

Course: Materials & Introduction to
Manufacturing Technology

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3D Printing

3D printing is the process of making 3 dimensional models from a digital file by layering a material into stacks until it forms the desired shape.

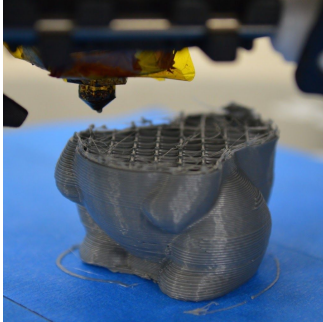


figure 1: a 3D printed model in the middle of being made(simplify3D).

The process starts by making a digital model of the thing you wish to print, this can be done by using CAD programs. The file is then uploaded onto the 3D printing software where the models will have to be arranged to fit into the printing pad before the printer can be started. Then the process differs slightly depending on the type of 3D printer being used, smaller printers will heat up the material and spray it onto the layers through a nozzle while larger industrial printers will melt the material with a Laser. Depending on the design that is being printed the printer may need to add supports to make sure the model doesn't fall over while it is still being made. If support material was used in the print it will need to be removed after the printing is done.

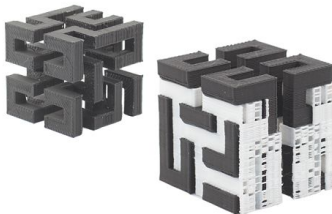


Figure 2: a 3D printed model with - on the right - and without - on the left - the support material(filabot, 2019).

The materials that can be used in 3D printing include a few plastics, metals and composites. One of the plastics that can be used in 3D printing is Acrylonitrile butadiene styrene (or ABS), it is a plastic that is strong, light and somewhat flexible and can be used for concept models and architectural models. Another plastic that can be 3D printed is Polylactic Acid (PLA) which isn't as strong as ABS but is both biodegradable and food safe, it can be used to make food containers, concept models and functional models. Another plastic that can be used is nylon which is strong and has a smooth surface when polished and can be used for concept models, medical purposes and visual arts.

A composite which can be used in 3D printing would be the material alumide which is a nylon aluminium mix which is strong and heat resistant, alumide can be used to make functional prototypes of products and DIY projects. A metal which can be used for 3D printing would be cobalt chromium, which is a strong, corrosion resistant material that is used in the medical and aerospace industries. Another metal that can be used in 3D printing would be bronze, a conductive, durable material which can be used in electrical engineering.

One of the advantages of using 3D printing is the freedom of design that it allows, using 3D printing allows you to make models of almost any design using support materials to stabilise it during the making process. Another advantage is it allows for prototype designs of a product to be made at a more affordable price than some other processes allowing mistakes to be spotted before large amounts would be spent on the real thing. Another advantage would be the cheaper process as very little work needs to be done once the printer is started saving on work costs.

A disadvantage of using a 3D printer would be the limited amount of materials a 3D printer can use with the technology not being advanced enough to use many with most of them materials it can use currently not being recyclable or food safe. Another disadvantage is the limited build room of 3D printers, most 3D printers have small building platforms which limits the size of products that can be made and if the product is larger than the printers build space it would need to be made into smaller parts or it couldn't be done.

Abrasive water jet cutting

Abrasive water jet cutting is the process of using high pressure water that has been mixed with an abrasive material to cut through hard materials.

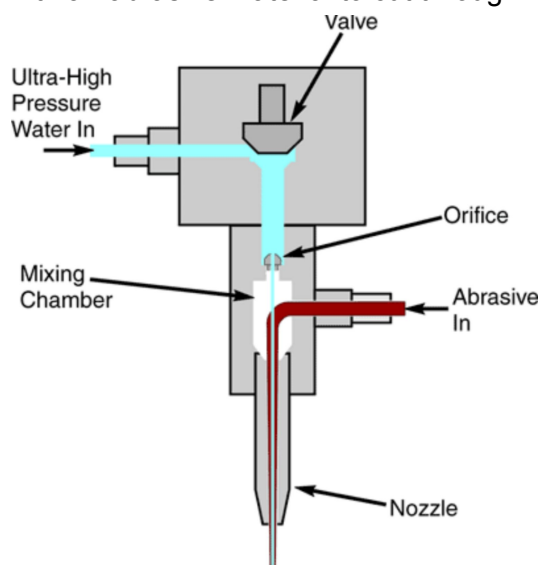


Figure 3: a diagram of a water jet cutting machine (blogspot.com, 2011).

The process uses CNC programs to guide the water where it needs to go in order to cut the materials in the desired way. The most popular material used as an abrasive material is red garnet, the garnet is good for water jet cutting as it will be non reactive with the material being cut and when it fractures it creates sharp edges to help it cut through the materials. The water used in water jet cutting can vary between 60'00 psi to 90'000 psi depending on how strong the material you are trying to cut is.

The process can be used on many different materials including metals and composites. Abrasive water jet cutting can be used to cut titanium of up to 20mm thick, Aluminium of 30mm thick and steel that's up to 25mm thick. It can also be used to cut ceramics up to 30mm Thick, glass up to 35mm thick and Concrete up to 50mm thick without problems. The

process is used by the aircraft industries and the automobile industries for cutting their materials. It can be used for cutting scrap materials into smaller more disposable pieces and robotised water jet cutting is used to destroy nuclear power plants.

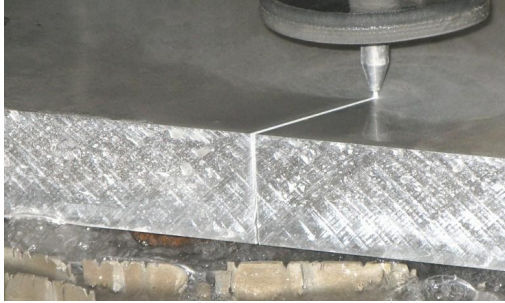


Figure 4: a water jet cutting machine cutting thorough a thick sheet of metal (Pradeep Nambiath, 2016).

One advantage of abrasive water jet cutting is the versatility of its uses, water jet cutting can cut through a large number of materials of various thickness letting it be used for many things. Another advantage is the smooth finish, due to the process using high pressure water to cut through the materials it leaves no marks on the material such as burn marks, cracking or burrs. Another advantage of the process is that there is no tool wear as tools aren't needed for the process which will help to save on funds.

A disadvantage of abrasive water jet cutting is the process actually takes longer than most others meaning that production output would be smaller than if you were to use one of the alternatives. Another disadvantage is that while the process can cut through thick materials it loses accuracy when the thickness of the material is increased meaning when cutting thicker materials it's more likely to cut outside of the desired parameters. A third disadvantage of abrasive water jet cutting is the costs of acquiring the abrasive materials, setting up the machine at first can be more expensive than other processes such as plasma cutting.

Nanomaterials

Nanomaterials are small materials with at least one dimension that is smaller than 100 nanometers, most nanomaterials are too small to be seen even with conventional microscopes. Nanomaterials can be made naturally but can also be made by scientists, these kind of nanomaterials are referred to as Engineered nanomaterials. Nanomaterials are used in both cosmetic and health field, for example they can be used in the health field for drug delivery. Nanoparticles are being developed that will be able to help deliver chemotherapy drugs straight to the cancerous growths. Nanomaterials are also used in sunscreen to help improve the UV protection in the long term.

An advantage of nanomaterials is that it can make energy production tools such as solar panel more efficient. Another advantage of nanomaterials is it will increase the accuracy of the construction of electrical circuits. Another advantage of nanomaterials is they allow for the bonding of cells and active ingredients in the medical fields meaning increased chances of fighting diseases.

A disadvantage of nanomaterials is our gaps in our knowledge about them often leads to difficulties during the manufacturing process. Another disadvantage is that if inhaled nanomaterials can possibly cause detrimental pulmonary effects such as pulmonary fibrosis. Titanium dioxide is a nanomaterial that is used in sunscreen due to its ability to reflect UV rays while also remaining transparent on the skin. Titanium dioxide has a tetragonal crystal structure meaning it has 3 perpendicular lines of atoms two of which are the same length.

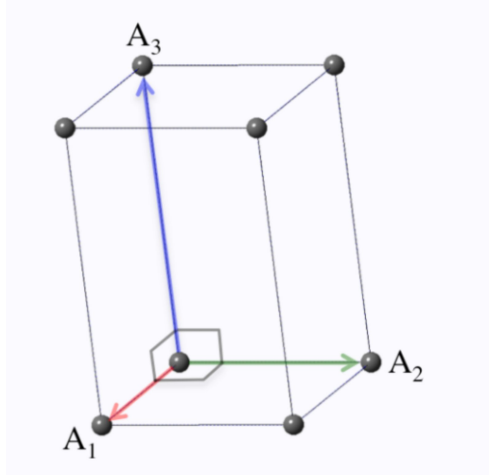


Figure 5: an diagram of a tetragonal crystal structure (aflowlib).

Titanium dioxide is a nanomaterial that is used in some sunscreens as its nanoparticles have a high Specific surface area and it contains many molecules that are effective at absorbing radiation from UV rays.

Titanium dioxide has been confirmed to be safe to use however it has been noted that Breathing in the nanoparticles can cause issues such as inflammation of the lungs and so should not be used in forms such as powders or sprays.

Bibliography

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Figure 3: blogspot.com (2011) accessed at:

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Figure 5: aflowlib accessed at:

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