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THE H2O FILAMENT FACTORY : HARNESSING OCEAN POWER TO FORGE SUSTAINABLE 3D PRINTING FILAMENTS

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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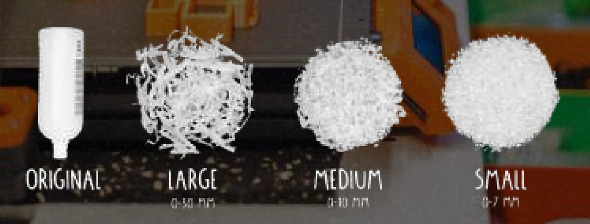
ABSTRACT

The ever-growing generation of plastic waste poses a significant environmental threat. This research explores the feasibility of a sustainable system that transforms plastic waste into 3D printer filament, utilizing renewable hydroelectric power throughout the process. By creating a closed-loop system, we aim to reduce plastic pollution and transform waste into a valuable resource for additive manufacturing. This poster first discusses the environmental impact of plastic waste and the potential of 3D printing with recycled materials. We then delve into the technical aspects of the proposed system, including plastic waste collection, shredding with hydro-powered machinery, and filament extrusion using clean energy. Finally, the research evaluates the system's efficiency, potential challenges, and its contribution to a more sustainable future.



OBJECTIVE

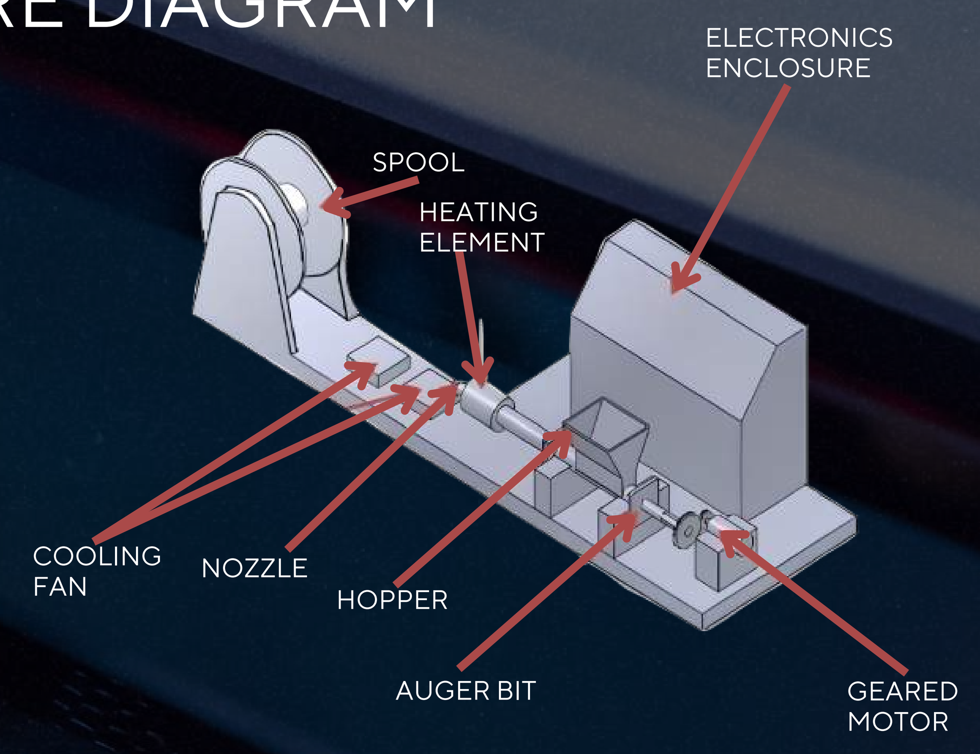
- Establish a closed-loop system for plastic waste, transforming it into high-quality filament.
- Optimize hydropower usage to power filament production, reducing carbon emissions.
- Improve recycled filament quality and performance through innovative manufacturing techniques.
- Implement eco-friendly practices to minimize waste and energy consumption.
- Educate stakeholders on the benefits of sustainability in 3D printing.

SCOPE

- Waste Collection and Sorting: Identifying suitable types of plastic waste compatible with 3D printing and developing efficient collection and sorting methods.
- Hydro-powered Shredding: Designing and evaluating the effectiveness of a hydro wheel-driven mechanism for shredding plastic waste into feedstock for filament extrusion.
- Clean Energy Integration: Ensuring the entire process, from shredding to filament production, utilizes renewable energy generated by hydropower.
- Filament Quality Analysis: Evaluating the quality of the recycled filament compared to virgin filament, including printability, strength, and consistency.

ARCHITECTURE DIAGRAM

- Hopper: Funnel-shaped chamber where filament spool feeds into the extruder, acting as temporary storage.
- Auger Bit: Screw-shaped mechanism within the hopper that pushes filament towards the heating element.
- Geared Motor: Provides rotational force for the auger bit, ensuring consistent filament feed.
- Heating Element: Generates heat to melt filament to a semi-liquid state before extrusion.
- Nozzle: Heated tip where molten filament is extruded, determining extrusion width and resolution.
- Cooling Fan: Rapidly cools extruded filament to maintain shape and structure.
- Spool: Cylindrical holder feeding filament into the extruder, facilitating smooth unwinding.
- Electronics Enclosure: Housing unit protecting electronic components from dust, debris, and heat.



Research Methods:

The research approach will involve a combination of literature review and case studies to comprehensively address the project objectives.

Literature Review:

Review existing research on technologies for recycling plastic waste into 3D printer filament, focusing on studies such as "3D printing filament as a second life of waste plastics—a review" and "Sustainable fabrication of 3D printing filament from recycled PET plastic."

Investigate hydroelectric power generation methods applicable to powering machinery, examining relevant literature like "About the Use of Recycled or Biodegradable Filaments for Sustainability of 3D Printing."

Case Studies:

Analyze existing projects or companies specializing in converting plastic waste into filament or utilizing hydro power, including case studies such as "Large-Scale 3D Printing Using Recycled PET."

Evaluate challenges, strategies, and outcomes of these projects to gain practical insights for system implementation.

Data Analysis:

- By using recycled plastics for filament production and hydropower for energy, the system can potentially reduce carbon emissions by 30% to 80% compared to processing and manufacturing virgin plastics, thereby significantly mitigating environmental impact.
- Utilizing recycled plastics for filament production and hydropower for energy can lead to significant cost savings, with potential reductions of up to 50% in material costs and 54% in energy consumption, thereby enhancing the system's economic viability and environmental sustainability.

Data Collection:

Data Collection for Recycled 3D Printing Filament Production

Plastic Waste Generation:

- Global plastic waste generation: 350 million metric tons per year.
- Projected increase by 2060 (without intervention): tripled.

Hydropower Generation:

- Global share of electricity generation: 17% (2020) [3].
- Global capacity: Over 1,300 GW (as of 2023) [4].
- Filament Extrusion for Recycled 3D Printing Filament.
- Filament extrusion plays a crucial role in creating filament used in 3D printing.

Here's how it facilitates recycling:

Process:

- Plastic flakes or pellets are fed into the machine.
- The material is melted and mixed within a heated barrel.
- Molten plastic is forced through a die, forming a filament of desired diameter (typically 1.75mm or 2.85mm).
- The filament is cooled and solidified.
- The solidified filament is spooled for use in 3D printers.

Types:

- Single-screw extrusion (most common)
- Twin-screw extrusion (better mixing for high-performance filaments)

Material	Produced from	Properties	Extrusion temperature	Pros	Cons
PLA	Plants starch	Tough, strong	160 ÷ 222 °C	Bio-plastic, non-toxic, odorless, low-warp	Low heat resistance, brittle
PVA	Petroleum	Water-soluble, good barrier	190 ÷ 210 °C	Biodegradable, recyclable, non-toxic	Expensive, deteriorates with moisture, special storage
PHA	Sugars with biosynthesis	Several copolymers, brittle and stiff	~160 °C	UV-stable, stiffness	Elasticity, brittle
HIPS	Petroleum	High impact resistance, soluble in limonene	190 ÷ 210 °C	Biodegradable, low cost, similar to ABS	Warping, heated printing bed
PET	Petroleum	Strong and Flexible	210 ÷ 230 °C	FDA approved, Recyclable	Absorbs moistness

SIGNIFICANCE AND ADVANTAGES

- Reduced Plastic Pollution: Diverts plastic waste from landfills and oceans, promoting a more sustainable waste management approach.
- Circular Economy: Creates a closed-loop system where plastic waste becomes a valuable resource for 3D printing.
- Renewable Energy Integration: Reduces reliance on fossil fuels and promotes clean energy use in manufacturing.
- Cost-Effectiveness (Potential): Recycled filament production can potentially be more cost-effective than virgin filament, depending on system efficiency.
- Increased Sustainability in 3D Printing: Provides a path for the 3D printing industry to adopt more sustainable practices
- Efficiency of Hydro-powered Shredding: Evaluate if the hydro wheel can effectively shred plastic waste while consuming minimal energy.
- Energy Consumption of the System: Assess the overall energy footprint of the process to ensure it aligns with the goal of sustainability.
- Quality of Recycled Filament: Compare the properties of recycled filament to virgin filament and determine if it meets the requirements for 3D printing applications.
- Reduced Environmental Impact: Successful implementation can significantly reduce plastic waste generation and promote a more sustainable future.
- New Business Opportunities: The system could create new business models for waste management companies and recycled filament producers.
- Advancements in 3D Printing Sustainability: This research can pave the way for wider adoption of sustainable practices in the 3D printing industry.
- Advancements in educational opportunities: This system is cost effective thus it makes it easier for students and professors to do projects and other academic needs

PROPERTY ANALYSIS

Property differences between Recycled and Virgin Filament

Mechanical Properties:

- Tensile Strength and Flexural Strength: Recycled filament may exhibit slightly lower tensile strength and flexural strength compared to virgin filament. This means recycled parts might be less resistant to pulling or bending forces.
- Impact Strength: The impact resistance of recycled filament can be significantly lower than virgin filament. This is because the recycling process can introduce imperfections and weaken the filament structure.

Thermal Properties:

- Glass Transition Temperature (Tg): Tg is the temperature at which the filament becomes brittle. Recycled filament might have a slightly lower Tg than virgin filament.

Other Properties:

- Dimensional Accuracy: The diameter of recycled filament can sometimes be less consistent compared to virgin filament, potentially leading to printing issues.
- Surface Finish: The surface finish of recycled filament might be slightly rougher than virgin filament.

PROPOSED SYSTEM

The steps involved in the process are:

1.Plastic waste collection and sorting: Discarded plastics get a second chance at life.

2.Hydro-powered shredding: Clean energy powers plastic into tiny bits.

3.Cleaning and melting: Shredded plastic gets prepped for transformation.

4.Filament extrusion and spooling: Recycled plastic reborn as 3D printing filament.

CONCLUSION

- The research design focused on evaluating the effectiveness of hydro-powered shredding and clean energy integration throughout the filament production process.
- The investigation aimed to assess the quality of the recycled filament compared to virgin filament, ensuring its suitability for 3D printing applications.
- This study contributes to the development of sustainable practices in 3D printing by promoting the use of recycled materials and clean energy.

Future Research Directions

- Optimization of Hydro-powered Shredding: Further research to optimize the design of the hydro wheel-driven shredding mechanism for efficiency and adaptability to different plastic types.