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Procedia CIRP 67 (2018) 238 – 243

www.elsevier.com/locate/procedia

11th CIRP Conference on Intelligent Computation in Manufacturing Engineering - CIRP ICME '17

A comparative study of various AM technologies based on their accuracy

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Abstract

The paper deals with the comparison of various Additive Manufacturing technologies regarding their manufacturing accuracy. Similar machines using the Fused Deposition Modelling technology are employed and described. A special specimen was designed for the purpose of accuracy assessment, and investigated not only with respect to the dimension tolerances but also regarding the possibility to assemble/disassemble specific geometric interferences. Similarly, appropriate criteria were proposed and used to compare specimens made by various machines. In the conclusion, the resulting performance table, including the obtained data, is presented and described.

Peer-review under responsibility of the scientific committee of the 11th CIRP Conference on Intelligent Computation in Manufacturing Engineering

Keywords: AM, FDM, 3D scanning, accuracy.

1. Introduction

The Additive Manufacturing (AM) technology has become applicable at various, both industrial and research workplaces dealing with product development. Therefore, it is important to validate and improve these progressive tools regarding their accuracy. Then manufactured components fit in the assembly and have a relatively comparable precision to series produced components. This aspect is moreover amplified by the current development of advanced materials. These make it possible with their properties to substitute numerous standing solutions.

2. Preparation

There have been several research projects dealing with AM technologies in terms of their accuracy [1–6]. Authors have usually described general comparisons of devices and selected geometrical tolerances. The collaborative project, under which this study has been performed, accounts for the sample design point of view and accounts also for another important aspect of 3D printed components – assembling – which will itself be subject of further work.

Presented project was part of an industrial project focused on benchmarking of various AM machines, in particular those suitable for 3D printing from high-resistance material. Based on the results of this project, the most precise and highest-quality candidate will be chosen and then purchased for the purpose of prototyping of functional components and manufacturing of tools. The comparison of accuracy clearly plays a crucial role within the resulting machine selection not only in this specific case but also in general.

Since it was essential for the presented project to evaluate also the assembling possibilities, a test specimen shown in Fig. 1 was designed.

Nomenclature

ABS	Acrylonitrile Butadiene Styrene = amorphous thermoplastic
AM	Additive Manufacturing
FDM	Fused Deposition Modelling
FFF	Fused Filament Fabrication
HDT	Heat Deflection Temperature
PC-ABS	Polycarbonate-ABS
PLA	Polylactic Acid = biodegradable thermoplastic
SLS	Selective Laser Sintering
ULTEM	Advanced polyetherimide

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doi:10.1016/j.procir.2017.12.206

2.1. AM devices specification

Various possible applications enable development of a wide choice of AM devices. A company or a user have to deal with a question regarding the importance of a professional device in comparison to the one, which is relatively cheap, and usually comes with an open architecture.

For the purpose of a comparative study, the authors have decided to choose AM devices from different fields of usage. Therefore, the two following categories were distinguished and considered:

- Low-cost devices – Leapfrog Creatr HS & Prusa i3 MK2;
- Professional devices – Objet Eden 260, Fortus 250mc & Fortus 400mc.

The most commonly used as well as the oldest technology is Fused Deposition Modelling (FDM). It is the case of all the herein assumed low-cost devices and from the professional ones Fortus 250mc and Fortus 400mc. Finally, Objet Eden 260 utilizes the Photopolymerization AM technology.

The AM devices which belong to the category of so called Low-cost devices are used mainly for hobby purposes, e.g. at home and to gain basic experience.
Advantages:

- Mostly open source,
- Possibility to optimize many parameters,
- Procurement cost,
- Filament cost.

Disadvantages:

- Low filament variety (mostly use ABS or PLA),
- Geometrical accuracy of the 3D printed model,
- Not suitable for any series.

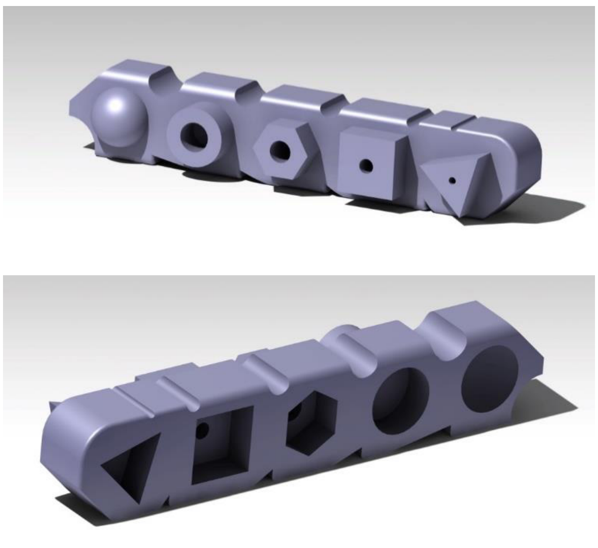

Fig. 1. Specimen designed for the presented comparative study.

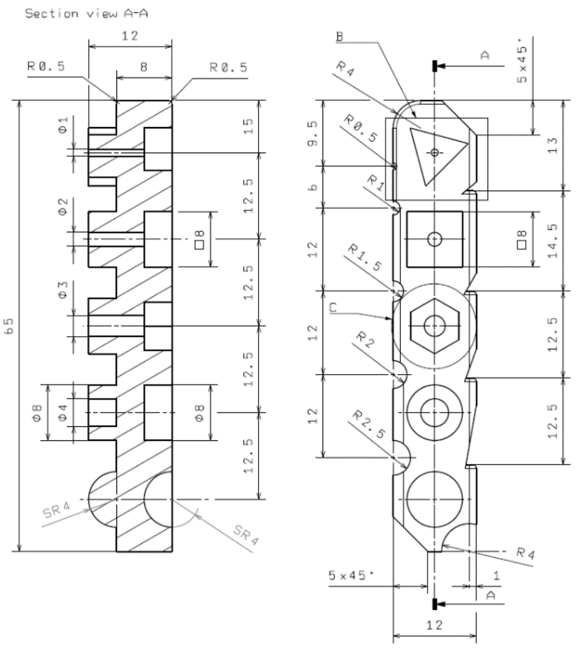

Fig. 2. Drawing of the specimen.

The category of Professional devices represents high-end 3D printers, used mainly in R&D departments, design studios, prototype shops or in production, which can make functional prototypes, presentation models, small series or tooling.

Table 1. Basic specifications of the used 3D printers.

	Build volume [mm]	Layer height [μm]	Precision [μm]
LeapFrog Creatr HS	240x280x180	200	±200
Prusa i3 MK2	250x210x200	50	-
Fortus 250mc	254x254x305	178	±241
Fortus 400mc	406x355x406	127	±127
Objet Eden 260	255x252x200	16	±20÷85

Advantages:

- Big variety of materials,
- Print functional prototypes,
- Different Shore (depends on AM technology),
- Suitable for small series production,
- Easy use and setup,
- Higher quality of devices components (such as nozzles),
- Higher heat resistance of special materials,
- Strength of special materials,
- Molds and jigs production,
- Tooling and fixture production.