A Study on Metal 3D Printing Manufacturing Technology

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1. Introduction

There's been a lot of publicity on 3D printing being the third industrial revolution in 2013. 3D (three dimensional) printing has been garnering considerable attention in the media these days, after President Obama's endorsement of 3D printing in his State of Union Address in 2013 that helped bring forward 3D printing as an industrial tool. The technology will completely change not only the manufacturing industry, but also our entire way of life in the future.

In recent years, 3D printing has been a rapid growth due to its wide application in different industries from medical, automotive and aerospace to consumer products. It can be divided into 3 different segments; technology, applications and raw materials. 3D printing, often referred to as additive manufacturing (AM), is an additive process that is used for producing the final products in the layer-upon-layer manner with the use of diverse materials such as plastic, metal, ceramics, and more. The implications of a machine being able to produce objects of any shape, as and when they are needed are immense-it is the beginning of a new era. This technology enables more cost-effective, less wasteful, rapid manufacturing of parts or components. It describes 3D printing as the technology that enables them to create their own designs and print objects based on them. Now what remains to be seen is how this technology of metal 3D printing will evolve and how the market will show their industries in order to be more competitive.

2. 4 Process Types in Metal 3D printing

3D printing process types have been categorized into seven areas from the ASTM (American Society for Testing and Materials) in 2012 [1]. Among the classification of additive manufacturing, those are Binder jetting, Sheet lamination, Powder bed fusion and direct energy deposition belonging to metal additive manufacturing.

[Table 1] Classification of metal additive manufacturing processes

ASTM Classification	Technology	Definition	Developers (Country)
Binder jetting	Digital part materialization	Liquid bonding agent is selectively deposited to join powder materials.	ExOne(US)
Sheet lamination	UAM	A process in which sheets of material are bonded to from an object.	Fabrisonic(US)
Powder bed fusion	DMLS EBM SLM	Thermal energy selectively fuses regions of a powder bed.	EOS(Germany) Arcam(Sweden) 3D Systems(US)
Direct energy deposition	DMD DMT EasyCLAD	A process in which focused thermal energy is used to fuse materials by melting as the material is being deposited.	Trumpf(Germany) Insstek(Korea) BeAM(France)

※ Additive manufacturing (ASTM 2012): Vat Photopolymerisation, Material jetting, Binder jetting, Material Extrusion, Powder bed fusion, Sheet Lamination, Direct energy deposition

Binder jetting operate by spraying liquid binder onto a bed of powder also known as Inkjet Powder Printing, solidifying it into a cross-section. Each layer is printed in much the same way a traditional paper printer prints ink onto a sheet of paper, only in this case, on a layer of powder. After each cross section is finished, an automated roller builds up additional powder to the next layer of the object. Binding jetting is one of the best options for 3D printing in full color and has led noticeable layer definitions, making it an ideal choice for producing end-use products. ExOne is the most representative enterprise in Binder jetting.

One of the first commercialization in 1991 additive manufacturing techniques was Sheet lamination. Sheet lamination involved layer-by-layer lamination of paper material sheets using heat and pressure, and then cut into the desired shape with a computer-controlled laser. There is UAM (Ultrasonic Additive Manufacturing) process of representative technology. Fabrisonic is creating sheet lamination that is capable of operating on a large scale.

Powder bed fusion is a point heat source selectively fusing or meltings a region of a powder bed. The metal powder bed fusion processes are known by the trade names SLM (Selective Laser Melting) and DMSL (Direct Metal Laser Sintering) for the laser beam process and EBM (Electron Beam Melting) for the electron beam processes. PBF has become a popular technology as it holds about 80% to 90% of the market share in metal 3D printing. EOS is most representative enterprise in PBF.

Direct energy deposition is an advanced additive manufacturing technology that enables repair and rebuild of damaged components, as well as manufacturing new components. It can be applied in a wide range of materials including, various steels, Ni-alloys, Co-alloys, Ti-alloys, refractory metals, such as dissimilar metal. It is that DMD(Direct Metal Deposition), DMT(Direct Metal Tooling) and EasyCLAD is most representative method of the direct energy deposition. Insstek is a Korean company affiliated into this category.

3. A Market of 3D Printing

According to a new market research report, 3D Printing Market by Technology, the 3D printing market is expected to grow at a CAGR of 23% from 2013 to 2020, and research US$8.41 billion in 2020 [2]. The main reasons for this expansion include new and improved 3D printing technologies, a wider range of materials, government funding, broad application scope, and increased awareness of the benefits of 3D printing over traditional technologies (injection molding and CNC machining). Metals are especially used in high-end industries such as aerospace, defense, automotive and medical.

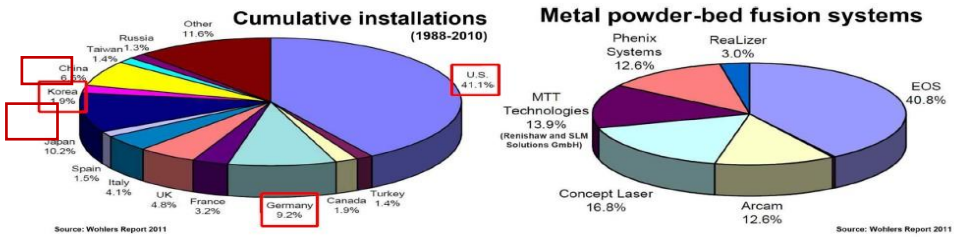

Figure 1. The future of additive manufacturing

The accompanying chart shows the percentage of cumulative industrial additive manufacturing systems installed for each country from 1988 through the end of 2012. The US (41.1%) continues to lead by a large margin. Japan (10.2%), Germany (9.2%), and China (6.5%) have the second, third, and fourth largest installed bases, respectively. Korea's market system is not sufficient compared to Japan and China [3].

The Korean market for 3D printers is almost non-existent. We have few domestic companies that their possess the technology for producing 3D printers. Carima (mainly plastic 3D printer) and Insstek (mainly metal 3D printer) are the most representative companies of 3D printer as small and medium business of Korea. In contrast to the US government, Korea's small and medium business played a key role in the 3D printing industry. It is difficult for small and medium business to develop R&D and find a market simultaneously. Therefore, it is essential for the Korean government to support and enable the development of 3D printing.

When global service providers were asked which technology they would most likely add, the most popular response was laser sintering from EOS, followed by PolyJet from Object, and FDM from Stratasy. EOS (40.8%), Arcam (12.6%), and Concept Laser (16.8%) are Germany's company and lead to metal powder-bed fusion systems. It dominates the Germany market with a 70.2% market share throughout the EU countries in metal base system [3].

4. Conclusion

3D printing is quickly drawing global attention as the third revolution that will bring sweeping changes to many industries, especially metal material. While products made through 3D printing are mostly focused on the prototype, with the expansion of the industry, they are slowly moving toward final products. In the near future, with further technological and material advancements of metal, it is possible that additive manufacturing could replace the traditional manufacturing. However, currently, our current practices of mass production are simply cheaper, faster and more efficient than metal 3D printing. There is cut-throat competition in plastic 3D printing. We were late coming into the market of metal 3D printing, therefore, it is essential for the Korean government to support 3D printing research like NAMI(National Additive manufacturing Innovation Institute) of US and to enable the development of metal 3D printing rather than plastic. In addition, we have to a strategy that set of powder material, 3D printing machine and process technology. There is a possibility to be the world leader in the industry of metal 3D printing field.

5. References

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[3] Terry Wohlers, "The future of additive manufacturing", Laser Additive Manufacturing Workshop, Texas, 2012.