INTERNATIONAL STANDARD

ISO 17296-2

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Additive manufacturing — General principles —

Part 2:
Overview of process categories and feedstock

Fabrication additive — Principes généraux —

Partie 2: Vue d'ensemble des catégories de procédés et des matières premières

Reference number
ISO 17296-2:2015(E)

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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).

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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 WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 261, *Additive manufacturing*.

ISO 17296 consists of the following parts, under the general title *Additive manufacturing — General principles*:

— *Part 1: Terminology*[1)]

— *Part 2: Overview of process categories, part types and feedstock*

— *Part 3: Main characteristics and corresponding test methods*

— *Part 4: Overview of data processing*

1) To be published.

Introduction

Additive manufacturing is a versatile technology that can be used throughout the product development process. The additive manufacturing processes can be used to manufacture prototypes, tool and fully functional end-use parts. In addition to engineering, the application areas of this interdisciplinary technology now include fields ranging from e.g. architecture and medicine, to archaeology and cartography, as well as arts, toys, education, entertainment.

During its somewhat turbulent development, different terms and definitions have emerged which are frequently ambiguous and confusing. Moreover, there are various different processes available on the market and it is not always clear what opportunities and limitations they offer in terms of application.

This part of ISO 17296 aims to offer a description of the general working principles for the different process categories and the processing of feedstock material into the desired product geometry. This will enhance the understanding of the process and improve the communication between the customer and suppliers of products and services.

The principles and process categories described in this part of ISO 17296 refer to commercially available technology that has proven practically useful and viable on the market for several years.

Additive manufacturing — General principles —

Part 2:
Overview of process categories and feedstock

1 Scope

This part of ISO 17296 describes the process fundamentals of Additive Manufacturing (AM). It also gives an overview of existing process categories, which are not and cannot be exhaustive due to the development of new technologies. This part of ISO 17296 explains how different process categories make use of different types of materials to shape a product's geometry. It also describes which type of material is used in different process categories. Specification of feedstock material and requirements for the parts produced by combinations of different processes and feedstock material will be given in subsequent separate standards and are therefore not covered by this part of ISO 17296. This part of ISO 17296 describes the overreaching principles of these subsequent standards.

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 17296-1, *Additive manufacturing — General principles — Part 1: Terminology*[2)]

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17296-1 apply.

4 Part types and their classification

4.1 General

Parts produced by additive manufacturing can be used as both prototypes and production parts (the term "prototype" is described in ISO 17296-1). Production parts are used for different applications at the end of the product development (cycle) and reflect all requirements of the desired product. For both prototypes and production parts, different processes and materials can be used depending on the type of the part, application and industry, and cost and delivery time requirements. It is the responsibility of the developer to design the parts and to decide on their specification. Close consultation with the component manufacturer is advisable, depending on the customer's expertise.

4.2 Classification of parts

Parts shall further be divided into different classes, from the most rigorous class regarding quality and traceability (class 1) to the least rigorous class regarding quality and traceability. The details of these classes will be defined in specific further standards related to the feedstock, process and application.

2) To be published.

5 Process chains

The process chain involved in additive manufacturing technologies is characterized by direct fabrication of parts based on 3D CAD data. Intermediate stages, such as tool manufacturing, are unnecessary.

There are basically two different categories:

— **single-step processes**: parts are fabricated in a single operation where the basic geometric shape and basic material properties of the intended product are achieved simultaneously,

— **multi-step processes**: parts are fabricated in two or more operations where the first typically provides the basic geometric shape and the following consolidates the part to the intended basic material properties.

NOTE Dependent on the final application, all processes can require one or more additional post-processing operations to reach all the intended properties in the final product.

The technologies involved are well-known and well documented non-additive processes and therefore it is unnecessary to describe them in further detail at this stage.

6 Process categories

6.1 General

There are multiple processes developed for additive manufacturing. These are grouped into seven basic categories based on fundamental parts of the machines' functionality.

In subsequent standards, detailed information and requirements for specific feedstock-process combinations (for example PA12 powder via powder bed fusion) will be given, such as:

— Information on fundamental properties of the feedstock,

— Requirements on feedstock (pre-conditioning),

— Informative process description,

— For each specific feedstock/process combination the relevant properties of parts (such as gas permeability, tensile strength etc.), including requirements of minimal values and information on feasible ranges of values,

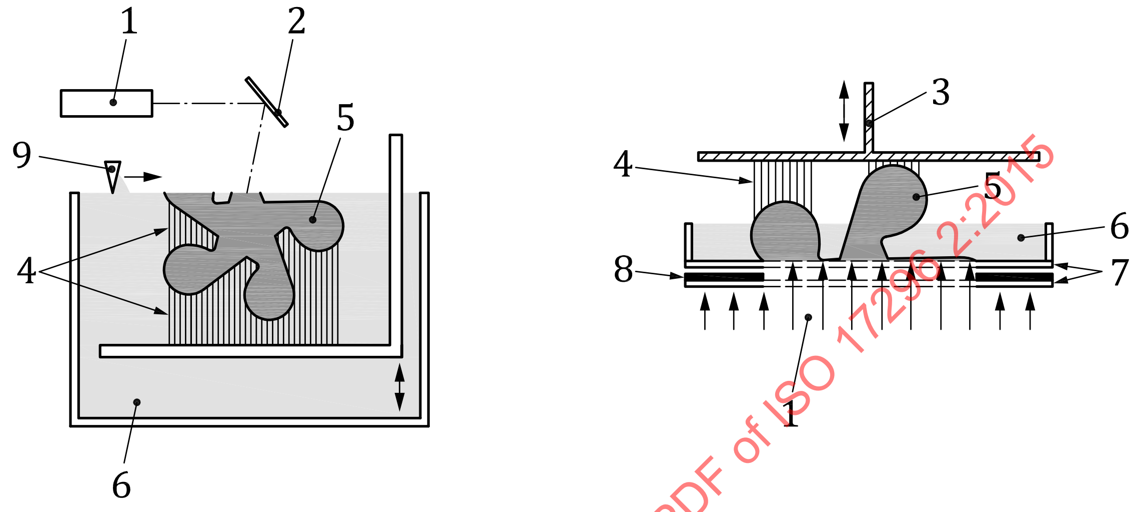
— Required quantification methods,

— Information on typical applications.

6.2 Existing process categories

6.2.1 Vat photopolymerization

The definition of Vat photopolymerization according to ISO 17296-1: additive manufacturing process in which liquid photopolymer in a vat is selectively cured by light-activated polymerization. See Figure 1.



a) Vat photopolymerization by laser light source

b) Vat photopolymerization by controlled area light source

Key

1 energy light source
2 tilted mirror with focus
3 build platform and elevator
4 support structure
5 product
6 vat filled with liquid photocurable resin
7 transparent plates
8 photo mask
9 recoating and surface levelling mechanism

Figure 1 — Schematic diagram of two alternative principles for vat photopolymerization

Feedstock: liquid or paste: photoreactive resin with or without filler.

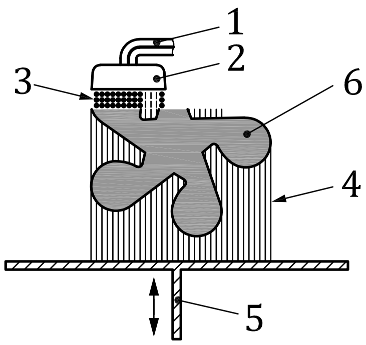
Binding mechanism: chemical reaction bonding.

Source of activation: typically UV radiation from lasers or lamps.

Secondary processing: cleaning, support material removal, post-curing by further UV exposure.

6.2.2 Material jetting

The definition of material jetting according to ISO 17296-1: additive manufacturing process in which droplets of build material are selectively deposited. See Figure 2.



Key

1 feedstock delivery system for build and support material (optional dependent on the specific process)
2 dispensing apparatus (radiation light or thermal source)
3 droplets of build material
4 support structure
5 build platform and elevator
6 product

Figure 2 — Schematic diagram of material jetting

Feedstock: liquid photopolymer or melted wax, with or without filler.

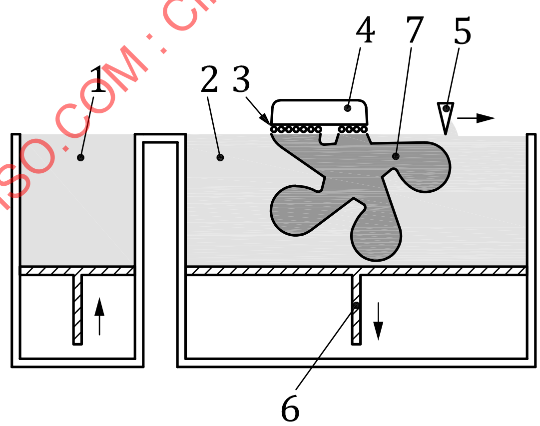
Binding mechanism: chemical reaction bonding or adhesion by solidification of melted material.

Source of activation: radiation light source for chemical reaction bonding.

Secondary processing: support material removal, post-curing by further radiation light exposure.

6.2.3 Binder jetting

The definition of binder jetting according to ISO 17296-1: additive manufacturing process in which a liquid bonding agent is selectively deposited to join powder materials. See Figure 3.



Key

1 powder feeding system
2 powder material distributed in a powder bed
3 liquid bonding agent
4 dispensing apparatus including connection to bonding agent feed system
5 powder spreading device
6 build platform and elevator
7 product

Figure 3 — Schematic diagram of binder jetting

Feedstock: powders, powder blends or particulate materials, and a liquid adhesive/bonding agent.

Binding mechanism: chemical and/or thermal reaction bonding.

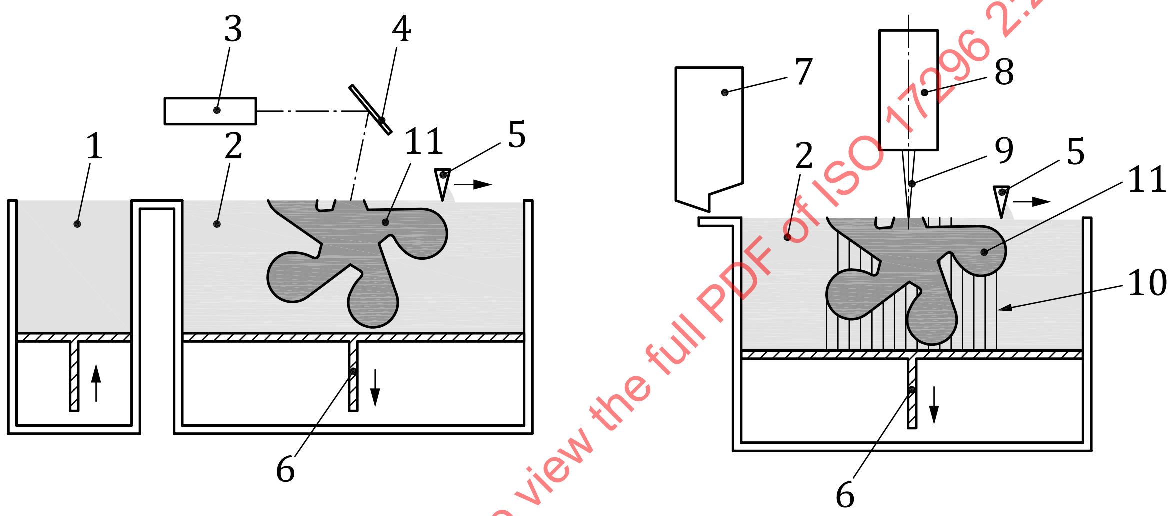
Source of activation: depending on the bonding agent: chemical reaction.

Secondary processing: removal of loose powder, impregnation or infiltration of suitable liquid material depending on the powder material and intended application.

NOTE Waxes, epoxies and other adhesives have been used for polymer materials, while metals and ceramics commonly are consolidated by sintering and infiltration with a melted material.

6.2.4 Powder bed fusion

The definition of powder bed fusion according to ISO 17296-1: additive manufacturing process in which thermal energy selectively fuses regions of a powder bed. See Figure 4.



a) Laser based powder bed fusion **b) Electron beam powder bed fusion**

Key

1 powder feeding system (in some cases powder container like 7)
2 powder material distributed in a powder bed
3 laser
4 tilted mirror with focus
5 powder spreading device
6 build platform
7 feedstock container
8 electron beam gun
9 focused electron beam
10 support structure
11 product

NOTE Support structure and a build substrate is normally required for the processing of metallic feedstock, whereas it is usually not necessary for polymer feedstock.

Figure 4 — Schematic diagram of two types of powder bed fusion

Feedstock: various powders: thermoplastic polymers, typically pure metals or metal alloys, structural or industrial ceramics. Any of the powder materials could be used with, or without, fillers and binders depending on the specific process.

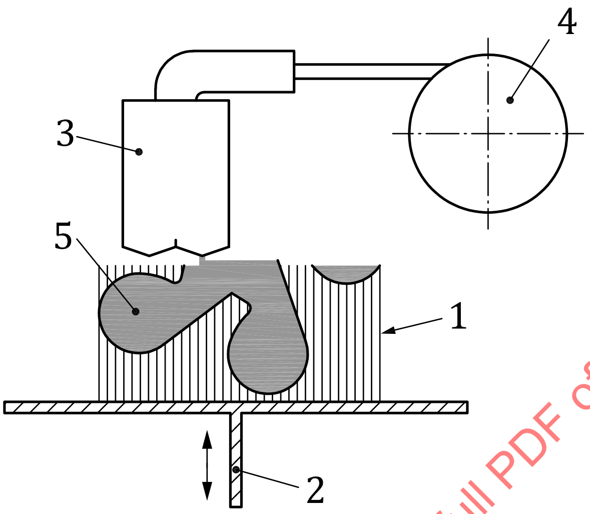
Binding mechanism: thermal reaction bonding.

Source of activation: thermal energy, typically transferred from laser, electron beam, and/or infrared lamps.

Secondary processing: removal of loose powder and, if applicable, support material, and various operations to improve surface finish, dimensional accuracy and material properties; for example micro blasting, finishing milling, grinding, polishing and heat treatments.

6.2.5 Material extrusion

The definition of material extrusion according to ISO 17296-1: additive manufacturing process in which material is selectively dispensed through a nozzle or orifice . See Figure 5.



Key

1 support structure
2 build platform and elevator
3 heated nozzle
4 feedstock supply
5 product

Figure 5 — Schematic diagram of material extrusion

Feedstock: Filament or paste, typically thermoplastics and structural ceramics.

Binding mechanism: thermal or chemical reaction bonding.

Source of activation: heat, ultrasound or a chemical reaction between components.

Secondary processing: removal of support structure.

6.2.6 Directed energy deposition

The definition of directed energy deposition according to ISO 17296-1: additive manufacturing process in which focused thermal energy is used to fuse materials by melting as they are being deposited. See Figure 6.

