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Common Issues in Fused Deposition Modeling 3D Printing: Analysis of Defects and Improvement Strategies

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INTRODUCTION & AIM

Fused deposition modeling (FDM) is a widely used additive manufacturing technique valued for its affordability and accessibility [1,2]. Despite its widespread adoption in education, prototyping and hobbyist use, FDM often suffers from quality and consistency issues. Common problems such as warping, stringing, first layer adhesion or dimensional inaccuracies reduce the functionality and reliability of 3D-printed prototypes. Understanding the causes of these issues is essential to improve print quality and expand the applicability of low-cost 3D printing.

METHOD

A series of standardized models were manufactured using desktop FDM printers under controlled conditions. Key variables such as nozzle temperature, material type, layer height, cooling and filament quality were systematically investigated. The manufactured pieces were evaluated through visual inspection and dimensional measurement to assess the presence and severity of defects.

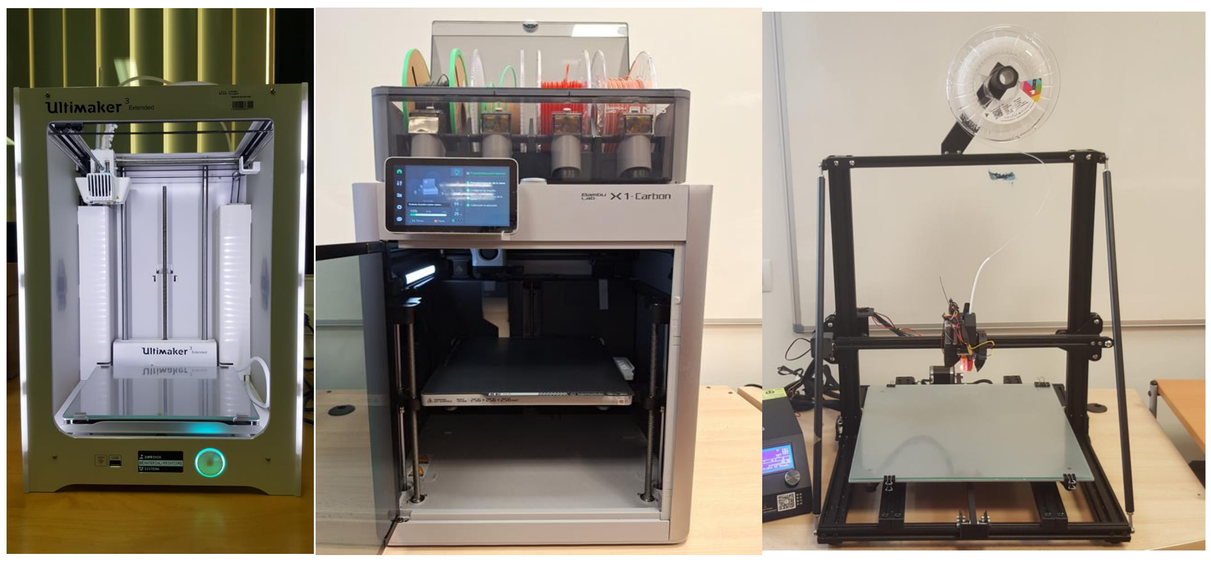

Figure 1. 3D printers: Ultimaker (left), Bambu Lab X1 Carbon (middle) and Creality CR10-S4 (right).

Figure 2. Polymers used: polylactic acid (PLA) 3D 850 (left), polypropylene (PP) (middle) and clean PLA (right).

RESULTS & DISCUSSION

This study identified clear correlations between specific printing parameters and the emergence of imperfections. Among the findings is that warping is strongly influenced by material choice and bed temperature. An excess of deposited material is a consequence of non-optimal nozzle temperature selection. Additionally, filament quality and printer maintenance were found to have a significant impact on print reliability.

Issues — Strategies

Nozzle clog and residues

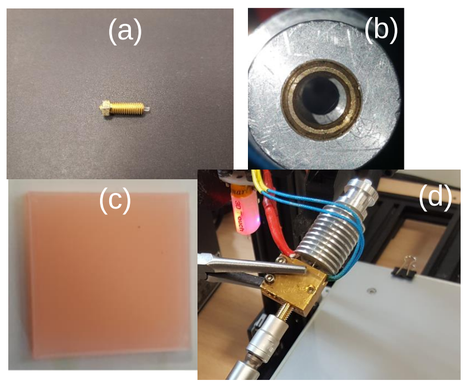

Figure 3. (a-b) Nozzle from the Creality CR-10 S4 printer completely clogged. (c) Natural PLA piece shows an orange tint due to a previous print with coral-colored PLA. (d) Disassembling the hotend to clear a clog.

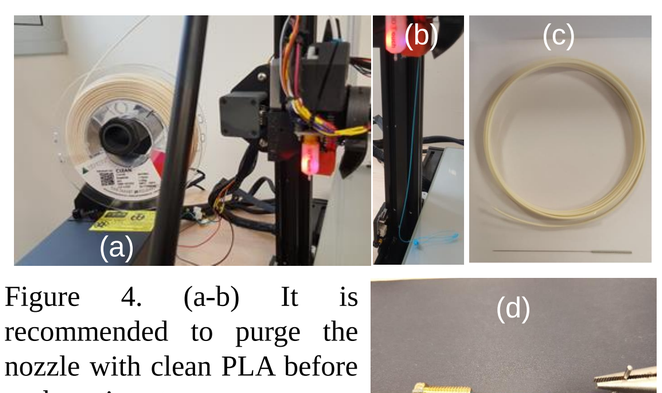

Figure 4. (a-b) It is recommended to purge the nozzle with clean PLA before each print to remove any residue from previous prints. (d) In case of a nozzle clog, a very effective trick is to extract the obstructed filament using a preheated Allen key.

Issues — Strategies

Warping

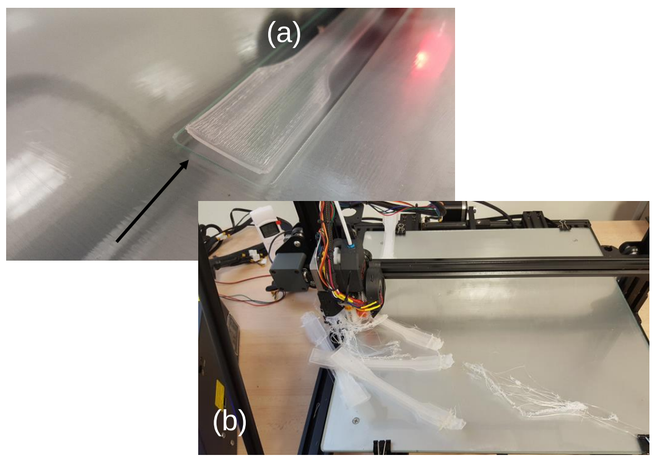

Figure 5 . Warping occurs when the first-layer lifts off the printing platform, usually due to poor bed adhesion. (a) The image shows pronounced warping (indicated by the arrow) in a PP part. (b) Successive warping of a series of printed parts resulted in the complete detachment of all the specimens.

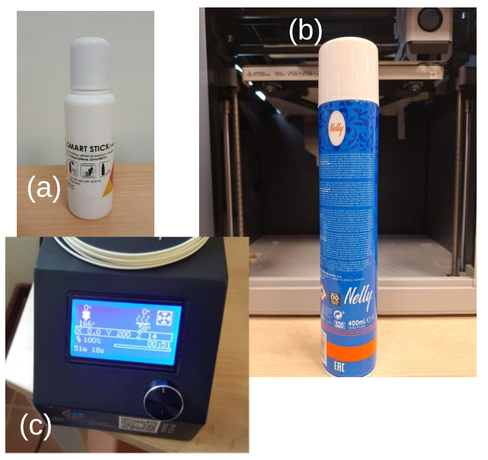

Figure 6. A good bed temperature is required for better first layer adhesion. Also, (a) the use of special adhesives or (b) hairspray improves the adhesion of the first layer to the print bed. (c) An appropriate bed temperature improves first-layer adhesion.

Poor or excess of material

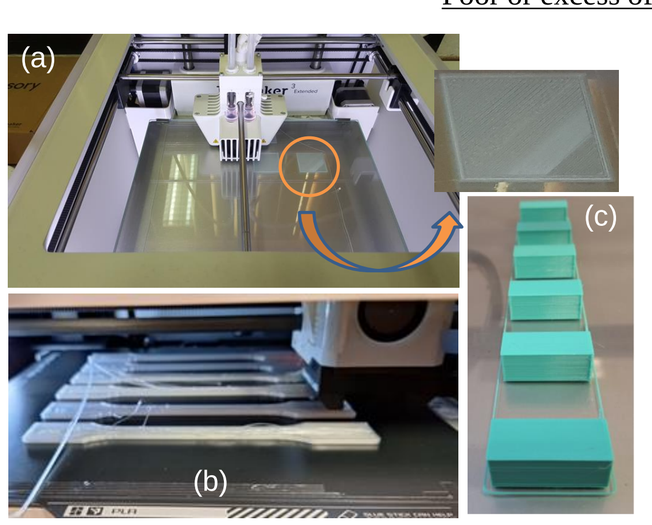

Figure 7. (a) A low nozzle temperature leads to reduced material flow. (b) Incorrect print height alignment results in inadequate material deposition. (c) PLA parts with an excess of material.

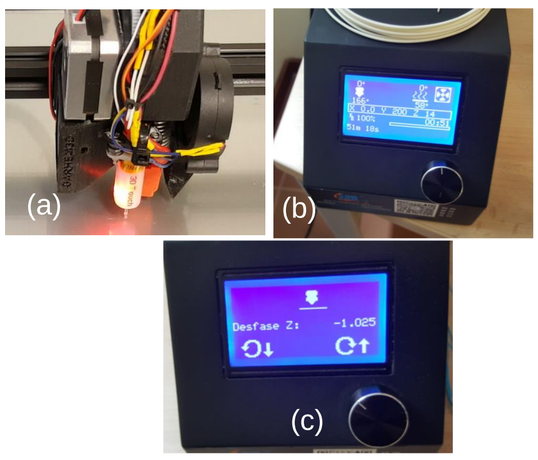

Figure 8. (a-b) A proper Z-offset adjustment improves the deposition of subsequent layers. (c) An adequate nozzle temperature optimizes the material flow during printing.

Effects on mechanical properties

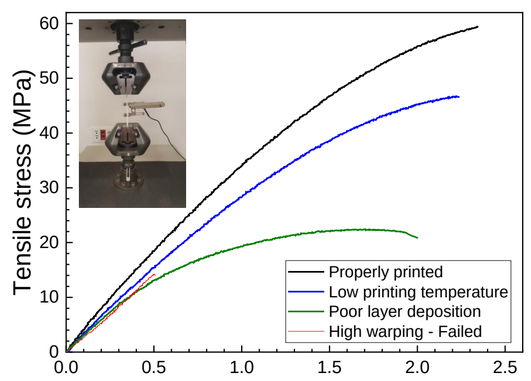

Figure 9. Tensile tests corresponding to properly PLA printed parts, at low extruder temperature, with poor layer material and high warping.

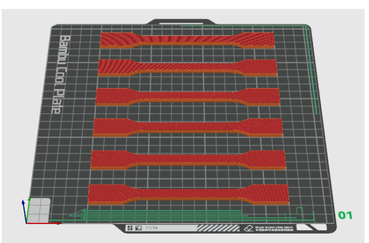

Figure 10. Designs of 3D specimens for tensile tests. The image corresponds to Bambu Slicer.

CONCLUSION

The findings of this work highlight the importance of parameter optimization and equipment upkeep in achieving consistent FDM print quality. A set of practical guidelines is proposed to help users diagnose and mitigate common printing issues. These recommendations aim to support both novice and experienced users in enhancing the performance of their FDM fabrications.

FUTURE WORK / REFERENCES

1. Tientcheu, S.W.T.; Djouda, J.M.; Bouaziz, M.A.; Lacazedieu, E. A Review on Fused Deposition Modeling Materials with Analysis of Key Process Parameters Influence on Mechanical Properties; Springer London, 2024; Vol. 130; ISBN 0123456789.

2. Rivera-López, F.; Pavón M.M.L.; Correa, E.C.; Molina, M.H. Effects of Nozzle Temperature on Mechanical Properties of Polylactic Acid Specimens Fabricated by Fused Deposition Modeling. Polymers. 2024, 16 (13), 1867, doi:10.3390/polym16131867.