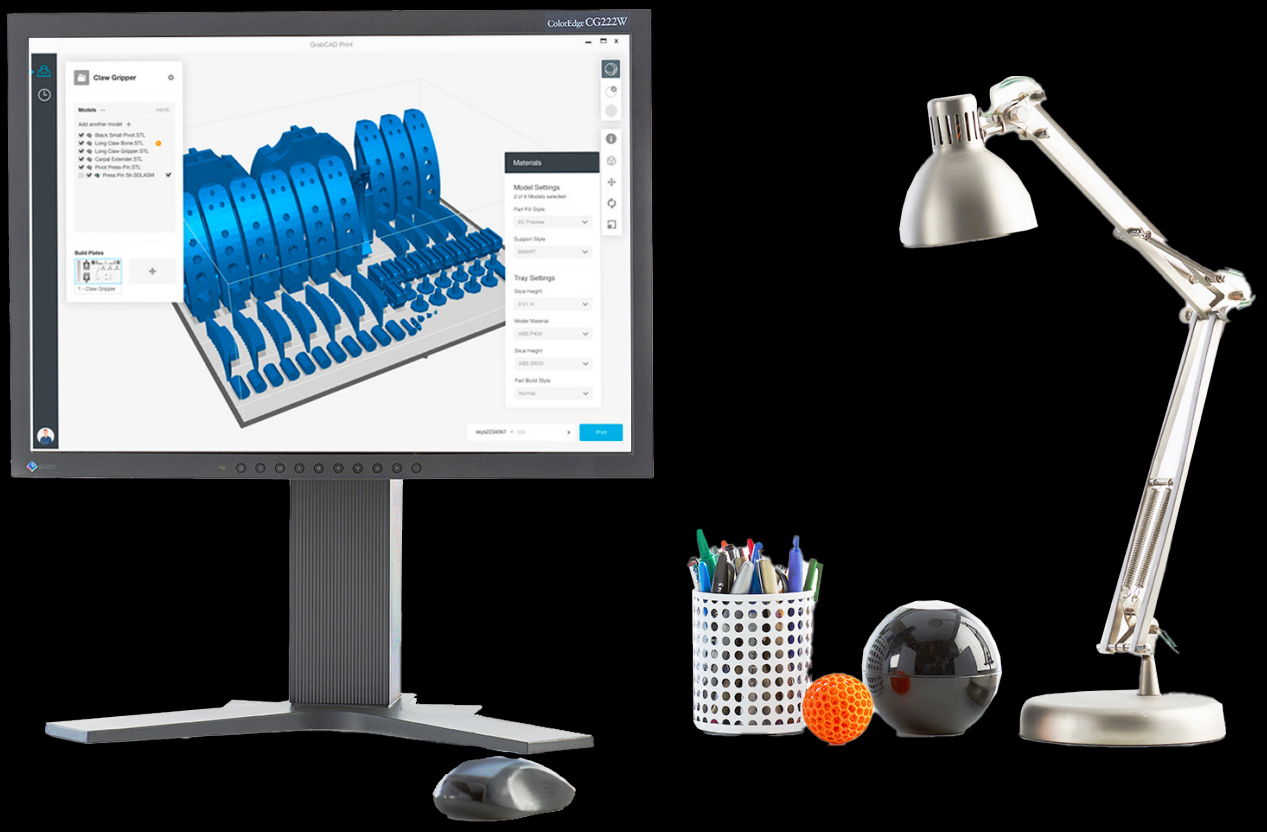
WHITE PAPER
FDM

From Waste to Resource: Transforming FDM Printing with Recycled Materials via OpenAM

Introduction

As the additive manufacturing (AM) industry continues to grow, so does its environmental footprint. Integrating recycled materials into 3D printing processes presents a critical opportunity to mitigate this impact, particularly in reducing carbon emissions and manufacturing waste. Utilizing a product like OpenAM™ to unlock third-party materials for select Stratasys fused deposition modeling (FDM®) printers, represents a significant leap towards sustainability in additive manufacturing.



OpenAM Technology: An Overview

Stratasys FDM OpenAM is a software platform that enables customers to retune or create their own material recipes on the Fortus 450mc™ and F900® platforms. On these machines, OpenAM software allows users to innovate with new materials and explore new use cases by providing the ability to adjust and create custom print parameters.

Becoming More Sustainable in AM

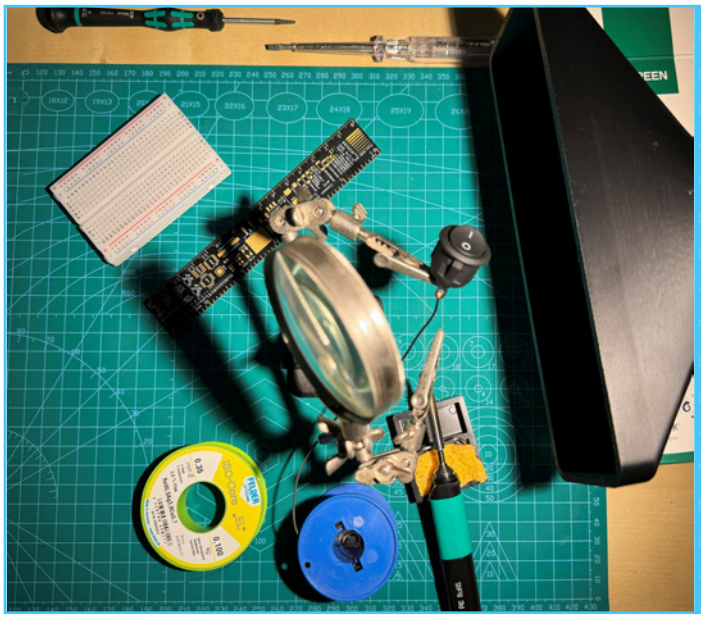
FDM has enjoyed 30 years of widespread adoption yet remains adaptable to current needs. For example, when first launched, only virgin thermoplastics could be utilized. Now, to meet increasing demand, it is also possible to print with recycled materials.

Using virgin thermoplastics in additive manufacturing is associated with high carbon emissions, largely due to the energy-intensive processes involved in extracting raw materials and producing the final product. In contrast, recycling thermoplastics for use in 3D printing significantly lowers the carbon footprint. Research has shown that recycled plastics can reduce carbon dioxide emissions for PETG by 35% compared to their virgin counterparts ([1*]). Recycling ABS can lower CO2 emissions by 28% ([2*])([3*]).

OpenAM's capability to process recycled materials not only extends the material's life cycle but also contributes to a substantial decrease in carbon emissions. By embracing recycled thermoplastics, the AM industry can significantly lower its environmental impact and contribute to global carbon reduction efforts.

Reduce and Reuse Wherever Possible

OpenAM allows the use of any third party filament, enabling the utilization of recycled materials. This capability reduces the demand for virgin plastics and impacts waste management practices within the industry. By recycling end-of-life parts and waste materials into new 3D printing filament, OpenAM-equipped printers allow customers to divert waste from landfills. This approach aligns with sustainable waste management practices, emphasizing material recovery and recycling over disposal.



Challenges and Limitations

The utilization of recycled thermoplastic materials in FDM 3D printing faces several significant challenges:

Changes in Material Properties

Not all thermoplastic materials are as viable for the FDM process as others. For example, amorphous polymers tend to exhibit more controllable printing behavior. Furthermore, observations of thermoplastic materials subjected to recycling processes show alterations in their material properties. These modifications can influence the properties positively or negatively in the initial cycles. Nevertheless, it has been documented that, without intervention, ABS demonstrates minimal degradation of material characteristics after five cycles ([4*]).

Research indicates that the thermal and chemical properties of the commonly used 3D printing materials PLA and ABS undergo negligible alteration through recycling processes ([4*]). To address the decline in mechanical properties observed after numerous recycling iterations, the incorporation of additives is a viable strategy. The introduction of such additives can restore the initial material properties in an ABS/PLA blend, even after 20 recycling cycles ([5*]).

Navigating Economic, Logistical, and Quality Challenges in Adopting Recycled Materials for AM

Integrating recycled materials into the AM process poses economic, logistical, and quality assurance challenges. Collecting, sorting, and processing waste materials into a usable form for 3D printing can be complex. Moreover, maintaining the quality and consistency of these recycled materials is also a significant hurdle . Variabilities in waste material properties, compounded by contaminants, may lead to inconsistencies in filament specifications such as diameter and roundness. This directly impacts the quality of the 3D printed products, highlighting the intertwined nature of logistical and quality-related challenges of recycled materials in additive manufacturing.

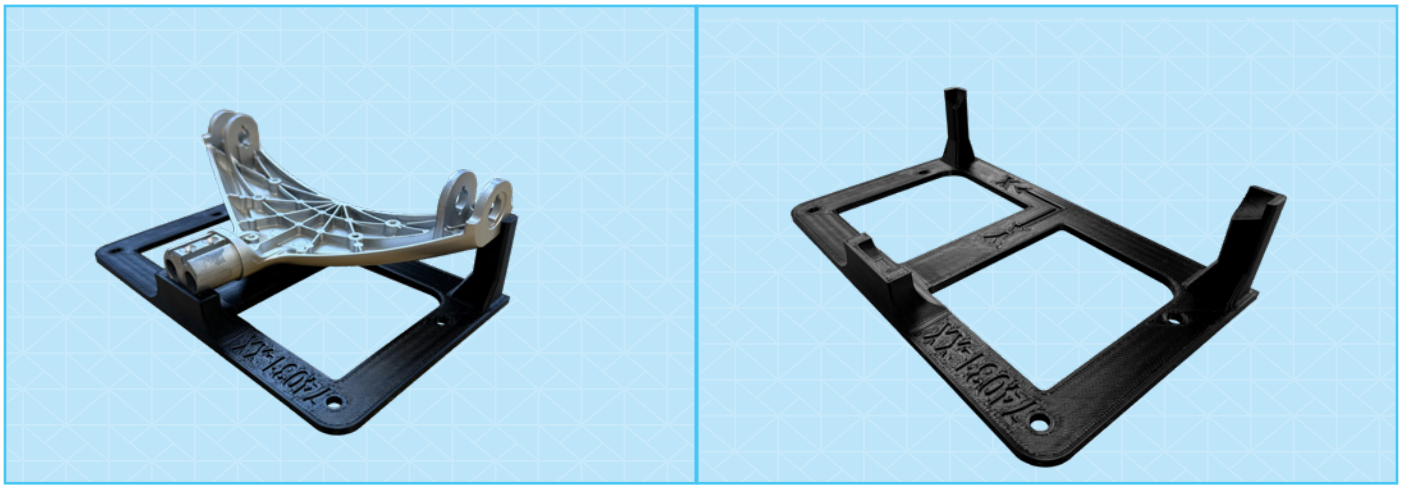
Stratasys investigations have found that industrial production waste generates some of the best sources for recycled filaments. Scraps or offcuts can be gathered from a single source and converted into new material, minimizing the risk of cross-contamination or complicated supply chains. For example, injection molding sprues and molding flash are suitable raw materials for new filament production.

Case Studies and
Real-World Applications

Jigs and fixtures are a necessary part of any manufacturing process. Usually made from metal, they're often costly and bulky, and many don't require highly precise dimensions. They just need to secure a part for machining or measurement. These tools are highly suitable for replacement with lower-carbon polymers or even recycled polymers.

CMM Measuring Fixture

CMM fixtures are another common device found on many shop floors. Often, they are only used a small number of times to measure parts but may have complex geometries. Fixtures like these are ideal candidates for printing from 100% recycled ABS since this material can easily meet the application requirements.



Vacuum Adapter

Stratasys engineers used a 3D printed vacuum adapter to push the limits of printing with 100% recycled ABS. They chose to test its air-tightness and surface finish using a design that incorporated thin walls and overhangs. The recycled ABS paired well with SR-30™ soluble support material and produced a usable and smooth surface on the final duct.

Conclusion

Recycled thermoplastics in AM, enabled by products like OpenAM, represent a pivotal movement toward more sustainable FDM technology. OpenAM's enablement of third-party materials not only promotes the reduction of carbon emissions and waste but also encourages economic efficiency, material innovation, and the advancement of a circular economy. As the AM industry continues to evolve, the importance of recycling and sustainable manufacturing practices will undoubtedly grow.

In-house recycling can pose challenges but practical solutions are available such as third-party recycling services or opting to purchase pre-processed recycled materials from larger aggregators. This approach facilitates the seamless integration of sustainability efforts within operations.

Finally, OpenAM allows users to alter print parameters to their exacting requirements should the need arise, a paradigm shift in the AM material market. Never before has such a major industry player in the material extrusion market opened up their platforms to customers' individual needs. Which materials could you recycle with OpenAM?

References

(1*) Armor Group. February 22, 2023. Kimya PETG Lifecycle analysis 35% CO2 savings compared to virgin material. Retrieved April, 2024, from https://www.armor-group.com/en/actualites/provide-more-sustainable-alternatives

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(3*) de Oliveira, R., Silva, M., Agrawal, P., Brito, G. (2023) Recycling of Acrylonitrile Butadiene Styrene from Electronic Waste for the Production of Eco-Friendly Filaments for 3D Printing. Retrieved from https://www.researchgate.net/publication/369339629_Recycling_of_Acrylonitrile_Butadiene_Styrene_from_Electronic_Waste_for_the_Production_of_Eco-Friendly_Filaments_for_3D_Printing

(4*) Hassan, M., Mohanty, A., Misra, M. (2023) 3D printing in upcycling plastic and biomass waste to sustainable polymer blends and composites: A review. Retrieved from https://www.sciencedirect.com/science/article/pii/S0264127523009747

(5*) Chiu, H.T., Huang, J.K., Kuo, M.T., Huang, J.H. (2018) Characterisation of PC/ABS blend during 20 reprocessing cycles and subsequent functionality recovery by virgin additives. Retrieved from https://doi.org/10.1007/s10965-018-1522-6

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