SLOVENSKI STANDARD
oSIST prEN ISO/ASTM 52911-2:2018

01-februar-2018

Aditivna proizvodnja - Smernica za tehnično načrtovanje taljenja praška na posteljici - 2. del: Laserska fuzija polimernih prahastih plasti (ISO/ASTM DIS 52911-2:2017)

Additive manufacturing - Technical Design Guideline for Powder Bed Fusion - Part 2: Laser-based Powder Bed Fusion of Polymers (ISO/ASTM DIS 52911-2:2017)

Additive Fertigung - Technische Konstruktionsrichtlinie für Pulverbettfusion - Teil 2: Laserbasierte Pulverbettfusion von Polymeren (ISO/ASTM DIS 52911-2:2017)

Fabrication additive - Lignes directrices techniques de conception pour la fusion sur lit de poudre - Partie 2: Fusion laser sur lit de poudre polymère (ISO/ASTM DIS 52911-2:2017)

Ta slovenski standard je istoveten z: prEN ISO/ASTM 52911-2

ICS:

25.030	3D-tiskanje	Additive manufacturing

oSIST prEN ISO/ASTM 52911-2:2018 en,fr,de

DRAFT INTERNATIONAL STANDARD
ISO/ASTM DIS 52911-2

ISO/TC **261** Secretariat: **DIN**

Voting begins on: **2017-11-14** Voting terminates on: **2018-02-06**

Additive manufacturing — Technical design guideline for powder bed fusion —

Part 2: Laser-based powder bed fusion of polymers

Titre manque —

Partie 2: Titre manque

ICS: 25.030

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/ASTM DIS 52911-2:2017(E)

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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 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.

The committee responsible for this document is Technical Committee ISO/TC 261. ISO 52911-2 was prepared by Technical Committee ISO/TC 261, Additive Manufacturing in cooperation with ASTM F42 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.

Under the general title Additive manufacturing — Technical Design Guideline for Powder Bed Fusion there are more standards under development, for example for Laser-based Powder Bed Fusion of Metals.

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.

ISO 52911-2 is based on the VDI-Guideline (The Association of German Engineers) VDI 3405 Part 3 Additive Manufacturing processes, rapid manufacturing — Design rules for part production using laser sintering and Laser-based Powder Bed Fusion of Metals.

The purpose of this Guideline is to provide support for technology users when designing parts that need to be manufactured by means of Laser-based Powder Bed Fusion of Metals. Furthermore, this guideline aims to extend the ISO/ASTM DIS 52910 Standard Practice/Guide for Design for Additive Manufacturing with a focus on the powder bed fusion process.

Introduction

Laser-based Powder Bed Fusion of Polymers (LB-PBF-P) describes an Additive Manufacturing (AM) process and offers an additional manufacturing option alongside established processes. LB-PBF-P 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 giving them appropriate consideration at the design stage and when selecting the manufacturing process. In the case of LB-PBF-P 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 LB-PBF-P offers designers and manufacturers with a high degree of freedom and this requires an understanding about the possibilities and limitations of the process.

Additive manufacturing — Technical Design Guideline for Powder Bed Fusion — Part 2: Laser-based Powder Bed Fusion of Polymers

1 Scope

This standard aims to give design and production engineers a working basis which enables them to have informed consideration about the use of Laser-based Powder Bed Fusion of Polymers. This standard describes the features of Laser-based Powder Bed Fusion of Polymers and provides detailed design recommendations. Some of the fundamental principles can also be applied to other AM processes, provided that due considerations are given to the process-specific features. The purpose of this standard is to help practitioners explore the benefits of Laser-based Powder Bed Fusion of Polymers and recognising the process-related limitations when designing parts.

The document also provides a state of the art review of design guidelines associated with the use of Powder Bed Fusion by bringing together relevant knowledge about this process and to extend the scope of ISO/ASTM DIS 52910.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 17296-2:2015, *Additive manufacturing — General principles — Part 2: Overview of process categories and feedstock*

ISO 17296-3:2014, *Additive manufacturing — General principles — Part 3: Main characteristics and corresponding test methods*

ISO/ASTM DIS 52910, *Standard Practice — Guide for Design for Additive Manufacturing*

ISO/ASTM DIS 52901:2015, *Additive manufacturing — General principles — Requirements for purchased AM parts*

ISO/ASTM 52900:2015, *Additive manufacturing — General principles — Terminology*

ISO/ASTM 52915:2016, *Standard Specification for Additive Manufacturing File Format (AMF) Version 1.2*

3 Terms and definitions

For the purposes of this standard, the terms and definitions as per ISO/ASTM 52900:2015 and the following terms and definitions apply:

3.1
curl effect
thermal and residual stress effects
<aspects of heat-induced warping> dimensional distortion as the printed part cools and solidifies after being built

3.2
downskin area
D
(sub-)area whose normal vector in relation to z-axis is negative (Figure 1)

3.3
downskin angle
δ
the angle between the plane of the build platform and the downskin area whose value lies between 0° (parallel to the build platform) and 90° (perpendicular to the build platform) (Figure 1)

3.4
upskin area
U
(sub-)area whose normal vector $\vec{n}$ in relation to z-axis is positive (Figure 1)

3.5
upskin angle
v
angle between the build platform plane and an upskin area whose value lies between 0° (parallel to the build platform) and 90° (perpendicular to the build platform) (Figure 1)

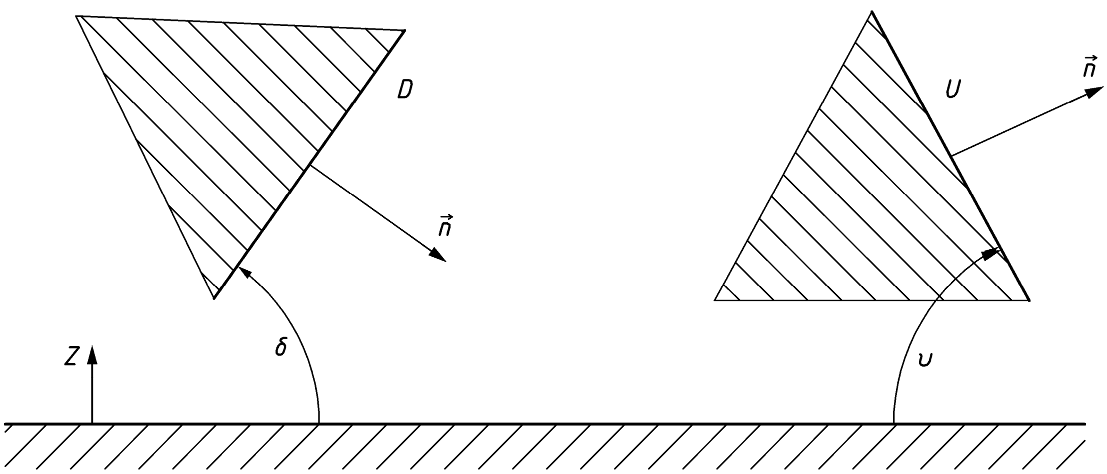

Figure 1 — Upskin and downskin areas U and D, upskin and downskin angles υ and δ, normal vector $\vec{n}$

[SOURCE: [0] VDI 3405 Part 3:2015]

4 Symbols and abbreviations

4.1 Symbols

The following symbols are used throughout this standard, see Table 1:

Table 1 — Symbols

Symbol	Designation	Unit
a	overhang	mm
D	downskin area	mm^2
I	island	mm^2
$\vec{n}$	normal vector	—
Ra	mean roughness	µm
Rz	average surface roughness	µm
U	upskin area	mm^2
δ	downskin angle	°
υ	upskin angle	°

4.2 Abbreviations

The following abbreviations are used throughout this standard:

AM Additive Manufacturing

AMF Additive Manufacturing File Format

DICOM Digital Imaging and Communications in Medicine

P part

CAD Computer Aided Design

CT Computer Tomography

HIP Hot Isostatic Pressing

MRI Magnetic Resonance Imaging

LB-PBF Laser-based Powder Bed Fusion

LB-PBF-M Laser-based Powder Bed Fusion of Metals (also known as e.g. Laser Beam Melting, Selective Laser Melting)

LB-PBF-P Laser-based Powder Bed Fusion of Polymers (also known as e.g. Laser Beam Melting, Selective Laser Melting)

PBF Powder Bed Fusion

STL STereoLithography format or Surface Tessellation Language

5 Characteristics of Powder Bed Fusion Processes

5.1 General

Consideration must be given to the specific characteristics of the manufacturing process used in order to optimise the design of a part. Examples of the features of Additive Manufacturing processes which need to be taken into consideration during the design and process planning stages are listed below.

5.2 Size of the Parts

The size of the parts is limited by the working area/working volume of the PBF-machine. Also, the occurrence of cracks and deformation due to residual stresses limits the maximal part size. Another important practical factor that limits the maximal part size is the cost of production having a direct relation to the size and volume of the part. Cost of production can be minimized by choosing part location and build orientation in a way that allows nesting of as many parts as possible. Also, the cost of powder needed to fill the bed to the required volume (part depth x bed area) may be a consideration. Powder reuse rules impact this cost significantly. If no reuse is allowed, then all powder is scrapped regardless of volume solidified.

5.3 Typical Advantages of the PBF process

PBF processes can be advantageous for manufacturing parts where the following points are relevant:

— Parts can be manufactured to near-net shape (i.e. close to the finished shape and size), without further post processing tools, in a single process step.

— Degrees of design freedom for parts are typically high. Limitations of conventional manufacturing processes do not usually exist, e.g. for

  — tool accessibility,

  — undercuts.

— A wide range of complex geometries can be produced, such as:

  — free-form geometries, e.g. organic structures [11];

  — topologically optimised structures;

  — infill structures, e.g. honeycomb, sandwich and mesh structures.

— The degree of part complexity is largely unrelated to production costs.

— Assembly and joining processes can be reduced through single-body construction.

— Overall part characteristics can be selectively configured by adjusting process parameters locally.

— Reduction in lead times until part production.