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# INFLUENCE OF ADDITIVE TECHNOLOGIES AND SELECTION OF MATERIALS ON THE QUALITY OF 3D PRINTED BRAILLE MODELS

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*This research paper aims to study the effects of additive manufacturing technologies and material selection on the accuracy and legibility of 3D printed Braille models. The article looks at the different additive manufacturing technologies used to create Braille models, as well as the advantages and disadvantages of each technology. In addition, the article examines different materials that can be used to create 3D printed Braille models and how the choice of materials can affect the accuracy and legibility of the models. The article also discusses how a comparison chart can be used to measure the impact of material selection on the quality of 3D printed Braille models. As a result, the analyzed information is obtained about the influence of additive manufacturing technologies and the choice of materials on the accuracy and legibility of 3D printed Braille models. This study offers researchers and manufacturers valuable information on the selection of materials and technologies for 3D printing followed by the formation of 3D models using Braille. Since the technology of additive manufacturing is a promising and modern technology that changes the principles of approaches to production, it is able to improve the quality of information transmission, including for people with visual impairments to receive the information from external sources. And for this, tools and technologies are needed that can develop inclusive education. At the same time, there are questions about how to use additive manufacturing technology for inclusive education and standardization regarding three-dimensional models with Braille. Therefore, it is necessary to carry out the analysis and research in this direction, and to bring the creation of three-dimensional models with the Braille font, using additive technologies to certain standards. A further direction of research can be the analysis of the properties of each material and the impact on the quality of models with relief dot font and the optimization of materials for 3D printing of such models.*

***Keywords:*** *3D-printing, Braille, models, materials, additive manufacturing.*

**Formulation of the problem.** Active development of additive manufacturing took place in the 21st century, integrating in many areas of production. The relevance of this topic lies in the research and analysis of additive manufacturing, that is, 3D printing and the impact of 3D printing materials on the creation of three-dimensional models with Braille. Since inclusive education is being actively implemented in the modern world, including for people with visual impairments, there is a problem that needs to be solved with the access to education, services, and information for people with vision problems.

To solve this problem, additive manufacturing can help and accelerate the development of inclusive education and open wide access to information.

**Analysis of recent research and publications.** Articles on the subject of this study are mostly devoted to the analysis of additive manufacturing, the influence of materials on the quality of three-dimensional models using Braille. Most often, scientists describe the working principle of additive manufacturing, 3D printing technology, and pay special attention to the field of medicine. However, most articles superficially describe additive manufacturing technology and problems that may arise in various areas of production. In addition, the least attention is paid to the influence of 3D printing materials on the model, especially the model where the raised-dot Braille font is used.

**Aim.** Determination and analysis of factors and materials for 3D printing that affect the quality of 3D models with relief dot Braille using additive manufacturing. The study of the factors affecting the technological processes of additive manufacturing will allow one to optimize it and achieve the desired result of 3D printing of models with Braille font.

**Presentation of the main research material**

Additive manufacturing technologies have revolutionized the way one creates three-dimensional models. The use of this technology has allowed one to create models with high accuracy and precision. This technology has also been instrumental in the development of Braille models. Braille is a writing system used by people with visual impairments. The use of 3D printing technology has enabled the creation of Braille models, which can be used to make the learning process for visually impaired people an enjoyable experience. However, the accuracy and legibility of 3D printed Braille models can be affected by various factors such as the selection of additive manufacturing technology and material.

The term "additive manufacturing" refers to the technologies used to build three-dimensional objects by layering superfine materials one at a time [1]. This type of production has revolutionized the manufacturing industry and has opened up a world of possibilities for the creation of intricate objects [2]. Additive manufacturing is also commonly referred to as 3D printing, and it is the opposite of subtractive manufacturing [3]. This type of production is broken down into seven main categories including material extrusion, sheet lamination, binder jetting, material jetting, directed energy deposition, powder bed fusion, and vat photopolymerization [4, 5]. Each of these techniques requires different materials, layering, and machine technology [6]. Additionally, there are a number of support technologies such as software systems, vacuum casting, and post-processing equipment that are necessary for the success of additive manufacturing [7, 8]. Furthermore, Additive Manufacturing Technologies provides an in-depth look at the digital methods and applications for adding materials together to form parts [2]. All in all, additive manufacturing has become an integral part of the modern manufacturing industry and has enabled new possibilities when it comes to creating Braille models.

Additive Manufacturing Technologies (AMT) offer a wide range of digitally driven methods and applications for adding materials together to form parts [2]. The term "additive manufacturing" (AM) or additive layer manufacturing (ALM) refers to the

technique of growing a three-dimensional object by adding one superfine layer at a time [1, 9]. This process is the opposite of subtractive manufacturing, which removes material from a solid block to form the desired object [3]. Additive manufacturing is a computer-controlled process that involves several steps, such as the preparation of a 3D file, slicing the file to create the digital model, and then printing the model [8, 9]. EWI specializes in all seven types of additive manufacturing processes. These include material extrusion, sheet lamination, binder jetting, material jetting, directed energy deposition, powder bed fusion, and vat photopolymerization [5, 6]. The selection of the proper additive manufacturing technology affects the accuracy and legibility of 3D printed Braille models. Each type of process has its own advantages and disadvantages. For instance, powder bed fusion is a high-precision process that produces products with a high level of detail, but it is also expensive and time-consuming [4]. On the other hand, material extrusion is a cost-effective process, but it is not as precise as other processes. AMT PostPro offers advanced 3D printing post-processing equipment that can help elevate the quality of prints [7]. By using the right combination of additive manufacturing technologies and post-processing equipment, the accuracy and legibility of 3D printed Braille models can be improved.

Additive Manufacturing (AM) is a process used to create three-dimensional objects from digital models. It is also known as additive layer manufacturing (ALM) [9]. It works by adding successive layers of material that are bonded to the object being printed [1]. This process is the opposite of subtractive manufacturing, where objects are created by removing material from a solid block [3]. Each additive manufacturing technology has advantages and disadvantages. For example, the most common type is material extrusion, which uses a nozzle to deposit plastic or metal in successive layers [4, 5]. This type of 3D printing is very efficient and cost-effective, but it is limited to using only one type of material [10]. Sheet lamination is another common type of additive manufacturing. This process uses sheets of material that are bonded together with adhesive to create an object [5]. The advantage of this technology is that it can use multiple types of materials, but it is less efficient than material extrusion [8]. Post-processing is also an important part of additive manufacturing [7]. This involves smoothing the surface of the object, depowering, and surface blasting to improve the quality of the 3D printed object. Post-processing is essential for achieving the highest quality 3D prints [6].

Material selection is a complex process which requires understanding of a wide variety of factors. In product development, the chosen material can significantly affect the success of the product, its performance, costs, lifespan, and environmental impacts [11]. For instance, when using a jig, choosing aluminium over mild steel can reduce carbon emissions by 60% and reduce costs [12]. However, it is important to note that different building materials have their own advantages and disadvantages [13], and inadequate material selection can lead to negative consequences. Therefore, there are many aspects to consider when selecting materials, from environmental and ethical issues to mechanical and electrical properties [14]. This process requires knowledge of the intricacies of each material and the ability to identify the possible trade-offs when selecting materials [15, 16]. Ultimately, the goal is to choose the optimal material which

meets the project's requirements without compromising its performance or causing harm to the environment.

Making the right material selection is a crucial step in achieving a successful product. The material selection process considers a range of criteria, from environmental impact and cost to performance and longevity [11, 15]. It is important to assess the environmental impact of the materials used [16, 17], as the extraction of materials for manufacturing can have a negative impact on the environment and local communities [12]. Moreover, it is essential to understand the trade-offs involved when making material selection decisions [13]. Each material has its own strengths and weaknesses, and the choice of materials can greatly impact the lifespan and performance of the product or structure. Poor material selection can lead to performance issues, cost increases, and environmental damage. This is especially pertinent when it comes to 3D printing Braille models, as the selection of material has a direct effect on the accuracy and legibility of the models (Table 1).

Table 1

**Compare materials for 3D-Printing**

| Material | Strength | Flexibility | Transparency | Water resistance |
|---|---|---|---|---|
| PLA | Average | Low | Low | Low |
| ABS | High | Average | Low | Low |
| PETG | High | High | Average | High |
| Nylon | High | High | Low | High |
| TPU (flexible plastic) | Low | High | High | Average |
| Resin | It varies | It varies | It varies | It varies |

In today's world, the choice of material selection for 3D printed Braille models is an important consideration for product development, as it can influence the performance, cost, and environmental impact of the product [11]. It is important to understand the trade-offs between the available materials for the 3D Braille models [13], such as aluminium and mild steel, as this will help identify the material that best meets the functional requirements of the 3D Braille models [18]. The environmental impact of the material used should also be taken into consideration [17], with sustainable materials obtained from recycled, reused or renewable sources being preferred [16]. The art of material selection extends beyond simply choosing a material that meets the project's basic requirements [15], and also involves taking into account the possible negative health and environmental impacts of the raw material extraction [12]. Therefore, a comparison table is a useful tool to measure the impact of material selection on the quality of 3D printed Braille models.

The impact of additive manufacturing technologies and material selection on the accuracy and legibility of 3D printed Braille models is a topic of great interest in the

manufacturing industry. The research paper highlights the various types of additive manufacturing technologies and the importance of material selection in the production of Braille models. The seven main categories of additive manufacturing, including material extrusion, sheet lamination, binder jetting, material jetting, directed energy deposition, powder bed fusion, and vat photopolymerization, each require different materials, layering, and machine technology. The selection of the proper additive manufacturing technology affects the accuracy and legibility of 3D printed Braille models, and a comparison table is a useful tool to measure the impact of material selection on the quality of the models. The study also emphasizes the importance of post-processing equipment, such as AMT PostPro, in elevating the quality of prints.

**Conclusions.** Additive printing is a very promising technology and can use many materials. While the research paper provides valuable insights into the impact of additive manufacturing technologies and material selection on Braille models, there are limitations to the study that should be acknowledged. For instance, the study does not explore the impact of environmental factors on the quality of 3D printed Braille models. Future research could study how factors such as temperature and humidity affect the accuracy and legibility of models. Overall, the research paper contributes to the ongoing advancement of knowledge in the field and highlights the potential of additive manufacturing in creating intricate objects such as Braille models.

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## ВПЛИВ АДИТИВНИХ ТЕХНОЛОГІЙ ТА ВИБОРУ МАТЕРІАЛІВ НА ЯКІСТЬ 3D-ДРУКОВАНИХ МОДЕЛЕЙ БРАЙЛЯ

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*Ця дослідницька стаття спрямована на дослідження впливу технологій адитивного виробництва та вибору матеріалів на точність і розбірливість 3D-друкованих моделей Брайля. У статті будуть розглянуті різні технології адитивного виробництва, які використовуються для створення моделей Брайля, а також переваги та недоліки кожної технології. Крім того, у статті розглядаються різні матеріали, які можна використовувати для створення 3D-друкованих моделей Брайля, і те, як вибір матеріалів може вплинути на точність і розбірливість моделей. У статті також буде обговорено, як порівняльну таблицю можна використовувати для вимірювання впливу вибору матеріалу на якість 3D-друкованих моделей Брайля. У результаті було отримано проаналізовану інформацію про вплив*

*технологій адитивного виробництва та вибору матеріалів на точність і розбірливість 3D-друкованих моделей Брайля. Це дослідження пропонує науковцям і виробникам цінну інформацію щодо вибору матеріалів і технологій для 3D-друку з подальшим формуванням тривимірних моделей за допомогою шрифту Брайля. Оскільки технологія адитивного виробництва є перспективною та сучасною технологію, яка змінює принципи підходів до виробництва, здатна покращити якість передавання інформації, в тому числі для людей з вадами зору отримувати інформацію від зовнішніх джерел. А для цього необхідні інструменти та технології, які зможуть розвивати інклюзивну освіту. Разом з тим, виникають питання, як використовувати технологію адитивного виробництва для інклюзивної освіти, та стандартизація щодо тривимірних моделей з шрифтом Брайля. Тому необхідно проводити аналіз та дослідження в цьому напрямки, та привести до певних стандартів створення тривимірних моделей з шрифтом Брайля, використовуючи адитивні технології. Подальшим напрямком досліджень може стати аналіз властивостей кожного матеріалу та вплив на якість моделей з рельєфним крапковим шрифтом та оптимізація матеріалів для 3D-друку таких моделей.*

***Ключові слова:*** *3D-друк, шрифт Брайля, моделі, матеріали, адитивне виробництво.*

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