Pacific Northwest
NATIONAL LABORATORY

The Mixing Extruder for fused filament fabrication is a new drop-in nozzle that enables printing of dissimilar materials for rapid prototyping in many industries, such as providing better functional system capability for medical supplies and components.

MIXING EXTRUDER

Breakthrough in Additive Manufacturing

COMBINES, EXTRUDES DIFFERENT FILAMENTS

No commercially available fused filament fabrication (FFF) printing nozzles can effectively combine and extrude two different filaments into blends with efficiency and precision. Until now.

A new mixing extruder developed at Pacific Northwest National Laboratory enables FFF printers to efficiently mix dissimilar polymer filaments—at the time of printing—to yield homogeneous prints.

The new drop-in nozzle successfully mixes a wide range of ratios of polymer materials with different attributes that include

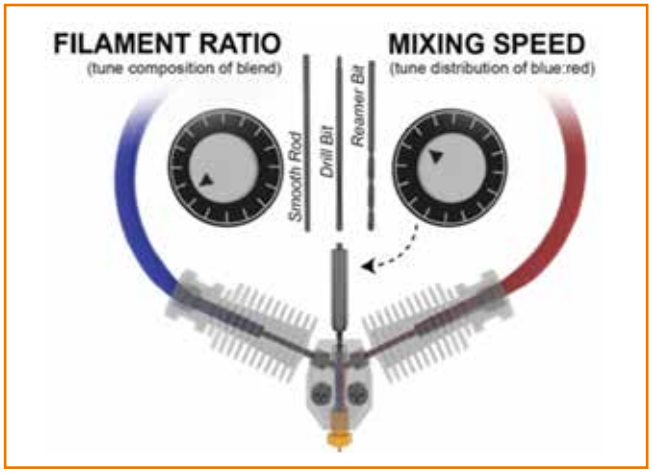
- conductive and insulating
- soluble and insoluble
- flexible and rigid filament
- in some cases, dissimilar melting points and composition.

MIXES WIDE RANGE OF MATERIALS AND MOFS

In FFF three-dimensional (3-D) printing, a thin layer of material is deposited, or extruded, in successive layers to create a fused physical object of a specific design. Originally designed for use with simple plastic filaments, this field is continually advancing. For example, new material feedstocks can improve the mechanical properties or introduce stimuli-responsive features in the final parts.

TECHNOLOGY FEATURES

- Effectively mixes different materials into homogenous prints
- Allows for tunable ratios of different input filament materials to be blended on demand during printing
- Extrudes more viscous filaments than existing technologies
- Can be dropped into current fused filament fabrication 3-D printers with minimal modifications
- Successfully incorporates metal-organic frameworks (MOFs) into poly (lactic acid) and thermoplastic polyurethane matrices that can be extruded into filaments and used for on-demand access to 3-D functional structures



Controlled using standard software, the Mixing Extruder is a drop-in design for current fused filament 3-D printers with minimal modifications.

However, some new or experimental materials can be too fragile or do not flow suitably for extrusion with current hardware. In addition, no commercially available FFF printing nozzles can effectively combine and simultaneously extrude two different filaments into blends with efficiency and precision. PNNL's Mixing Extruder bridges this gap.

The technology successfully mixes a wide range of ratios of polymer materials with different attributes, as well as dissimilar melting points and composition, in some cases. In addition, specialized filaments containing embedded MOFs results in parts with chemical sensing capabilities. These specialized composite parts are useful for building absorption and detection-based devices, such as those intended for catalysis, gas capture, or selective chemical sensing applications.

In recent research, MOFs (Zeolitic imidazolate framework; ZIF-8) were successfully incorporated homogeneously into both poly (lactic acid) and thermoplastic polyurethane matrices, extruded into filaments, and utilized for on-demand access to 3-D structures by fused-deposition modeling.

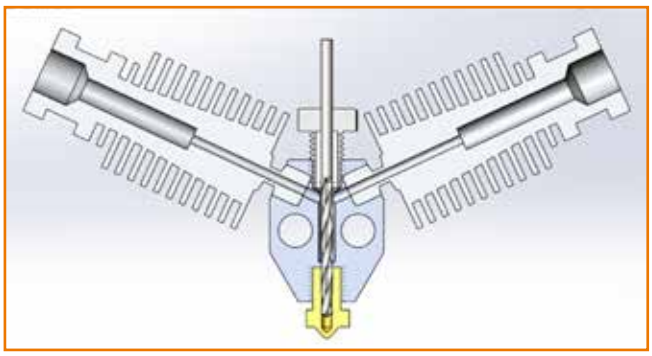
INNOVATIVE DESIGN

PNNL's Mixing Extruder uses an auger bit that rotates within the heated chamber of the extruder's hot end. This design produces the shear forces necessary to induce mixing of the molten plastics. The rotating auger bit also acts as a secondary driving mechanism to assist with extruding highly viscous or soft filaments.

The design allows for rapid screening and fine tuning of material properties in final parts, including strength and flexibility. This combination of properties is otherwise difficult to acquire through traditional composite formulation and subsequent 3-D printing cycles.

INDUSTRY APPLICATIONS

This invention can yield greater material strength and flexibility for multi-material prints—making it ideal for a variety of manufacturing processes. In addition, when used with specialized filaments containing chemically responsive particle fillers, the ability to tune the dispersion and concentration of the active component may be attractive for absorption and detection applications. The extruder is a drop-in design for current fused filament 3-D printers with minimal modifications and may be controlled using standard software.



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AVAILABLE FOR LICENSING

Most 3-D additive manufacturing industries can benefit from PNNL's Mixing Extruder, which currently is available for licensing in all fields of use. To learn more, visit availabletechnologies.pnnl.gov or contact our commercialization experts.

LET'S CONNECT

If you have questions, regarding this technology, please send inquiries to commercialization@pnnl.gov. You can view all PNNL technologies available for licensing at www.pnnl.gov/available-technologies.