Monotonic load datasets for additively manufactured thermoplastic reinforced composites

Octavio Andrés González-Estrada *, Alberto David Pertuz Comas, Jorge Guillermo Díaz Rodríguez

**A B S T R A C T**

In additive manufacturing (AM), thermoplastic components made by fused deposition modeling (FDM) offer low strength and stiffness, as required for fully functional and load-bearing parts. Composite materials are a practical solution to improve mechanical properties [1,2]. A new technology to reinforce thermoplastics with continuous fibers has been developed recently by Markforged [3]. It introduces continuous fiber to reinforce a thermoplastic matrix, thus, taking static mechanical performance close to Aluminum alloys [4]. These printers for continuous fiber reinforced thermoplastic composites (CFRTPC) have taken this technology to a whole new level in terms of mechanical properties and efficient production. Mechanical properties under monotonic load were studied for different kinds of printing configurations. Tensile monotonic tests under controlled displacement were performed until rupture. Raw data showing tensile monotonic behavior provides the researchers with the ability to perform data fitting, to validate more advanced constitutive models, or to perform a further interpretation of the data, among others. Data is presented here as plain text files without any analysis. A preliminary data analysis has been published already in [5]. The text files contain information about time, displacement, and force. The data is useful for design engineers and researchers involved with AM.

© 2020 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).
1. Data description

Data sets files are presented in plain text format displaying the following columns: axial force (in N, and it is the applied force as given by the 25 kN load cell attached to the MTS Bionix 370.02 machine), axial displacement (in mm, and it is the axial displacement as given by the LX500 laser extensometer), axial displacement (in mm, and it is the axial displacement as given by the MTS Bionix 370.02 machine’s crosshead), axial count (number of applied loading cycles), and running time (in s as measured by the MTS suite software which controls the MTS Bionix 370.02 machine). The name and description of each file are shown in Table 1.

2. Experimental design, materials, and methods

Samples were made of composite materials reinforced with long fibers [1,2] and were manufactured using the Markforged Two printer [3,1,4] following ASTM D638-14 (Standard Test Method for
Tensile Properties of Plastics) [6] using the dimensions of the type IV specimen. The tensile tests were conducted using displacement control, which was applied at a 5 mm/min rate. The tests were conducted in the following manner. First, the matrix was tested to assess the performance of each filling (triangular at 20% filling, triangular at 50% filling, and hexagonal at 50% filling). Then, for the matrix filling at 20% and a triangular pattern, the fiber orientation was tested at 0°/C14, 45°/C14 and 60°/C14 from the loading axis. The previous configurations with the three available fibers (Kevlar, carbon, and fiberglass) were tested. Finally, tests were done for two different carbon fiber reinforcement configurations using concentric rings: two rings with four layers, and four rings with two layers.

Acknowledgments

A. D. Pertuz and O. A. González-Estrada acknowledge the support of project FM-2018-1, Convocatoria VIE, Universidad Industrial de Santander. J. G. Díaz acknowledges VIE’s financial support from the postdoctoral program at Universidad Industrial de Santander.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2020.105295.

References

[1] P.A. Chacón Santamaría, A. Sierra, O.A. González Estrada, Shape optimization of a control arm produced by additive manufacturing with fiber reinforcement, J. Phys. Conf. 1386 (2019) 1–8, https://doi.org/10.1088/1742-6596/1386/1/012003.
[2] C.F. Rojas-Cristancho, F. Dinzart, O.A. González-Estrada, Micromechanical approach for the analysis of wave propagation in particulate composites, Rev UIS Ingenierías 18 (2019) 41–50, https://doi.org/10.18273/revuin.v18n2-2019004.
[3] G. Thomas, M. Antoni, S. Gozdz, Three Dimensional Printer with Composite Filament Fabrication, US9156205B2, 2015.
[4] Markforged, Markforged composites mechanical properties, REV 3 (2018) 1–2, 1 - 5/10/2019, https://static.markforged.com/markforged_composites_datasheet.pdf. [Accessed 10 August 2019].
[5] A.D. Pertuz, S. Díaz-Cardona, O.A. González-Estrada, Static and fatigue behaviour of continuous fibre reinforced thermoplastic composites manufactured by fused deposition modelling technique, Int. J. Fatig. 130 (2020) 105275, https://doi.org/10.1016/j.ijfatigue.2019.105275.
[6] American Society for Testing and Materials (ASTM), Standard Test Method for Tensile Properties of Plastics, ASTM D638-14, American Society for Testing and Materials, West Conshohocken, PA, 2014.

Table 1
Description of each provided file.

| #  | Filename      | Description                                                                 |
|----|---------------|-----------------------------------------------------------------------------|
| 1  | FC 2A4C.txt   | Carbon fiber reinforced with 2 concentric rings in a nylon matrix with 4 layers |
| 2  | FC 2C4A.txt   | Carbon fiber reinforced with 4 concentric rings in a nylon matrix with 2 layers  |
| 3  | FC 20%.txt    | Carbon fiber with nylon matrix at 20% filling                                 |
| 4  | FV60 20%.txt  | Fiberglass reinforced with nylon matrix at 20% filling and 60° from the longitudinal axis |
| 5  | FV60f 20%.txt | Fiberglass reinforced with nylon matrix at 20% filling and 60° from the longitudinal axis |
| 6  | K0 20%.txt    | Kevlar reinforced in nylon matrix at 20% filling and 0° from the longitudinal axis |
| 7  | FV0 20%.txt   | Fiberglass reinforced with nylon matrix at 20% filling and 0° from the longitudinal axis |
| 8  | FV45 20%.txt  | Fiberglass reinforced with nylon matrix at 20% filling and 45° from the longitudinal axis |
| 9  | Hex50.txt     | Nylon with hexagonal 50% filling                                              |
| 10 | Tri20.txt     | Nylon with triangular 20% filling                                              |
| 11 | Tri50.txt     | Nylon with triangular 50% filling                                              |

Finally, it has to be highlighted that the files K020%.txt, FC20%.txt, FC 2A4C.txt, FC 2C4A.txt, FV60f 20%.txt do not have cross head axial displacement data and the FC 2A4C.txt, FC 2C4A.txt, FV20%.txt, FV60f 20%.txt files do not have cycle count data.