AMT

IMPACT OF 3D METAL PRINTING (ADDITIVE MANUFACTURING) IN INDUSTRIAL APPLICATION

Overview of 3D Metal Printing (Additive Manufacturing) Technology

3D printing technologies are not a recent novelty, after all its invention goes back to the 1980s when Chuck Hull first developed and patented the idea of stereo lithography – a method and apparatus for making solid objects by successively "printing" thin layers of ultraviolet curable materials on top of the other. The timeline below helps to illustrate the journey made insofar.

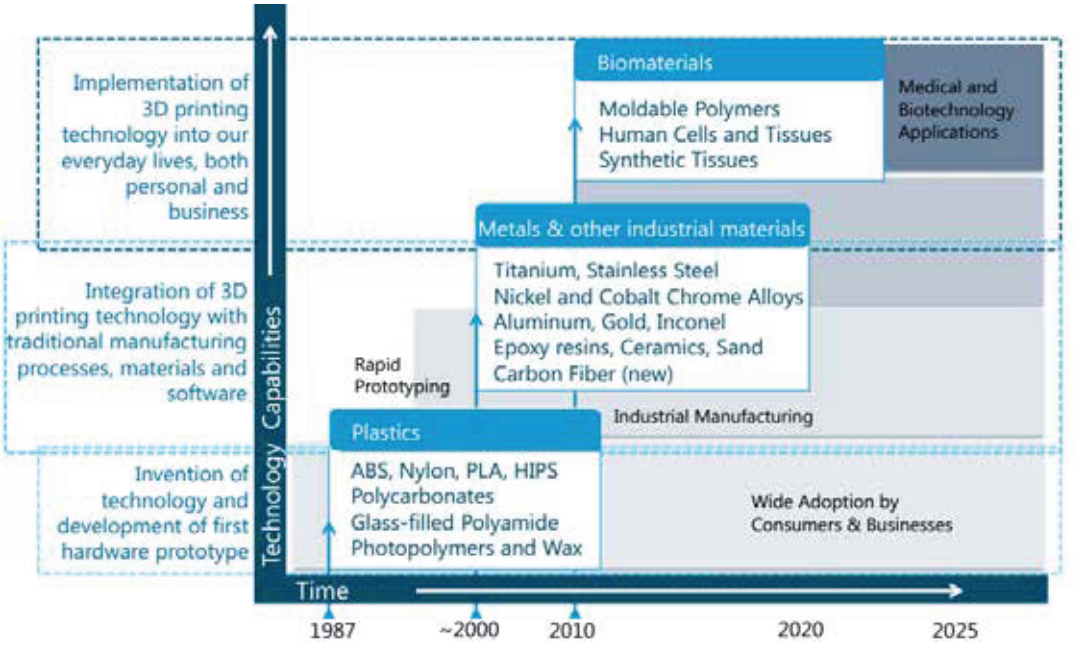


Fig 1 – Evolution of 3D printing technologies [1]

What has changed recently is the explosion of plastic desktop systems becoming readily available in the consumer market place (for example Makerbot) and the increased prominence and interests in the potential application within the industrial space mainly driven by metal 3D printing technology. With 3D metal printers now being able to work with materials such as titanium, stainless steel, aluminum and inconel, it positions the technology as a possible transformative game changer when it comes to making parts for industrial application.

Fig 2 - Makerbot

What is the difference between 3D Printing vs. 3D Metal Printing vs. Additive Manufacturing?

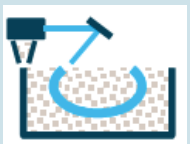
Essentially, all three terms refer to the same thing. They are all based on layer based manufacturing techniques, however the specific material or method in which each layer of material generated may be different. A commonality amongst all three is the elimination of any tooling to generate the manufactured goods and the need to have some form of support structure that is built as part of the model (like miniature scaffolding) during the layering process.

Fundamentally all three terms point to the same manufacturing process. The question is what material is to be used – plastic or metal. But what about Additive Manufacturing? Referring to the text of engineering technology, the term Additive Manufacturing includes all processes that add material to attain the creation of manufactured goods. Conversely, conventional machining could be framed as a subtractive process as one would be removing excess materials to attain the final manufactured goods.


Fig 3 – Support structure

Overview of 3D Metal Printing (Additive Manufacturing) Technologies

The table below provides an overview of the four 3D metal printing technologies available for use of metal forming. The Powder Bed Fusion has the most relevance for metal and is the most often used technique due to higher accuracy and relative surface quality. Directed Energy Deposition for metal is less widespread due to lower accuracy and post-disposition heat treatment being required.

Technology	Description	Typical Markets	Relevance for Metal
Powder Bed Fusion 	Thermal energy selectively fuses regions of a powder bed.	- Prototyping - Direct parts	High
Direct Energy I 	Focused thermal energy is used to fuse materials by melting as the material is deposited.	- Direct parts - Repair	Moderate

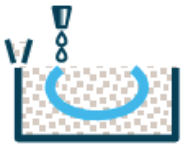
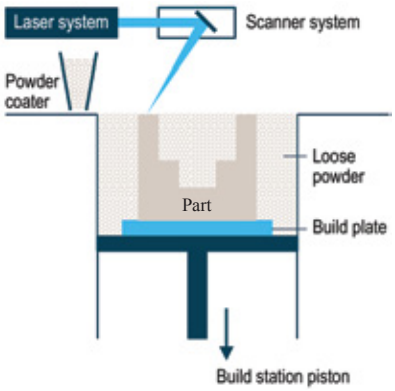
Sheet Lamination 	Sheet of materials are bonded to form an object.	- Prototyping - Direct parts	Low
Binder Jetting 	Liquid bonding agent is selectively deposited to join powder material	- Prototyping - Direct parts - Casting molds	Low

Table 1 - Overview of 3D Metal Printing Technologies [2]

The Key Steps for Powder Bed Fusion Technology

1. Powder is dispensed on powder bed.
2. Parts are precisely fused via laser.
3. Build station is lowered.
4. New powder is dispensed.
5. Repeat (1) to (4) until complete part is formed
6. Remove support structures.



Support Structures

Let us examine the aspect of support structure in more detail. One major implication of building a part one layer at a time is that, as the geometry builds upward, any downward facing surface will require some support, as the material would be less solid during the printing process. Most processes will require a support structure like miniature scaffolding. This can be easily removed in most instances, but in more complex design or when printing with materials such as titanium, the removal process could involve considerable cost and time. Issues like support removal and other post processing considerations and requirements directly affect the economical viability of 3D metal printing (Additive Manufacturing) technology. Finding a reliable partner who is skilled in minimizing the need and has existing infrastructure to manage these operations while being proficient in design engineering is key to making these parts as economically efficient as possible.

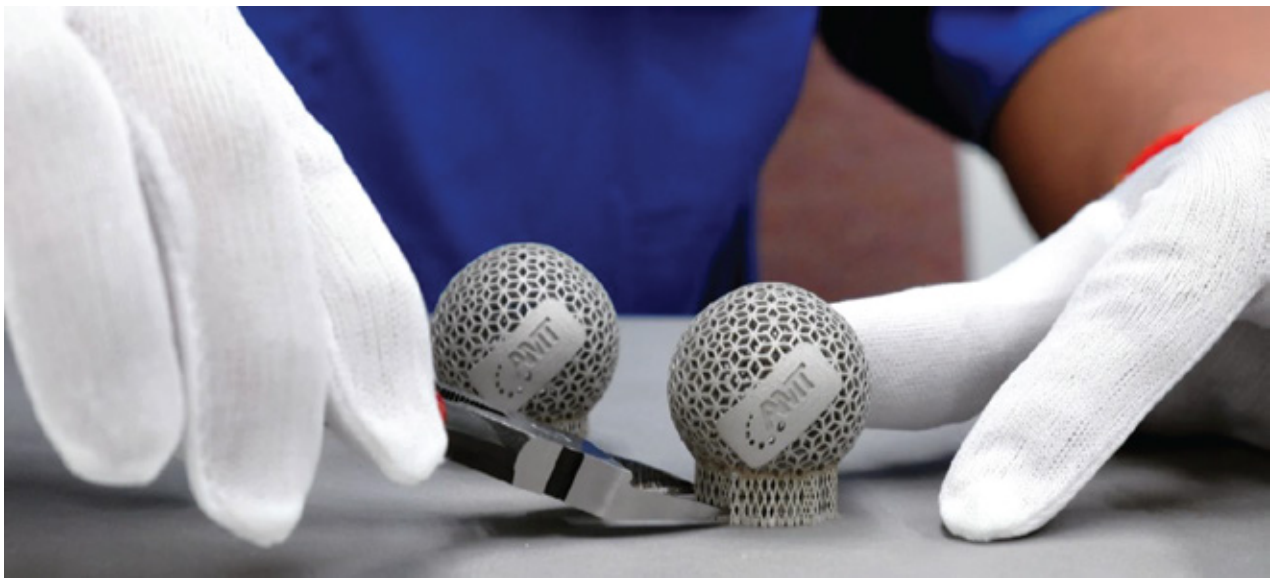


Fig 4 – Support removal

In Summary

A recent analysis by Frost & Sullivan points toward personal manufacturing and small scale production is paving the way for the diffusion of Additive Manufacturing. Undoubtedly, the technology holds several advantages in terms of performance and efficiency, however firms in the industrial space are still exploring and choosing different approaches in attempting to unlock the value of this evolving technology.

While the concept of virtually being able to print all conceivable designs and achieve absolute design freedom is attractive, the reality is that the ecosystem has only begun to take shape and real industrial applications and issues will continue to surface.

Whichever process you wish to use, one good suggestion would be to talk to the potential supplier as early as possible in the design process. This is because a successful and economic design of part made for manufacture using 3D metal printing is more closely associated with their production process as compared to conventional molded components. Layout of parts in the build, the orientation and minimization of supports all has direct impact on the design of the part.

Sources

(1) 2014 HIS – Engineering 360 on Additive Manufacturing
(2) ASTM International Committee F42 on Additive Manufacturing Technologies