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Application of the computed tomography to control parts made on additive manufacturing process

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Abstract

The article presents possibilities of application computed tomography to study elements made with additive methods. 3D printing is currently growing very rapidly and already allows to execute ready-to-use, structurally complex elements consisting of one or more parts. Similarly, computed tomography (CT), as the youngest measurement technique and methods to control the geometrical size of the parts, allows to control through any element and evaluate both the quality of each individual components and their assembly.
This technique is especially valuable for the evaluation of additive methods. What is more, the evaluation of porosity on the individual sections of the parts might be conducted. It is also possible to obtain information about the location and thickness of each of the outer wall and inaccessible by any other techniques of non-destructive quality control of construction elements filling the various parts of the printed parts.

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Keywords: Computed tomography; X-Ray CT; Metrology; Accuracy of measurement; Additive manufacturing

1. Introduction

The world develops permamentally. In recent years, two new fields which change approach to the manufacture and metrology might be observed. In the area of manufacturing, there are additive manufacturing techniques wchich develop fast [1, 2, 3]. A few years ago, these techniques allowed only to execute elements only for spatial visualizations of designed parts. Currently, we can print 3D elements made of different types of plastics or metals. In the area of metrology of geometrical quantities, we observe development of computed tomography. These devices are similar to medical CT scanners in some aspects, however, allow for better accuracy, and their power allow for inspection of large objects made of, among others, metal.

Additive printing technologies allow for production of elements which have hitherto been considered as the non-technological and not possible to made from the point of view of production capacity and cost-effectiveness. 3D printing has enabled production of the moving parts without having to connect the individual elements - for example may be even planetary gears and bearings. Similarly, computed tomography opened new field of measurement. So far, the measurement of geometry took place in a contact or optical mode. Therefore, it was necessary to touch the surface being measured by a measuring tip or "to see" it by the optical system. What is more, computed tomography allows not only for measurement and evaluation of external but also internal geometry without the need to destroy the object being measured [4, 5].

Combining additive manufacturing technology with CT measurement provides a double possibility. On the one hand, to form elements impossible to obtain by any other techniques. On the second hand, to control those elements without destroying.

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2. Additive manufacturing

Rapid Prototyping (RP) is additive technology, in which three-dimensional physical objects are created by overlapping successive layers of material. Executing object is modelled in CAD, and after performing can be put to cleaning and further machining. Wild range of materials are used in rapid prototyping methods, e. g.: plastic, paper, ceramics, metal or specially selected composites [1,6]. RP method allows to produce items with very complex internal and external shapes, which would have been impossible or very expensive to produce using conventional methods [6].

Rapid Prototyping is widely used in all industries where it is necessary to create real models. Typical areas of application of additive manufacturing methods are:

- design and ergonomic research,
- testing and evaluation of design solutions based on real models,
- assessment of manufacturing processes and assembly,
- marketing research and evaluation of new products,
- multifunction models used in foundry and metal forming,
- design and manufacture of medical implants.

Nowadays, there are many kinds and varieties of RP methods. Some of them are similar to each other and differ only in small details [6, 7, 8].

2.1. Fused Deposition Modeling (FDM)

Fused Deposition Modeling (FDM) – is now one of the most commonly used methods of rapid prototyping. It is an incremental imposition of semi-solid material by moving the heated nozzle head. The material is supplied in the form of fibers with diameter of about 0.18 mm. When the layer is applicated it is cooled and hardened [7, 9].

The path of the added material may have a width from 0.254 mm to 2.54 mm, and the thickness of the layers is from 0.13 mm to 0.33 mm. In the FDM technology is necessary to use the support legs and parts of the model underlying the construction of the entire model. The primary materials used in the thermoplastic FDM technology is ABS and PC (Fig. 1). The most important advantage of the FDM technology is the possibility of making functional prototypes with very good mechanical properties and a high dimensional accuracy. FDM is also one of the few technologies RP spanning the unit production of finished products. The disadvantages can include poor quality of the obtained surface, quite a long time to build the model, the high wall thickness, cumbersome removal of supports and anisotropy of the mechanical properties of the material, depending on the geometry of construction elements to the direction of applied layers of plastic [10, 11, 12].

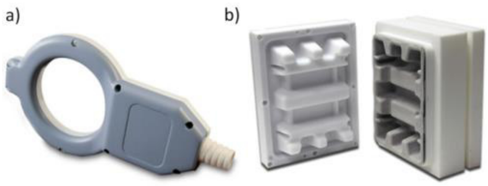

Fig. 1. Examples of models made of ABS plastic (a) PC (b) by FDM methods.

2.2. Stereolithography (SLA)

Stereolithography (SLA) was the first method of rapid prototyping. The first commercial machine was presented in 1987 by 3D Systems Company. Stereolithography process is laminated hardening liquid resin using laser light of low power. There can be separated following stages during the process of creating a model layers [13]:

- Hardening layer by the so-called cross-hatching. Thereby creating a stiff mesh used to reinforce the border and to retain the shape of the model.
- Hardening of the layer contour.
- Filling of the layer contour.

After curing resin layer followed by application of another layer of liquid resin. Layer alignment, and giving the adequate thickness is carried out with the scraper. The model is separated from the platform by supports and therefore processing of the model is necessary. The supports are in the form of thin vertical rods, which are tapered in contact with the model, which facilitates their subsequent removal [1, 14] (Fig. 2). The laser beam hardened polymer only in 96%, so it is necessary to complete the process of curing the material by the UV light. The materials used in the stereolithography process are photo-curable resin: acrylic and epoxy. Significant advantages sterolitografii high accuracy and surface quality made model. It is worth mentioning the high resolution, which allows to do a model holding a lot of details. The condition method is sterolitografii photo curability by a variety of materials are limited, and the process lengthy [15].