

Rationale for Vertical Filastruder Orientation

Thesis:

In this paper, we argue that vertical orientation of a Filastruder extrusion system provides fundamentally superior process stability, material homogeneity, and filament dimensional accuracy compared to horizontal configurations.

Background information:

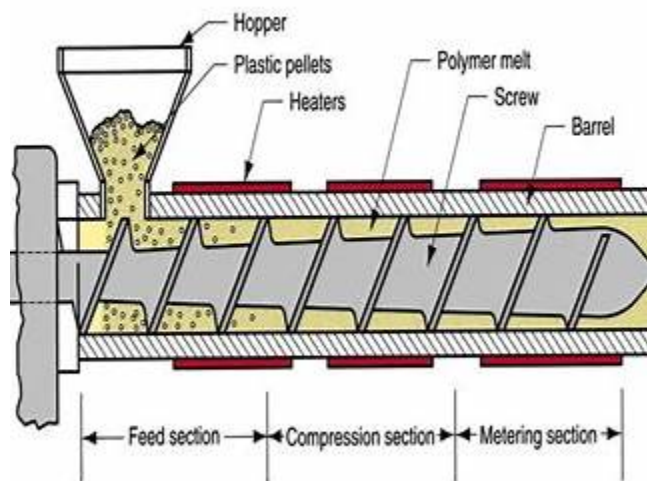
A **Filastruder** is a machine that takes shredded or recycled plastic and feeds it through a rotating metal screw while applying heat until the material becomes molten. This molten plastic is then forced through a precision nozzle with a carefully controlled diameter—typically around **1.75 mm**—to produce filament suitable for **FDM (Fused Deposition Modeling) 3D printers**. By regulating temperature, pressure, and flow, the Filastruder converts waste plastic into usable printing material. Additional machines can be integrated with the Filastruder to automate the preprocessing stage, such as grinding failed prints and support material into pellets, enabling a fully closed-loop recycling system for 3D printing.

Problem:

The primary design challenge lies in determining the **orientation of the extruder itself**, whether it should be positioned vertically, horizontally, or at an intermediate angle such as 45 degrees.

Summary:

This paper argues that a **vertical Filastruder orientation produces higher-quality filament than horizontal designs** because gravity directly stabilizes both molten plastic flow and particle distribution. When the extruder is vertical, gravity assists material transport, keeping pressure steady and producing filament with a more consistent diameter. In horizontal systems, gravity causes molten plastic to pool and form air pockets, leading to unstable flow and dimensional defects. For composite filaments such as magnetic polymers, vertical orientation also prevents heavy particles from settling sideways, preserving uniform material composition. Together, these effects make vertical Filastruders better suited for producing stable, precise, and functional 3D-printing filament.



The Role of Gravity in Material Flow Stability

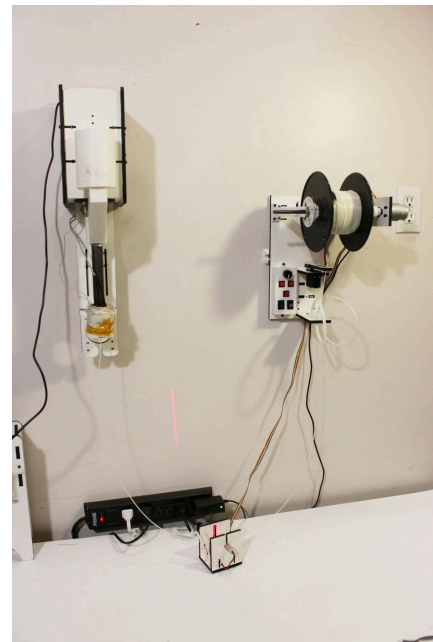
Positioning the machine in a **vertical orientation** provides one major advantage: **gravity**. While gravity affects both horizontal and vertical configurations, it acts **against** material flow in a horizontal setup and **assists** it in a vertical one.

Prior numerical studies demonstrate that gravity plays a dominant role in controlling molten polymer flow, extrusion velocity, and filament morphology. Increasing gravitational force in the extrusion direction produces thinner, faster, and more stable material flow. Therefore, orienting a Filastruder vertically—so gravity acts along the extrusion axis—should inherently improve filament stability compared to horizontal configurations. ([Xin Jiang, Ryo Koike](#))

Here's what we mean by that: inside the heated barrel of a Filastruder, the polymer is transformed from solid pellets into a **high-viscosity molten fluid** that must be continuously transported toward the nozzle. In a vertical configuration, gravity acts in the same direction as this flow, helping to keep the screw channels fully filled and maintaining a consistent hydrostatic pressure in the melt column. This results in a steady and predictable flow of material through the nozzle, which is essential for producing filament with a uniform diameter.

In contrast, when the extruder is positioned horizontally, gravity causes the molten polymer to pool at the bottom of the barrel. This leads to uneven filling of the screw, localized variations in pressure, and the formation of air pockets within the melt. These effects disrupt the continuity of material flow and introduce fluctuations in the extrusion rate, which directly translate into diameter inconsistencies and internal voids in the resulting filament.

Because filament diameter is governed by the stability of melt pressure and flow at the die, even small gravitationally induced disturbances in a horizontal system can produce significant defects. By aligning gravity with the direction of material transport, a vertical Filastruder inherently suppresses these instabilities, enabling smoother extrusion and higher-quality filament output.



Particle Suspension and Composite Material Uniformity

In addition to stabilizing melt flow, vertical Filastruder orientation plays a critical role in maintaining **uniform distribution of solid filler particles** within composite filaments. Many advanced functional filaments—including magnetic, conductive, and reinforced polymers—contain solid particles that are significantly denser than the polymer matrix. In magnetic filaments, these particles are typically iron, ferrite, or rare-earth powders whose densities are several times higher than that of molten thermoplastic.

When a composite polymer melt is subjected to gravity, these particles naturally tend to migrate in the direction of gravitational acceleration. In a horizontally oriented extruder, gravity acts perpendicular to the direction of material transport, causing heavy particles to settle toward the bottom of the barrel and screw channel. This produces **concentration gradients**, where one side of the melt becomes particle-rich while the opposite side becomes particle-poor. As this non-uniform mixture is forced through the nozzle, the resulting filament exhibits spatial variations in magnetic strength, stiffness, and printability.

In contrast, when the extruder is oriented vertically, gravity acts along the same axis as material flow. Instead of causing particles to separate sideways, gravitational forces help keep the composite mixture aligned with the direction of transport. This greatly reduces transverse sedimentation and promotes a more **axially uniform particle distribution** as the material advances toward the die. As a result, the extruded filament retains a more consistent internal composition along its length and cross-section.

Uniform particle distribution is particularly important for magnetic filaments used in soft robotics, where mechanical response and magnetic actuation depend directly on filler concentration. Variations in particle content lead to unpredictable magnetization, non-uniform bending forces, and inconsistent actuation behavior. By minimizing gravity-induced particle segregation, a vertical Filastruder enables the production of composite filaments with predictable magnetic and mechanical properties, which is essential for reliable soft-robot fabrication.

Resources:

[\(High-gravitational effect on process stabilization evaluation for material extrusion using polylactic acid filament\)](#)

- This study experimentally investigates how increased gravitational acceleration (up to about 5 G) affects material extrusion, finding that higher gravity improves the surface quality and appearance of extruded parts by enhancing material flow and deposition. It shows that gravity can be a controllable factor in stabilizing extrusion processes and improving part quality.

[\(A Computer Model of Starve Fed Single Screw Extrusion of Wood Plastic Composites\)](#)

- Wilczyński and Buziak develop a computer model for starve-fed single-screw extrusion of wood-plastic composites, analyzing how partially and fully filled screw sections melt and flow during extrusion. Their model predicts temperature, pressure, melt rate, and screw filling, offering insight into how changes in screw fill influence overall extrusion behavior.

[\(Numerical Study of the Effect of High Gravity in Material Extrusion System and Polymer Characteristics during Filament Fabrication\)](#)

- This numerical investigation evaluates how varying gravitational conditions affect filament material extrusion, showing that gravity influences melt flow, material deposition, and resulting filament characteristics. The study supports using a high-gravity (HG-MEX) extrusion system to better understand and potentially improve extrusion quality and efficiency.