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3D Printing Guide

Fused Deposition Modelling (FDM) and Stereolithography (SLA)

Fused Deposition Modelling (FDM)

This guide covers information on Fused Deposition Modelling and Stereolithography for the purpose of prototyping both functional and non-functional parts.

Fused Deposition Modelling or FDM is an additive manufacturing method. FDM is the most recognized form of 3D printing. The FDM process involves melting a thermoplastic which is then extruded through a nozzle in thin layers. Each line and layer is precisely placed utilizing stepper motors controlled via Computer Numerical Control (CNC) with special instruction codes referred to as gcode.

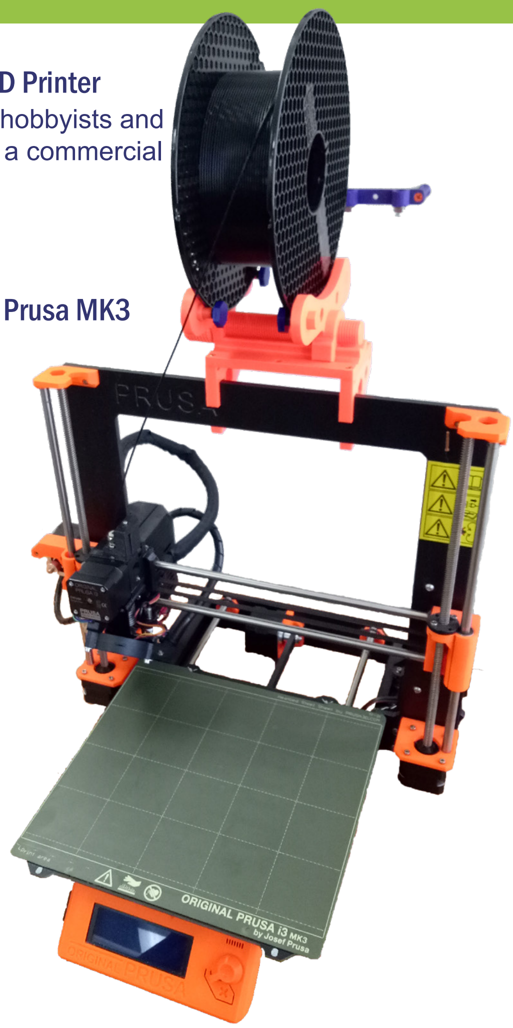
The gcode which is generated using a slicing program (see page 4) is based on a 3D Computer Aided Design or CAD model. During the product design phase, we produce a CAD model to conceptualize the idea and get a clear idea of the product and its geometry. The same model can be used to produce a prototype for testing.

Depending on the use case for the product in question the FDM part may be suitable as a functional prototype performing as intended and reaching the objectives placed on it, or at the very least a non-functional part that can demonstrate the physical dimensions and geometry.

Even if the model does not work functionally it is important to produce a prototype as it could highlight problems and mistakes in the conceptual design or even the features of the CAD model. If the final product requires significant tooling to be produced thousands of dollars can be saved by finding issues at this stage.

Typical FDM 3D Printer
Used by both hobbyists and businesses in a commercial setting.

Prusa MK3



FDM 3D Printed Part

Fused Deposition Modelling (FDM)

Fused Deposition Modelling as a process has its short comings. However, since the models are produced in layers, the final object is significantly weaker to forces applied perpendicularly to the layer direction. In most cases this is fine, the models can be rotated before printing to align the layers with the highest forces that will be subjected on it.

Depending on the application this is not always possible. Even if the material is rated for a certain stress and strain the non-homogenous structure of the part significantly reduces the actual stress and strain the part can endure.

Is FDM the right choice for your part? If the part is small and subjected to relatively low forces FDM works well. As mentioned before if you are looking for a non-functional prototype FDM is well suited as it does not require any special tooling and has a relatively high turn around speed.

Fused Deposition Modelling allows for the use of a variety of materials. These include PLA, ABS, TPU, PETG, PEEK and Nylon. Generally, PLA and ABS are used as it is easier to achieve a successful result.

FDM Part with Layer Lines

PLA Filament Spool

Fused Deposition Modelling (FDM)

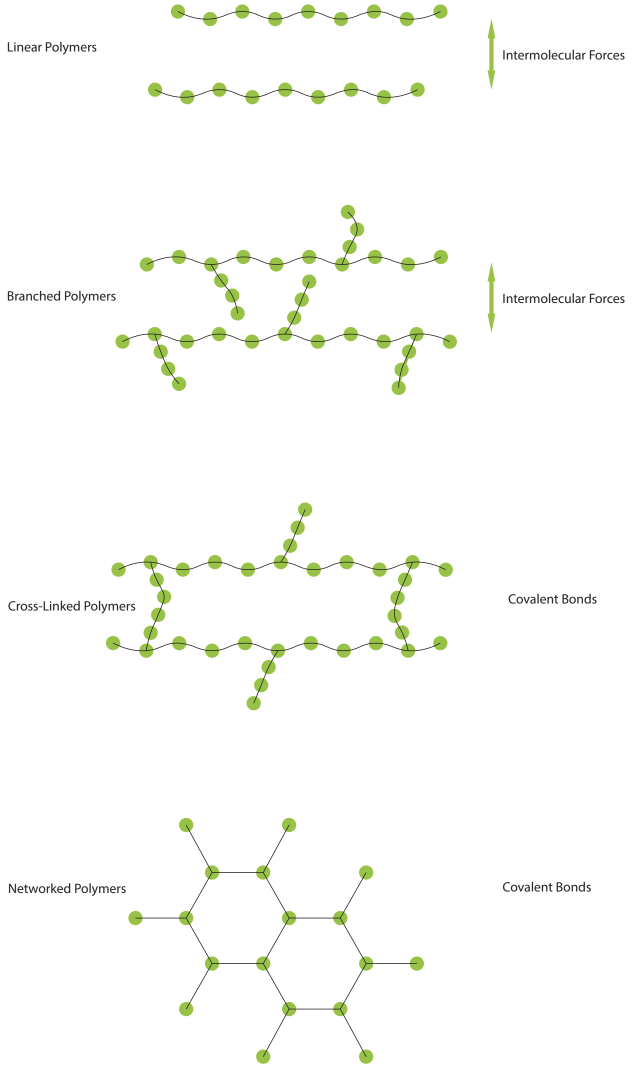
What is a Thermoplastic?

A thermoplastic is a polymer capable of being reshaped when heated. Materials like Bakelite (phenolic) cannot be printed using Fused Deposition Modelling because the chains and branches making up the polymer bond with strong covalent bonds. This can occur in a crosslinked configuration or as a network.

Thermoplastics on the other hand are able to untangle themselves the polymers appear in either linear or branched configurations.

Both are held together by weak intermolecular forces, although the branched configuration causes distinct polymer chains to tangle with one another preventing dislocation. When reheated the weak intermolecular forces are overcome (also allows for untangling) allowing the molecules to slide over each other enabling the FDM printing process.

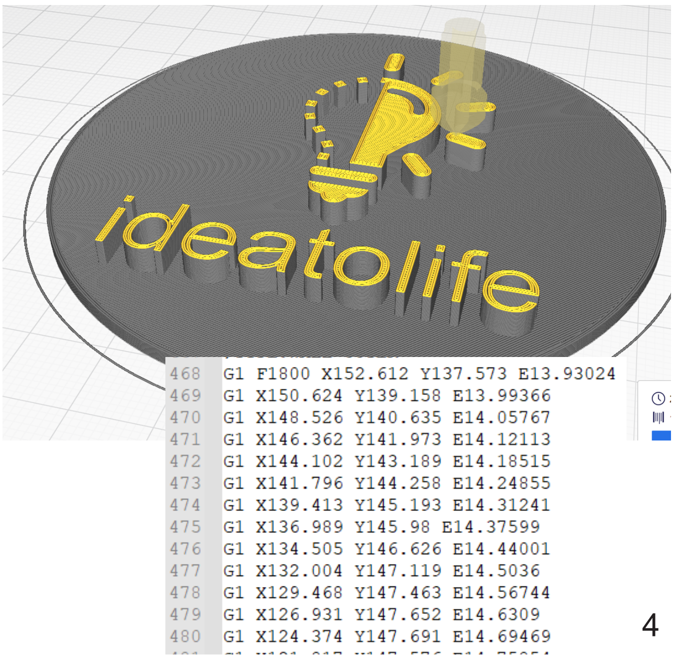
Polymer Bonding Configurations



What is a Slicing Program?

A slicing program is used as an intermediate step between the 3D Model containing all the necessary geometric information of the part and the generation of usable gcode. Depending on the complexity of the model the gcode could be as little as a few hundred lines to several thousand lines if not more. The slicing program automatically produces the gcode from the model allowing the user to select from a list of settings.

Sliced Model and Partial Gcode



Stereolithography (SLA)

Stereolithography (SLA) is another form of additive manufacturing that makes use of UV sensitive resin. Unlike FDM which remelts a thermoplastic solid in the form of a wound filament roll; SLA 3D printers can make use of thermoset materials.

Thermoset materials once formed cannot be remelted. This may be beneficial depending on the part being produced as FDM parts often run into the issue of melting when near high heat. For polylactic acid (PLA) this can happen as low as 185 degrees Celsius.

The process of producing an SLA part still relies on building layers of material up. A focused UV light is used to cure specific parts of the UV sensitive resin in a vat causing photopolymerization.

This process is repeated to build up successive layers until the part is completed. The part must then be rinsed off with isopropyl alcohol (IPA) and cured with a UV light. Avoiding this crucial step will leave the part soft and could result in dis-colouration and poor tolerances.

SLA 3D Printer - Prusa SL1

SLA Silicone Mould

Stereolithography (SLA)

The main benefit to an SLA part over FDM is the improved resolution and layer height. FDM processes are limited by both the nozzle diameter and the stepper motors used to position the nozzle. SLA however relies on directing light allowing for higher precision.

SLA printers can achieve layer heights between 0.025mm and 0.1mm whereas FDM is limited to 0.1mm on the low end. The higher resolution allows the final product to appear almost completely smooth. This is especially beneficial when producing small parts that require high detail or movement.

If you need a part that is relatively small and is part of a mechanical system SLA may be the option to consider as the surface quality and dimensions can be rendered more accurately. If the part is relatively large an SLA prototype may take significant time to print. If the functionality of the part is not necessary, it may be beneficial to use FDM instead as it is a significantly cheaper option. SLA is limited to UV sensitive resins with limited exotic mixes providing differing qualities.

SLA Print showing Layer Lines

Prusa SLA Calibration Models

Contact Details

Faz Pollard, Director
E: faz@adarsh.com.au
T: +61 8 9209 3866
F: +61 8 9209 3766

Mark Vella, General Manager
E: gm@adarsh.com.au
T: +61 8 9209 3866
F: +61 8 9209 3766

Email: info@ideatolife.com.au

Address: 6 Crocker Drive Malaga, Western Australia, 6090 Australia

Web Address: https://www.ideatolife.com.au/

ABN: 76 177 275 729