

3D Printer Extruder

Application Note

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Abstract

The purpose of this paper is to instruct the reader on how to construct an extruder for a 3D printer and perform extruding. Throughout this application note, the reader will be introduced to the process of extrusion; type of extrusion used in 3D printing, the steps in assembling an extruder in order to perform extrusion as well as intended applications. The extruder will be described in detail as to what specific parts and components are necessary for assembly, the available compatible materials and finally how an extruder is implemented into a 3D printer.

Keywords

Extrusion, filament, extruder, Fused Deposition Modeling

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Introduction

Extrusion is a process adopted to create objects of a fixed cross-sectional profile. A particular material is pushed or unwound through a die of the desired cross-section to form a specific object. The two main advantages of this process as opposed to other manufacturing processes are its ability to create very complex cross-sections, as well as work with frail materials, because the material only encounters compressive and shear stresses. It also forms finished parts with an excellent surface finish. Extrusion may be continuous in which case it would theoretically produce an indefinitely long material or it may be semi-continuous in which case it can produce numerous individual pieces (Extrusion Process Basics: Aluminum Extruders Council). This process can be executed with the material being hot or cold. Figure 1 below shows the basic extrusion process.

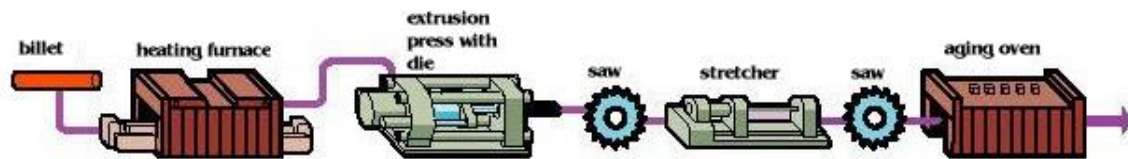


Figure 1. *This diagram shows the basic steps involved in extruding an aluminum profile*

The previously mentioned properties make this process ideal for 3D printing also commonly referred to as additive manufacturing. Specifically, this method applies to the type of additive manufacturing known as Fused Deposition Modeling in which case the extrusion process is slightly modified to be implemented into 3D printers and performed using an extruder.

Procedure

Assembling the Extruder

The extruder used in the team's 3D printer design is an EZStruder Cold End Kit as depicted in figure 2 below. It is the newest, most compact versatile extruder yet. The advantage of this Cold End Kit is that it is compatible with any groovemount style hotend in either 1.75 or in the team's case 3mm sizes (EZStruder Cold End Kit: 3dsupplyworld).



Figure 2. EZStruder Cold End Kit

The kit includes a hobbed drive roller for 5mm shafts, all screws, PTC adapter for use with Bowden fittings, and also an optional mount for the Rostock MAX original side mounted spool/extruder stand (EZStruder Cold End Kit: SeeMeCNC). Additional pieces intended for the full construction of the extruder not included in this kit is the stepper motor and the hot end kit. A general stepper motor was used along with a MendelMax 1.5 + Hot End Kit which include the J-Head Mk V-BV, heat resistor, and Epcos thermistor to complete the extruder. The followings steps were taken to fully assemble the extruder for the 3D printer:

- 1.) Obtain the EZStruder Cold End Kit, the MendleMax 1.5 + Hot End Kit and stepper motor.
- 2.) Place the hobbed drive wheel onto the bearing of the stepper motor. Then take the allen wrench and tighten the inlet screw on the side of the wheel until the drive wheel is nice and snug on the bearing.
- 3.) Take the plastic case containing the heavy duty spring and line it up with the top two holes of the stepper motor, placing the plastic case with the hole where the drive wheel can be inserted. Then, with a screw driver, tighten the two screws into the stepper motor. Be sure not to over tighten, just enough where the case does not move.
- 4.) Grab the black plastic hot end case and with the same screw driver, remove both screws. Open the case and remove the Bowden adapter and replace it with the J-

Head hot end (figure 3) in the end of the case with the 3mm inlet as 3mm filament will be used. Re-close the black plastic case, re-insert the screws and tighten.

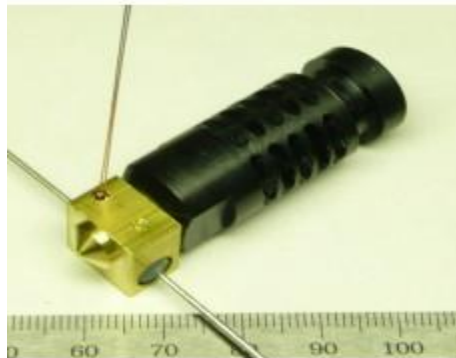


Figure 3. J-Head Mk V-BV Hot End

- 5.) Orient the black plastic case so that the J-Head is pointed downward and line the case up with the two holes at the bottom of the stepper motor. Now insert the two shorter M5-.8 thread screws that were included in the EZStruder kit and tighten.
- 6.) Figure 4 shows how the extruder kit should look attached to the stepper motor without the J-Head hot end inserted.



Figure 4. Extruder attached to stepper motor without J-Head Hot End

- 7.) The thermistor should then be inserted into the hole placed near the tip of the J-Head hot end. Also place the thermistor along the side of the J-Head and using electrical tape, tape both the heat resistor and the thermistor firmly in place. The completed extruder is depicted in figure 5 below.



Front View



Side View

Figure 5. Fully assembled extruder.

Implementation in 3D printer

Previously mentioned, 3D printers, as it pertains to the team's design, utilizes the extruder to perform the type of additive manufacturing referred to as Fused Deposition Modeling. Fused Deposition Modeling also known as FDM begins with a software process that includes the processing of an STL (stereolithography file format). The STL file mathematically slices and orients the particular model for the physical build process. The part is then produced by extruding small beads of thermoplastic material to form layers as the material immediately hardens after extrusion from the J-Head hot end. There is typically a worm-drive or drive wheels (powered by the stepper motor) that feed the filament into the nozzle at a controlled rate. Inside the nozzle, the thermoplastic is then heated past its glass transition temperature by the heated resistor and thermistor, deposited by the extrusion head onto the build platform or base (FDM Technology: Stratasys). If required, support structures may also be generated. In this instance, the machine may dispense multiple materials to serve different purposes. It may dispense one material to build the model up and another material to serve as the support structure or base upon which the model is built. The nozzle can be moved in both horizontal and vertical directions by a controlled mechanism which follows a tool path configured by a computer-aided manufacturing (CAM) software package. In relevance to the team's 3D printer design, the extruder along with the motor is placed directly onto the z-axis and the stepper motor is plugged into an Arduino Mega 2560 microcontroller. The Arduino is

then instructed by the user through the CAM program the appropriate dimensions and parameters upon which to build the model. The model is then built from the bottom up, one layer at a time. Figure 6 depicts the layer sequence, while figure 7 illustrates the Fused Deposition Modeling process.

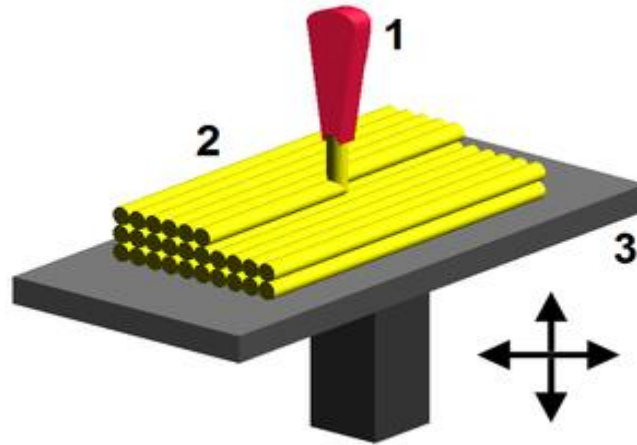
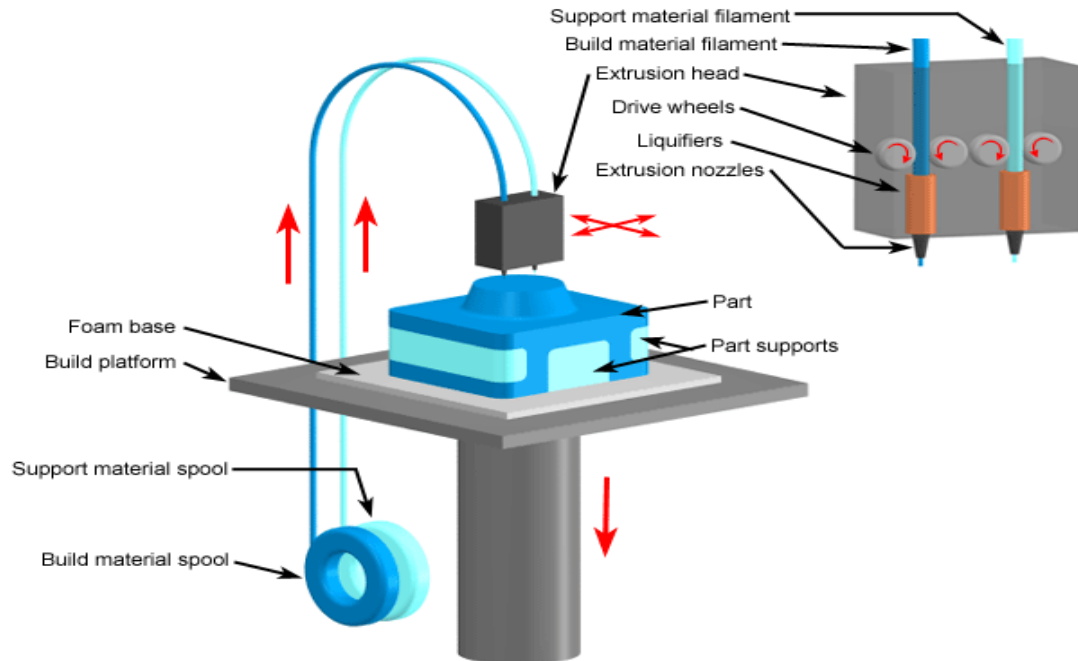


Figure 6. Extrusion layer sequence.



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Figure 7. Fused Depositon Modeling process.

Conclusion

In this document, an extruder for a 3D printer was constructed. The reader was informed of the general extrusion process, as well as the necessary steps in assembling an extruder. The implementation of the extruder into a 3D printer was also explored and explained through a detailed description of the Fused Deposition Modeling process which 3D printers use in order to create physical models and parts.

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