Latest Technologies, Design Considerations, and Quality Concerns of Additive Polymers Manufacturing

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***Abstract* — Additive manufacturing (AM or 3D printing) is known for large capacities like design freedom, reduced tooling, and production hours. AM evolving exciting advancements for new business models in different industries. Few research papers and studies are limited to material specifications, processes, or quality issues. So, this literature review combined with considerations of AM for polymers materials to quality process to get basic ideas or to lay the groundwork for future researchers. To outline the critical points for investigative queries and identify research gaps in this literature with primarily detailed info on innovation technologies. This review states polymers materials optimization and its manufacturing, all-purpose design considerations, and limitations define CAD source printing and step-by-step quality processes for the fortitude of the analysis to create previous research intended to advantage researchers for future business practices in Industrial revolution 4.0.**

***Keywords* — Additive Manufacturing (AM), Digital Manufacturing, Polymers, Quality Control, Technical Trends.**

I. Introduction

AM [14] developments are innovative technologies accompanying alternate subtractive manufacturing. This 3D printing is the reverse of subtractive construction rather than eliminating raw material from processed parts, but this additive technology adds material to build a shape. The American Society for Testing and Materials (ASTM) [6] describes AM expertise for building 3D models from a CAD source. Additive processes, wherever created by layering successive layers of material [31]. This resource mentions a limit of AM layering procedures directly from a digital source (3D model).

AM comprises a wide-ranging range of machinery and procedures, using the photochemical process using X-Rays, UV lights, or temperature factors to form parts or objects after fibers, residues, or powders. Such techniques like FDM, SLS, SLA, etc., are used to tailor or optimize materials. Part designers print models and validate parts or samples before significantly advancing innovative products and processes. Moreover, AM technologies are evolving to allow creative projects and establishments to be more accessible for broader usage.

Researchers are now reviewing manufacturing Technologies from different viewpoints. Though, researchers frequently entitled unique procedures by companies to maintain competition between manufacturers.

To progress more information on AM for future studies, this review goal of guiding on four aspects: polymers, engineering practices, quality concerns, and technical innovations. So, manufacturers are developing unique materials and Advanced Digital Manufacturing technologies to meet the high product quality for essential features to satisfy end-user requirements.

II. AM Materials

A. Polymers

The primary reason is that AM differs significantly from traditional processes such as injection molding and requires resins and compounds tailored to provide the expected properties [29]. To meet this need, polymers [50] lined up with printing procedures' features and met the higher performance demands of production parts for usage in different circumstances.

Different Additive Polymer materials used for evolving prototypes in other fields are shown in Table I.

TABLE I: Polymer Applications in Different Areas

Materials	Fields
ABS, PA [59]	Automotive
PA, PEI, PEKK, PEEK [2]	Aeronautic
PA, TPU, Photopolymers [61]	Sport
ABS, PLA, Photopolymers [68]	Consumer products
Photopolymers [7]	Electronic

Different ABS is the thermoplastic commonly used in most plastic types and manufactured Lego blocks. PLA is now increasing the demand in the usage as it is stretchable, also existing in the finishes of rigid and soft. In this PLA, a third type gives the finishing of a rubber, enduring ductility. PVA [4] is a material that stands as a pillar within 3D printing which can melt after the final design is ready; these pillars wash away as they are dissolvable. Polycarbonate is a material that is not in demand, but there are possibilities for its increase in the future. The market is less due to the nozzle that carries an elevated temperature.

Plastic/polymers material usage in industries for building prototypes before producing an actual one. The plastic resins and compounds depend on selecting the suitable material for the process, design, and end-user applications. AM is progressing rapidly in various aspects, intending to expand from a prototyping or partial production to a robust and reproducible production process; optimized materials are limited.

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B. Polymers Manufacturing

The AM process allows the polymers to combine with carbon fiber, due to which the manufactured product produces with less weight and has enough strength. Polymer materials develop by optimization techniques [39]. At the same time, the selection is eventually based on each application requirement and the process of manufacturing. The following are the significant considerations in AM.

1) SLS - Selective laser sintering

The SLS process involves using a high-power laser. A very minute particle of thermoplastic material powder blends by heat. The powdered particles combine in a specific location by building a platform for developing a solid, 3D printed part using a thermal source with Selective Laser Sintering for Thermoplastic materials [46].

2) DLMF/DLMS - Direct laser metal forming/sintering

The DMLS [49] started in 1994, mutually via RPI (Rapid Product Innovations) [10] and Electro-Optical System (EOS – Germany) [71], to manufacture metal parts into one process as the first commercialized speed prototyping method. This technology is familiar to accomplish, with significant expertise in complex tooling. The metal crushes at 20 to 40 micrometers using a high-energy laser beam. The metal powder is free of binder, or fluxing agent is trashed by scanning. The metals used are steel, aluminum, and bronze. A new layer is a sinter on the existing layer by recoating the powder on the new layer [69].

3) Electron beam melting

EBM process develops using a high-power electron beam to generate the energy required for high melting and productivity. The hot process allows no residual trauma, and the vacuum safeguards a clean and controlled environment [27].

4) Stereolithography

The SLA is the first commercialized AM process technology, which 3D Systems developed precisely to treat light-activated resin (photopolymer) cross-sections using an ultraviolet laser to change them from liquid to solid. Using the 3D parts manufactured in layers to prototypes, speculating casting patterns, tools, and features directly from CAD data [67].

After finishing the printing process of SLA, the produced parts clean themselves using a solvent to remove any residual untreated binder from the region's surface using the UV oven.

5) Laser engineered net shaping

The LENS welds a metallic powder stream by blustering air to custom parts and manufacturing shapes using computer-controlled lasers. Using this technique, the final form of the end-product produces where there is no need for rough machining. Making small lots of high-density shapes or molds is one of the primary purposes of LENS [13].

A pool of metal powder is through each nozzle at a pivotal point and simultaneously heated at the end using a high-voltage laser beam. The producing parts and their substances move to new levels by metal deposits continually while the laser and jets remain unmoved. Later, it expands into layers until a desired cross-sectional structured geometry forms a 3D metal product.

6) FDM - Fused deposition modeling

The FDM [52] adjusted to constructing models, practical prototypes, and end-use parts in standard engineering-grade and high-performance polymers. This specialized AM technology is compact for production-grade polymers so that the mechanical products are peerless, thermal, and chemical strength. The ink used in 3D printers for fused deposition modeling (FDM) is a filament wire. Though composite filament fabrication faces challenges when used as a raw material for the FDM 3D printer [1], an inadequate selection of biocompatible, bioactive materials. It is also challenging to produce a filament with a constant diameter.

Materials optimized with different procedures using chemical, electric, radioscopy, and thermal processes. These methods are unique from company to company as per the manufacturer's expertise. Augmented materials should be cost-effective, have high energy, reinforcement, high mechanical and physical properties. As explained below, raw materials are still developing to achieve suitable properties; custom-made materials fed for printing parts through layer deposition through different machinery or methods.

III. Engineering Practices

A. Manufacturing Methods

AM procedures or types of machinery or by machine construction, such as nozzle dimensions, spindle speed limit, and layout setup. 3D printing construction or sorted according to materials and includes patterning energy, creating primeval geometry, material texture, and assembly procedures. These types of machinery classify by methods and type of input material.

1) Solid-based

In these types of machinery, the feedstock settles in solid-state. Amongst solid-based [32], procedures vary; below are the most widespread.

Fused Deposition Modeling (FDM) [62]: The operating principle of FDM is based on layered engineering technologies. In this method, the polymers (raw materials) squeeze out or fuse in melted or paste-like filaments through the nozzle.

Freeze-form extrusion fabrication (FEF) [36]: This procedure is driven by a triple-extruder mechanism relating to computer software and hardware technologies to construct functionally grouped portions from several aqueous pastes. It is a planned and developed mechanism prepared with three servo-controlled extruders and a paste mixer.

Laminated object manufacturing (LOM) [41]: In this process, the raw material is squeezed out or extruded in the form of the Laminates using pressure and heat. This method is only for prototyping but not for actual manufacture. During this process, coatings of polymers, adhesive-coated paper, or metal laminate adhesive together uninterruptedly.

2) Liquid-based AM

In these machines, input raw material is in a liquid state. Among existing liquid-based AM machinery, below are the well-known liquid-based AM.

- Stereolithography (SLA) [15]- Polymers are manufactured layer over layer during SLA. Usually, the models or prototypes are by the photochemical process where oligomers and monomers connect to form a strong polymer. The produced part is consequently reinforced by using UV light.

- Multi-jet modeling (MJM) [64]- This procedure utilizes different jets to supply wax as required. Through the manufacturing procedure. MJM creates parts with detailed features and a smooth surface finish. It is like a traditional inkjet printer.
- Rapid freeze prototyping (RFP) [56] - This procedure manufactures part through deposition and cooling the aqueous or saltwater for the duration of a layer over layer approach to construct the ice 3D models by the usage of binders, catalyst, ceramic powders, and separating agents.
- Digital light processing (DLP) [63] - This procedure is like SLA utilizing the photochemical process. The only difference is the usage of light sources. Still, in DLP, a projector light or traditional Arclight supplies production by eliminating the wastage, which leads to low production costs.

B. Powder-Based AM

In powder-based AM types of machinery, the key raw material is in powder state. Among so many existing AM technologies, below are distinct ones:

a. *Three-dimensional printing (3DP)* [24]: In this production, the liquid binder uses ink-jet printing for binding the ceramic powders or metallic powders. This is one of the economic processes in AM.
b. *Electron beam melting (EBM)* [25]: This process uses a high-level energy electron beam to achieve a high melting point and higher efficiency. The high-temperature production allows manufacturing the parts by eliminating the residual stress, and the vacuum ensures.
c. *Selective Laser Sintering (SLS)*: In SLS, the laser beam uses a sinter or melts the spread layer powder particles. The energy beam selectively sinters or melts the powder particles through scanning the layers on the building platform. It helped build the most critical features, components, or complicated shapes.
d. *Selective laser melting (SLM)* [71]: The fabrication of parts by the layer method through the sintering of powdered materials to form thinner layers using a laser source.
e. *Laser-engineered net shaping (LENS)*: This method allocates restoring, altering, and adding values to active components of features by utilizing the matching material or superior material.
f. *Laser metal deposition (LMD)* [5]: In this method, the 3DP leader links to a robotic arm. Here jets incorporate for a deposit where the laser beam provides energy power to build the desired shapes.

AM has flexible chances for any material to be layer-based. Still, the material selection is essential to identify the end usage and its impact. The end-product manufactures virtually to any shape without using complex tooling is additive, like molds, dies, or fixtures. In digital manufacturing, the 3D model or CAD source plays a fundamental role. To plan a design, the designer should study and consider material properties, manufacturing process, manufacturability conditions, and end usage. The part model with certain factors should pass the CAE analysis; the 3D model can be built with considerations and ideas.

C. Design Considerations and Limitations

1) Design considerations

Digital fabrication technologies, like 3D printing, and CNC machining [23], will generate components quickly from a CAD source [38], linking the digital domain to the real world. The common element is that there is no need for tooling and significantly reducing production hours, which can be profitable for manufacturing. Still, other technologies for manufacturing, like injection molding (for an inexpensive mold), can manufacture quickly using AM. Few design considerations for the product are utilization, sustainability, business, process, properties of the material, geometric, and communication considerations.

Below are the common concerns for designing any material model [6].

2) Design effectiveness

The designer creates parts, models, and configurations to optimize performance and efficiency. The designed features should have preferred properties like weight, withstand stiffness, and so on. The developed part must perform multiple functions by using varied materials and complicated shapes with significant benefits.

3) Consolidation of part or product

General practice is to have as much smaller than possible in assembly but not lose their functionality for supposing two pieces. In this case, it can merge into the corresponding part, not to move proportionate to one another, and the other part should not enable access when removed [22].

4) Assembly features

The standard design considerations for assembly are the designed parts should be able to insert and fixate while assembling quickly. With the help of AM, even the assembly features can be enabled into most part designs such as locking-fits, edge matching and ribs or hoses (features to support), and another alignment to develop and meet the assembly conditions. The AM can manage to fabricate complex designs, which encourages designers to innovate in designing assembly features. The assembly requirements follow by mating surfaces that require additional machining, especially for metal parts [32].

5) Multi-part mechanisms

In AM processes, it is possible to design the parts that move relative to each other like assemblies, and there is no need for another operation. For example, the design of kinematic joints like sliding, revolute, and cam joints permits relative motion between parts.

In photopolymerization processes, the stream of liquid comes out of joints, which enables movement. Other methods required support structures and moving mechanisms if the supporting material removes quickly from joint regions [16].

6) Compliant mechanisms

AM permits innovative designs of complex 2D and 3D tools. The structural elements of the bending mechanism that cause desired input-output behavior.

This contrasts with different part mechanisms, other links cause relative movement through designed bending patterns between the input and the output. An example is when pin joints replace with thin plates, which is a complaint hinge.

7) Relationships with processes and process chains:

A sequence of process chains (activities) requires achieving an anticipated accuracy and finish requirements, which the user must consider. Even after designing an appropriate process chain, though the procedure cannot meet the design considerations, it can still use the AM process for part production.

Manufacturing consists of planning, designing, and production, which comes under Computer-Aided Design and Computer-Aided Manufacturing. So, it is necessary to consider the limitations of the CAD before designing.

D. CAD files and process limitations

The conceptual design builds a 3D version of the manufactured part; the format issues it. STL and without interpretation of manufacturing competencies of FDM printers are the fundamental errors that occur.

1) Challenges in manufacturing from created CAD parts

A cloud-based manufacturability tool defines an AM process that can manufacture fewer feature parts, but the existing CAD file size can be minimum (Forbes tech council, 2018). Based on the printer's capabilities, there can be a mismatch with the CAD file. Therefore, comments or inputs are given to the designer to make a better design or to take the other AM process. To develop a test, part work manages which defines the ability plot for FDM [54] printer-material mixtures. For assessing the powerful capabilities of a 3D printer, the database information analysis is qualitatively and quantitatively.

2) Development of cloud-based manufacturing

Additionally, algorithms were developed that accurately assess the designed features on a 3D printer, CAD model without using the format.STL file [34] evaluated the user's interaction with the tool. The designer can request comments on design manufacturability during the design process, including a CAD system using an intelligent digital manufacturability assistant. This provides a new perception of cloud-based manufacturing [66]. The post-heat treatment circumstances can control the mechanical properties of 3D printer parts. For example, tensile strength is low by heat treatment [37], which is a desirable mechanical property for processed parts. For the aerospace and automotive sectors, the refined microstructure component is essential. So, 3D printers have design freedom by surface remelting using a high-frequency laser to achieve microhardness for a fine microstructure. Manufacturing overhang structures [43] are a challenge for metal AM. The possibility of dross defects and acquiring distortion provides an improved understanding of the manufacturability of overhang structures in applications.

Geometrically replacing the parts is effortless than manufacturing parts and replacing them with one piece or a smaller number of factors due to this development of lighter features with better performance rather than replacing assemblies. However, few guidelines are followed by the designer to stable cost, deliver value, and risks when deciding whether they can meet requirements. The CAD part satisfies the design requirements after manufacturing parts should pass through various quality processes to ensure part quality, as explained below.

IV. Quality Concerns

In recent times, AM quality control [11] is outstanding to reach high achievability, reliability, and mechanical and material characteristics used in various fields. QC steps are initially concerned with AM to achieve high quality in every stage, i.e., Design Process, Printing Process, Post-process, and Evaluation Process.

A. Design Process

The design process [40] is known as preliminary QC judging thru material's quality to shape design.

The raw materials assortment is crucial for producing one; part material directly impacts part mechanical properties. A best 3D model always sets the ability to set up optimized values for design constraints related to the component's quality. To study construction support, shape meeting requirements by obtaining improved design variables and production parameters engendered from physical examinations. This methodology definitively makes the optimized strap part independently tailored for meeting individual patients' clinical requirements for medical treatment [30]. Though, it involves a lengthy period to construct and duplications of mechanical examination by different procedures of ideal model variables. One study explored creating actual production control methods to fix model and production issues in the end-user [51].

MJP method evaluates from paper level to actual component level through automaton or digital concept, evaluating the critical features, assembly conditions, tolerances, and depth adjustment with the sheets, and produces a reaction to the computer to control the unit nozzle drip infusion. This method begins with the actual model procedures during manufacturing. Researchers have studied improving model limitations before creating analytic development and records-extracting built on excellent forecast processes.

However, few conventional AM techniques still need to be efficient by trending technologies that allow the preprocessing quality check for manufacturing the part, followed by other QC processes.

B. Printing Process

The printing process [47] technique is known for in-process quality control from manufacturing setup to parts development. The inner surface imperfections of manufactured parts could be eliminated by FDM factors optimization [3]. Similarly, high production system constraints such as inlet and outlet pressures, ambient conditions, machinery setup, functionality check, feed, speed, and assembly conditions are crucial for achieving quality. Few investigations have been conducted to check the AM process in comparison with other methods. analyzed the consequences of the layer-to-layer production lag on AM jobs for mechanical and fundamental properties checks used for improved collections of production factors to achieve the best manufacturing conditions [19].

Accurate model/design standards (temperature, feed, and speed, etc.) and geometric calculation factors (accuracy and interior model) were applied to define the significance of manufacturing elements [35].

Although the parts printed as per design may not satisfy the customer's requirements, it is necessary to perform post-product quality control to yield products that adapt to engineering, business, and customer expectations.

C. Post-Process

Post-processing [70] is known as Quality Control for the post-processing of manufactured parts. This quality is excellent after production activity and before part assessment [17]. The techniques for process improvement through internal study stresses and mechanical properties of manufactured components by CAE analysis. The research attempts to eliminate EBM processing for alloy components by enhancing the worst conditions from heat to reduce enduring tensions.

DSIAC in-situ checking method includes utilizing infrared cameras to note the heat slope between one layer to another layer formation. However, this checking has limitations regarding the different approaches in usage [42].

During recent developments, automated post-processing checks were made by global companies recommending automatic post-treating solutions, for example, Post Process Technologies (US), Additive Manufacturing Technologies (UK), and Dye Mansion (Germany) [26]. Such as insignificant classification, there is a lot of activity in this segment. For example, Post Process Technologies has announced proposals to expand into Europe with Rosler Oberflachentechnik, a producer of polishing systems for conventional manufacturing.

These post-processing techniques help to improve the dimensional accuracy of parts by reducing the internal stresses and surface roughness of manufactured products.

D. Evaluation Process

After passing the manufacturing process quality check, the evaluation procedure [65] is for manufactured parts reliability. This incorporates activities of gauging exterior and interior qualities of produced parts, whether it matches the design specification or physical and mechanical constraints. The external attributes are measured by such a caliper, robot system, CMM, coarseness tester, etc., as the interior physical qualities are gauged with NDT tests. Studies have optimized assessment procedures, developing Swept Vue, a unique audio microscope adapter, for price-valuable microfabrication QC. The assessment of geometry accuracy and interior structure qualities. Still, the final assessment technique involves excessive expenditure and huge volumetric capacity. Though, no clear standards for assessment/ measurements are apparent in the AM process [21]. The final evaluation process is a significant criterion that should satisfy the design requirements and customer requirements.

E. Demand for Reliability and Quality

AM today departs skilled practitioners through a bit to no vision into the procedure. Nor does it provide in-process feedback about part quality. Manufacturers expect the detailed AM struggles with quality and reliability, particularly for complicated components that remained extremely problematic for additional production procedures in the past [48].

The larger-level implementation of direct AM faces reliability and QC challenges:

a. The machinery and methods are fundamentally adjustable, like a setup from machinery to machinery and within machinery, affecting industrial and fabrication reliability discrepancies.
b. The development process has several flexible contributions that directly impact producing a part and finish quality.
c. The manufacturing requires only modeling guidelines, supervising techniques, or standards for completed manufactured goods.
d. Make Sure reliable, repeatable quality for finishing fabrication components.

The two common ways to validate that a part gathers excellence assurance standards for destructive testing and CT testing is very costly, consumption of time, inefficient, and but cannot generate accurate results. Quality tools can only be used after the component has been manufactured. Extremely challenging manufacturing processes anywhere, the hazardous be substantial like space, military, defense, automobile, fume, etc. must be confident that their parts can withstand many usage cycles and physically rigorous environments.

Depending upon part reliability, the performance under the stated purpose of a proposed end-user is determined.

As per the global market, the USA and Europe are top in the marketplace. Understanding the global market needs to know the developments in processes and quality; knowing the marketplace is essential. In 2019, Wohler's Report showed a polymer sales rise in the USA, which shows that final quality product is always in demand [12]. Global market development cannot be limited to mano material or single technology or field—AM is highly advanced in the industrial revolution 4.0 in all the areas with current trends.

V. Technical Innovation

Modern technologies, tailored materials, and other developments in the AM are taking place here and there, which may not address in this single paper. But let us refer briefly to the advancements of polymers and their role in different fields/technologies. oersted's. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity in an equation.

A. Polymers Innovations

Hack the Pandemic (Copper3D Inc) [53], and the medical supplies group that responded to the COVID-19 crisis tried to facilitate the medical devices by rapidly producing ventilators face masks with protective respiratory containing copper oxide, etc.

As Polymers technology ripens and continues to penetrate various products and industries. The government has initiated AM usage for critical medical devices, as per the FDA Draft Guidance article, to supply in emergency conditions [58].

Stabilization of Biospecimen: AM components made of lignocellulosic uses for elegant or delicate substances storage/maintenance of Biospecimens such as dry storage of DNA, RNA, and proteins under suitable environmental conditions. (GE)

Plastic welding by Laser: Laser-type joining of polymers has advantages, such as outstanding quality, reproducibility, and entirely without solvents. Laser type even replaces custom industrial processes such as adherent bonds and welding with ultrasound. (Trumpf) Laser welding efficiently protects the components from input heat, which is less heat than conventional welding. Usually, plastic welding cannot resist elevated temperatures to protect the internal components effectively. Generally, for all plastic welding (four different welding methods such as quasi, counter, mask, and simultaneous welding), 300 watts of laser power is used approximately [57].

Attractive look: Color components or parts are more attractive compared to neutral or base elements. Typically, post-processing is to get the desired color. Still, the color mixing solution from Ultracur3d helps the manufacturers to produce the parts in a wide variety of colors by adding a color solution to the base resin before manufacturing. (BASF 3D Printing Solutions GmbH)

Above are brief instances where AM polymers have progressed in a wide range. These days, digital engineering technologies significantly transform according to the manufacturer's mindset as per the manufacturability conditions or quality matters may be due to other factors.

B. Other AM Advanced Improvements

AM is not limited to specific materials for metals or plastics; it is a continuously evolving process in different fields irrespective of the materials or technologies as per necessity.

1) Medical field

In treatment, AM developments towards the structural models can be custom made to the patient, are becoming more designed for surgical procedure to reduce the risk for the patient, decrease operation time, and overall improvement for the excellence of treatment. In the medical division, Cora notes that AM's real benefit is the capability for mass production, personalized parts for medical instruments and devices or implants [28].

Advancements are in electromechanical eyes and organs, for example, the heart and membrane (skin), which could currently be in the MGA Medical network [45]. Research and Development department. The usage of titanium facial transplants to treat cancer patients for years in the Central University of Technology's Centre for Rapid Prototyping and Manufacturing (CRPM) in South Africa. In recent times, CRPM designed cages incorporated in the implantation to hold proteins that encourage jawbone growth. Bone growth to the patient can receive dental implants after therapy [31]. Biocompatible substance, like cobalt-chromium-molybdenum alloy (type 4 corresponding to ISO 22674), is CE-certified (CE 0537) for the dental industry. The 3D printing system EOS M 100 complies with manufactured dentures (EOS) requirements.

2) Naval field

The University of Maine discovered 3Dirigo (large boat) which constitutes the new iconic technological method for constructing a giant ship using 3D manufacturing, a 25-long foot, 2267.5 KG boat. The latest records have been set for the heaviest long solid 3D-modeled boat. Parenthetically, it is built by the prototype polymer's most oversized 3D belt [44]. Administrative Director of Maine's University, Dr. Habib Dagher, from the Advanced Structures & Composites Center, informed that this conventional advancement and engineering process for a 3Dirigo "could take months or even a year for similar craft or size" just printed in the three days.

3) Aerospace industry

SAE International first published polymer specifications for Aerospace Engineering. AMS7100: Fused Filament Fabrication Process and AMS7101: Material for Fused Filament Fabrication represent the first specifications released under the AMS-AM AM Non-Metallic (AMS-AM-P) committee (SAE 2019). The Fast Radius company manufactures Aerospace components like land gearing equipment, engine parts, cabinet components, and housing fixtures by using AS9100 quality standards. To meet the assembly requirements of Conventional manufacturing as well as AM.

4) Automotive industry

The leading automotive companies, like Volkswagen, BMW, and General Motors, are incorporating 3D technologies. For instance, Volkswagen chose one of the most advanced 3D technologies, HP Metal Jet, GKN, for the high-rate production of various metal parts of manufacture-quality material, as the basis for its approach to mass-produce using AM with a design and production roadmap. Close to ten thousand noble quality parts manufactured by the latest technologies with a good production lead. Similarly, BMW [33] has been employed and experimented with 3D technology for years by using functional and blue-sky innovation projects. For this, the BMW company has been awarded for 3D printed roof brackets, and its remodel of the S1000RR motorcycle frame serves as an expression of its capabilities.

5) Structural engineering/ construction industry

The Cambridge shire County Council [60] initiated the building of the Ely southern bypass in 2017 to reduce congestion in and around the small city of Ely. This bypass road connects to the Cambridge shire link and the Suffolk. Overcrowding in this field has been affected by its immediacy to Ely train station, which instigated queues of up to four miles. Therefore, this overpass bridge can remedy traffic.

The collaborative project in 2015 was the first 3D printed bridge in Amsterdam, between an Imperial College of researchers at London and The Institute Alan Turing. Four robots constructed this bridge in six months, which replaced temporarily with the 3D-printed bridge for two years, during which renovation of the original bridge [9]. This bridge's construction limited to only medium size buildings, but US-based startup Contour Crafting developed a new large, semi-autonomous 3D printer called the Contour Crafter [55].

The innovative technologies let manufacturers start production rapidly by turning on or off or scale output at any time in the demand for manufactured goods in different fields. Various networks help generate maintainability and advancements to make profitable products to develop technology or innovate per demand. To predict the usage of analytics and advanced skills toward forecasts that will advance conspicuousness and judgment. To adapt the work and business strategy to reach customer expectations. Adaption is essential to initiate new techniques by considering factors like connect prediction.

VI. Conclusion

Presently, the best practices are product quality improved in aviation and aerospace, but other fields modernize to enhance quality standards with different technologies. More Standards in measurement methods, process standards, and reliability conditions are improving.

However, other countries' governments should support AM technologies, allowing technology development and production to increase. This will reduce the overall costs of AM adoption.

To summarize the review, these collective considerations and findings of AM are helpful for future researchers to fulfill the ultimate gaps for creating groundwork or knowledge for manufacturers. AM technology has reached an intersection precisely to being applied as end-part production. AM remains a revival of long-lasting means for rapid prototyping, the technologies, and new findings of a new life occupancy in industrial applications like tooling and end parts. Different techniques develop to react to Additive manufactured parts' need for high-level quality, but additional research is anticipated to enhance their quality and procedures.

Below are the critical essentials from the findings of the review.

Polymer Materials: For manufacturing polymers, clarified manufacturing methods, different optimized or tailored materials development are in detail. Moreover, polymers advances are documented in various fields developed as the product but not only for prototypes. This literature review discussed different polymers which have less weight and good strength. Materials selection is essential for design conditions.

CAD considerations: This review studied various materials, design considerations, and their manufacturing procedures with applications in multiple fields. Based on material, the designers create 3D models and perform CAE analysis. Accordingly, the CAD file with the medium of cloud-based source and limitations with the CAD source studied for a future researcher's glimpse.

Quality: To aim for decent 3D printing, continuous optimization should be composed of design constraints for ensuring part quality. To achieve reliability, quality control is crucial in every phase. Those four phases, from design to evaluation process, make a list in this review. Excellent findings through this study help analyze different innovations (such as medical, naval, aerospace, automotive) to discover technology updates. After the 2000s, there was a sudden rise in companies proposing technologies that can give high-quality polymer parts with warranty details. Individual companies have developed their patent standards to assure product quality, which helps to withstand competition. Quality benchmarks continue refining the efficiency of AM procedures as it is growing day by day. High investment in rapid digitalization and materialization in AM is inclined up to the increased production cost. Therefore, innovations develop gradually in different fields to low production costs to benefit every single manufacturer. This study explores within reach of engineering practices for polymers, and it will require continued research and growth surplus eras due to the highly elaborative sort of 3D printing.

Conflict of Interest

We declare that there is no conflict of interest.

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