Scope of Additive Manufacturing in Industries - Research Review

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Abstract

Recently, manufacturing sector plays major role in all the industries to convert the raw materials into finished product with high accuracy and dimensional tolerances. There are lot of manufacturing industries are available in the market such as assembly industry, process industry, analytical industry, synthetic industry, paper industry, chemical manufacturing, metal manufacturing, furniture manufacturing, machinery manufacturing, computer and electronics manufacturing. Additive Manufacturing (AM) is one of the recent manufacturing activities and this system has transformative approach to invention that enables the establishment of lighter, stronger parts and systems. This approach develops 3Dimensional objects by adding layer by layer of material with high precession and accuracy. In recent year's Additive manufacturing is fascinated global as an emerging manufacturing process of developing complex three dimensional objects in various applications such as healthcare, biomedical, aerospace, textile and construction industries. The main objective of this paper is to review the various 3D printing industries for competitive environment by means of focus on accomplishment strategies.

Keywords: Additive Manufacturing, Industries, 3Dimension Printing, Process Simulation, Industry 4.0

I. INTRODUCTION

Advanced and intelligent research efforts correlated with manufacturing processes, materials, and product design are crucial for the success of industries. Market competitiveness in today's manufacturing sectors is related with the need for sophisticated goods, with shorter life cycles, shorter lead times, and more, in addition to the typical demands for lower costs and greater quality. In the real world, the existing product line is quite complicated and challenging to develop a new innovative idea. Recently, Additive Manufacturing (AM) plays a crucial role in the entire manufacturing sector to enhance the quantity and quality of the product. Many researchers have investigated and analyzed the latest manufacturing process with low cost and high quality is listed below.

Nazir et al. (2023) reviewed about the recent innovations and developments in Multi-Material Additive Manufacturing (MMAM). The applications, limitations, challenges and future trends in MMAM are initiated in this paper. Evolution illustrates remarkable precision in design and production by selecting application-specific compositional and functional gradation of both materials and structures. Metamaterials and advanced lattice structures may be used in materials with flexibility and have possible applications in aerospace, civil, textile, and tissue engineering.

Abdullah Alhijaily et al. (2023) addressed the major research challenges and future perspectives in Additive Manufacturing (AM). It enhances productivity and improves resource efficiency, it is a crucial facilitator and technical pillar of Industry 4.0. The present state-of-the-art in the usage of cooperative AM systems based on gantry systems, robotic arms, and mobile robots is discussed in this review study. This design overcomes some of the present AM constraints, increasing system adaptability and productivity while also opening up new options for integrating different printing technologies employing multiple printing heads.

Fengyang He et al. (2023) investigated how recent advances in Wire Arc Additive Manufacturing (WAAM) present a potential option for creating high value-added medium to large metal components for a variety of sectors, including aerospace and marine. Through the use of AI approaches, it is anticipated that WAAM would progressively develop into a smart/intelligent manufacturing technology in the context of Industry 4.0.

Gurushanth B Vaggar et al. (2023) concentrated on three major areas of additional substance creating late gains in material science, process improvement, and plan idea upgrades. The fundamental goal of the article is to organize the continuing information on added substance production and to highlight its anticipated applications.

Ramesh Raju et al. (2022) explored such problems and prospects in additive manufacturing through controlled processing parameters for component surface integrity. The application also sees potential in the creation of customized features by overcoming metallurgical and mechanical problems. The principle of additive manufacturing also allows both material selection and material utilization flexibility. When compared to traditional manufacturing procedures, components manufactured using additive manufacturing have reduced material waste.

Ali Raza et al. (2022) examined the use of Machine Learning (ML) approaches in many domains of Additive Manufacturing (AM), stretching from material and alloy creation to AM process parameter optimization. ML data training also helps in establishing the link between the AM process, structure, and property relationships, as well as fault identification in printed products. AM provides advantages in developing complicated 3D forms and establishing well-defined control over processing parameters, which ultimately affect the quality of a finished product.

Mahyar Khorasani et al. (2022) examined the relationship between Industry 4.0 and Additive Manufacturing (AM), focusing on the integration of data-driven production systems and product service systems as a major component of the Industry 4.0 revolution. The purpose of this study is to emphasize the possible implications of Industry 4.0 on AM using techniques like digitalization, data transmission, tagging technology, information in Industry 4.0, and intelligent features. The five major pillars that might see the Internet of Things (IoT), artificial intelligence, robots, and materials science allowing unprecedented levels of interactivity and dependency between suppliers, manufacturers, and users are highlighted in this study of Industry 4.0 and Additive Manufacturing (AM).

Vignesh et al. (2021) illustrated the stated properties for 3D printed biomedical implants manufactured using Laser Additive Manufacturing (LAM), Friction Stir Additive Manufacturing (FS-AM), Paste Extruding Deposition (PED), and Selective Laser Melting (SLM) techniques, as well as its future Additive Manufacturing (AM) process scope. Additive Manufacturing (AM) is a rapidly evolving technique for the production of biomedical implants. Because of its customized construction, shorter production time and cost, it offers an excellent and broad possibility for bio-mimicry of required complicated features of body implants.

Daniel Moreno Nieto et al. (2021) recommended collecting multiple Computer-Aided Engineering (CAE) tools specifically created for Additive Manufacturing (AM) that maximize the possibilities of this technology in terms of product creation in an organized approach. The versatility of the AM process enables the creation of exceedingly intricate structures that would be impossible to create with any other available technology. This article demonstrates the redesign process geared towards additive manufacturing of a typical mechanical design component: a bicycle stem. Significant gains in mass reduction are obtained in this approach by employing topological and mesostructural optimization tools and demonstrating their use step by step.

Gulnaaz Rasiya et al. (2021) addressed the various Additive Manufacturing processes, as well as materials and applications. It improves in effective material utilization and decreases waste or the buy-to-fly ratio. It also cuts down on processing and production time. Improvements in setup, automation, and failure minimization are topics that still require much investigation. In the last 20 years, there has been remarkable advancement in the field of Additive Manufacturing. With the help of Additive Manufacturing, tremendous progress has been made in the fields of medicine and architecture. Researchers are currently aiming to apply this approach in the civil and military aerospace sectors.

Suvranshu Pattanayak et al. (2021) investigated the Gas Metal Arc Welding-Based Additive Manufacturing (GMAW-AM) technique, performance capabilities, variables influencing deposition performance, and solutions used to solve these challenges. Several topics are also discussed and presented in depth, including mathematical modelling, optimization, essential process parameters, and their combinations for a wide variety of wire electrode material and percentage contributions. In addition, the entire content of this review, as well as future perspectives, are examined afterwards. The current review effort will assist future researchers in selecting alternative wire materials and GMAW-AM settings to get better results. Finally, numerous future research paths are indicated, notably the necessity for a framework for GMAW-AM procedures for producing excellent items with little distortion.

Cheng Sun et al. (2021) outlined the crucial debate and potential for addressing global energy concerns through the use of breakthrough additive manufacturing technology. The clash between rapidly increasing global energy consumption and climate change is a massive challenge that will need considerable scientific and technological advances. Advanced manufacturing has the potential to significantly reduce greenhouse gas emissions and pollution while also shortening time-to-market. It presents crucial debate and opportunities for addressing global energy concerns by means of the use of breakthrough additive manufacturing technology.

Rakesh Kumar et al. (2021) aimed to consolidate the contributions of various researchers in the area of AM, with a particular emphasis on applications in the medical field using various AM technologies, materials, and mechanical properties, so that this review paper could serve as a torch bearer for future researchers working in this field. Additive manufacturing (AM) is a digital manufacturing technique that is quickly transforming the medical sectors by printing different body parts with intrinsic forms and providing personalized solutions to each patient. AM has been employed in the medical field for several decades as a flexible and cost-effective approach for creating geometrically complex shapes.

Jing Zhang et al. (2020) examined the most recent Machine Learning (ML) applications in the Additive Manufacturing (AM) area. These applications, which include parameter optimization and anomaly detection, are classed as ML tasks, which include regression, classification, and clustering. In these sorts of AM tasks, the performance of various ML algorithms is compared and assessed. Finally, some potential study directions are proposed.

Nihan Tuncer et al. (2020) categorized major solid-state metal AM techniques into two broad categories (plastic deformation based and sinter based) based on metallurgical bonding mechanisms, range of processible alloys, and resulting microstructures. The limited and recent data available in the literature demonstrate that, whereas deformation-based AM techniques are generally confined to very ductile alloys, sinter-based AM is capable of producing a wider range of materials. Deformation-based procedures often enhance the microstructure by recrystallization, whereas sinter-based AM methods, in most situations, result in grain expansion and a more isotropic microstructure owing to high-temperature processing.

Ankita Jaisingh Sheoran et al. (2020) demonstrated that Additive Manufacturing (AM) has numerous applications in a variety of fields such as aviation, defense, manufacturing, automotive sector, industrial, education, and research, but most notably in the Bio-Medical, healthcare, and pharmaceutical industries due to its ability to fabricate complex customized parts with extensive ease, flexibility, and with various biomaterials. This paper summarizes the biomedical uses of AM to date. This analysis emphasizes the healthcare industries that are being transformed by additive manufacturing, such as bio-printing, tissue engineering, dentistry, printing patient-specific customized implants, medical devices/surgical equipment, orthopaedics and prosthesis, drug delivery, and virtual surgical planning. Also covered are the various bio-inks and biomaterials used for printing cell-seeded tissues, 3DP implants, replacement organ printing, and scaffolds.

Samad M. E. Sepasgozar et al. (2020) identified the primary obstacles and benefits of their stated methods, such as aggregate size constraints, nozzle size limitations, standards, post-occupancy satisfaction, end product quality, productivity issues, and other associated hazards. The study discusses significant limitations and suggests future research options. According to both the English and Chinese papers studied in this work, the benefits, limits, and future development paths of 3DP are comparable in China and other countries. As a result, cooperation between China and other nations would be mutually beneficial. This article also examined the nozzle's size and form restrictions, problems, and optimization directions in 3DP. More research is needed to investigate the possible link between the nozzle and the mechanical performance of printed components.

Paulo Bartolo et al. (2019) presented the idea of robotic-assisted additive manufacturing. The major additive manufacturing methods that can be employed with a robotic system are introduced and examined in depth. The information flow necessary to build an object from a CAD model using a robotic-assisted system, which differs from the usual information flow in a standard additive manufacturing technique, is also discussed. Examples of robotic-assisted additive manufacturing systems are provided.

II. CONCLUSIONS

In terms of cost reduction, speed, freedom in designing complicated components, production in a single step, and sustainability, advanced 3D printing has several benefits over conventional and unconventional manufacturing processes. Additive manufacturing is a layer-by-layer production technology that lowers the machining and removal of surplus material from bigger stocks. This method immediately builds the components to their final shape, resulting in minimizing material waste and achieving the desired geometric dimensions. Due to the availability of a greater range of 3D printing processes, it is difficult to select a desired additive manufacturing approach for a certain material and application.

A CAD design is created, and the data for each layer is saved as STL files, also known as stereolithography. The setup includes a PC that controls everything, robotic arms, CNC, nozzle, shielding environment, and scanning and recording devices. ANN, as well as other more advanced software and algorithms, have been created. When compared to traditional machining procedures, Additive Manufacturing results in greater material usage, a lower buy-to-fly ratio, lower processing and finishing costs, less time, improved mechanical qualities, and so on. These characteristics are market drivers that are attracting the attention of researchers all around the world.

3D printed components are increasingly being used in fields such as aerospace, structural, biomedical, complicated component production, and so on. Among the aforementioned uses, 3D printing has received the most interest in the biomedical industry due to its adaptability in generating cost-effective, rapid surgical equipment and patient-specific bio-implants. It is utilized not only to repair or manufacture human body tissues such as dental implants, artificial livers, artificial cardiovascular systems, and orthopedic implants, but also to manufacture medical electronic and microfluidic devices.

This review will help researchers and engineers create and manufacture sophisticated nature-inspired products.

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