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When selecting a filament to use for FFF printing, the user needs to consider the thermal properties and adhesive strength of the material. Adhesion is extremely important, otherwise, layers may slip off of each other. Thermal properties are necessary to consider given that melting points of different materials range from 190-210 degrees Celsius in student-made 3D printers. As the heating temperature increases, the amount of energy and thermal insulation needed will increase as well. Other factors include the strength of the material, as that is important in most real world applications.

The challenge of printing onto uneven surfaces necessitates a method of preventing structural flaws in the materials laid due to gravity or the nature of the surface. One possible approach to solving this, especially if metals are being printed, is through the utilization of magnets. The extruder would apply a low magnetic field to the material printed, and the material would be mixed with magnetized platelets. Using a two-component material would also optimize control.

**Tensile Strength of PLA**

Researchers at Northwestern Polytechnic University conducted a study testing the ultimate tensile strength (UTS) of PLA with different printing orientations and thicknesses. They printed a thin, plate-like structure at 0, 15, 30, 45, 60, 75, and 90 degrees with respect to the flat surface, and did this for thicknesses of 0.1, 0.2, and 0.3 mm [[23]](https://www.zotero.org/google-docs/?ktVhG3).

The researchers used a tensile machine to determine the UTS of each plate. In this case, the direction of the filament grain determines which angle will be strongest, and the filament was strongest at 90 degrees. Both their theoretical and experimental results showed that the UTS decreased as the angle went from 90 to 0 degrees; specifically, for angles between 85 and 45 degrees, there was a sharp linear decrease from 55 MPa to 30 MPa, then the UTS levels off at around 27 MPa for angles less than 45 degrees [[23]](https://www.zotero.org/google-docs/?pOqMYo). Findings from [[23]](https://www.zotero.org/google-docs/?DNgYT2) also showed that as layer thickness increased from 0.1mm to 0.3mm, the UTS decreased.