Scopus

Documents

Md Yasir, A.S.H.[a] , Sukindar, N.A.[b] , Abdul Rahman Putra, A.A.[c] , Choong, Y.C.[c] , Kamaruddin, S.[c] , Aziz, A.[d] , Aminanda, Y.[b] , Sulaiman, M.H.[e]

Effect of heat treatment on mechanical properties and dimensional accuracy of 3D-Printed black carbon fiber HTPLA

(2024) *Heliyon*, 10 (11), art. no. e32282, .

DOI: 10.1016/j.heliyon.2024.e32282

[a] Faculty of Resilience Rabdan Academy, 65, Al Inshirah, Al Sa'adah, PO Box:114646, Abu Dhabi, 22401, United Arab Emirates

[b] School of Design, Universiti Teknologi Brunei, Jalan Tungku Link Gadong BE1410, Brunei Darussalam

[c] Department of Manufacturing and Materials Engineering, International Islamic University Malaysia, 53100 Jalan Gombak, Kuala Lumpur, Malaysia

[d] Engineering Faculty, Universiti Teknologi Brunei, Jalan Tungku Link Gadong BE1410, Brunei Darussalam

[e] Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra, Serdang43400, Malaysia

Abstract

This present study investigated how heat treatment affects the mechanical properties of 3D-printed black carbon fiber HTPLA by manipulating two parameters: heating temperature and holding time. The mechanical properties of 3D-printed black carbon fiber HTPLA components are crucial for assessing their structural integrity and performance. The shrinkage and dimensional accuracy of the 3D-printed parts were also explored using a vernier caliper. The microstructure of both heat-treated and non-heat-treated HTPLA black carbon fiber 3D-printed parts was examined using scanning electron microscopy. Samples were prepared, printed, heat-treated, and mechanically tested, and their microstructure was observed and recorded. The results showed that heat treatment improved the material's strength, hardness, and crystallinity, leading to better mechanical properties. However, statistical analysis indicates no clear evidence that the two factors, optimum heating temperature and holding time, affect the mechanical properties of heat-treated printed parts. Nonetheless, further study suggests that these factors might be important in optimizing the heat treatment process. © 2024 The Authors

Author Keywords

3D printing; black carbon fiber HTPLA; Dimensional accuracy; Taguchi method

References

- Singh, T., Kumar, S., Sehgal, S.
  3D printing of engineering materials: a state of the art review
  (2020) *Mater. Today Proc.*, 28, pp. 1927-1931.
- Rouf, S., Raina, A., Irfan Ul, H.M., Naveed, N., Jeganmohan, S., Farzana, K.A.
  3D printed parts and mechanical properties: influencing parameters, sustainability aspects, global market scenario, challenges and applications
  (2022) *Adv. Ind. Eng. Polym. Res.*, 5, pp. 143-158.
- Luo, H., Tan, Y., Zhang, F., Zhan, J., Tu, Y., Cui, K.
  Selectively enhanced 3D printing process and performance analysis of continuous carbon fiber composite material
  (2019) *Materials*, 12, p. 3529.
- Sanei, S.H.R., Popescu, D.
  3D-printed carbon fiber reinforced polymer composites: a systematic review
  (2020) *J. Compos. Sci.*, 4, p. 98.

- Ferretti, P., Leon-Cardenas, C., Sali, M., Santi, G.M., Gianese, F., Donnici, G.
Material characterization analysis of PLA & HTPLA FDM-sourced elements with annealing procedure and optimized printing parameters
(2021) *J. Funct. Biomater.*, 12, p. 63.

- Yao, T., Deng, Z., Zhang, K., Li, S.
A method to predict the ultimate tensile strength of 3D printing polylactic acid (PLA) materials with different printing orientations
(2019) *Compos. B Eng.*, 163, pp. 393-402.

- Tseng, M.L., Thampy, A., Ismail, E.A.A., Awwad, F.A., Gorji, N.E.
Heat treatment and tensile test of 3D-printed parts manufactured at different build orientations
(2023) *Open Phys.*, 21 (1).

- Nassar, A., Younis, M., Elzareef, M., Nassar, E.
Effects of heat-treatment on tensile behavior and dimension stability of 3d printed carbon fiber reinforced composites
(2021) *Polymers*, 13, p. 4305.

- Jayanth, N., Jaswanthraj, K., Sandeep, S., Mallaya, N.H., Siddharth, S.R.
Effect of heat treatment on mechanical properties of 3D printed PLA
(2021) *J. Mech. Behav. Biomed. Mater.*, 123.

- Wickramasinghe, S., Do, T., Tran, P.
FDM-based 3D printing of polymer and associated composite: a review on mechanical properties, defects and treatments
(2020) *Polymers*, 12, pp. 1-42.

- Bhandari, S., Lopez-Anido, R.A., Gardner, D.J.
Enhancing the interlayer tensile strength of 3D printed short carbon fiber reinforced PETG and PLA composites via annealing
(2019) *Addit. Manuf.*, 30.

- Tamașag, I., Beșliu-Băncescu, I., Severin, T.-L., Dulucheanu, C., Cerlincă, D.-A.
Experimental study of in-process heat treatment on the mechanical properties of 3D printed Thermoplastic polymer PLA
(2023) *Polymers*, 15, p. 2367.

- Melnikova, R., Ehrmann, A., Finsterbusch, K.
3D printing of textile-based structures by fused deposition modelling (FDM) with different polymer materials
(2014) *IOP Conf. Ser. Mater. Sci. Eng.*, 62.

- Akhoundi, B., Nabipour, M., Hajami, F., Shakoori, D.
An experimental study of nozzle temperature and heat treatment (annealing) effects on mechanical properties of high-temperature polylactic acid in fused deposition modeling
(2020) *Polym. Eng. Sci.*, 60, pp. 979-987.

- Wang, K., Long, H., Chen, Y., Baniassadi, M., Rao, Y., Peng, Y.
Heat-treatment effects on dimensional stability and mechanical properties of 3D printed continuous carbon fiber-reinforced composites
(2021) *Compos. Appl. Sci. Manuf.*, 147.

- Melenka, G.W., Schofield, J.S., Dawson, M.R., Carey, J.P.
Evaluation of dimensional accuracy and material properties of the MakerBot 3D desktop printer
(2015) *Rapid Prototyp. J.*, 21 (5), pp. 618-627.

- Shbanah, M., Jordanov, M., Nyikes, Z., Tóth, L., Kovács, T.A.
The effect of heat treatment on a 3D-printed PLA polymer's mechanical properties
(2023) *Polymers*, 15, p. 1587.

- Zhen, H., Zhao, B., Quan, L., Fu, J.
Effect of 3D printing process parameters and heat treatment conditions on the mechanical properties and microstructure of PEEK parts
(2023) *Polymers*, 15, p. 2209.

- de Avila, E., Eo, J., Kim, J., Kim, N.P.
Heat treatment effect on mechanical properties of 3D printed polymers
(2019) *MATEC Web of Conferences*, 264.

Correspondence Address
Sukindar N.A.; School of Design, Jalan Tungku Link Gadong BE1410, Brunei Darussalam; email: noraimansukindar@gmail.com

Publisher: Elsevier Ltd

ISSN: 24058440
Language of Original Document: English
Abbreviated Source Title: Heliyon
2-s2.0-85194866264
Document Type: Article
Publication Stage: Final
Source: Scopus