections

Fabrication additive de métaux — Fusion sur lit de poudre — Classification des imperfections

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Foreword

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Introduction

Industrial additive manufacturing (AM) with powder bed fusion (PBF) processes for metallic materials, using a laser beam (PBF-LB/M) or an electron beam (PBF-EB/M), is in full development. The principle is based on depositing layers of powder on a build platform and selectively fusing each layer with a laser or an electron beam. It is thus possible to produce parts of high geometric complexity.

The control of this process is the subject of numerous studies to attain the best possible quality. It is essential to supplement the approaches addressed by these studies with a standard describing observable imperfections to serve as a basis for non-destructive testing (NDT) and destructive testing (DT).

Knowledge of the imperfections generated by the manufacturing process and their standardised classification are preliminary and essential steps in defining and determining acceptance criteria.

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Additive manufacturing of metals — Powder bed fusion — Classification of imperfections

1 Scope

This document specifies the classification of imperfections possibly generated during an additive manufacturing process by PBF-LB (laser beam powder bed fusion) or PBF-EB (electron beam powder bed fusion) for metallic parts.

This document also indicates the most probable causes of the formation of imperfections and includes illustrations.

This can be extended to other additive manufacturing process categories, nevertheless, the indication of probable causes is process specific.

Acceptance criteria and dimensional description or scale for imperfections are not included in this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the version cited applies. For undated references, the latest version of the referenced document (including any amendments) applies.

ISO 3252, *Powder metallurgy — Vocabulary*

ISO/ASTM 52900, *Additive manufacturing — General principles — Fundamentals and vocabulary*

ASTM B243, *Standard Terminology of Powder Metallurgy*

3 Terms and definitions

For the purposes of this document, the terms and definitions of ISO 3252, ISO/ASTM 52900, ASTM B243 and the following apply.

ISO and IEC maintain terminology databases for use in standardisation at the following addresses:

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

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

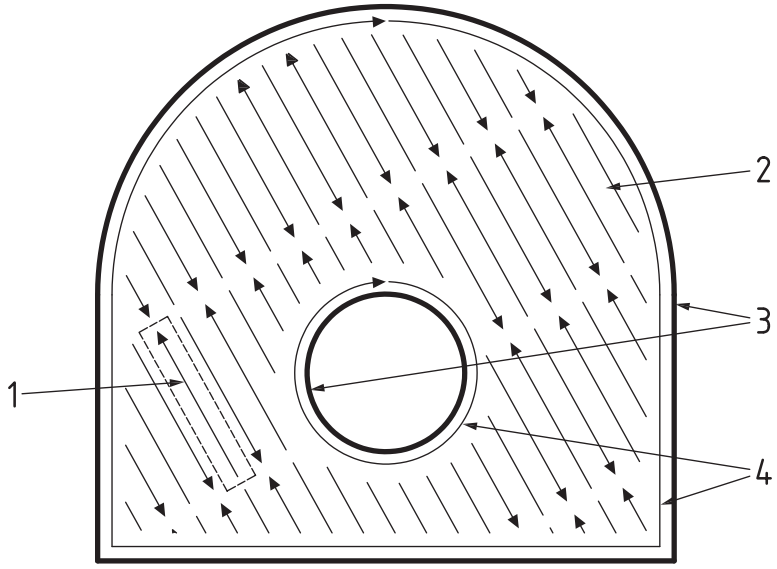
3.1
bead
continuous line of fused metal

3.2
contour
one or a set of scan trajectories following the edges of a part on a layer

Note 1 to entry: Among scanning strategies (see 3.8), it is very common to use one or more contours, which consist of paths that follow the edges of a part on a layer.

Note 2 to entry: See Figure 1.

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Key

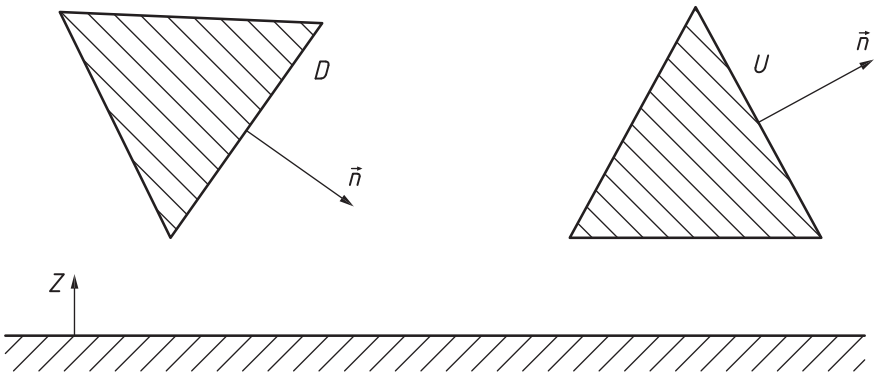
1	bead
2	core scanning strategy
3	geometric edge
4	contour

Figure 1 — Example of a manufacturing strategy using a contour

3.3
downskin area
D
(sub-)area where the outward-pointing normal vector $\vec{n}$ projection on the Z-axis is negative

Note 1 to entry: See Figure 2.

[SOURCE: ISO/ASTM 52911-1:2019, 3.2, modified — Inclusion of "outward-pointing".]



Key

$\vec{n}$	normal vector
D	downskin area (left)
U	upskin area (right) (see 3.9)

Figure 2 — Upskin and downskin areas *U* and *D* (extracted from Figure 1 of ISO/ASTM 52911-1:2019)

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3.4
imperfection
departure of a quality characteristic from its intended condition

[SOURCE: ISO/TS 18173:2005, 2.13]

3.5
inclusion
foreign material, either non-metallic or metallic, incorporated into the deposited material

Note 1 to entry: Inclusions are typically oxides, nitrides, hybrids, carbides, or a combination thereof and may or may not have some coherency with the surrounding material.

[SOURCE: ASTM E3166-20]

3.6
lack of fusion
LOF
type of process-induced porosity, in which the powder is not fully melted or fused onto the previously deposited substrate

Note 1 to entry: In PBF, this type of flaw can be an empty cavity, or contain unmelted or partially fused powder, referred to as unconsolidated powder.

Note 2 to entry: Lack of fusion typically occurs in the bulk, making its detection difficult.

Note 3 to entry: Like voids, lack of fusion can occur on the build layer plane (layer/horizontal LOF) or across multiple build layers (cross layer/vertical LOF).

[SOURCE: ISO/ASTM TR 52905:2023, 3.2 modified — Deletion of "or wire".]

3.7
powder spreading device
powder supply mechanism, which distributes and evenly spreads the powder on the build surface

[SOURCE: ISO/ASTM 52941:—, 3.4]

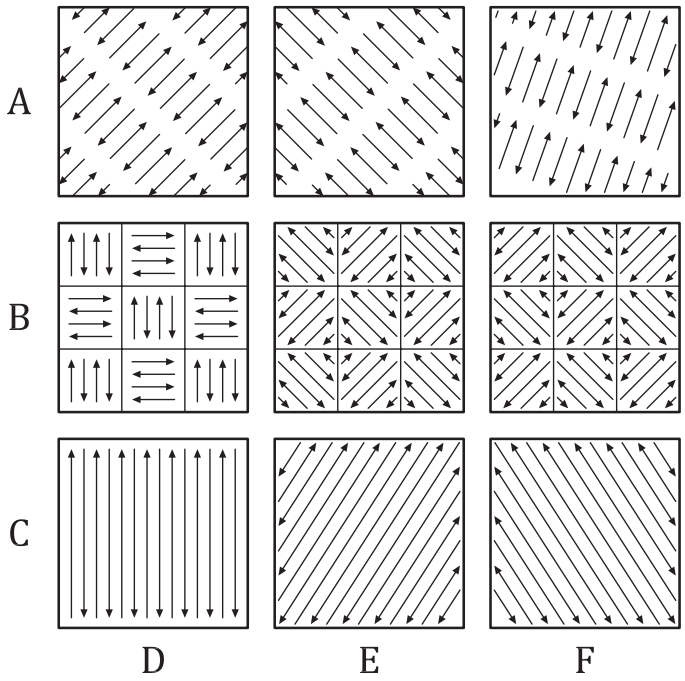
3.8
scanning strategy
concept that describes the laser or electron beam path at each layer

Note 1 to entry: The scanning strategy is automatically generated by the machine or by upstream software. There is a wide variety of scanning strategies.

Note 2 to entry: See Figure 3 where each arrow represents a bead and its direction.

Note 3 to entry: Scanning strategy can refer to both the path and process parameters along these paths such as laser power, laser speed, beam shape, etc.

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Key

A	stripes
B	checkboard pattern
C	parallel beads
D	layer *N*
E	layer *N*+1
F	layer *N*+2

Figure 3 — Different types of scanning strategy

3.9
upskin area
U
(sub-)area where the normal vector $\vec{n}$ projection on the Z-axis is positive

Note 1 to entry: See Figure 2.

[SOURCE: ISO/ASTM 52911-1:2019, 3.4 modified — Reference to Figure 2 instead of Figure 1.]

4 Classification of imperfections

4.1 General

The principle of the classification (or numbering) system is based on six groups of imperfections according to Table 1.

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