A Review on the significant classification of Additive Manufacturing

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Abstract: Additive manufacturing (AM) implementation has advanced beyond prototyping towards becoming an extremely configurable manufacturing process with the illustrated ability to change conventional manufacturing in the future generations entirely. AM is completely based on Rapid Prototyping (RP), which helps fabricate critical and immense structure with 3D CAD software. The primary goal of this method is to create a product with optimal features such as compact, increased energy absorption, material reduction, insulation, and heat exchange. On the opposite, modeling and generating lattice structures and implementing different applications are all required. This review will get into the concepts of various classifications of additive manufacturing and its features.

Keywords: Additive manufacturing, manufacturing, rapid prototyping, AM methods.

1. Introduction
Combining materials to produce complex structures from 3D model data, typically layer by layer, is known as additive manufacturing (AM). The product is created using CAD software and then printed using one of the methods of additive manufacturing. It can also print pieces that can't be made with conventional production methods. Complex and intricate products can be produced with significantly reduced processing cost, processing time, and waste reduction. In the 1980s, AM tools were used in manufacturing, rapid prototyping, data interpretation, and advanced manufacturing. In the decades since, they've been working on expanding into production. For the first time in the early 2010s, industrial manufacturing positions in the metalworking industries reached substantial scope. AM device sales have increased dramatically since the turn of the century, and their cost has decreased significantly. 3D printing is the most known and advanced method of additive manufacturing, and other than that there are few more method which helps the manufacturing process to be done quickly in their way and features [1-5].
2. Classification of additive manufacturing

In additive manufacturing, some of the methodologies are there other than 3D printing. There are numerous design parameters in a standard additive manufacturing process, such as manufacturing speed, better surface, efficiency, resolution, dimensional accuracy, build size, expense, and component strength [6-9]. Lightweight materials are widely used in various industrial applications [10-12]. Other methodologies of additive manufacturing that can also achieve these parameters are shown in figure 1. They are,

- Material extrusion
- Material jetting
- Binder jetting
- Vat photopolymerization
- Sheet lamination
- Direct deposition energy
- Powder bed fusion

![Figure 1. Seven Classification of additive manufacturing](image)

2.1. Material Extrusion

The material extrusion is also known as FDM, a Stratasys trademarked name. This device employs a glue gun-like nozzle that layers molten material in small flattened strings to create structural models. Material is extruded through a nozzle or orifice in tracks or beads at a constant speed and fully solidifies, converted into a multi-layered structure. It also completely binds to the previous layer so that the components remain in a required design. Figure 2 represents the schematic of material extrusion.

**Advantages:**

- Inexpensive and easy-to-use polymer and plastics.
- Permit to use the multi-colored object.
Ideal for high-strength models.

**Suitable Materials of this process**: Thermoplastic filament and pellets, Liquids and slurries.

### Figure 2. Schematic of material extrusion

2.2 Material jetting

In this method, the jet drops of wax or other material, including metals, binding layer by layer to create an entire component. It has three methods for curing by photocuring, UV light curing, and Solidifies under room temperature. Here minimum resolution is that the volume of the single droplet. Figure 3 shows the material jetting process.

**Advantages**:

- Able to fabricate components with different materials.
- High accuracy and superior surface finish.
- Makes various colored products.

**Suitable Materials of this process**: Polymers, wax and photopolymers.
2.3. Binder jetting

Liquid bonding agents are selectively deposited onto thin layered powder material, fabricating the products as layer by layer. These liquid binders are of two classifications: organic and inorganic. The printing head of the binder jetting is provided with the bonding agents, which join with the powder to be layered. Figure 4 depicts the binder jetting setup.

**Advantages:**
- Prints significant components in a short period.
- Cost-effective process.
- Usage of more varieties of materials is possible.

**Suitable Materials of this process:** Powdered plastic, metal, glass, sand and ceramics.
2.4. Vat photopolymerization

Vat photopolymerization is also referred to stereolithography process. A vat of liquid polymer resin is made cured by selectively exposing to the light like laser or projector. By doing so, it proceeds the polymerization process and converts the exposed region as a solid component. The Schematic diagram of vat photopolymerization is shown in figure 5.

**Advantages:**
- Better surface finish.
- Makes larger components.
- Provides more accuracy for the component.

**Suitable Materials of this process:** UV curable photopolymer resins.

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**Figure 4.** Binder jetting

**Figure 5.** Schematic diagram of vat photopolymerization
2.5. Sheet lamination
The process of stacking sheets of materials and laminating them together to fabricate an object is called sheet lamination. Each layer is laminated using adhesives or some other chemical bonding for plastics, brazing and ultrasonic welding for metals. The excess region is removed by cutting layer by layer after completing fabrication. The sheet lamination entirely depends on laminated object manufacturing and ultrasonic additive manufacturing. The process of sheet lamination is represented in figure 6.

Advantages:
- Makes a combination of metal foils.
- Simple and cost-effective process.
- High manufacturing rate.

Suitable Materials of this process: Paper, metal tapes or metal foils and plastics.

![Sheet lamination diagram]

Figure 6. Sheet lamination

2.6. Direct deposition energy
In this process, the powder or coil is fed into the extruder with makes the melt pool by applying heat to the specific part of the extruder and makes the layer of the part. Each layer is adhered to the following layers, making the complete component by the energy process using electron beam or lazer. It is one of the automated build-up welding processes. The direct deposition energy is shown in figure 7.

Advantages:
- Economical and cost-effective.
- Provides multi-colored part and can be suited for the office environment.
- Not limited by axis and directions.

Suitable Materials of this process: Metal powder and wire with ceramics.
Figure 7. Direct deposition energy

2.7. Powder bed fusion
It is one of the methods of additive manufacturing that is completely based on the thermal-powered process. The lasers are introduced to partially or entirely fuses the powdered material with the base layer followed by layer by layer. Sintering and melting is the significant principle process of this powder bed fusion method. The unfused powder associates parts which act as a support material for overhanging structures. The diagrammatic representation of powder bed fusion is shown in figure 8.

Advantages:
- Better for complex designs.
- Availability of a wide range of materials.
- The powder acts as a support material.

Suitable Materials of this process: Metals, plastics, sand and ceramic powders.

Figure 8. Powder bed fusion
3. Conclusion

This article précises the fundamental method of additive manufacturing. Since 3D printing is a well-known method in all sectors, few primary techniques are especially suited for the particular processes. Most of these seven methods have a lenient that can work with many varities of materials and produce multi-colored components. Each method has its advantages in the strength of the components fabricated. Overall, these methods are required when manufacturing is to be done quickly, and most of them are cost-effective, leading to the betterment of the industrial world.

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