Comparative study of different extrusion 3D printed ceramic parts regarding surface finish and dimensional error

Departament d'Enginyeria Mecànica
Tecnologies de Fabricació

Irene Buj-Corral[1], Alejandro Domínguez-Fernández[1], Ramón Casado-López[1], Joaquim Minguella Canela[1]

1 Escuela Técnica Superior de Ingeniería Industrial de Barcelona. Universitat Politècnica de Catalunya (UPC). Av. Diagonal, 647. 08028. Barcelona.
Tel. 934054015 E-mail: irene.buj@upc.edu

INTRODUCTION

Extrusion Additive manufacturing (AM) processes correspond to one of the seven categories into which additive manufacturing processes are divided`according to ISO/ASTM 52900 standard [1]. They allow obtaining complex-shaped parts in a cheap and relatively quick way. However, surface finish in lateral walls is poor and dimensional accuracy is low, especially when low-cost machines are used [2]. In recent years, ceramics parts have been obtained by means of Fused Filament Fabrication (FFF) with ceramic-filled filaments [3] and by means of Direct Ink Writing (DIW) of Ceramic-filled inks [4].

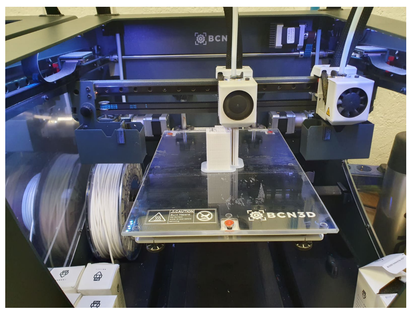

Figure 1. FFF of ceramic-filled filaments

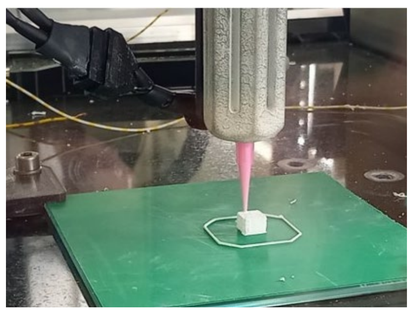

Figure 2. DIW of ceramic-filled inks

METHODOLOGY

- ❑ Prismatic shapes of 10 x 10 x 20 mm were 3D printed (Figure 3).
- ❑ Three different samples were printed for each material, with layer height 0,2 mm and 80 % infill rate, with linear structure (0-90º). Nozzle diameter was 0.6 mm for $CaCO_3$ and glass fibre, while it was 0.58 mm for YSZ.
- ❑ FFF materials were printed in a Sigma R19 FDM machine, and DIW materials in an Amfeed printer extruder:
  - PP with 35 % $CaCO_3$ (Ca35),
  - PP with 50 % $CaCO_3$ (Ca50),
  - PP with 5 % glass fibre (GF05),
  - Pluronic acid with 3 % mol ytttria stabilized zirconia (YSZ)
- ❑ Dimensions were measured with a Mitutoyo digital micrometer.
- ❑ Roughness in lateral walls was measured with a Taylor Hobson Talysurf 2 contact roughness meter.

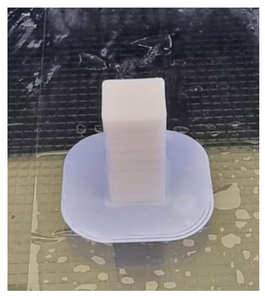

Figure 3. Example of a 3D printed prismatic shape.

RESULTS

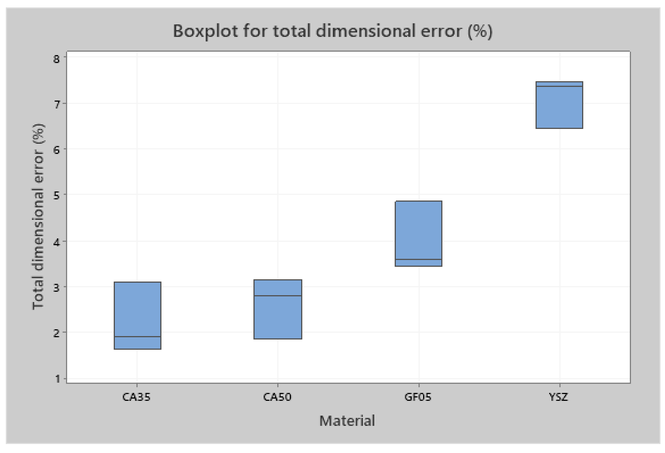

Figure 4. Boxplot for total dimensional error (%)

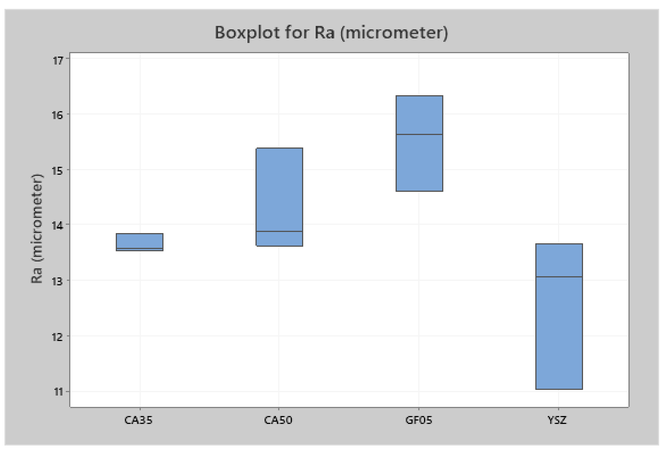

Figura 5. Boxplot for average roughness Ra

CONCLUSIONS

- ❑ DIW-printed YSZ parts showed higher dimensional error than FFF-printed glass fiber and $CaCO_3$ parts.
- ❑ Dimensional error below 4 % was obtained for $CaCO_3$ parts, below 5 % for glass fibre parts and below 8 % for YSZ parts.
- ❑ Roughness values below 17 µm were obtained in all cases.
- ❑ The median of Ra for YSZ was slightly lower than the median of Ra for $CaCO_3$. GF parts showed the highest median of Ra.

References:

[1] ISO/ASTM 52900:2015. Additive manufacturing. General principles. Terminology. International Standardisation Organsation. 19 pages. 2015.

[2] Gibson, I., Rosen, D., B. Stucher. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing. Springer, 2014.

[3] Zhaobing L., Qian L., Shuaiqi X. Mechanical characteristics of wood, ceramic, metal and carbon fiber-based PLA composites fabricated by FDM, Journal of Materials Research and Technology 2019, 8(5), 3741-3751.

[4] Buj-Corral, I.; Domínguez-Fernández, A.; Gómez-Gejo, A. Effect of Printing Parameters on Dimensional Error and Surface Roughness Obtained in Direct Ink Writing (DIW) Processes. Materials 2020, 13, 2157..

ACKNOWLEDGEMENTS

The present research was funded by the Spanish Ministry of Industry, Economy and Competitiveness, grant number PID2020-115647RB-C21. It was co-financed by the European Union Regional Development Fund within the framework of the ERDF Operational Program of Catalonia 2014–2020 with a grant of 50% of total cost eligible, project BASE3D, grant number 001-P-001646. The authors would also like to thank Dr. Miquel Domingo and Dr. Elena Xuriguera for their help. The author Joaquim Minguella Canela is a Serra Hunter fellow professor (lecturer).