

The impact of the mechanical properties of 3D Prints produced by the Fused Deposition Modelling technique on proper selection for selected application

Sara Ibrahim Abdl-Rahman Ramadan

Advertising , Printing and Publishing Dept. -Faculty of Applied Arts- Benha University
bu.sara.ramadan@gmail.com

Abstract:

3D printing technology; It is a technique that uses computer-aided design (CAD) and is one of the most modern manufacturing methods recently due to its capabilities in manufacturing different models without being restricted to a specific form of design, as well as printing models that have the required mechanical properties with lighter weight and less consumption of raw materials as well as the diversity of raw materials used, which made it invade most important industries In proportion to its applications, and to achieve this, it is necessary to take into account the mechanical properties most appropriate for the purpose of use in order to achieve the highest printing quality, as well as saving time, effort, and replacement costs through the appropriate selection of the appropriate material for each application separately.

Research problem: - Printing 3D prints using the Fused deposition modeling technique with polymeric materials that are not chosen in proportion to the mechanical stresses to which the 3D print is exposed in various applications. - The short service life of the 3D prints produced with this technology due to its inability to withstand the mechanical stresses of use, such as the tensile and corrosion resistance that arises from friction.

Objective: - Printing three-dimensional prints with mechanical properties that meet the purpose of their use.

- Make maximum use of the mechanical properties of each raw material.

- Determine the suitable material (polymer) for the production of 3D prints using the Fused deposition modeling technique, in proportion to the mechanical stresses of the application.

Significance: - The importance of determining the optimal raw materials for printing products with mechanical properties suitable for use is an important indicator of the effectiveness of 3D printing in the functional performance entrusted to it, which achieves better efficiency and higher suitability to withstand pressure and thus achieve high quality. - Increasing the operational life of the 3D print due to its ability to withstand tensile and corrosion stresses for longer periods, and thus the length of its operation or consumption, and thus saving replacement costs and printing a new print to replace it.

Research sample: Printing five samples of 3D prints from different materials (the most common in the Egyptian market) and measuring them with force measuring devices.

Methodology: The research followed the experimental descriptive approach, where the theoretical study follows a comprehensive presentation of 3D printing techniques in general and the Fused deposition modeling technique in particular, and the most common raw materials in use in Egypt in this technique and a review of the basic mechanical properties and an experiment by printing 3D prints and measuring them and deducing the purpose of using both Of which .

Experimental work: Practical experiments to measure the tensile and corrosion resistance separately for five samples of 3D prints printed with different polymeric (resin) materials separately (the most widely used in the Egyptian market), which are used in 3D printing by the Fused deposition modeling technique; And to reach the most appropriate applications for each material by monitoring the tensile and corrosion resistance values of the prints produced from these resin materials.

Results :

- 1- 3D prints printed with PLA are characterized by: Higher tensile strength than ABS , Higher modulus of bending than BETG, ABS, PLA Wood, Higher in flexural strength and tensile modulus than PC-ABS, PLA Wood, ABS), Highest fracture stress of PC- ABS, PLA Wood, More abrasion resistant than PLA Wood, ABS,
- 2- 3D prints printed with BETG material are characterized as: The highest tensile strength, flexural strength and corrosion resistance of all materials, Higher tensile strength than PC-ABS, ABS, PLA., Higher in fracture stress than PLA Wood, PC-ABS, PLA Wood, Higher modulus of bending than (PLA Wood, PC-ABS)
- 3- 3D prints printed with ABS material are characterized by: The highest stress fracture and bending coefficient ever , Lowest corrosion resistance, tensile strength and tensile modulus ever , Higher in flexural strength than (PLA Wood, PC-ABS).
- 4- The 3D prints printed with PC-ABS material are characterized as: The highest tensile strength of ABS, PLA,

Citation: Sara Ramdan (2023), The impact of the mechanical properties of 3D Prints produced by the Fused Deposition Modelling technique on proper selection for selected application, *International Design Journal*, Vol. 13 No. 3, (May 2023) pp 247-259

- Highest tensile modulus of ABS, • The least ever in bending strength, Higher wear resistance than PLA Wood, ABS, Higher in fracture stress and flexural modulus than PLA Wood
- 5- The 3D prints printed with PLA Wood are characterized by: - Highest tensile strength ever. - Higher tensile modulus than PC-ABS, ABS, Higher in bending strength than PC-ABS. - Higher corrosion resistance than ABS, The least ever in stress fracture and bending modulus.

Keywords :

Abrasion resistance Fused deposition modeling , tensile strength

References :

- 1- Alaa Jabbar Almaliki, The Processes and Technologies of 3D Printing, Universiti Utara Malaysia, October 2015
- 2- Ahmad Adnan Bin Abu Bakar and 7 authors, The study of mechanical properties of poly(lactic) acid PLA-based 3D printed filament under temperature and environmental conditions, June 2022
- 3- José Luis Dávila , Algorithms-aided design applied to the tool-paths generation for hybrid manufacturing, Dec 2020, Fundação de Apoio à Capacitação em Tecnologia da Informação Campinas, Brazil
- 4- Adam Hehr and others , Smart Build-Plate for Metal Additive Manufacturing Processes, , 2020, USA
- 5- Yayue Pan and others , Machine learning for continuous liquid interface production: Printing speed modeling, Journal of Manufacturing Systems, January 2019
- 6- Mattias Miedzinski, Materials for Additive Manufacturing by Direct Energy Deposition, Master's thesis in Materials Engineering, Department of Materials and Manufacturing Technology, chalmers university of technology, Gothenburg, Sweden 2017
- 7- R. Hedrick and others , Fused Deposition Modeling Design Rules for Building Large, Complex Components, CAMufacturing Solutions Inc, USA, 2016
- 8- M. Shellabear and others , DMLS – DEVELOPMENT HISTORY AND STATE OF THE ART, EOS GmbH Electro Optical Systems, Germany; 2004.
- 9- Marek Pagac , A Review of Vat Photopolymerization Technology: Materials, Applications, Challenges, and Future Trends of 3D Printing, technical University of Ostrava, 2021.
- 10- Yi Suping and others , Accuracy Study on Laminated Object Manufacturing for the Metallic Functional Parts with Complex Surface, Chongqing University, Japan.
- 11- Ahmed Selema and others , Metal additive manufacturing for electrical machines : technology review and latest advancements, Department of Electromechanical, Systems and Metal Engineering, 2022
- 12- Jigang Huang , A Review of Stereolithography: Processes and Systems , Sichuan University , 2020
- 13- Ż. A. Mierzejewska and others , Selective Laser Sintering – Binding Mechanism And Assistance In Medical Applications, Bialystok University of Technology, 2015
- 14- John R. Tumbleston and others , Continuous liquid interface production of 3D objects, 2015
- 15- Dilan Ezgi DÜZGÜN and others , Continuous liquid interface production (CLIP) method for rapid prototyping, Journal of Mechanical and Energy Engineering, 2018
- 16- Yanis Gueche , Selective Laser Sintering (SLS), a New Chapter in the Production of Solid Oral Forms (SOFs) by 3D Printing, Université de Montpellier, 2021
- 17- Ali I. Al-Mosawi, Study of some mechanical properties for polymeric composite material reinforced by fibers , Al-Qadisiyah Journal for Engineering Sciences , 2009.
- 18- Wenjun Xie and others, Corrosion Resistance of Stainless Steel and Pure Metal in Ternary Molten Nitrate for Thermal Energy Storage, 10th International Conference on Applied Energy , 2018, Hong Kong, China.
- 19- Rajan Kumaresan , Fused deposition modeling: process, materials, parameters, properties, and applications , The International Journal of Advanced Manufacturing Technology, 2022
- 20- Anup Kumar Deyin , What is Tensile Strength, Civil, Mechanical, Piping Stress Analysis, Piping Stress Basics
- 21- https://uomustansiriyah.edu.iq/media/lectures/5/5_2020_03_23!09_45_39_PM.pdf
- 22- <https://cdn02.plentymarkets.com/pvdtvofq45f2/propertyItems/43/material%20data%20sheet%20wood%20filament%20purefil.pdf>
- 23- Ahmad Adnan Bin Abu Bakar and 7 authors, The study of mechanical properties of poly(lactic) acid PLA-based 3D printed filament under temperature and environmental conditions, June 2022
- 24- https://www.stratasys.com/contentassets/0cbbbe43e9ab4200a16c507eb99ebe7e/mds_fdm_pc-abs_0222a2.pdf
- 25- <https://www.bcn3d.com/pla-vs-abs-comparing-3d-printing-filament/>

Citation: Sara Ramdan (2023), The impact of the mechanical properties of 3D Prints produced by the Fused Deposition Modelling technique on proper selection for selected application, International Design Journal, Vol. 13 No. 3, (May 2023) pp 247-259

26- https://prusament.com/media/2020/01/PETG_TechSheet_ENG.pdf

27- <https://www.flashforge.com/product-detail/flashforge-creator-pro-3d-printer>

Paper History:

Paper received 27th January 2022, Accepted 15th April 2022, Published 1st of May 2023