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3D-Metal Printing Technologies: Comparative Study of the 'Electron Beam Melting' and 'Selective Laser Sintering'

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Abstract

***3D**-printing is an innovative manufacturing methodology. In this 3D-models can be set up using computer aided solid models. Those are digital files. A part is created in this method by establishing layers of material one over the other until the total part is formed. These layers can be thought of as a thin material slice. These methods are widely used in life-sciences, footwear, aerospace, automobile, jewelers and biomedical engineering. 'Stereo-lithography', 'FDM', 'SLS', and 'EBM' are different forms of printing techniques. Through these 3D-printing methodologies complex shaped parts can also be device with increased correctness. This paper explains the comparative study of electron beam melting with selective-laser-melting.*

Keywords: 3D Printing, CO_2 laser, SLM, EBM.

1. Introduction

3D-Printing generally referred to as rapid prototyping, where a 3D-structure is formulated by establishing the successive material layers. The highly complex parts that are not able to generate using traditional methods can also be easily fabricate within a small period of time. This technology saves design time at lower cost. This processing methodology whirl the ideas into 3d-real models. This technology is very multifaceted. No skilled person is needed to operate the machine. Generally in printing on the paper liquid ink can be used, but in 3D-printer a vide verity of ferrous and non-ferrous materials can be printed. These include thermoplastics, composites made from thermoplastics, pure metals, metal alloys, and ceramics. The need for personalized implants such as tooth crowns, hearing aids, and replacement orthopedic parts has made the life sciences industry an early adopter of 3D design. It is commonly used in different industries such as dental implants in the life sciences, bone replacements, hearing aids and jewellery, aerospace, automotive.etc.

2. Literature Survey

The development of the 3D-printing process can be traced back to 1976, when the inkjet printer was invented. In 1984 Charles Hull first innovated 3D-Printing machine. Charles Hull drumped up the first commercial 3D-printer in 1986, tendered it for sale through his 3D-Systems business. He gave the name to this technique as stereo-lithography. In the 1990's this technology became more popular. [1] In 1993 the MIT institute of technology changed its name from stereo-lithography to 3D-Printing. In 1996 three big products were inaugurated by three separate companies such as 'stratagies', 'Genisys', 3D-system was 'Actua-2100',and 'Z-Company', 'Z-402'. The 1st 3d hd-colour printer on the market called Spectrum. Z-510 was released in 2005 by Z Corporation. In 1993 the technology institute MIT changed its name from stereo-lithography to 3d-printing technology. Three separate companies launched three big products in 1996, such as 'Genesis' from strategy's, "Actual 2100" from 3D-system and Z-402 from Z-

Corporation. In 2005, Z-Corporation launched the first 3D-hd-color printer on the Spectrum Z-510 market. In 2006, another 3D printer was released that rip-rap, which aimed at self-replicating 3D-printers. In 2007, Z-450 was launched with an emphasis on ease of use and compatibility of offices. As wise in 2008 , Z-650 with size and efficiency increase and in 2009, Z-350 with a new degree of affordability for 3d-printing developed [1]. In September 2011-Vienna University of Technology elobarated a lighter 3D-printer. It is very cheaper and smaller. [2] G Kishan and B.V.S.Rao presented a conference paper describing all 3D-printing processes. [3] This present paper deals with comparative study in between selective-laser-sintering and electron-beam-melting.

The selective-laser-sintering is one of the most accurate 3D-printing methods. It not only implement in batch production but also in prototyping. The method utilizes a carbon di-oxide laser. It directly traces the appropriate shape from a 3D-computer aided model through an STL file. Laser focuses across a compact material powder layer. The layer of material can be fused at the time of laser contacting with the first layer of metal powder to form the appropriate shape, when each and every layer has finished the powder bed moves down fractionally, so that the next layer of powder is inserted on to the previous one. It can be sediment or fused with it. The powder bed is used to give the necessary support for the building parts. [4] The experimental setup phenomena of melting and sintering process is shown in the Fig:1&2.

3. Selective Laser Sintering

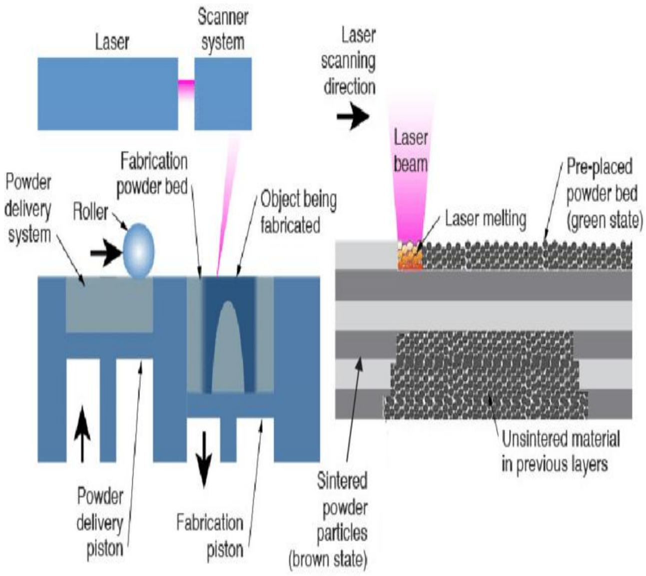

Fig.1: Selective Laser Sintering[5]

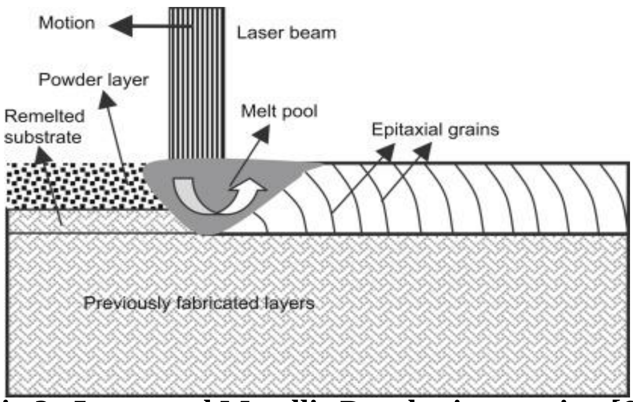

Fig.2 Laser and Metallic Powder interaction [6]

4. Electron Beam Melting

The process is a method of 3D-printing. The electron beam is used in this process to melt the metal powders to obtain the appropriate shape configuration of the component. A recent advancement in this process is the use of an electron beam. The more developments in the aerospace and medical sectors have already been made to generate complex and irregular shaped parts. The parts bring forth by this method will be a greater accuracy. It would be costly. The research personnel have given a great deal of effort to make the process more efficient because of the greater value of quality. Electron beam melting starts with the powder material re-coater method, which permits a single layer of pre-heated powder metal to the plot shape of the create. The electron beam, after a layer of material to be placed on the build table, focuses on that layer, by the effect of the electron beam focusing melting taking place. Electron beams are controlled through electromagnetic coils. That directs the beam towards the metal powder. When the electron beam which focuses on the metal powdered particles causes melting together. Experimental set-up and melting phenomena shown in the Fig.3 and 4.

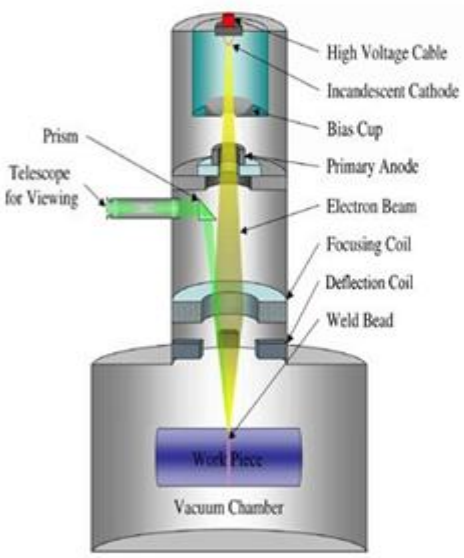

Fig.3: Electron Beam Melting Experimental setup [7]

Create plot shape shifts downward direction for a layer thickness after forming a layer of content. Then the material re-coater comes to form a fresh powdered sheet, and then the focus of the electron beam to melt the metal then. This method is continuous until the whole 3D component has been printed. Inside the EBM scheme, High energy density electrons are produced to melt the metallic powder which allows high melting point material to be processed. At the same time, when processing the reactive or responsive materials such as titanium, the vacuum chamber atmosphere prevents the disruption of oxygen, nitrogen, etc. The greatest pre-heating temperature up to 1100^{0} c used to decrease the residual stress in in the printe parts [5] These advantages mean that EBM is ideal for the printing of high precision metal components with complex geometry sections. Great for complex metal parts with excellent surface finish that need to be produced rapidly and precisely completely dense pieces. EBM technology is used primarily in medical and aeronautical applications. The mechanical properties and bio-compatible properties make titanium alloys especially fascinating. The technology is commonly used to make turbine blades or engine components.

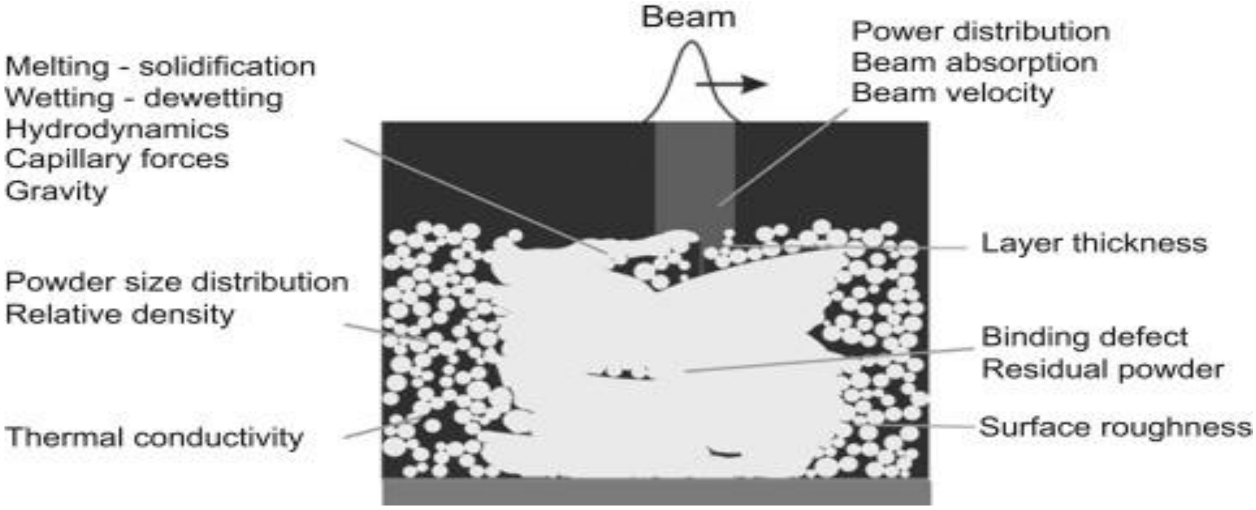

Fig.4: Electron Beam Melting and Metallic Powder Interaction[6]

Table.1 Process Comparison of Electron Beam Melting Vs Selective Laser Sintering

Process ⇨ Parameter	Selective Laser Sintering (SLS)	Electron Beam Melting(EBM)
Energy source	Energy source come from a CO_2 laser.	Energy source comes from an electron beam.
Size of the Printed parts	The scale of the parts that SLS can produce is 700 mm x 720 mm larger than EBM	The scale of the parts that EBM will produce is 350 mm x 308 mm smaller than SLS.
Printing Materials	SLS works on Metals, Plastics, Ceramics Nylon (Duraform PA), Glass-Filled Nylon (Duraform GF), Durable Nylon (Duraform EX Black & White)	EBM also uses titanium alloys, and can not print plastic or ceramic parts. That is because the system is based on electrical charges. Printing of metals such as Titanium (Ti6Al4V Grade 5), Stainless Steel (316L).
Production Speed	SLS Slower than the EBM	Electron Beam Melting technology will manufacture parts more rapidly, but the process is less reliable and the finish will be of lower quality because the powder is more granular
Penetration Depth	SLS Penetration depth is less	The depth of penetration is many times greater than Selective Laser Sintering
Width of Beam	It is not necessary to increase the laser beam diameter so we can not do a high density moulding,	Can increase the width of the electron beam, so we can carry out a high-density moulding even while using materials with a high melting point of about 2000 ° C

Conclusion

1. 3D printing is the process by which computer aided design of solid model is transformed into real object using 3D printer. We can see 3d printer in any home after the arrival of some years.
2. If they want to make some toy or something then instead of the product they can buy the 3d version.
3. This technology is to be applied in many industries now days. 3D printer's drawbacks are fewer but it's the most preferred tool.
4. Electron beam melting process is an effective 3d metal printing process over the selective laser melting.

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