

## 9. 3D-PRINTING: ACHIEVEMENTS, PERSPECTIVES AND ISSUES

*Kulik M.I.*

*Belarusian State University of Informatics and Radioelectronics  
Minsk, Republic of Belarus*

*Bulavskaya T.V. – Senior Lecturer*

This paper has a purpose to explain what 3D printing is, which technologies are used there and what 3D printing applications are. Additionally, the article covers 3D printing limitations and issues.

The concept of 3D printing, creation of 3D physical object from a digital design, emerged in 1940s and 1950s in science fiction stories, leading to early patents and developments in the 1970s and 1980s by figures like Johannes F. Gottwald and Chuck Hull. Additive manufacturing processes like stereolithography and fused deposition modeling (FDM) were pioneered during this time. In the 1990s, further advancements led to the development of metal sintering and melting techniques. The 2000s witnessed the expansion of 3D printing into industries like architecture and medicine, with projects like RepRap and Fab@Home making strides in affordable, open-source printing. As the technology matured in the 2010s, 3D printing became integral to industries like aviation, with notable applications in jet engine manufacturing. By 2020, 3D printers became more accessible, and groundbreaking developments like the world's first fully 3D-printed prosthetic eye in 2021 showcased the technology's potential for medical innovation [1]. Unlike manual manufacturing, 3D printing production does not require a line of machines for each specific task or component.

There exist seven primary types of 3D printing technologies [2], each offering unique processes and capabilities. Among these, the simplest is material extrusion, a method where materials such as plastics, concrete, metals, and even food substances are extruded through a nozzle in successive layers. Moving on, vat polymerisation represents another method, which involves the use of light to solidify photopolymer in a vat. Despite usually requiring post-processing, vat polymerisation offers enhanced precision and surface finish, making it suitable for applications where details and accuracy are crucial. Similarly, powder bed fusion operates on the principle of layer-by-layer construction, utilising powder particles as the base material. In this process, a thermal source selectively melts the powder particles, which fuse together to form the desired object. This method allows the creation of intricate and precise components, particularly in metals and ceramics. Material jetting combines aspects of material extrusion and vat polymerisation by depositing tiny droplets of material that are solidified using light. This technique enables the production of parts with high resolution and intricate texturing, making it ideal for prototyping and small-scale production. Binder jetting, on the other hand, employs a liquid binding agent to bond powder particles together layer by layer. This method offers versatility in material selection and can produce large, complex parts with relatively fast build times. Directed Energy Deposition (DED) represents a distinct approach that utilises a focused energy source, such as a plasma arc, laser, or electron beam, to melt material as it is simultaneously deposited by a nozzle. DED is particularly suited for repairing and adding material to existing components, as well as for producing large-scale metal parts with high precision. Lastly, sheet lamination differs from the aforementioned methods by utilising mechanical force to bend and cut sheets into the desired form.

3D printing technology revolutionises various industries with its versatility and efficiency (Figure 1).

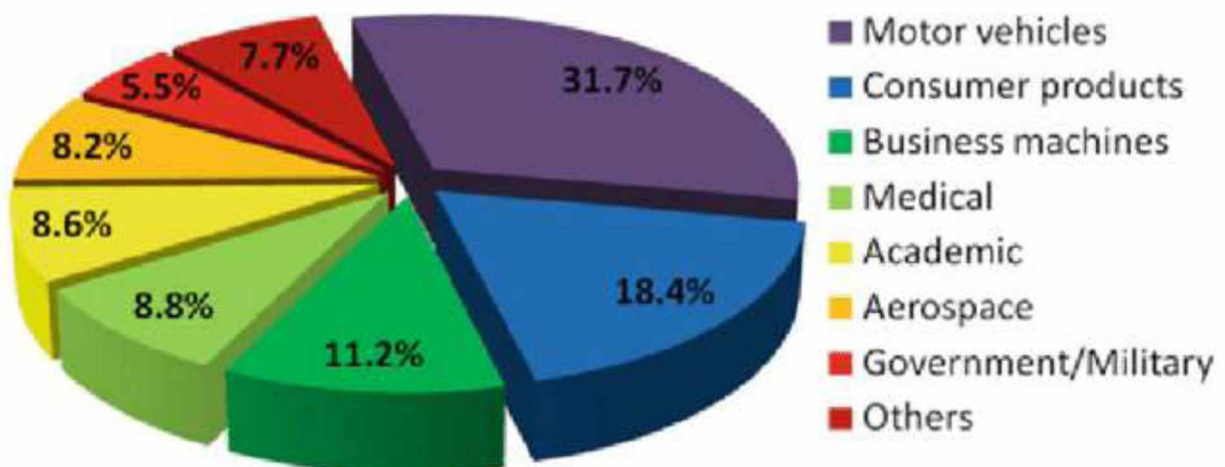


Figure 6 – Industries that use 3D printing

In aerospace, it enables the production of lightweight components with intricate designs, reducing energy consumption and material usage while facilitating the rapid manufacturing of spare parts for critical components like engines. Similarly, in automotive manufacturing, 3D printing allows creation of complex structures, exemplified by innovations such as 3D-printed electric cars and buses. Companies like Ford and BMW utilise this technology for prototyping and manufacturing engine parts, streamlining production processes and reducing costs. In the food industry, 3D printing caters to specialised dietary needs by customising food products and enhancing nutritional profiles, minimising waste in the process. Healthcare benefits from 3D printing through the creation of skin, tissues, and organs, offering personalised medical solutions and advancing research in various medical fields. Architecture and construction leverage 3D printing for intricate building components and entire structures, streamlining design processes and improving communication between stakeholders. In the fabric and fashion industry, 3D printing enables the production of customised clothing, shoes, and accessories, offering consumers unique products while optimising supply chains. Finally, in the electric and electronic industry, 3D printing drives innovation in the production of electronic devices and components, offering cost-effective and sustainable manufacturing solutions. Furthermore, 3D printing allows us to create visual examples for study purposes, such as chemical elements structures, geology maps, some biological replicas, historical artefacts, inventions prototypes, and so on [3].

Despite significant advancements in accuracy and versatility, 3D printing still faces certain limitations that influence its adoption and effectiveness. Speed remains a concern, especially for large or intricate objects, as the layer-by-layer process inherently consumes time. Balancing resolution and speed is crucial, as achieving high resolution often comes at the expense of printing speed, and vice versa, demanding careful consideration based on project requirements. Moreover, many 3D-printed objects necessitate post-processing to achieve desired surface finishes, strength, and functionality, adding to production time and costs. Size constraints of print volumes can limit the scale of objects produced, requiring assembly of larger components or specialised printing techniques. Additionally, because of 3D printers' versatility, it is much harder to use it as a part of a conveyor belt that is extremely effective and time-saving in manufacturing.

3D printing also raises significant concerns regarding health, copyright infringement, and the proliferation of illegal activities. One pressing issue involves health risks associated with the release of hazardous fumes during the 3D printing process. As materials melt and solidify, they emit potentially harmful particles and chemicals, posing health hazards to operators and nearby individuals. Furthermore, the ease of access to 3D printing technology has amplified concerns regarding copyright infringement. With the ability to replicate intricate designs with relative ease, individuals can produce counterfeit products, violating intellectual property rights and undermining the efforts of creators and innovators. Another critical concern revolves around the potential misuse of 3D printing technology for manufacturing guns and facilitating illegal activities such as drug distribution and counterfeit production. The advent of the Liberator, a 3D-printed gun, has sparked debates about the regulation of 3D-printed firearms and the implications for public safety and national security [4]. Moreover, the anonymity and accessibility of 3D printing platforms enable individuals to produce untraceable and illicit items, posing significant challenges for law enforcement agencies and regulatory bodies. Addressing these issues requires a comprehensive approach that balances innovation with regulatory measures to mitigate risks and ensure the responsible use of 3D printing technology in society.

In the future, 3D printing promises transformative changes across industries. Through customised implants and organs, 3D printing revolutionises healthcare, offering tailored solutions that improve patient outcomes and accessibility. By minimising waste and optimising material usage, additive manufacturing promotes sustainability in manufacturing, enabling the creation of lightweight, durable components for various applications. Moreover, in design and architecture, 3D printing unlocks new creative possibilities, allowing architects and designers to explore intricate forms and structures previously unattainable. The accessibility of 3D printing tools empowers individuals to prototype and manufacture inventions, fostering a culture of innovation and entrepreneurship. However, realising the full potential of 3D printing requires addressing challenges such as regulatory frameworks, intellectual property rights, and ethical considerations to ensure responsible innovation. By embracing the transformative power of 3D printing, we can create a future where creativity, sustainability, and accessibility drive progress and reshape industries and societies for the better.

#### **References:**

1. 3D printing [Electronic resource]. – Mode of access: [https://en.wikipedia.org/wiki/3D\\_printing#History](https://en.wikipedia.org/wiki/3D_printing#History). – Date of access: 01.03.2023.
2. The 7 Main Types of 3D Printing Technology [Electronic resource]. – Mode of access <https://all3dp.com/1/types-of-3d-printers-3d-printing-technology/>. – Date of access: 02.03.2023.
3. Shahrubudin N. An overview on 3D printing technology: Technological, materials, and applications / Shahrubudin N., Lee T. C., Ramlan R // *Procedia Manufacturing*, 2019. – P. 1286-1296.
4. Walther G. Printing insecurity? The security implications of 3D-printing of weapons / Walther G. // *Science and engineering ethics*, 2015. – P. 1435-1445.