CAD/CAM, generative technologies, additive manufacturing*

Rashmi Mallappa Hatti*

DKTE's Textile and Engineering Institute, Ichallaranji, Maharashtra

**Presented in 1st National Conference on Smart Manufacturing & Industry 4.0 (NCSMI4) at Central Manufacturing Technology Institute (CMTI), Bengaluru, during May 30-31, 2019.*

ABSTRACT

Speed in customer desire is rapidly increasing henceforth increase in speed of product manufacturing is primer. To lead these requirements for customization, the technologies should perform the function of 'mass customization'. With use of smart CAD/CAM modeling technologies there has been constraint for Product development time. The Paper includes the key technologies which are gaining momentum nowadays are Rapid Manufacturing, Rapid tooling, Rapid Prototyping, Additive manufacturing, CAD/CAM. The paper also gives the brief overview of Reverse Engineering. The paper contains some of 3D Scanners. The paper highlights the Recent Developments using these technologies in the world with few examples are also included in this paper.

Keywords:
Rapid Manufacturing,
Rapid Prototyping,
Rapid tooling,
Additive Manufacturing,
CAD/CAM,
Manufacturing,
3D Scanners,
Product Development.

1. Introduction

Additive Manufacturing (AM) is the manufacturing process based on 3D set visual model or CAD model using the layers of counters of even thickness. It is the 'Layer based automated fabrication process' for making 3D objects directly from 3D Cad model without using part depending tools. Usually known as 3D Printing. The Design software play a very important role in additive manufacturing such as 'Computer Aided Design' [CAD] with concept of design and 'Computer Aided Manufacturing' [CAM] with concept of manufacturing.

Industrial 3D Printing is at its tipping point, Rapid manufacturing leads to safe and durable products within less time and also possible for mass customization. When the first approach of AM was introduced in market it was known as 'Rapid Prototyping' or 'Generative 'Manufacturing'.

Additive manufacturing can be defined by the technologies which are capable of transforming virtual 3D Cad data into physical models in quick and easy process. This is new descipline which eliminates tooling having profound implications in design, manufacturing, etc.

*Corresponding author,
E-mail: Rashmihatti07@gmail.com(Rashmi Mallappa Hatti)

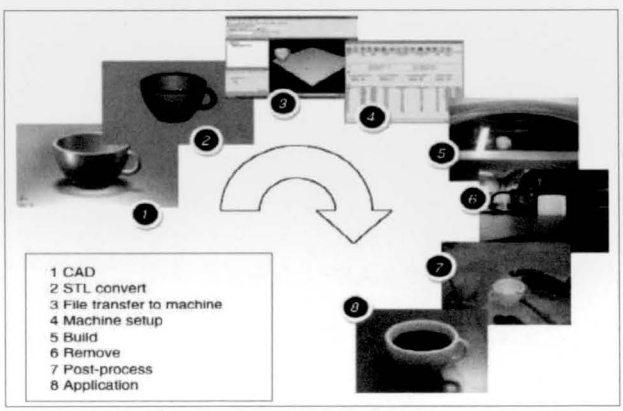


Fig.1. Generic process of CAD to part.

2. Additive Manufacturing

The first approaches to additive manufacturing entered in 1987 it was also known as 'Rapid Prototyping' or 'Generative Manufacturing'. The term 'Generative manufacturing' covers any imaginable way of adding material in order to create 3D physical part. And the term Additive is solely based on 'layer based technology' or 'layer oriented technology'.

The patent by Charles Hull is recognized as most

influential as it gave rise to 3D Systems. This was the first company commercialize the AM technology with Stereolithograpy apparatus.

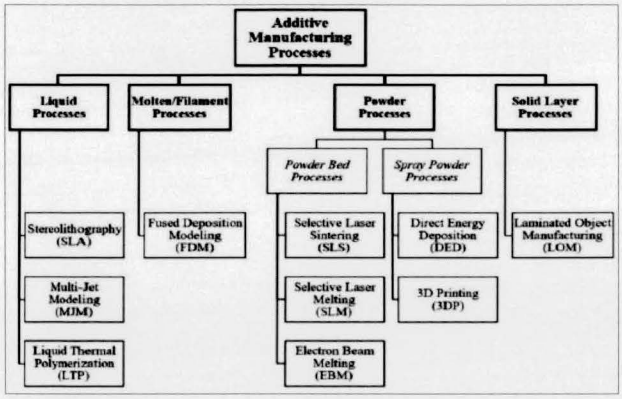


Fig. 2. Various additive manufacturing processes.

3D Printing is synonym used for AM; it describes a 'professional production Technique which is clearly distinguished from conventional methods of material removal.

In Additive Manufacturing each layer is countered according to the corresponding 3D data set and put on the top of the preceding one. After an automated process of mesh fixing, slicing, and hatching the desired structures transferred into photopolymer volume by scanning the lasers focus point in layer by layer process. In AM each layer must be of finite thickness to it and hence resulting n approximate CAD data. The thinner the layer the part will be duplicate to the original.

Steps in AM-

1. Data set is obtained 3D CAD design.
2. Countered virtual slices of even thickness are obtained using special software.
3. The all gathered information from data set, such as layer thickness, number of layers is feed into machine which creates the part layer by layer.
4. Merging the layer on each other till final part is ready
5. These basic steps known as "process chain" are same in most of AM machines.

2.1. Application levels of additive manufacturing

Table 1.
Application level in AM.

Technology level	Additive Manufacturing
Application level	1. Rapid prototyping
	2. Rapid Manufacturing

Rapid Prototyping deals with the applications leading to model; While Rapid Manufacturing is when final part is made.

3. Rapid Prototyping

The prototype is the vital part of product design process. It is the preliminary version or model which is further used for development of part. Rapid prototyping process of creating prototypes rapidly.

Rapid prototyping new trend in prototyping technology.

Rapid Prototyping

Concept modeling Functional prototyping

Concept modeling is the family of parts that are applied to verify a basic concept.

These are also known as "show and tell models".

Functional prototyping is applied to allow checking and verifying the functions of later produced product in order to take decision. The part resembles the 3 dimensional statue not the original part.

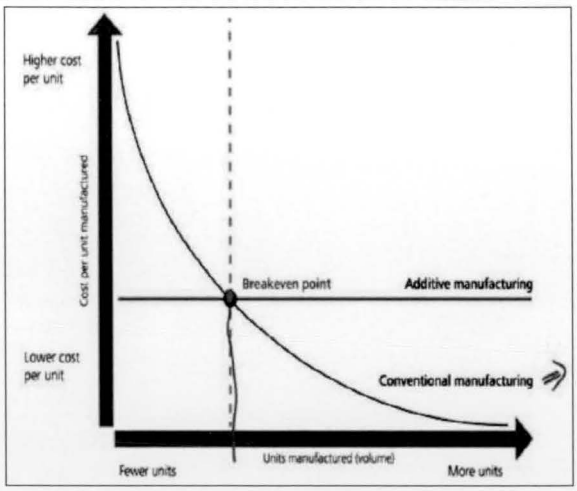
4. Rapid Manufacturing

Rapid Manufacturing is defined as 'the use of computer aided design (CAD) based automated additive manufacturing process to construct the parts that are directly used as finished components'.

Why Rapid Manufacturing?

Rapid Manufacturing is creating safe and durable products for real customers in moderate to large quantities.

Shrinking of Product manufacturing time.



The price of additive manufacturing is decreasing. (ref fig 3)

5. CAD, CAM CAE

CAD/CAM are enabling technologies in product development and manufacturing development. CAD< CAM and CAE are virtual model software's used under domain Ax.

CAD - computer aided design is primarily used for visualizing the end product on computer as rendering, assigning materials and design aspects.

CAM-computer aided manufacturing is used for assembly, maintenance, manufacturing using computer software.

CAE- computer aided engineering is used for virtual validation of product for various loading conditions it might face during actual use. It includes Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), Multi body dynamics (MFD), and optimization.

Additive Manufacturing technology primarily makes use of the output from the 3D CAD model. CAM represented the channel of converting virtual images created by CAD into physical one that we use in our day today lives.

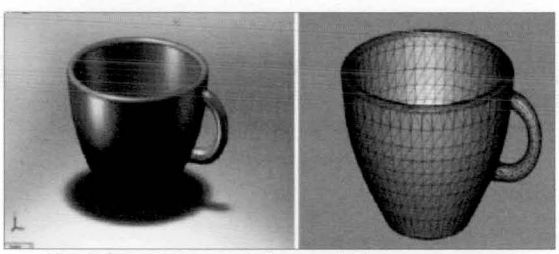


Fig 4.1a. CAD model onto left is converted into STL (Standard triangulation language) format on the right.

The CAD technology has been rapidly improved along realism, engineering content, speed, accuracy, usability and user interface, complexity. The Constant development of product design and manufacturing increasingly inflict impacts upon smart CAD/CAM technologies, proposing greater requirements for the research on and growth of CAD/CAM.

6. Subtractive Versus Rapid Manufacturing

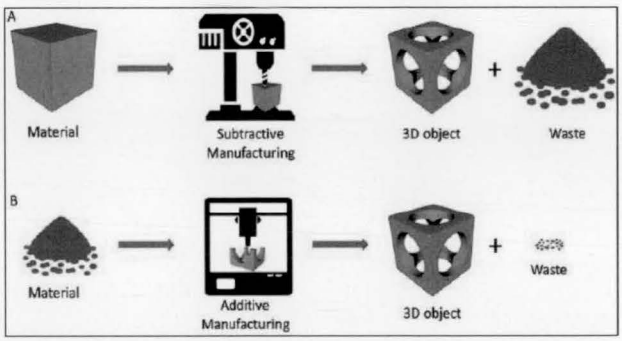


Fig. 5.1. Comparision between RM and CNC machining.

Table 5.1
Comparison between RM and Subtractive Manufacturing.

Rapid manufacturing	Subtractive manufacturing
Speed in terms of time and product development process	More time consuming
What you see is what you built in single step	Multiple and iterative steps.

As complexity increase RM has advantages than computer numerical controlled (CNC). But the material removing rate of CNC is faster than material addition of same volume in RM.

7. Reverse Engineering

One of the important approach in reducing product development cycle.

Reverse engineering is the process of obtaining the 3D CAD model by scanning the part existed. (Ref. Fig. 6.1)

Object → scanning→ RE bridge→ CAD model Again manufacturing cycle. RE is legal if the

intention is not to copy. Scanners may be contact type (co-ordinate measuring machine), non contact type (laser).

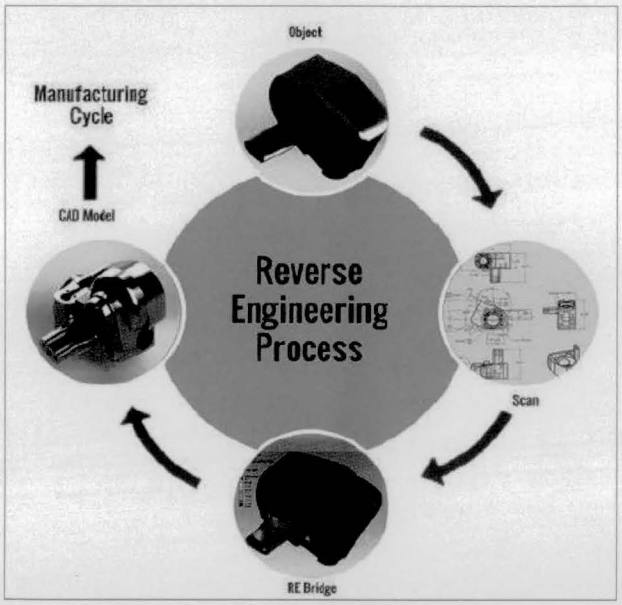


Fig. 6.1. Reverse engineering cycle.

8. 3D Scanners

Artec Eva, Space spider, .PICZA (LPX 600) (Ref. Fig. 7.1 &7.2)

Fig. 7.1. PICZA (LPX 600).

Artec Eva and space spider are with high resolution 3D scanners are easy to carry as they are portable. Scanners are compatible for laptops,

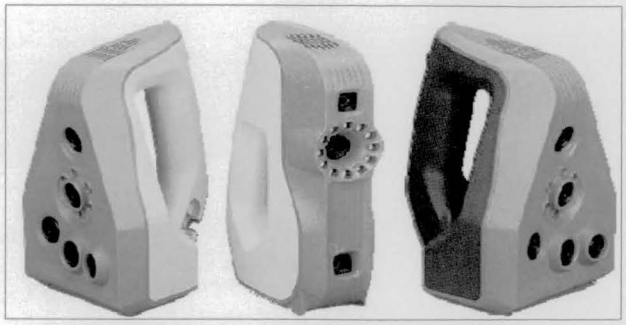


Fig. 7.2. Artec eva and space spider.

tablets. Scanners with 6 hours of battery pack. Scanners are focusing on Reverse engineering, prosthetics, orthostics etc.

PICZA (LPX 600) is non contacting type laser scanner and it is closed type. High speed scanner

9. Recent Developments With Examples In This Technology

The U.S. Army combat capabilities development command (CCDC) of army research laboratory (ARL) is using customized steel alloy powder to 3D print high strength spare parts for ground vehicles in a bid to " to revolutionize logistics"

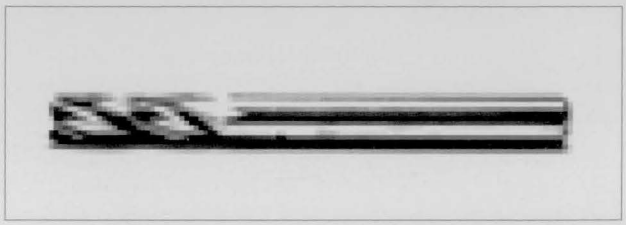


Fig 8.1. The prize winning LMD 3D printed cutting tool.

Fig. 8.2. The TRUMPF true laser cell 7020 within RMIT advanced manufacturing project.

California headquarter medical imaging company QT Ultrasound has used its detailed pictures of microanatomy to 3D print a model of women's breast tissue. A tangible model of complex duct system, the model present potential avenue for diagnosticians working with breast cancer.

A 3D printed grade of steel, capable of producing tools that cut titanium, has won a $10 thousand USD prize for a PhD candidate at RMIT University, Melbourne. (Ref. Fig. 8.1. & & 8.2.)

10. Conclusions

1. "Additive manufacturing is going to have a huge impact on sustainment"-Dr Brandon.
2. Additive manufacturing is giving tough competition to the conventional technologies.
3. Additve manufacturing is going to lead lot of development in CAD, CAM, and CAE.
4. Reverse Engineering is playing major role in development of technology.
5. Additive manufacturing is leading to mass customization.

References

1. Janakarajan Ramkumar and Amandeep Singh: Rapid Manufacturing, NPTEL courses IIT Kanpur, 2019.
2. Hopkinson, Neil; Hague, Richard; Dickens, Phill: Rapid Manufacturing- An industrial revolution of digital age, 2006.
3. Gibson, I; Rosen, D; Stucker, B: Additive Manufacturing Technologies, 2010.
4. Raqeyah Jawad Najy: The Role of Computer Aided Design (CAD) in the Manufacturing and Digital Control (CAM), vol. 6, 2013.
5. Chua Chee Kai, Leong Kah Fai Lim Chu Sing: Rapid Prototyping - principles and applications, 2 Lim Chu Sing003.
6. Hart, John: An introduction to additive manufacturing, 2015.
7. Yakout, Mostafa; Elbestawi, MA; Veldhuis, Stephen, C: A review of Metal Additive Manufacturing Technologies, vol. 278, 2018.
8. 3Dsystems.com ◘

Rashmi Mallappa Hatti
Final Year Mechanical Engineering student,
DKTE's Textile and Engineering Institute, Ichalkaranji Maharashtra