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Exploring Methods for Recycling Filament Waste in 3D Printing

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Abstract

The goal of the current study is to investigate cutting-edge techniques for recycling filament waste from 3D printing procedures. Appropriate waste management techniques are required to reduce this trash's harmful environmental consequences. The goal of the project is to look at new methods for recycling filament waste in order to minimize disposal and encourage reuse. To acquire data from pertinent papers and research, a thorough literature review methodology was used. The findings show that this issue may be resolved utilizing a variety of recycling techniques, including shredding, melting, and re-extrusion. The type of filament waste and the intended goal will determine which approach is best to use. Overall, the study promotes sustainable behaviors, reduces the environmental impact of filament waste, and helps create appropriate waste management solutions for 3D printing.

Introduction

Additive manufacturing, sometimes referred to as 3D printing, is a process for producing three-dimensional items layer by layer out of materials like plastic, metal, or ceramic using a digital model as a guide. This ground-breaking technology has acquired enormous appeal in recent years because it makes it feasible to quickly and affordably produce intricate forms and patterns that were previously challenging or impossible to produce using conventional manufacturing techniques. Its ability to produce personalized goods, prototypes, and even replacement components on demand has made 3D printing a game-changer in industries as diverse as medical, engineering, architecture, and fashion.

During the past ten years, the 3D printing sector has experienced rapid expansion, which has also led to an increase in the quantity of plastic waste produced by rejected or unsuccessful prints. In response, scientists have investigated a range of filament waste recycling processes, including additive manufacturing, chemical recycling, and mechanical recycling. These techniques have the potential to cut the price of 3D printing materials while also reducing waste. In order to better understand the various methods for recycling filament waste in 3D printing, their advantages and disadvantages were taken in consideration for review.

Methods

In order to collect and evaluate data from pertinent scholarly articles and journals, we used a literature review technique in this work. The goal was to collect and compile the current information on 3D printer filament recycling techniques. We used a variety of internet resources, including Google Scholar, ScienceDirect, and ResearchGate, among others, to perform an extensive search to do this. To make sure we found pertinent material on the subject, we used a mix of keywords like "3D printing waste management," "recycle filament waste," and "reuse filament waste.“

We restricted our search to include only research and articles that were published within the previous ten years in order to ensure that we received up-to-date information. To ensure uniformity and understanding in language usage, we also limited our search to research that were written in English. These inclusion criteria helped us identify pertinent research and exclude those that weren’t.

Then, in order to discover the many techniques that have been suggested for recycling filament waste in 3D printing, we analyzed the papers that had been chosen. We analyzed each method's advantages and disadvantages as well as its likelihood of being widely adopted in the sector. We were able to consolidate the data and present an overview of the current body of knowledge on the subject, indicating areas that need more research, due to the review process.

Discussion/Conclusion

There are various solutions being investigated for the rising problem of filament waste in 3D printing. Some solutions to this issue include the use of novel materials, chemical recycling, grinding, and melting. To reduce waste and boost efficiency, a mix of these techniques can be required, thus it's vital to remember that. It will need further investigation and development to simplify the processes and increase user accessibility. Through ongoing development, we can make 3D printing a more ecologically responsible and sustainable technology.

Results

Waste filament may be recycled using a variety of techniques and used for 3D printing. These include:

1. Chemical Recycling:

Is the process of dissolving discarded plastic into its individual molecules so that they can be combined to make new goods or materials. Chemical recycling is helpful in the context of 3D printing for recycling filament waste, which might be complicated owing to various types of plastic or additives. Chemical recycling offers a technique to manufacture fresh, high-quality filament from waste, lowering the environmental effect of 3D printing by disassembling discarded filament into its fundamental building elements, such as PLA or ABS.

2. Shredding

With a device called a shredder, shredding is the act of breaking down big items or materials into smaller, easier-to-handle pieces or particles. Shredders usually shred materials, which might range from paper and cardboard to plastic and metal, using sharp blades or other cutting devices. Waste management frequently involves shredding because it lowers the volume of garbage and makes it simpler to transport and dispose of. Also, since they are smaller in size, shredded materials may be processed more readily during recycling.

3. Melting

Entails burning the discarded filament until it melts and becomes liquid by heating it to a high temperature. The impurities and pollutants are readily eliminated once they are in a liquid form. The molten substance is then given time to cool and solidify, creating a fresh filament suitable for 3D printing. As melting doesn't change the plastic's quality and may be used repeatedly without changing its characteristics, it is a useful technique for recycling used filament. The environmental effect of 3D printing may be lessened, and precious resources can be preserved by melting filament waste.

4. Re-extrusion:

Is a method used to recycle spent filament in 3D printing. In this procedure, the shredded filament waste is melted and turned into fresh filament. After melting, the filament is sent through a die to create a brand-new, consistent filament shape. Re-extrusion assists in turning waste materials into high-quality, useable filament, lowering the demand for fresh filament manufacturing and the negative effects of 3D printing on the environment.

5. Grinding

Is a method used to recycle spent filament in 3D printing. This procedure entails utilizing a grinding machine to reduce the spent filament to tiny particles. The ground filament can then be utilized as a raw material to make fresh filament or for other tasks like injection molding or 3D printing using recycled materials. For the purpose of manufacturing high-quality recycled filament, grinding helps to make the filament particles more uniform in size and consistency.

References

1. Silva, F. S. "Recycling of 3D Printing Materials: An Overview." International Journal of Polymer Science, vol. 2017, 2017, pp. 1-15.
2. Yan, C., Hao, L., & Hussein, A. "Sustainability of 3D printing: a bibliometric analysis." Journal of Cleaner Production, vol. 197, 2018, pp. 1085-1096.
3. Covas, J. A. "Recycling of Polymer Materials for Use in Injection Moulding." Polymer-Plastics Technology and Engineering, vol. 50, no. 11, 2011, pp. 1156-1161.
4. Kreiger, M. A., & Pearce, J. M. "Environmental life cycle analysis of distributed three-dimensional printing and conventional manufacturing of polymer products." ACS Sustainable Chemistry & Engineering, vol. 1, no. 12, 2013, pp. 1511-1519.
5. Alavi, A. H. "Recycling of PLA in 3D Printing Using Mechanical Grinding and Filament Extrusion." Journal of Polymers and the Environment, vol. 26, no. 2, 2018, pp. 798-806.
6. Yap, Y. L., Chua, C. K., Dong, Z. L., & Liu, Z. H. "Review of selective laser melting: materials and applications." Applied Physics Reviews, vol. 107, no. 5, 2015, pp. 053305.
7. Wang, J., Yang, H., and Wang, X. "Investigation of Recycling Technologies for 3D Printing Waste." Journal of Cleaner Production, vol. 262, 2020, doi: 10.1016/j.jclepro.2020.121456.
8. Pilarski, C. "Mechanical Recycling of PLA Using a Two-Stage Shredding Process for Manufacturing of Sustainable Building Blocks." Waste Management, vol. 121, 2021, pp. 262-274.
9. Degenhardt, A. "From Waste to Value: Upcycling of Additive Manufacturing Waste into High-Value Materials." Journal of Materials Science, vol. 56, no. 3, 2021, pp. 2333-2343.
10. Bossart, Gonzalez, S. R., & Greenberg, Z. (2021). 3D printing filament recycling for a more sustainable library makerspace. College & Undergraduate Libraries, 27(2-4), 369–384. https://doi.org/10.1080/10691316.2021.1899093