Polyjet – An Additive Manufacturing Process

Dharmendra B Patel
Lecturer
Department of Mechanical Engineering
Dr. S & S Ghandhy College of Engineering & Technology Surat, Gujarat, Pin-395001 India,

Abstract— Additive manufacturing (AM) is a new variant of manufacturing processes where in the part is built by adding material layer by layer. Many AM processes are being used today and Polyjet process is one of them. Polyjet process used two heads; one dispenses the model material, while the other prints support material. The support material is then washed away easily. The process yields extremely good accuracy, allowing the machines to be used in the jewelry industry. This paper brings in site to the Polyjet technology, it's advantages and limitations. Additionally information on 3D printers based on Polyjet process has also been touched upon.

Key words: Polyjet, Additive Manufacturing, Rapid Prototyping, 3D Printer

I. Introduction

Every engineer aims to make human life more comfortable, for that he/she is continuously associated with invention of new/improved products and processes. The product are made by various manufacturing processes, which are broadly classified as material removal processes and material addition processes. The material addition processes, formerly known as Rapid Prototyping (RP), are also known as Additive Manufacturing (AM) processes.

In AM processes the product is built by adding material layer by layer. The basic steps involved are as below [1]:

- Create a CAD model of the product as per design
- Convert the CAD model to STL format
- Slice the STL file into thin cross-sectional layers
- Construct the model one layer atop another
- Clean and finish the model

The material addition processes according to Kruth [2] may be divided by the state of the manufacturing material before part formation as three categories:

- Liquid-based processes
- Powder-based processes
- Solid-based processes

AM processes can be classified according to the raw material used as under [3]:

1) Liquid-based techniques
- Stereolithography (SLA)
- Holographic interference solidification (HIS)
- Beam interference solidification (BIS)
- Solid ground curing (SGC)
- Liquid thermal polymerization (LTP)
- Fused deposition modeling (FDM)
- Multijet modeling (MJM)
- Ballistic particles manufacturing (BPM)
- Shape deposition manufacturing (SDM)

2) Powder-based techniques
- Selective laser sintering (SLS)
- Laser engineered net shaping (LENS)
- Three-dimensional printing (3DP)

3) Solid-based processes
- Solid foil polymerization
- Laminated object manufacturing (LOM)

Some of these methods depend on solidifying a liquid polymer by the impact of laser or light or by the curing of powders to create the part. Other processes are based on melting, deposition, and resolidification of plastic or resin materials.

Additive manufacturing is widely used in the automotive, aerospace, medical, and consumer products industries. Although the possible applications are virtually limitless, nearly all fall into one of the following categories:

- prototyping,
- rapid tooling
- rapid manufacturing
- bio-manufacturing

II. Polyjet Technology

This technology is similar to stereolithographic in that parts are made with a photosensitive resin. The difference is in how the resin is applied and cured to build the part. This technology may also referred as Inkjet or Multijet technology.

Polyjet technology uses a jetting head to accurately build each layer at 16 microns (0.0006 inches) thick, which is about 1/5 that of stereolithographic layers. The jetting head slides back and forth along the X-axis, jetting tiny droplets of UV resin onto the build tray as shown in fig. 1. Immediately after building each layer UV bulbs alongside the jetting head cure and harden each layer subsequently.

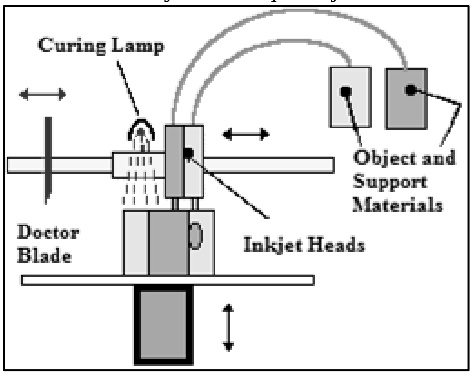

Fig. 1: Polyjet Process

Two different materials are used for building: one material is used for the actual model, while a second, gel-like UV resin is used for support. Each material is simultaneously jetted and cured layer by layer. When the model is completed, support material is easily removed with pressurized water. Because of the super thin layer thickness, the resulting parts are very accurate and have a very smooth surface finish.

There has been rapid growth in employing inkjet printing for different non-graphical applications as the technology can deposit a wide range of materials on almost every substrate in a precise and controlled manner [4]. In addition, the digital nature of inkjet printing gives it an advantage as information can be flexibly chosen from a computer for printing. Reproducibility is another advantage of inkjet printing as fault recognition and quality monitoring is easy to achieve in this type of printing [5]. This has resulted in the technology being used as a manufacturing tool in a wide range of applications including printed electronics, additive manufacturing and bioprinting [6 - 8].

Inkjet technology has been classified into two main techniques based on the jetting head used: continuous mode and drop-on-demand (DoD) mode. Detailed information on these modes can be found in the literature [5, 8, 9 cited by 10].

A train of droplets is made in continuous mode inkjet printing by pressurizing the liquid through a feeding system and then vibrating a piezoelectric element inside the print head. In a DoD mode inkjet head, a voltage signal is sent to a transducer that forces liquid material through a nozzle and a droplet is generated to hit the substrate when needed. Several actuation systems have been developed for DoD mode printing in which the thermal and piezoelectric systems are the most widely used [5]. Thermal actuation systems are mainly limited to water-based inks whereas a wide range of materials can be used with piezoelectric inkjet systems which enable the technology to be used as a manufacturing tool.

Additive manufacturing processes were developed based on printing photopolymer resins where an ultraviolet (UV) light could cure and solidify the deposited pattern. The first commercialization of such a technique was introduced with Polyjet technology of Objet Geometries in 2001 [11 cited by 10].

III. POLYJET 3D PRINTERS

3D printers are made by Objet, which one of the brands of Stratasys. The brand began with Objet Geometries Ltd, a corporation engaged in the design, development, and manufacture of photopolymer 3D printing systems. The company, incorporated in 1998, was based in Rehovot, Israel [12]. In 2011 it merged with Stratasys. It held patents on a number of associated printing materials that are used in PolyJet and PolyJet Matrix polymer jetting technologies. It distributed 3D printers worldwide through wholly owned subsidiaries in the United States (Objet Geometries Inc), Europe (Objet Geometries GmbH), and Hong Kong. Objet Geometries owned more than 50 patents and patent-pending inventions.

The company provides different series of 3D printers based on Polyjet process. The some of the printers are named as Objet24, Objet30, Objet30 Pro, Objet Eden260VS, Objet260 Connex3, Objet30 Orthodesk, Objet30 Dental Prime, Objet Eden260VS Dental Advantage, etc. [13] and the fig. 2 shows the Objet30. It also provides the materials of different variety to print the parts with different properties and look. The materials are also available in different color, and they are categorized as Digital Materials, Digital ABS, High Temperature, Transparent, Rigid Opaque, Simulated Polypropylene, Rubber-like, Bio-compatible, Dental Materials [13]. The fig. 3 shows some of the parts made using Polyjet 3D printers.

Fig. 2: Objet30 – 3D Printer [14]

Fig. 3: Parts Using Polyjet 3D Printer [14]

Applications of the Polyjet process includes

- Presentation models
- Master patterns
- Form and fit models
- Flexible, rubber-like models
- Medical device prototypes
- Prototypes for fittings, valves, and parts with complex interior features

Advantages of Polyjet process are

- The Only Multi-Material 3D Printing Technology
- More than 100 materials and digital material combinations to choose from
- Rigid to rubber-like, opaque to transparent and ABS-simulating performance
- High-resolution parts with detailed features that simulate final-product aesthetics

Presently Polyjet process is facing the following limitations

- Changes properties overtime when exposed to light and heat
- Poor mechanical properties
- Requires manual support removal

IV. CONCLUSION

Additive manufacturing is a new variant of manufacturing and Polyjet process is one of the additive manufacturing processes. Using this process it is possible to combine several materials to simulate over-molding, build flexible and multi-colored parts, and create complex models as fine as 16 microns. PolyJet is best suited for small parts when accuracy, detail, and surface finish are essential.

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