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Comprehensive Analysis and Review of Advancement in 3D Printing

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Abstract: *The use of 3D printing, also known as additive manufacturing, has revolutionized various industries by making actual objects from digital models. This investigation looks atthe rapid advancement and widespread application of 3D printing in sectors like healthcare, aviation, agriculture, and autos. It demonstrates how intricate patterns may be created using 3D printing with minimal materialwaste and post-processing. The analysis of 124 papers from 2014 to 2018 demonstrates an increase in interest in the benefits of 3D printing. It also examines how technology is used in pharmaceuticals and personalized medicine, emphasizing how it may be used to create state-of-the-art medication delivery and medical equipment. The foundation for adetailed analysis of the advancements and implications of 3D is laid forth in this introduction*

Keywords: 3D printing

I. INTRODUCTION

The production of physical products has undergone a significant transformation becauseto 3D printing, also known as additive manufacturing, which makes it possible to fabricate complex geometries straight from digital models. With the invention of stereolithography and the STL file format by Charles Hull in the 1980s, this technology had its commercial debut. 3D printing has a wide range of uses, from creating complex jewelry and mechanical heart pumps to creating rocket engines and corneas. This creative method highlights the adaptability of 3D printing, starting from the layer-by-layer creation straightfrom CAD files. Manufacturing has advanced significantly as a result of the capacity to makeintricate components with complicated surfacesthat are difficult to do with conventional methods. Industry 4.0 emphasizessustainability, material compatibility, andintegration.

Using a variety of techniques, additive manufacturing turns digital data into three- dimensional structures and prototypes. For these technologies to function, solid modeling in CAD is essential as it allows complicated forms to be precisely created layer by layer. This has prompted research into a range ofmaterials and sustainability initiatives, particularly in the electronics, automotive, and aerospace industries. The potential of 3Dprinting has been further enhanced by its confluence with nanotechnology, which has made it possible to create novel medication delivery systems, tissue engineering methods, and cutting-edge medical equipment. Researchers are able to produce complex structures at the nanoscale through the use of nanomaterials in 3D printing methods, which can improve medication efficacy and enable customized therapies. The capacity to create personalized goods with improved qualities is a significant change from conventional production techniques.

Particularly in Europe and Asia, research on 3Dprinting technology has increased dramatically,with a concentration on case studies and experimental study. Fewer studies focus on thesocial implications of 3D printing, even as manywork to enhance 3D printing technology and product development. Reduced lead times, better designs, less prices, and higher-quality goods are some advantages of 3D printing. Butproblems like rising prices and scalability problems still exist. 3D printing has become more widely available to consumers because tomethods like stereolithography (SLA) and fused deposition modeling (FDM), which also lower waste and production costs. The potential of 3Dprinting technology to transform conventional manufacturing processes and have an influenceon everyday life is becoming more and more evident as it advances, pointing to a day when inexpensive, high-quality, personalized itemswill be readily available in the future.

II. HISTORICAL BACKGROUND AND EVOLUTION

The earliest additive manufacturing techniques were developed in the late 1970s, which is when the history and development of 3D printingtechnology began. The practical applications of3D printers were first limited by their size and cost. Hideo Kodama of the Nagoya Municipal Industrial Research Institute printed the first physical object from a computer design, marking an important milestone. In 1984, Charles Hull, the creator of 3D Systems Corp., created the first 3D printer, advancing the technology even further. Technology progressed over time, giving rise to a range of additive manufacturing techniques that revolutionized the sector. The review articleexplores the modeling and finishing procedures related to 3D printing, including utilizing finishing techniques and CAD design software to generate printable objects from 3D scanners.

After being adopted by the automobile industry for quick prototyping, 3D printing quickly spread to manufacture gearbox parts, drive shafts, and brake system components. It evolved into a useful tool in the dentistry and medical domains for making personalized implants and prostheses, with ground-breaking potential for 3D bioprinting to create bones, tissues, and even live organs. Because 3D printing is so effective at turning ideas into reality, the creative and fashion sectors have also embraced technology.Designers are now able to create a vast array ofaccessories, such as hats, spectacles, and shoes. The study emphasizes the revolutionary effects of nanotechnology and 3D printing, especially their combined promise for novel pharmaceuticals and tailored medical treatments. Researchers have discovered new avenues for producing complex nanoscale structures through the integration of nanomaterials, perhaps leading to improved medication

III. TECHNOLOGICAL ADVANCEMENTS

In order to meet the challenges of complicated in situ printing situations, technologicaldevelopments in "Visual control for robotic 3Dprinting on a moving platform" constitute asignificant step forward. An innovative platform-independent 3D manufacturing approach that allows printing on platforms withnon-cooperative movement has been made possible by the combination of robotics andcomputer vision. The creation of a closed-loop visual feedback-controlled robotic printing method is a crucial component of this breakthrough. With two asynchronous loops— an outer measurement loop and a high-speed inner control loop—this system uses a marker- based visual detection and tracking controller configuration. While the outer loop manages marker recognition and picture capture, the inner loop creates positional control commandsin GCODE format. Using real-time feedback and marker-based detection, Even in noisy settings, the technology improves tracking accuracy and printing precision by dynamically adapting to unanticipated motions. In order to simulate an unfriendly platform with one degreeof freedom, the experimental setup consists of atesting platform with a flat surface placed atop a servo-controlled linear stage. By using sophisticated filtering techniques like Kalman filters, a camera follows a marker on the printing platform to guarantee synchronization between visual input and printing processes.

Another major advancement in 3D printing technology is the use of Machine Learning (ML), which enables more advanced and effective production procedures. With the use of machine learning algorithms, machines may learn from data on their own and make predictions and judgments based on patternsfound. These methods fall into four categories: semi-supervised learning, reinforcement learning, unsupervised learning, and supervised learning. Each of these categories makes a distinct contribution to the field of 3D printing.To help with tasks like anticipating geometric errors and optimizing printing material ratios, supervised learning entails training an algorithm on labeled data. Elhoone et al. employed artificial neural networks (ANNs) to identify the ideal process parameters, whereas Gu et al. suggested a self-learning approach to improve convolutional neural networks (CNNs)for material design. Techniques like dimensionality reduction and grouping are useful in unsupervised learning.

vital for figuring out anisotropic behavior and finding printing flaws. For fault classification, Scime et al. used a high-speed camera and the Bag of Words (BoW) method, whereas Khanzadeh et al. used self-organizing maps (SOM) to examine anisotropic characteristics. The goal of semi-supervised learning is to improve accuracy and computing efficiency by combining supervised and unsupervised aspects. Samie et al. classified printed goods according to dimensions changes using aspectrogram technique, while Chan et al.created a framework for cost estimate utilizing big data analysis. Researchers such as Shen et al. have proposed a deep neural network (DNN)-based framework for print distortion compensation, and Malik et al. have introduceda cyber-physical system for real-time interaction, facilitating personalized production. Reinforcement learning (RL) is a technique that addresses complex control issues by learning optimal behaviors through environmental interactions.

The ongoing progress in additive manufacturing technology demonstrates how these developments are revolutionizing a number of sectors. Researchers have produced complex structures at the nanoscale level by fusing nanotechnology and 3D printing, which has led to the development of sophisticated medication delivery systems and tissue engineering solutions. The possibilities of 3D printing technology have been extended by new materials and methods, such as fused deposition modeling (FDM) for polymers and laser-engineered net shaping (LENS) for metallic components. There is also discussion of the potential and challenges associated with 3D printing, especially in the pharmaceutical sector. Although they have productivity limits, technologies like FDM and inkjet printing provide great accuracy and quick medication delivery. The development of 4D printing and the investigation of novel 3D printing technologies portend well for customized medical care in the future. When it comes to tissue engineering, The use of 3D printing technology to produce scaffolds that resemble real tissues has important ramifications for regenerative medicine as it promotes cell growth and regeneration. The final printed product's performance and qualities are largely determined by the material choice. To improve the usefulness and quality of 3D-printed goods, researchers are experimenting with novel biomaterials and cutting-edge printing methods, opening up new avenues for biomedical application development. These developments demonstrate the revolutionary potential of 3D printing and portend more breakthroughs in a range of sectors

IV. MATERIALS IN 3D PRINTING

Biomaterials have come a long way thanks to three-dimensional (3D) printing, which makes it possible to create highly personalized biomedical devices and scaffolds for tissue engineering that are suited to the needs of individual patients. In this discipline, technologies such as Stereolithography (SLA) and Fused Deposition Modeling (FDM) are essential. Thermoplastic polymers, such polycaprolactone (PCL) and bioactive glass composites, which are regarded for their advantageous qualities in tissue engineering, are commonly used in FDM. In contrast, SLA uses photopolymerizable, biocompatible polymers to enable high-resolution production. Due to their biocompatibility and appropriateness for scaffold building, materials for bioplotting and bioprinting have expanded to include polylactic-co-glycolic acid (PLGA), collagen, chitosan, and other composites that assist tissue regeneration. The necessity to handle issues including dimensional correctness, material removal from narrow channels, and protecting these improvements. FDA clearance of biodegradable polymers with the goal of addressing the changing needs of the production of biomedical devices.

The development and utilization of 3D printing technologies depend heavily on materials. Polymers are frequently used because of their cost, adaptability, and simplicity of usage. While acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA) are common materials used in automotive components and prototypes, polyethylene terephthalate glycol (PETG) is becoming more and more popular because to its strength and flexibility in mechanical parts. In addition, medical supplies and automobile parts employ flexible polymers such thermoplastic elastomers. The use of materials like titanium, cobalt-chromium, aluminum, stainless steel, and their alloys in a variety of industries, including aerospace and healthcare, has led to a rapid expansion in the field of metal 3D printing. Carbon fiber and fiberglass are examples of fiber-reinforced composites that give increased strength and stiffness, while intelligent materials that adapt to their surroundings offer fascinating opportunities for creative uses.

In the field of metal 3D printing, procedures such as Direct Metal Laser Sintering (DMLS), Electron Beam Melting (EBM), Selective Laser Sintering (SLS), and Selective Laser Melting (SLM) are essential for the layer-by-layer construction of metal components, allowing for a high degree of efficiency and precision. Precision, cost, and manufacturing efficiency are just a few of the variables that are greatly impacted by material choices. Numerous uses and design options are available for metals, composite materials, and ceramics. Manufacturers may improve product quality, productivity, and cost-effectiveness in the manufacturing of metal components using 3D printing technology by tailoring material choices and process parameters to the needs of individual applications. The need of continuing research and development to examine a wider range of materials and improve control over material characteristics is highlighted by the continued evolution and sophistication of additive manufacturing technology.

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V. APPLICATIONS AND INDUSTRYIMPACT

Especially in the construction and pharmaceutical industries, 3D printing hasbecome a game-changing technology. The capacity of 3D printing to create intricate tabletstructures that are difficult for conventional technologies to achieve is revolutionary in the pharmaceutical industry. This breakthrough makes it possible to create customized dosage alternatives that are based on the needs of each patient, possibly completely changing how drugs are delivered. 3D printing simplifies the production process, cutting costs and improvingproductivity by removing the need forextraneous and specialized equipment. A number of studies have been conducted to assess important quality aspects, including tablet mass, drug content, and dissolvingqualities, in order to ensure the quality andconsistency of 3D-printed medicinal products. The FDA and other regulatory agencies are essential in steering the development of these technologies, focusing on point-of-care manufacturing and customized medicine in the context of already-existing frameworks, revolutionizing patient care and the creation of pharmaceutical products.

3D concrete printing (3DCP) technology is advancing the construction industry significantly by providing benefits includinglower waste, quicker building schedules, and the capacity to create elaborate, one-of-a-kind patterns. Custom building components like walls, columns, and slabs can now be producedon-site thanks to this technology, which cuts down on shipping requirements and speeds up construction. Moreover, 3DCP helps create materials that seamlessly integrate with pre- existing materials to restore damaged buildings. 3DCP has a significant influence on the building sector by encouraging eco- friendliness, intelligence, and customization in projects. 3DCP improves concrete's rheology, sustainability, and durability by adding industrial waste as supplemental ingredients. This promotes innovation and industry growth.

Beyond the building and pharmaceutical industries, 3D printing is transforming the medical industry as well as other industries including electronics, forensic research, and education. Personalized medication delivery systems, improved treatment results, and realistic surgical models for training are all made possible by 3D printing in the medical field, which enhances surgical proficiency and patient care. The potential of 3D printing in thedevelopment of solid drug dispersions and customized treatment is highlighted by the use of Hot Melt Extrusion (HME) in pharmaceuticalresearch. Point-of-care manufacturing also makes it possible to quickly produce medical equipment in situations when resources are fewor emergency situations. 3D printing has severaluses, including industrial prototype in industries like automotive and aerospace, forensic science for simulating physical injuries, and tissue scaffolding in biomedical engineering. The potential for 3D printing technology to revolutionize industries and increase creativity is enormous.

Boundaries in a wide range of disciplines are being pushed by the adaptability and creativity that 3D printing technology brings. 3D printing is essential to tissue engineering in biomedical engineering because it allows for the creation of personalized scaffolds for tissue regeneration. These scaffolds facilitate the development of new tissues, potentially leading to advances in organ transplantation and regenerative medicine. 3D printing ensures compatibility and efficacy in tissue regeneration applications by providing fine control over the scaffold structure and material composition.

3D printing has shown to be a very useful technique in forensic science for making anatomically accurate representations of injuries. By offering precise physical models that may be utilized to evaluate and interpret trauma, identify weapons, and present evidence in a court of law, this capacity supports forensic professionals in their investigations. 3D printing is a crucial technology for boosting forensic investigations and forensic results' accuracy because of its accuracy and intricacy.

The use of 3D printing technology benefits educational institutions as well. Teachers may provide students practical learning experiences that improve comprehension and memory of difficult ideas by building interactive, physical models. 3D-printed models are useful teaching tools in disciplines like biology, engineering, and architecture because they help students understand theoretical ideas more deeply by giving them a tangible representation.

3D printing has a significant influence on the field of microfluidics, since it is utilized in the creation of lab-on-a-chip devices. These gadgets combine several laboratory operations onto a single chip, enabling automated, high- throughput, and miniature analysis. The accurate and economical manufacture of these instruments made possible by 3D printing advances the fields of environmental monitoring, drug testing, and diagnostics research and development.

The manufacturing of circuit boards and other electronic components is being revolutionized in the field of electronics via 3D printing. 3D printing shortens development time and lowers costs by enabling quick prototype and customization. This technique is especially useful for building intricate yet small electronic devices, which opens up new possibilities for innovation in the consumer electronics, aerospace, and defense sectors.

Significant advantages of 3D printing are also enjoyed by the industrial sector, especially in production and prototyping. The automotive and aerospace sectors use 3D printing to produce strong, lightweight parts that increase performance and fuel economy. 3D printing makes it possible to create personalized items in the consumer goods industry, which improves customer happiness and brand distinction.

The potential of 3D printing technology to spur creativity and efficiency in a wide range of sectors is yet unbounded. 3D printing is at the vanguard of technological innovation, changing how we create, produce, and interact with the world around us. Applications include customized medicine, sophisticated construction techniques, educational tools, and industrial production.

VI. CHALLENGES AND OPPORTUNITIES

Numerous obstacles confront 3D printing technology, especially with regard to precise printing and material management. Accurate extruder adjustments are essential to prevent the filament from being squashed, particularly when working with powder materials such as plaster and polymer combinations, wood filament, and printable waxes. The distinct qualities of every substance make precise printing more difficult. Because liquid materials have different mechanical characteristics from thermoplastics, they add another degree of complexity. Examples of these materials are UV-curable resins used in stereolithography and inkjet printers. The larger problems that continue to impede the general acceptance and effectiveness of 3D printing technology, such as high costs, poor printing rates, limited part sizes, and strength concerns, exacerbate these material-specific limitations.

To overcome these obstacles, further research and development are needed to improve the technology's functionality and accessibility. The technique has very significant potential for use in medical applications, notwithstanding these obstacles. Advances in bioprinting have demonstrated great promise in repairing damaged cartilage in the nose, ears, and knees using human cells. For example, utilizing human cells to bioprint ear shapes has shown potential in vivo mice models, indicating that this technique may be essential for future medical interventions. Furthermore, the ability to create a wide range of items with particular attributes is made possible by the adaptability of 3D printing, which can be used to create products from PLA, ABS, PVA, and TPE. This flexibility is especially useful for sectors where producing complicated, bespoke designs may spur efficiency and innovation, such as aerospace, automotive, healthcare, and food. One of the most intriguing features of 3D printing is its potential to transform these sectors by making it possible to produce intricate forms and patterns that were previously unachievable.

Despite its limited use in chemical research at the moment, 3D printing has great potential in the domains of biotechnology and chemical sciences. The method has demonstrated significant promise for use in biological applications, including in tissue scaffolding and engineering. For instance, scientists may bioengineer different tissues, design tailored scaffolds for tissue regeneration, and even construct intricate biological structures like bionic ears. Novel avenues for drug delivery research, tissue engineering, and customized therapy are made possible by the capacity to print living human tissue and organs. The use of inkjet-based printing for drug manufacture and integration with pharmacokinetics and pharmacodynamics has been investigated, demonstrating the technology's potential to transform drug delivery systems and advance pharmaceutical research. By improving material design, managing the printing process, and assessing the caliber of building components, machine learning offers the construction sector great prospects to advance 3D printing. Researchers can monitor printing progress in real-time, study anisotropic behavior, and increase overall efficiency and sustainability by utilizing machine learning to improve interlayer bond performance. Three- dimensional printing has enormous potential benefits for the pharmaceutical sector as well. A significant obstacle is the narrow range of materials appropriate for medication formulation. Increasing the variety of materials accessible can improve customized treatment, medication delivery, and formulation. To fully realize the promise of additive manufacturing in the pharmaceutical industry, issues including restricted biomaterials for medication usage, sterilization limitations, and technological advancements must be addressed. A significant possibility for innovation exists in the use of 3D printing to improve medicine delivery methods, increase patient compliance, and generate customized dose forms. The combination of 3D printing with nanotechnology creates new opportunities for tissue engineering, targeted medication delivery, and diagnostic applications. The enormous potential for innovation and progress in a variety of industries, including healthcare and construction, highlight the revolutionary potential of 3D printing even in the face of ongoing hurdles.

VII. FUTURE DIRECTIONS AND EMERGING TRENDS

The construction industry's future The development of 3D printing is concentrated on incorporating this technology into established supply chains for the building industry. One noteworthy feature of this progression is the shifting beyond of simple buildings and into the realm of complicated geometries and forms in construction projects. With this change, the full potential of 3D printing technology will be unlocked, and its advantages and capabilities in the construction industry will be better understood. Scholars and practitioners in the field are continuously enhancing frameworks to adapt to the fast progress in technology and changing construction laws. It is important to envision futures in which 3D printing techniques are easily integrated with rules and technology advances. It is anticipated that this kind of imagining would result in notable increases in project efficiency and production rates, transforming the way the construction sector approaches the design and construction of buildings.

In order to keep up with the quick speed of technical breakthroughs and changes in building codes, the study highlights the need of extending and improving optimistic frameworks. Improvements in output rates, total effort, and project efficiency as a whole are anticipated with this proactive strategy. The goal of study is to maximize the use of 3D printing technology in construction supply chains by imagining limitless situations in which technology has advanced and rules have changed to include 3D printing methods. These initiatives are thought to be essential for developing the construction sector and realizing the full potential of 3D printing.

In conclusion, the development of hopeful frameworks, the investigation of intricate geometries, and the flexibility to adjust to changes in regulations and technology will define the future of 3D printing in the building industry. It is essential to keep up with current trends and to keep up with technological advancements. In order to fully use 3D printing in building projects, researchers and business experts are putting up endless effort. This effort is propelling advancement and innovation in the sector. The emphasis on intricate shapes and conformity to developing rules and technology creates the foundation for a revolutionary future in 3D printing for building, opening doors to increased productivity and creativity in the industry.

The course of building in the future The way that 3D printing is integrated into conventional building supply chains has a big impact on it. The investigation and use of intricate forms and geometries in building projects—which go beyond traditional structures—is a crucial component of this integration. The goal of this paradigm shift is to fully realize the benefits of 3D printing technology in the construction industry and to fully utilize its potential. Scholars and professionals in the field are always enhancing frameworks to adapt to the fast progress of technology and evolving building codes. It is critical to envision futures in which 3D printing techniques are easily integrated into rules and technology has reached a mature state. It is anticipated that this kind of imagining would lead to significant improvements in project efficiency and production rates, which will transform the way the construction industry approaches the design and construction of buildings.

The study emphasizes how important it is to develop and improve optimistic frameworks in order to keep up with the rapid advancement of technology and changes in building codes. Improvements in output rates, total effort, and project efficiency as a whole are anticipated by this proactive approach. Through the creation of unrestricted situations in which technology has advanced and laws have been modified to accept 3D printing techniques, researchers want to stimulate creativity, increase output, and maximize the application of 3D printing technology in building supply chains. These initiatives are considered essential to realizing the full potential of 3D printing in building projects and advancing the industry.

In summary, the investigation of intricate geometries, the refinement of hopeful frameworks, and the adjustment to regulatory changes and technical improvements will define the future of 3D printing in the building industry. It's critical to stay up to date with current developments and to keep developing with the technology. To further advance innovation and advancement in the construction industry, researchers and industry practitioners are assiduously working to fully realize the potential of 3D printing in building projects. The emphasis on complex geometry and conformity to changing standards and technology creates the foundation for a revolutionary future in 3D printing for building, opening doors to increased productivity and creativity in the field.

VIII. CONCLUSION

In conclusion, the assessment of 3D printing developments emphasizes the technology's transformational potential while highlighting notable breakthroughs in a number of sectors. Improvements in printing materials, methods, and applications are among the major developments. 3D printing has become more versatile with the introduction of new materials like metal alloys and biocompatible polymers, which allow for the construction of intricate structures with improved characteristics. Advancements in printing methodologies, including hybrid manufacturing and multi- material printing, have enhanced the accuracy, velocity, and adaptability of three-dimensional printers. Significant applications in the aerospace, automotive, healthcare, and construction industries have resulted from these breakthroughs.

In the world of healthcare, 3D printing has drastically changed the way prostheses, implants, and tissue engineering are done, allowing for more tailored medical treatments. This technology has also provided substantial benefits to the aerospace and automotive industries by developing lightweight and robust components, which improve performance and fuel efficiency. Furthermore, in the construction industry, 3D printing offers environmentally friendly and cost-effective building structures. Despite these great improvements, there are still problems to overcome, such as high costs, restricted material options, and regulatory requirements. Future research should overcome these challenges in order to fully realize the potential of 3D printing technology. Overall, the advancements in 3D printing demonstrate its growing significance and ability to alter a wide range of industries.

REFERENCES

[1]. Tracy, T., Wu, L., Liu, X., Cheng, S., & Li, X. (2023). 3D printing: Innovative solutions for patients and pharmaceutical industry. International Journal of Pharmaceutics, 631, 122480.

[2]. Ayyagari, R., Chen, Q., & de Soto, B. G. (2023). Quantifying the impact of concrete 3D printing on the construction supply chain. Automation in Construction, 155, 105032

[3]. Chaudhry, M. S., & Czekanski, A. (2024). Visual control for robotic 3D printing on a moving platform. Mechatronics, 100, 103191.

[4]. Geng, S., Luo, Q., Liu, K., Li, Y., Hou, Y., & Long, W. (2023). Research status and prospect of machine learning in construction 3D printing. Case Studies in Construction Materials, 18, e01952.

[5]. Shahrubudin, N., Lee, T. C., & Ramlan, R. J. P. M. (2019). An overview on 3D printing technology: Technological, materials, and applications. Procedia Manufacturing, 35, 1286-1296.

[6]. Huo, J., & Zhang, G. (2022). New process for integrated manufacturing of copper alloy shells by bimetal 3D printing remanufacturing technology. Energy Reports, 8, 11052-11063.

[7]. Tu, H., Wei, Z., Bahrami, A., Kahla, N. B., Ahmad, A., & Özkılıç, Y. O. (2023). Recent advancements and future trends in 3D printing concrete using waste materials. Developments in the Built Environment, 100187.

[8]. Jandyal, A., Chaturvedi, I., Wazir, I., Raina, A., & Haq, M. I. U. (2022). 3D printing–A review of processes, materials and applications in industry 4.0. Sustainable Operations and Computers, 3, 33-42.

[9]. Dong, C., Petrovic, M., & Davies, I. J. (2024). Applications of 3D Printing in Medicine: A Review. Annals of 3D Printed Medicine, 100149.

[10]. M. Khan, C. McNally, Recent developments on low carbon 3D printing concrete: Revolutionizing construction through innovative technology, Cleaner Materials (2024), doi: https://doi.org/10.1016/j.clema.2024.100251.

[11]. Pereira, G. R., Gasi, F., & Lourenço, S. R. (2019). Review, analysis, and classification of 3D printing literature: types of research and technology benefits. IJAERS, 6, 167-187.

[12]. Rajora, Anjali & KUMAR, RAJEEV & SINGH, REETU & SHARMA, SHIWANI & KAPOOR, SAPNA & MISHRA, ASHISH. (2022). 3D PRINTING: A REVIEW ON THE TRANSFORMATION OF ADDITIVE MANUFACTURING. International Journal of Applied Pharmaceutics. 14. 35-47. 10.22159/ijap.2022v14i4.44597.

[13]. Jayakrishna, M., Vijay, M., & Khan, B. (2023). An Overview of Extensive Analysis of 3D Printing Applications in the Manufacturing Sector. Journal of Engineering, 2023.

[14]. Jiménez, M., Romero, L., & Dom-nguez, I. A. (2019). Research Article Additive Manufacturing Technologies: An Overview about 3D Printing Methods and Future Prospects.

[15]. Kamran, M., & Saxena, A. (2016). A comprehensive study on 3D printing technology. MIT international journal of mechanical engineering, 6(2), 63-69.

[16]. Jayakrishna, M., Vijay, M., & Khan, B. (2023). An Overview of Extensive Analysis of 3D Printing Applications in the Manufacturing Sector. Journal of Engineering, 2023.

[17]. Gokhare, V. G., Raut, D. N., & Shinde, D. K. (2017). A review paper on 3D-printing aspects and various processes used in the 3D-printing. Int. J. Eng. Res. Technol, 6(06), 953-958.

[18]. Gross, B. C., Erkal, J. L., Lockwood, S. Y., Chen, C., & Spence, D. M. (2014). Evaluation of 3D printing and its potential impact on biotechnology and the chemical sciences.

[19]. Iftekar, S. F., Aabid, A., Amir, A., & Baig, M. (2023). Advancements and limitations in 3D printing materials and technologies: a critical review. Polymers, 15(11), 2519.

[20]. Chia, H. N., & Wu, B. M. (2015). Recent advances in 3D printing of biomaterials. Journal of biological engineering, 9, 1-14.