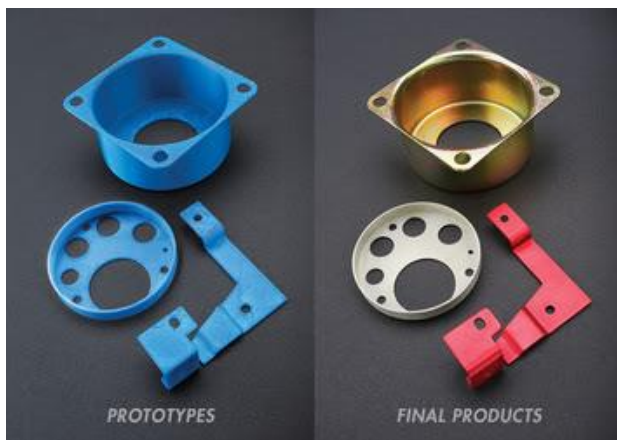


3D Printing & The Environment

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Keenan Pearce
BSc Product Design & Technology

3D Printing has had a massive impact on the world of manufacturing. Used in applications for prototyping, custom parts, small batch production and is now commonly used by hobbyists. It has revolutionized the way products are designed and created, but what are the ecological costs of this process?



Example of 3D printed prototypes

We live in a finite world and global warming is no longer a theory. People are now more conscious of the impact of their actions, and rightly so. Companies are doing their bit by making products from sustainable, recycled or reused materials. Not only is this great for the environment, but it can provide a reduction in business costs. For example, alternative power sources can often provide a reduced bill as opposed to burning fossil fuels.

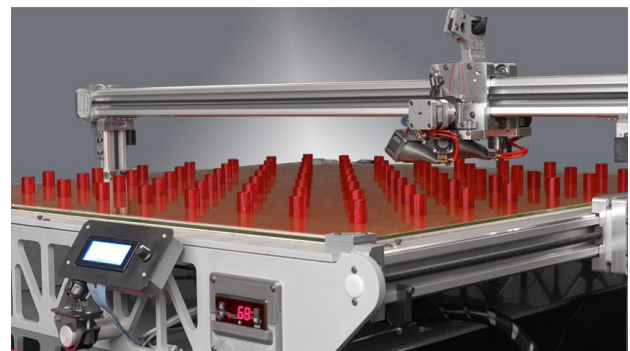
A survey taken in 2015 found that 66% of consumers were willing to pay extra for a more sustainable product¹. While this can get a larger profit, it also incredibly improves a company's image, attracting more clients. These consumers are doing their research and paying attention to the public is key to gaining positive image. Green is good and has little or no negatives to arise from designing and producing with the environment in mind.

The 3D Printing industry is growing tremendously, it is said by the US Department of Energy that the technology could be worth \$5 billion by 2020 and could drop energy costs by 50% and reduce material costs by 90%².

There are three categories for 3D Printer environments, Consumer, Industrial and Services. **Consumers** are the hobbyists, often owners of desktop FDM or SLA printers. Not heavy usage and nothing too complex. **Industrial** is commonly used for prototyping and testing but can be used in production if appropriate. Factories use test prints to check sizing and functionality of designs before moving onto more traditional machinery, such as injection moulding. Lastly, **Services** is a bit more modern where you can be offered 3D printing services as opposed to printing objects yourself. Websites such as 3D Hubs allow you to upload CAD files, these are printed by local production "printing farms" and then shipped to you.³ This site also offers CNC machining and injection moulding as other services.

Energy

In 2008, the Loughborough University and experts in the industry created the ATKINS project. A study that focuses on research towards low carbon additive manufacturing methods. They found using lasers or heat to melt plastic consumed up to 100 times more energy to produce an object of the same weight on a conventional manufacturing machine.⁴ In more basic terms; a 3D printer that produces 100 items a day would use the same amount of electricity as an injection moulding machine, that is capable of 1000 items a day. Not efficient for bulk production, but you do benefit from using less materials compared to alternative machining.

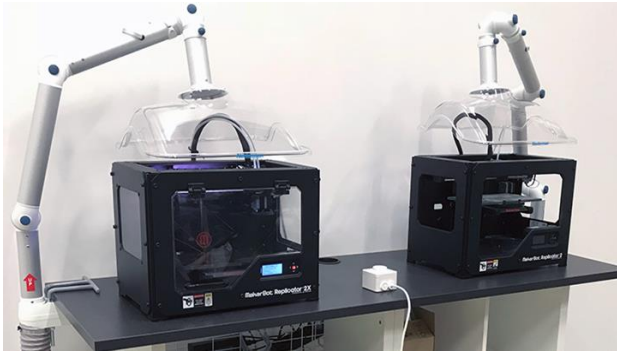


3D printer being used for bulk production

Materials

There are many materials a 3D printer can such as plastics, ceramics, organic materials, resins, starch, elastomers and even metals are printable. Each of these resources have their own benefits and limitations. **PLA** is a common FDM printable plastic made from corn starch, which is bio-degradable. It has a low melting temperature, reducing energy usage. However, it is not as strong as **ABS**, an alternative printable material.

ABS is not bio-degradable, but it is recyclable. It is also printed at a higher temperature, raising costs in energy. Some materials are known to emit harmful fumes when being melted. These are advised to be used with caution and appropriate extraction and ventilation should be used. **ABS** contains styrene which is a possible carcinogen and is reported to cause fatigue and headaches when fumes are inhaled⁵. Due to the properties of this material, it tends to warp unless it's being printed in an enclosure, which usually would have some sort of filtration device to improve safety.

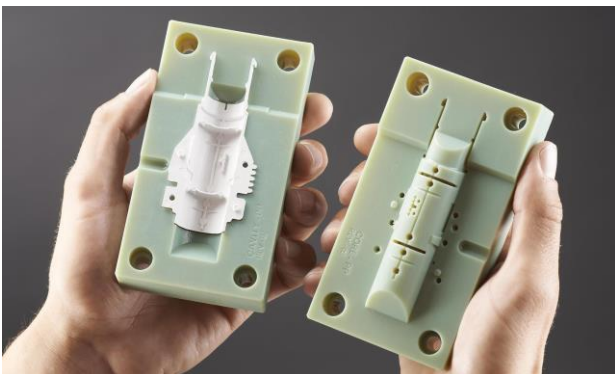


Fume extraction being used on printers

Waste Reduction

Using 3D printing constantly for large scale production can cause huge amounts of waste material from support structures and failed prints. Currently this excess material hasn't got much use unless the material being used is recyclable. In FDM printing, companies have started creating machines capable of melting waste plastic into useable filament. At this stage in development it's not very consistent and reliable compared to professional factory-made filaments.

Methods such as Injection Moulding and Casting require tooling or dies to create products. Even these methods have limitations what on shapes and forms you able to create. With 3D printing, you do not require any unique tools or moulds to create an object, reducing initial costs and labour. It is also possible to create more complex shapes.



Example of an injection mould die

Most people dispose of products if they get damaged or broken. With the help of 3D printing, consumers can repair and improve products. Fixing simple items such as a door handle, zipper pulls and even able to extend the life of phone chargers with printed braces/support. Replacement parts for flying drones are widely available on the internet as these parts tend to break often.

Transporting Products

In the previously mentioned ATKINS project, they also investigated the reduction of weight within 3D printed parts. The lighter transport cargo is, the less fuel the vehicle will use. 3D Printed parts can be up to 55% lighter than products made through traditional manufacturing methods and can also be stronger⁶. Printed parts are being utilized in the Aerospace industry. The Trent XWB is an engine that uses 1000 3D printed parts and according to Airbus this reduced the weight of the plane by over a ton. They also quoted that reducing the weight of a single pound across their fleet could save 14,000 gallons of fuel per year⁷.



The Trent XWB engine made from 3D printed parts

Case Studies

Although 3D printing has been around for about 35 years it's still being developed and improved rapidly. There are thousands of more possibilities to cover, including solutions to the world's current problems.

The University of California Los Angeles have figured a way to create a material like concrete from Carbon Dioxide using 3D printing. Concrete is utilized massively in our modern society, the turnover of cement and ready mixed concrete combined is around £2 billion in the UK alone⁸. Unfortunately, it's also one of the biggest contributors to greenhouse gas emissions when being produced. Currently UCLA are collecting CO₂ from smoke stacks in factories, then using 3D printers to create small parts⁹. As it stands this material has only been produced in a lab, but the concept shows the potential for future use.

The major sports clothing brand Adidas teamed up with the environmentalists Parley for the Oceans, and created a sustainable shoe made from

waste plastic in the ocean¹⁰. Part of the top of this shoe is woven with reclaimed gillnets, the rest of the top is made from plastic collected on Maldivian beaches. This repurposed plastic is processed using 3D printers. They quoted to have made 1 million sports shoes from 11 million plastic bottles¹¹. This has not only created a valuable product to the fashion industry but has cleaned the planet up.

While on the subject of oceans, a Caribbean Island called Bonaire is using 3D printers to help preserve their coral reefs¹². These fascinating reefs are home to some of the most diverse ecosystems on earth. Due to climate change and pollution, coral reefs are in danger of extinction. Ocean preservationists managed to replicate and print artificial coral pieces to attract sea life such as algae, crabs, anemones and many fish species. Coral reefs play a very important part in our ecosystem, and it's fantastic to see 3D printing being used to prolong their lives.



Examples of 3D Printed Coral Pieces

Conclusion

Overall, 3D printing helps reduce energy waste and give a smaller carbon footprint. The eco-friendly results of this technology are promising and expected to improve in the future. However, currently the technology we have is not 100% ecological. It's mostly reliant on plastic, a material which is in most cases considered bad for the environment. Researchers have already started to show confidence in alternative sustainable materials, including biodegradables and fully recyclables. Extracting raw materials for these plastics alone causes a large amount of energy consumption, finding a more environmentally compliant way of creating these materials is key to a healthy future. The possibilities are endless.

Printing products is very slow compared to other manufacturing methods, but it is ideal for prototyping and small batch production. Research is already showing a great improvement on speed and production capacity. Future technologies are only going to improve, and we could expect 3D printing to overtake traditional manufacturing methods.

As for the toxic fumes, there is no major evidence of harmful damage to humans, animals or plants. Although there still needs to be additional research into this subject, use of appropriate ventilation and safety equipment will counter the harmful effects. Manufacturers of desktop 3D printers have even started incorporating filtration systems into their products as standard, giving the consumer multiple material choices straight from the box.

In comparison to typical machinery used to create products, 3D printers are far less harmful to the environment and are only going to get better. We can expect printers to become carbon neutral and only use sustainable materials. This technology has revolutionized production and is only going to get faster, better and eco-friendlier.

Glossary

3D	Three-dimensional
ABS	Acrylonitrile butadiene styrene, a 3D printable thermoplastic.
CAD	Computer aided design.
CNC	Computer numerical control, the usage of a computer to control machine tools.
CO ₂	Carbon dioxide.
FDM	Fused Deposition Modelling, an extrusion-based printing method.
PLA	Polylactic acid, a 3D printable thermoplastic.
SLA	Stereolithography, a resin & laser-based printing method.
UCLA	The University of California, Los Angeles.

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