Baldwin Printer: A Large-Scale FGF 3D Printer for Recycled PET and AM Additives

User Guide

June 2025

Abstract

The Baldwin Printer is a custom-built, large-scale Fused Granular Fabrication (FGF) 3D printer designed for rapid production of roofing, wall, siding panels, and fencing using recycled polyethylene terephthalate (PET) from plastic bottles, enhanced with carbon fiber and other additive manufacturing (AM) powders. With a 10 ft x 10 ft x 10 ft build volume, it operates outdoors with a waterproof enclosure and is controlled via a Raspberry Pi with user-developed software. This guide details the build process, parts list with purchase links, five iterative enhancements, and documentation artifacts with their timestamps.

1 Introduction

The Baldwin Printer leverages recycled PET and AM additives like carbon fiber to produce durable, large-scale structural components. Its design prioritizes cost-efficiency, sustainability, and outdoor operation, making it ideal for architectural applications. This document provides a comprehensive guide to building the printer, sourcing parts, enhancing its capabilities, and understanding the documentation artifacts used.

2 Material Compatibility

The printer uses recycled PET pellets from plastic bottles, blended with additives such as:

- **Carbon Fiber**: Chopped fibers or powder (10–20% by weight) for enhanced strength and stiffness, suitable for structural panels.
- **Other AM Powders**: Glass fiber, hemp fiber, or fly ash to improve mechanical properties and sustainability.

A high-flow screw extruder with a mixing chamber ensures uniform blending, supported by research on carbon fiber-reinforced recycled PET [1].

3 Printer Capabilities

The Baldwin Printer is optimized for:

- **Build Volume**: 10 ft x 10 ft x 10 ft (3048 x 3048 x 3048 mm).
- **Print Speed**: 100–150 mm/s with a 2 mm nozzle, up to 200 mm/s with a 3 mm nozzle in later iterations.
- **Applications**: Rapid production of modular roofing panels (e.g., 4x4 ft), wall panels, siding panels, and fencing.
- **Materials**: Recycled PET with carbon fiber, glass fiber, or hemp fiber additives.
- **Outdoor Use**: IP65-rated enclosure with UV-resistant polycarbonate panels and sealed joints.
- **Sustainability**: 90% recycled materials, with options for solar/wind power.

4 Bill of Materials (BOM)

The following table lists all components required to build the Baldwin Printer, with estimated costs and purchase links.

Table 1: Bill of Materials for Baldwin Printer

Component	Description	Quantity	Cost (USD)	Link
Frame	80/20 T-slot, 40x40 mm, second-hand	200 ft	1,100	eBay Aluminum
Panels	Polycarbonate, 4 mm, UV-resistant	400 sq ft	700	Polycarbonate Sheet
Insulation	Foam board	400 sq ft	150	Foam Insulation
Seals/Fasteners	IP65 gaskets, T-slot nuts	Lot	200	IP65 Gaskets
Ventilation	HEPA fume extractor	1	200	Fume Extractor
Linear Rails	V-slot, 20 mm, 3200 mm	8	720	V-Slot Rails
Lead Screws	Trapezoidal, 16 mm, 3200 mm	4	360	Lead Screws
Stepper Motors	NEMA 23, 4 Nm	5	225	NEMA 23 Motor
Belts/Pulleys	GT2 belts (10 m), pulleys	Lot	90	GT2 Belt Kit
Extruder	DIY pellet extruder with mixing chamber	1	300	Precious Plastic
Nozzle	Hardened steel, 2 mm	1	40	Steel Nozzle
Hopper	Custom, 10 kg, recycled materials	1	50	Build from recycled materials
Build Surface	PEI-coated aluminum, 10x10 ft	1	450	Aluminum Plate
Heater Pads	Silicone, 2000W total	4	280	Heater Pad

Table 1: Bill of Materials for Baldwin Printer (Continued)

Component	Description	Quantity	Cost (USD)	Link
Insulation	Ceramic fiber blanket	Lot	90	Ceramic Blanket
Controller	Raspberry Pi 4, 4GB	1	60	Raspberry Pi
Drivers	TMC2209	5	50	TMC2209 Driver
Power Supply	48V, 1000W	1	140	Power Supply
Sensors	BLTouch, filament runout	2	90	BLTouch
Touchscreen	7-inch	1	80	Touchscreen
Shredder	DIY shredder	1	300	Precious Plastic
Recyclebot	DIY pellet extruder	1	200	Recyclebot Parts
Cleaning Setup	Manual washing station	1	100	Washing Station
Tools/Wiring	Soldering kit, cables	Lot	150	Soldering Kit

Total Cost: $6,355

5 Build Instructions

5.1 Frame and Enclosure

1. Cut 80/20 extrusions to 10 ft lengths.
2. Assemble base frame (10x10 ft) using T-slot fasteners.
3. Build vertical supports and cross-braces for rigidity.
4. Mount 4 mm polycarbonate panels with IP65 gaskets for waterproofing.
5. Add foam insulation to inner surfaces, avoiding the heated bed area.
6. Install HEPA fume extractor with external ducting to prevent water ingress.

5.2 Motion System

1. Install V-slot rails on X and Y axes (4 per axis, parallel alignment).
2. Mount lead screws on Z-axis corners, coupled to NEMA 23 motors.
3. Configure CoreXY belt system with GT2 belts and pulleys.
4. Test motor alignment using Raspberry Pi jogging commands.

5.3 Extruder and Bed

1. Assemble DIY pellet extruder with mixing chamber for carbon fiber/powder additives.

2. Mount extruder on X/Y gantry with a 2 mm hardened steel nozzle.
3. Attach custom 10 kg hopper with agitator for uniform material feed.
4. Install PEI-coated aluminum bed on Z-axis frame.
5. Wire silicone heater pads under bed, insulated with ceramic fiber.
6. Connect thermistors for bed and extruder temperature control.

5.4 Electronics

1. Set up Raspberry Pi 4 with user-developed software (e.g., Klipper).
2. Wire TMC2209 drivers, power supply, sensors, and touchscreen.
3. Install BLTouch for auto bed leveling and filament runout sensor.
4. Test electronics with a dry run via the touchscreen interface.

5.5 Plastic Recycling Setup

1. Assemble DIY shredder to process PET bottles into 2–5 mm flakes.
2. Build DIY recyclebot for pellet production (230–250°C melt temp).
3. Set up a washing station with soap, water, and drying racks.
4. Test pellet quality with small prints before scaling up.

5.6 Calibration and Testing

1. Level bed using BLTouch and Raspberry Pi interface.
2. Configure slicer (e.g., Cura) for PET: 230–250°C nozzle, 70–90°C bed, 100–150 mm/s speed, 0.8–1.2 mm layer height.
3. Print a 100x100x100 mm test cube to verify accuracy and adhesion.
4. Adjust retraction and flow rate to minimize stringing.

5.7 Outdoor Setup

1. Ensure IP65 seals prevent water ingress.
2. Anchor frame to a concrete base for stability.
3. Route ventilation to an external exhaust.
4. Optionally, place under a shelter to protect from direct rain.

6 Iterative Enhancements

To maximize performance, cost-efficiency, and sustainability, the following five iterations are proposed:

1. **Mixing Chamber Optimization**: Enhance the extruder's mixing chamber for uniform carbon fiber distribution, improving panel strength. *Cost*: $100 (custom parts). *Benefit*: Enhanced material properties.
2. **Larger Nozzle**: Upgrade to a 3 mm nozzle for faster deposition (3 kg/h). *Cost*: $40 (3mm Nozzle). *Benefit*: Reduced print time for large panels.
3. **Thinner Panels**: Use 3 mm polycarbonate panels to reduce enclosure costs. *Cost*: $550, saving $150 (3mm Polycarbonate). *Benefit*: Cost reduction.
4. **Recycled Frame Materials**: Source salvaged aluminum extrusions. *Cost*: $900, saving $200 (eBay Aluminum). *Benefit*: Cost reduction and sustainability.
5. **Solar Power**: Add 500W solar panels for auxiliary power. *Cost*: $300 (Solar Panel). *Benefit*: Reduced energy costs and environmental impact.

7 Sustainability Features

- **Recycled Materials**: 90% of input materials (PET, frame, hopper) are recycled.
- **Eco-Friendly Additives**: Hemp fiber and fly ash reduce reliance on virgin materials.
- **Energy Efficiency**: Solar/wind power options lower carbon footprint.
- **Circular Economy**: Local PET sourcing and recycling minimize waste.

8 Troubleshooting

- **Warping**: Increase bed temperature to 90°C or enhance enclosure insulation.
- **Clogging**: Dry PET pellets at 60°C for 4 hours to remove moisture.
- **Stringing**: Adjust retraction settings (2–4 mm) in the slicer.

9 GitHub Repository

The build guide, CAD files, and sample designs are hosted in a GitHub repository:

- **URL**: `github.com/yourusername/baldwin-printer`
- **Structure**:

```
baldwin-printer/
├── CAD/
│   ├── frame.step
│   ├── gantry.step
├── Firmware/
│   ├── klipper_config.cfg
├── Slicer_Profiles/
│   ├── pet_carbon_cura.profile
├── BOM/
│   ├── bom.csv
├── Guides/
│   ├── assembly.md
│   ├── calibration.md
├── Designs/
│   ├── roofing_panel.stl
│   ├── wall_panel.stl
├── README.md
├── LICENSE (CC BY-NC-SA 4.0)
```

10 Documentation Artifacts

This document is part of a series of artifacts generated for the Baldwin Printer project. Each artifact is identified by a unique identifier (UUID) and is associated with a creation timestamp. Below is a list of the artifacts used in creating this guide:

- **Artifact ID**: `bc2b44bf-7c51-4145-92ca-406b845671d2`
  - **Version ID**: `3d9ec410-efbb-4291-9f05-4134a74df2c4`
  - **Title**: Large-Scale FGF 3D Printer Build Guide
  - **Content Type**: `text/markdown`
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- **Artifact ID**: `c4a228b7-a243-4929-afdc-1173b363769e`
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  - **Title**: GitHub Repository Structure
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All artifacts were generated on June 7, 2025, at approximately 06:31 PM EDT. The artifact IDs are version 4 UUIDs, which are randomly generated and do not contain timestamps. The timestamps are provided as separate metadata to indicate when each artifact was created.

References

[1] Developments in 3D printing of carbon fiber reinforced polymer containing recycled plastic waste, ScienceDirect 2023.

[2] Large-Scale 3D Printing Using Recycled PET, Springer 2023.

[3] Carbon Fiber 3D Printing: Revolutionizing Additive Manufacturing, Ultimaker 2025.

[4] Precious Plastic Community Solutions, Precious Plastic.