FLORIANÓPOLIS.SC
May 27, 28 and 29
SIMPEX
Simpósio Internacional de Ensino Pesquisa e Extensão
International Symposium on Learning, Research and Continuing Education
2025
AI in Industry
Exploring New Frontiers of Technology

EVALUATING GEOMETRIC PRECISION IN ADDITIVE MANUFACTURING SLA AND FFF

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1. Introduction

Commonly called 3-D printing this technology started in the 1980s, the Additive Manufacturing (AM) concept was created as a way to rapid prototyping by the technique of Stereolithography (SLA). In the same decade, another technique freely called Fused Filament Fabrication was created with the appropriate name Fused Deposition Modeling, both methods are widely used and are the easiest to find. Its development evolves to rapid manufacturing where the final product is perfectly able to compound the function of the project, revolutionizing the whole industry and becoming the prime of development we can see today [1-3].

The SLA technique consists of a liquid-base process for solidifying a photosensitive polymer with ultraviolet contact, creating high-definition layers of solid material. Meanwhile, the FFF involves the extrusion of a thermoplastic filament through a heated nozzle, the filament, usually supplied in spools, is heated to a specific temperature and extruded in thin layers. Both consist of an exchange of precision, cost-benefit, accessibility, and time-demanded [1-4].

There are some kinds of errors, usually happening in the use of AM, that impact directly the geometric precision and usability of the final product. Their causes are connected with the used material properties, the preset for printing, layer height, print speed, extrusion temperature, bed temperature, contact with the environment, calibration, and infill density, among others. The SLA method is known to have a printing definition higher than FFF but there are some kinds of errors at the beginning of the process that happen in both methods due to CAD tolerances and, when a CAD file is exported to Computer-Aided Manufacturing (CAM), it commonly loses some accuracy between software to software [4-7]. All these sources of errors cause differences in the geometry of the final product mainly by: anisotropy and mechanical strength; thermal deformation (warping); stair-stepping; and dimensional deviation.

2. Case Study

In this case study, the link shown in Fig. 1 was used to evaluate geometric errors experimentally. Four links were printed by: (1) FFF using a Creality Ender-3 Pro printer and (2) SLA using an Anycubic Photon

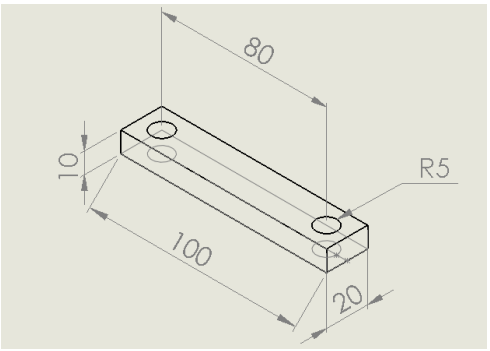

Fig. 1. Link model. *Own authorship 2025.*

(a) (b)

Fig. 2. Geometric e*valuation. Own authorship 2025.*

Mono M5s printer. The geometric was evaluated using a caliper manufactured by the Digimes, model 100.170 shown in Fig. 2(a) and digitally evaluated using a Creality CR Scan – Lizard shown in Fig. 2(b).

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For this analysis, the material of the FFF method was polylactic acid (PLA), a widely available, cost-effective and biodegradable thermoplastic. The material of the SLA method was standard casting resin, which is also commonly used, affordable and readily accessible. In each method, four links models are shown in Fig. 1.

3. Results and Discussions

Using some common statistical methods such as mean, standard deviation, and variance, it was possible to evaluate the two AM methods, i.e. FFF and SLA.

Table 1 shows the main dimensions errors analyzed ware: the length (L), the width (W), the hole diameters (D1 and D2), and the distance between the centers of the holes (DBC).

	L	W	D1	D2	DBC
FFF	0,855mm (0,855%)	0,408mm (2,038%)	0,325mm (3,250%)	0,399mm (3,988%)	0,789mm (0,987%)
SLA	0,613mm (0,613%)	0,221mm (1,106%)	0,425mm (4,250%)	0,405mm (4,050%)	1,26mm (1,575%)

Table 1. The mean error between Caliper and CR Scan measurement. Own authorship 2025.

Results in Table 1 show the mean error between the Caliper and the CR Scan based on the measurements of all links, i.e. 4 links printed in FFF and 4 links printed in SLA. The percentage of the error is dimensionless so it is possible to compute the mean of all measurements which is 5,219% for SLA and 4,468% for FFF. However, the measurements obtained by CR Scan could have a small deviation based on the material light absorption. Results only using the caliper provide the error of 4,894% for SLA and 2,947% for FFF as expected. Note the digital method provides much higher precision than the manual method, but only for materials with high absorption (FFF samples). Thus, from the materials used, we observe that the FFF method is more accurate.

4. References

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Acknowledgments

We want to acknowledge the Federal University of Santa Catarina for providing free access to the bibliography base used in the development of this, and also for the materials provided. We would also like to thank CNPq for the support provided for its development.

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