3D Printing Technology: Design and Performance in Civil Structures and Biomedical Applications

Figure 1. 3d printer (Created by Jakub Zerdzicki)

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Imagine downloading an image tonight and holding it in your hands tomorrow. No factory, no shipping, just a printer creating it on your desk. That is the reality of 3D printing.

WHAT IS 3D PRINTING?

Three-dimensional technology was created with the intent of creating an even more lifelike and immersive experience through the replication of human binocular vision, allowing flat images to have depth.

WHAT WAS THE PROBLEM?

- Traditional manufacturing was so slow
- It could take weeks or months to create an initial version of a part.
- Creating molds and using machines to make prototypes was very expensive, even making a single part expensive.
- Because the entire manufacturing process would have to be recreated when a designer needed to make a design change, it was difficult for designers to make design changes.
- Because they couldn't afford to waste time, engineers wanted to test and revise their designs rapidly.

Chuck Hall

Charles Hull states he initially wanted to resolve an actual workplace issue. He worked at a company using UV light to dry tabletop coatings, when in 1983, he needed to produce prototype plastic parts with the aid of injection molding.

Hull stated that the process of making prototypes via injection molding was very slow and cumbersome. He realized producing mold would require a lot of time and labor. As such, he started looking into ways to rapidly and easily produce prototype parts.

This search for increased workplace efficiency eventually led to the development of printed three-dimensional parts, which formed the basis for today's three-dimensional printing technology.

Fig 2. Chuck 3d printing versions of himself (epo.org)

What?

He created "**Stereolithography**" (SLA), allowing CAD computer-aided design software to translate data to create 3D objects. This is a method of printing 3D objects layer by layer using ultraviolet light to cure resin.

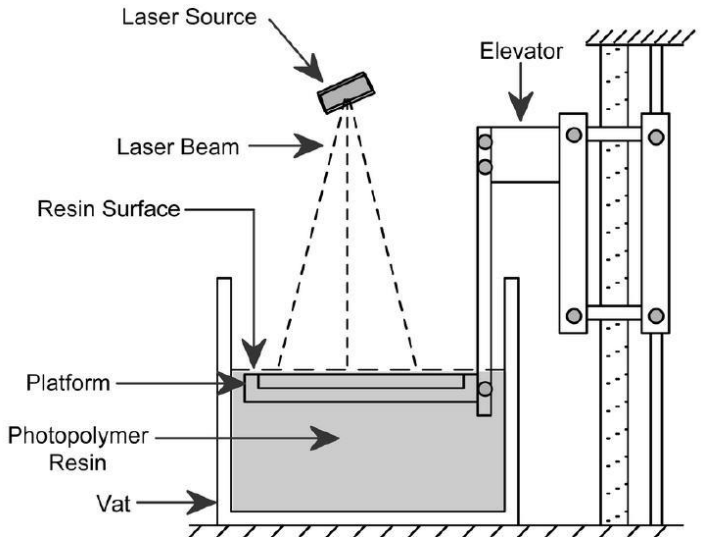


Fig 3. Stereolithography machine (White clouds)

When:

The first 3D printed part was created in 1983, with the **patent** filed in 1984. The First Official Product: The first commercial 3D printer, the SLA-1, was released in 1987.

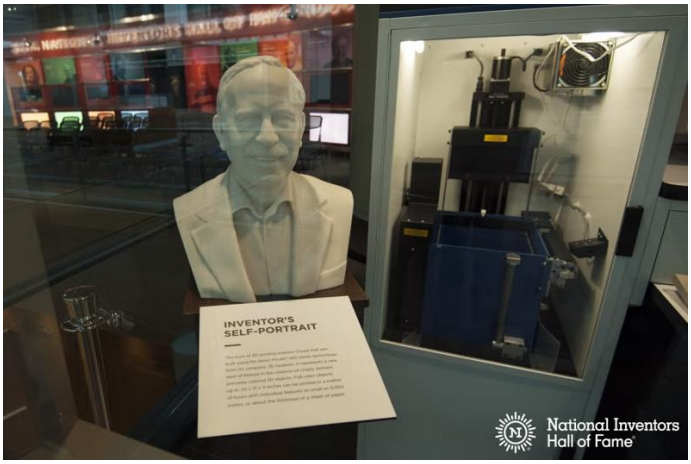


Fig 4. The first 3D printer ever made, the SLA-1 (3D systems)

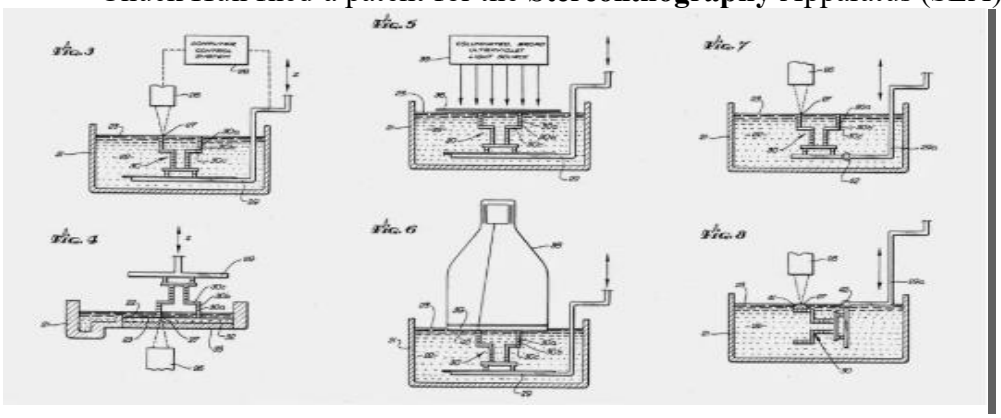
Timeline

1983

- Inventor Chuck Hull created the first-ever 3D printed item and invented **Stereolithography.**

1984

- Chuck Hull filed a patent for the **Stereolithography** Apparatus (SLA).



1986

- Chuck Hull founded 3D Systems which became the first 3D printing company.

1987

- Chuck Hull's 3D Systems commercialized the first 3D printer, the SLA-1 Stereolithography (SLA) printer.

1989

- Selective Laser Sintering (SLS) was patented.

1993

- Filing of a patent on an innovative force-feedback haptic device.

1996

- Color Jet Printing (CJP), a 3D powder-based system class, was commercially developed.

- MultiJet Printing (MJP) 3D printers were commercially released from 3D Systems.

2000

- First Simbionx virtual reality surgical simulator released.

2006

- Scan-based design software for reverse engineering that has been patented has been brought to the marketplace.

2009

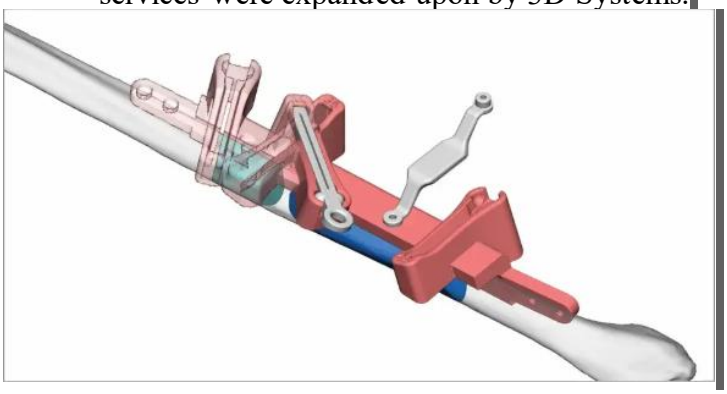
- On-Demand Parts Manufacturing capability launched by 3D Systems.

2013

- Direct Metal Printing (DMP) added to the portfolio at 3D Systems.

2014

- Virtual Surgical Planning (VSP) and other industry-leading 3D healthcare products and services were expanded upon by 3D Systems.



2014

- National Inventors Hall of Fame induction for Chuck Hull; European Inventor Award received.

2016

- Next Generation Stereolithography, Figure 4 SLA technology showcased by 3D Systems.

2018 - Entry-level industrial and projector-based imaging added to 3D Systems offerings in 3D printing.

Key Words

Stereolithography - Stereolithography (SLA), is an extremely accurate method of 3-dimensional printing, in which layers are created using a UV laser to "cure" a liquid plastic resin to create a hard, highly detailed plastic part

LiDAR - LiDAR (Light Detection and Ranging) is an advanced remote-sensing technology that measures distance by using rapidly firing laser pulses, thousands every second, to generate extremely accurate three-dimensional representations of a user's surroundings.

Patent - A patent is a temporary (normally 20 years), exclusive right given to an inventor by the government for the invention of something new. The inventor obtains the exclusive right to manufacture, use, or sell the invention.

Relation to Biomedical Engineering

Implants and Prosthetics: 3D printing allows the creation of customized, patient-specific implants, such as cranial plates or bone scaffolds, which improve fit and reduce recovery time.

Fig 5. World's first 3d printed titanium chest implant (created by Commonwealth Scientific Industrial Research Organization CSIRO)

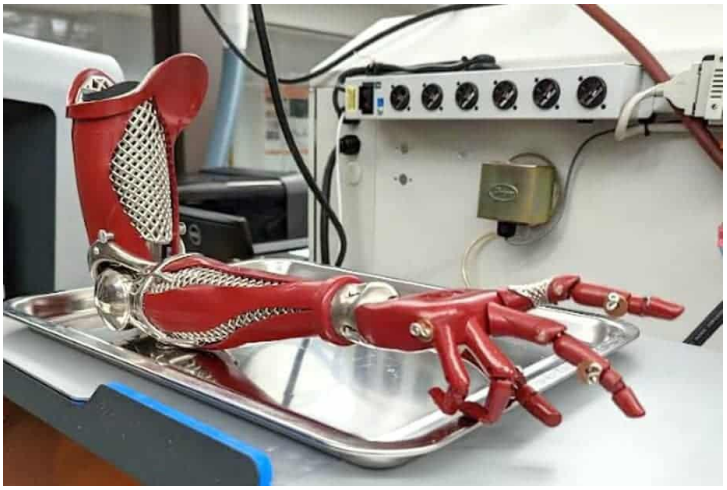


Fig 6. A 3D prosthetic arm (Photo credit: Dr. Jade Myers)

Relation to civil engineering

Civil Engineers used Autodesk software such as AutoCAD to create 3D models for the machine to 3D print. This helps them to visualize complex designs and how to go about starting construction and saving time on creating a faster prototype.

Fig 7. The future of 3d printed bridges (New Civil Engineer)

Fig 8. Pictures showing the first 3d built bridge

3D printing in Civil Engineering

Three-dimensional (3-D) printing or "Additive manufacturing" is a process in which buildings and parts are created using digital models. As compared to traditional construction processes, 3-D printing reduces waste, decreases cost, and increases the speed of construction.

Fig 8. A 3D machine printing a house

• Drone technology has changed civil engineering for the better. Civil engineers can now use drones to collect information about a site from an elevated view, assess structural damage without putting people at risk, improve on-site safety, and lower their project timeline and budget.

Fig 9. A picture showing how a drone can be used to collect information from a cite.

• The **LiDAR** system uses a series of high-speed laser pulses that generate 3-D models of topography and man-made objects with detail. These 3-D models allow civil engineers to make more accurate plans and designs for future construction and infrastructure development.

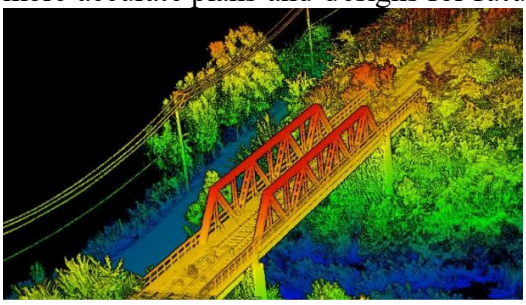


Fig 10. The LiDAR system using laser beams

Resources

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