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Additive manufacturing — General principles —

Part 4: Overview of data processing

Fabrication additive — Principes généraux —

Partie 4: Vue d'ensemble des échanges de données

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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).

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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 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*

— *Part 2: Overview of process categories and feedstock*

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

— *Part 4: Overview of data processing*

Introduction

Additive manufacturing are an inherent part of the product development process. They are used to manufacture prototypes, tools, and production parts.

In addition to engineering, the scope of this interdisciplinary technology now covers fields ranging from architecture and medicine to archaeology and cartography.

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

This International Standard aims to offer field-tested recommendations and advice to users (customers) and manufactures (both external and internal service providers), to improve communication between customer and supplier, and to contribute to an authoritative performance design and a smooth handling of the project.

It assumes that the reader has a basic understanding of the process flow of different additive processes. It explains the processes used in practice in only much detail as it necessary to understand the statements.

Additive manufacturing — General principles —

Part 4:
Overview of data processing

1 Scope

This part of ISO 17296 covers the principal considerations which apply to data exchange for additive manufacturing. It specifies terms and definitions which enable information to be exchanged describing geometries or parts such that they can be additively manufactured. The data exchange method outlines file type, data enclosed formatting of such data and what this can be used for.

This part of ISO 17296

— enables a suitable format for data exchange to be specified,

— describes the existing developments for additive manufacturing of 3D geometries,

— outlines existing file formats used as part of the existing developments, and

— enables understanding of necessary features for data exchange for adopters of the International Standard.

This part of ISO 17296 is aimed at users and producers of additive manufacturing processes and associated software systems. It applies wherever additive processes are used, and to the following fields in particular:

— production of additive manufacturing systems and equipment including software;

— software engineers involved in CAD/CAE systems;

— reverse engineering systems developers;

— test bodies wishing to compare requested and actual geometries.

2 Normative reference

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

ASTM F2792-12a, *Standard Terminology for Additive Manufacturing Technologies*

ASTM F2915-11, *Standard Specification for Additive Manufacturing File Format (AMF)*

DIN 66301, *Industrial Automation — Computer Aided Design — Format For The Exchange Of Geometrical Information*

1) To be published.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17296-1[2] and ASTM F2792-12a apply.

4 Data exchange

4.1 Dataflow

4.1.1 General

A complete 3D data set of the part forms the basis of additive manufacturing. Most commonly, this is created by direct 3D CAD modelling. The data sets can also be generated by measurements if the parts exist in a physical form (see Figure 1).

A representation based on facets is then generated from the volume or area model through polygonization or triangulation (see 4.1.2.4) and transferred to the additive manufacturing process in STL or VRML format (see 4.2.2 and 4.2.3). This software-assisted process runs automatically as far as possible.

4.1.2 Explanation of the key terms used in Figure 1

4.1.2.1 3D CAD modelling (solid modelling)

3D CAD modelling is the process most commonly used during design to produce a digital 3D model. The starting point can be an idea for a product, which takes shape and becomes increasingly defined directly on the computer screen during the process, or a previously generated image of the object in the form of sketches, drawings, etc., which are then simply converted to 3D data. Volume can be described using two different techniques, or a combination of both. The object is either composed of basic volumes (shapes) (e.g. cuboid, wedge, cylinder, cone, sphere, and toroid) which generate the actual object via a sequence of Boolean operations, or the volume is described by its surrounding boundary surfaces and the location of the material relative to the boundary surfaces.

4.1.2.2 3D digitalization (reverse engineering)

3D digitalization is the process in which the surface geometry of a physical object is measured using appropriate hardware and software and recorded in a digital point cloud model. The objects can be manually produced or finished models which need to be copied in digital form. The use of 3D digitalization is particularly efficient if the model has empirically drafted, freeform surface areas, since these are difficult to reproduce through direct 3D CAD modelling.

4.1.2.3 Surface reconstruction

Surface reconstruction is a means of processing data generated through 3D digitalization. Starting from the computer-generated point cloud, mathematically described curves and surfaces are generated with sufficient topological information to adequately recreate the object surface. These data can then be stored separately or integrated into an existing CAD volume model. Reverse engineering thus creates a bridge between 3D digitalization and CAD modelling.

2) To be published.

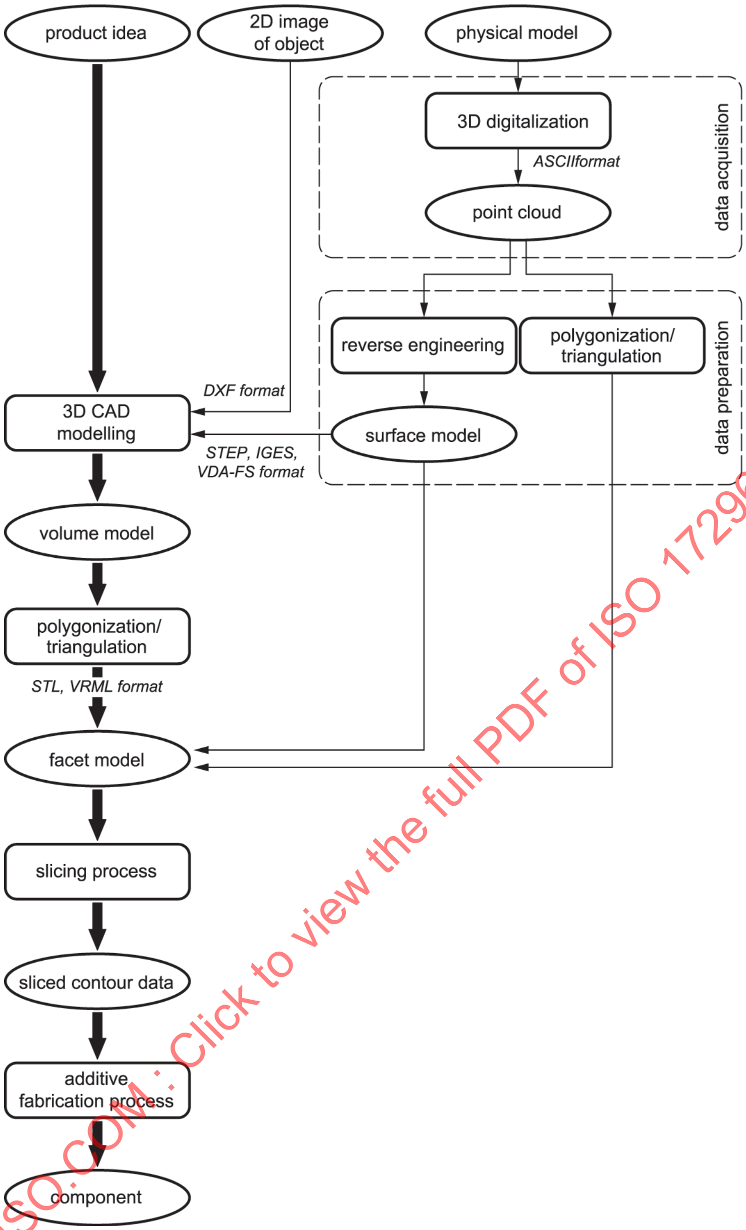

Figure 1 — General overview of traditional data flow from product idea to actual part (terminology)

4.1.2.4 Polygonization/triangulation

This software-assisted process is used to generate a volume-based facet model either from the point cloud following 3D digitalization or from the volume model after 3D CAD modelling. The object surface is represented by a multiplicity of tiny, planar facets, or polygons, which are stretched between the points. The number and size of the facets determine how accurately the actual surface geometry is reproduced. This process creates an STL data set.

4.1.2.5 Slicing process

The slicing process is an essential pre-manufacturing stage in all additive manufacturing processes. It involves slicing the facet (volume) model into several successive layers and recording the information contained within each layer. The sliced contour data are no longer connected to one another in the z-axis, which means that subsequent scaling is no longer possible. With some technologies, this process is automatically performed by the software, once the necessary parameters (e.g. layer thickness) have been set. Other systems require separate software to prepare and store this layer data.

4.2 Data formats

4.2.1 General

The most common interface formats used within the dataflow are explained in 4.2.2 till 4.2.7.

The STL format is the standard data format for data transfer. Some systems can read and process data in VRML format.

If the STL format cannot be exported due to the absence of the interface module (not supplied as standard with all CAD software programs), the data can be transferred to other CAD programs via interface formats (e.g. STEP, IGES, or VDA-FS), which shall then enable an STL output.

NOTE Conversion problems can arise when transferring data through system-neutral interfaces, since interfaces capabilities (despite established standards) vary greatly and programs operate with varying degrees of accuracy (e.g. in the acceptance of the joining of two adjacent surfaces).

4.2.2 STL

The STL file format (surface tessellation language, or stereolithography) has established itself as a quasi-industry standard format for transferring data to additive manufacturing technologies. It is a system-neutral data format for exchanging pure geometric coordinates. The boundary surfaces of volume models are described by triangles (planar facets) and their normal vectors. STL data sets can be stored using either ASCII or binary representations, the former being a more human-readable format, the latter substantially reducing the file size. The STL data format is unsuitable for exchanging data between CAD/CAM systems because the geometry is irreversibly faceted.

4.2.3 VRML (WRL)

VRML (virtual reality modelling language) ISO/IEC 14772-1:1997 and ISO/IEC 14772-2:2004, file extension “wrl” (world) or “wrz” (for compressed VRML files), is a platform-independent, three-dimensional image format supported by network functionality. VRML is not restricted to the input of point or edge data in the form of lists; it also describes 3D objects or scenarios in an object-orientated way in one type of computer language (plain text ASCII or UTF-8). The basic components of VRML are “node types” and communication channels: shape nodes (basic geometrical shapes such as cuboids, cylinders, cones, and spheres), appearance nodes [colour, texture (material properties), and geometric transformations], light nodes, camera nodes (parallel perspective projection), and group nodes to implement hierarchical structures, as well as prototypes to extend the existing range of node types. More recently the VRML format has become an XML format called “eXtensible 3D” by Web3D (Consortium cf. ISO/IEC 19775-1.2:2008).

4.2.4 IGES

IGES (initial graphics exchange specification) is a neutral data format and international standard for exchanging CAD data between different CAD systems. IGES was mainly developed for transferring geometric data relating to 2D drawing models and 3D surface models (including Bezier and NURBS surfaces). IGES version 5.3 and above also use volume elements (cuboids, cylinders, spheres, etc.) and around 40 additional geometric elements (surfaces, curves, arcs, points, coordination systems, etc.) and more than 35 non-geometric elements (text, dimensioning, tolerances, etc.). IGES version 6.0 is the latest and also the last version of the standard; further action will be continued by STEP.

4.2.5 VDA-FS

VDA-FS (Verband der Automobilindustrie-Flächenschnittstelle) is a CAD interface standard of the VDA (the Association of German Automotive Manufacturers) primarily designed for exchanging body work data. VDA-FS is particularly suited to exchange freeform surfaces which have been generated by surface-orientated 3D software. Points, point volumes, and vectors can also be transferred. Volume models cannot be exchanged. VDA-FS was standardized in DIN 66301, which primarily describes the exchange of geometric data.

4.2.6 STEP

STEP (standard for the exchange of product model data) is a system-neutral interface format to describe and exchange product model data between different CAD systems. STEP can be used to transfer product data (e.g. colours, text, or layer support) in addition to geometric data (as with DXF or IGES). All forms of CAD data model can be integrated in the geometric representation (wireframe models, surface models, and volume models).

4.2.7 AMF

The Additive Manufacturing Format (AMF) is an XML-based format specifically designed to address the needs of additive manufacture. As with STL a tessellated surface description of the part (or parts) exists but additionally data such as material, texture, and colour has been included (see ASTM F2915-11).

4.3 Data preparation

4.3.1 The importance of data quality for part quality

A faultless reproduction of the geometry in the STL data set is a prerequisite for ensuring high-quality, trouble-free manufacturing of parts using manufacturing technologies. Attention shall be paid to the following:

— all surfaces of surface models should be smoothly blended together and trimmed (a perfectly sealed, watertight model);

— all surfaces should be oriented in such a manner that the volume can be clearly identified;

— when performing triangulation, no construction aids (layers, cylinders, axes, elements in the noshow, etc.) shall be selected;

— surface models shall ideally be converted to solid volumes before performing polygonization/triangulation.

The generation or supply of poor quality data can call for data set repairs, which in some cases can be very time-consuming and costly and therefore require individual approval.

For this reason, and due to tolerance problems, it is advisable to supply dimensioned drawings.

4.3.2 STL export parameters

The setting of export parameters when inputting the STL data set and thus the accuracy of polygonization/triangulation determines how accurately the desired geometry is approximated. A too coarse resolution affects the accuracy and appearance of the finished prototype. However, a very high resolution demands a large storage capacity (excessive file size) and increases preparation time (see Table 1).

Various export parameters can be set depending on the CAD program:

— chord height, aspect ratio, and resolution;

— surface tolerance, absolute surface smoothing, absolute facet deviation, max deviation distance, conversation tolerance, adjacency tolerance, etc.;

— triangle tolerance, angular tolerance, angle control, surface plane angle, etc.