BSI Standards Publication

Additive manufacturing — Design

Part 3: PBF-EB of metallic materials

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A list of organizations represented on this committee can be obtained on request to its committee manager.

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European foreword

This document (EN ISO/ASTM 52911-3:2023) has been prepared by Technical Committee ISO/TC 261 "Additive manufacturing" in collaboration with Technical Committee CEN/TC 438 “Additive Manufacturing” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2023, and conflicting national standards shall be withdrawn at the latest by September 2023.

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Foreword

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This document was prepared by Technical Committee ISO/TC 261, *Additive manufacturing*, in cooperation with ASTM Committee F42, *Additive Manufacturing Technologies*, on the basis of a partnership agreement between ISO and ASTM International with the aim to create a common set of ISO/ASTM standards on additive manufacturing, and in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 438, *Additive manufacturing,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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Introduction

Powder bed fusion of metals (PBF/M) is an additive manufacturing (AM) process that offers additional manufacturing options alongside other established AM processes. PBF/M has the potential to reduce manufacturing time and costs, and increase part functionality. Practitioners are aware of the strengths and weaknesses of conventional, long-established manufacturing processes, such as cutting, joining and shaping processes (e.g. by machining, welding or injection moulding), and of giving them appropriate consideration at the design stage and when selecting the manufacturing process. In the case of PBF/M and AM in general, design and manufacturing engineers only have a limited pool of experience. Without the limitations associated with conventional processes, the use of PBF/M offers designers and manufacturers a high degree of freedom and this requires an understanding about the possibilities and limitations of the process.

The ISO 52911 series provides guidance for different powder bed fusion (PBF) technologies. In addition to this document on PBF-EB/M, the series is made up of ISO 52911-1 on laser-based powder bed fusion of metals (PBF-LB/M) and ISO 52911-2 on laser-based powder bed fusion of polymers (PBF-LB/P). Each document in the series shares Clauses 1 to 5, where general information including terminology and the PBF process is provided. The subsequent clauses focus on the specific technology.

This document provides support to technology users, such as design and production engineers, when designing parts that need to be manufactured by means of PBF-EB/M. It will help practitioners to explore the benefits of PBF-EB/M and to recognize the process-related limitations when designing parts. It also builds on ISO/ASTM 52910 to extend the requirements, guidelines and recommendations for AM design to include the PBF-EB/M process.

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Additive manufacturing — Design —

Part 3: PBF-EB of metallic materials

1 Scope

This document specifies the features of electron beam powder bed fusion of metals (PBF-EB/M) and provides detailed design recommendations.

Some of the fundamental principles are also applicable to other additive manufacturing (AM) processes, provided that due consideration is given to process-specific features.

This document also provides a state of the art review of design guidelines associated with the use of powder bed fusion (PBF) by bringing together relevant knowledge about this process and by extending the scope of ISO/ASTM 52910.

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 edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

3 Terms and definitions

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

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
curl effect
<aspect of heat-induced warping> dimensional distortion as the melted material cools and solidifies after being built or by poorly evacuated heat input

3.2
downskin area
D
(sub-)area where the normal vector $\vec{n}$ projection on the Z-axis is negative

Note 1 to entry: See Figure 1.

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3.3
downskin angle
δ
angle between the plane of the build platform and the *downskin area* (3.2) where the value lies between 0° (parallel to the build platform) and 90° (perpendicular to the build platform)

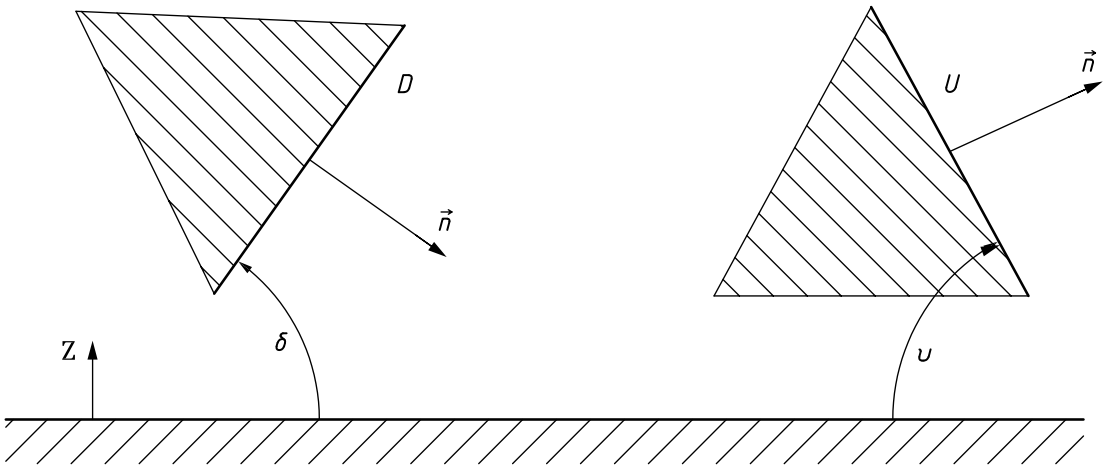
Note 1 to entry: See Figure 1.

3.4
upskin area
U
(sub-)area where the normal vector $\vec{n}$ in relation to Z-axis is positive

Note 1 to entry: See Figure 1.

3.5
upskin angle
υ
angle between the plane of the build platform and the *upskin area* (3.4) where the value lies between 0° (parallel to the build platform) and 90° (perpendicular to the build platform)

Note 1 to entry: See Figure 1.



Key

δ	downskin angles	***U***	upskin (right) areas
$\vec{n}$	normal vector	***υ***	upskin angles
D	downskin (left) areas	Z	build direction

NOTE Source: VDI 3405-3:2015[3].

Figure 1 — Orientation of the part surfaces relating to the build platform

4 Symbols and abbreviated terms

4.1 Symbols

The symbols given in Table 1 are used in this document.

Table 1 — Symbols

Symbol	Designation	Unit
a	overhang	mm

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Table 1 *(continued)*

Symbol	Designation	Unit
D	downskin area	mm^2
I	island	mm^2
$\vec{n}$	normal vector	—
U	upskin area	mm^2
δ	downskin angle	°
υ	upskin angle	°

4.2 Abbreviated terms

The following abbreviated terms are used in this document.

CT computed tomography

DICOM digital imaging and communications in medicine

PBF-EB/M electron beam powder bed fusion of metals

HIP hot isostatic pressing

PBF-LB laser-based powder bed fusion

PBF-LB/M laser-based powder bed fusion of metals (also known as, for example, laser beam melting, selective laser melting)

PBF-LB/P laser-based powder bed fusion of polymers (also known as, for example, laser beam melting, selective laser melting)

MRI magnetic resonance imaging

5 Characteristics of powder bed fusion (PBF) processes

5.1 General

Consideration should be given to the specific characteristics of the manufacturing process used in order to optimize the design of a part. Examples of the features of AM processes which need to be taken into consideration during the design and process planning stages are listed in 5.2 to 5.8. With regards to metal processing, a distinction can be made between, for example, laser-based PBF (applied for metals and polymers) and electron beam-based PBF (applied for metals only).

Polymers PBF uses, in almost every case, low power lasers to sinter polymer powders together. Electron beam powder bed fusion for polymers is not usually considered because the negative charge from the electron beam will accumulate in non-conductive polymer powder and cause repulsive events that will ruin powder layer continuity and make any controlled sintering or melting impossible. As with polymer powders PBF, metals PBF includes varying processing techniques. Like polymers, metals PBF often requires the addition of support structures (see 6.3.3). Metals PBF processes may use low-power lasers to bind powder particles by only melting the surface of the powder particles or high-power (approximately 200 W to 1 kW) energy beams to fully melt and fuse the powder particles together.

PBF-EB/M and PBF-LB/M have similar capabilities, although differences between these processes leads, in general, to PBF-EB/M supporting faster build rates at lower feature resolution compared to PBF-LB/M. The beam energy from the electron beam is of a higher intensity (due to a high energy source 3 kW to 6 kW), and the mechanism to raster the beam (i.e. electromagnetics for PBF-EB/M, optics for PBF-LB/M) differs between the two types of PBF processes. PBF-EB/M also tends to utilize a larger beam spot size, larger powder size distribution, and larger layer thickness. In general, PBF-EB/M

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