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## Additive Layer Manufacturing

The ALM (Additive Layer Manufacturing) technology applies the addition of successive layer into a desirable shape, unlike its alternative, subtractive manufacturing, where materials are removed to attain the desirable form and function. The former allows the production of 3D parts with the control of a computer, allowing for precision and rapid prototyping. This technology offers a broad range of fabrication capabilities ranging from aerospace and car parts through a compilation of existing materials into new alloys such as Titanium and Inconel (Farinia. com, 2017). The basis of this report is to extensively divulge into the Laser based and Electron-based additive production methods in the creation of Titanium alloys. The primary focus is on melting rates, modes of heating and melting, quality of alloys produced, as well as the problems and difficulties associated with the process.

### Electron Based Additive Layer Manufacturing

The application of electron-based additive manufacturing ranges from rapid prototyping, tooling, and biomedical engineering. The method relies on a combination of metal powder at high velocity and energy to make dense parts. The melting of metal parts layer by layer revolutionized the art of manufacturing reliable parts.

The technology offers geometry freedom and flexibility when working with first class constituents. The strategy in development not only applies to steel and titanium alloys but also other conductive metals. The primary motivation of the technique builds on the creation of excellent materials at high speeds (Koptioug et al., 2016).

The methods rely on a Computer-aided design (CAD) to assist in modification and optimization of complex parts. This application facilitates the customization of parts into a form hard to attain through traditional methods such as lead, sand, or investment casting. The use of the CAD allows for the fast production of fully functioning high geometry parts. This hastened process allows for a designer to have a fully working functional detail within 24 hours.

The idea of CAD to Metal technology relies on a compilation of metal layers of powder melted by an electron beam. The melting occurs to the precision of the geometry stipulated by the CAD program. The first step involves designing the intended structure through a CAD program (Ptc. com, 2017). The nest step includes the transfer of the file to a processing software where the model undergoes manipulation inside a vacuum chamber. After completion, the net shape undergoes end through conventional methods.

The layering of metal layers occurs through melting with an electron gun. The gun produces a stream of electrons from the filament. The beam then focuses on the model partly being deflected to reach the entire region. The stream carries high energy from the accelerated electrons that vibrate against each other. The beam passes through an electric field at half the acceleration of light. The stream of particles passes through two magnetic lenses: the first focusing the beam on a particular area, whereas the second one allowing deflection of the focused beam to desired points (Gong, Anderson, and Chou, 2014).

## Electron Beam Melting

The EMB (Electron Beam Melting) first commercialized by ARCAM in 1997(Arcam. com, 2017) requires certain specific calibrations to occur properly. The requirements for the process are powdered metal and an electron gun. The vacuum should be regulated within 10-4 to 10-5 mbars, to allow for the elimination of impurities and establishment of a decent milieu for freeform fabrication. The electrons move with a kinetic energy of 60 KeV, they are then controlled to a range of 1 to 50 mA and further focused down to 0. 1mm. The resultant typical layer will then range from 0. 05 to 0. 2 mm. Moreover, the computerized beam controls new contours and features to the model.

The advantages of using the EMB are countless. The technology allows attainment of uniqueness in design and application. The production of parts for aerospace and motor industries has become easier, faster, and efficient. Furthermore, the time and cost of machining have been leaned out allowing for ready availability of parts for installation and analysis.

The EMB allows the application of a variety of metals as possible powdered components. In a bid to obtain massive and high tensile parts, the use of a high-density electron beam proves invaluable. This unique quality potentiates the different application of the technique to a variety of metals such as Steel, Aluminum, Titanium, and Cobalt. The ability to work with these metals also allows the creation of super alloys with low density, corrosion resistant, with high mechanical forte and with suitable biocompatible (the case with biomedical applications).

The step by step layering not only allows for geometry freedom but also the fabrication of the compound features. This application is valuable during bioprinting parts to match the anatomy and biology of the implant. Most of the body organs are porous to allow for smooth passage of blood and other fluids, and EMB allows for installation of such convoluted structures. Additionally, it helps in creating meshed and cellular surfaces obtainable with the aid of a well-programmed CAD. The most prominent use of sophisticated surfaces forms the working principle of the temporomandibular joint prosthesis - the hardware employed by NASA astronauts to breathe in space.

The limitation of the EMB cover the low output volumes and environmental risk to the operators. The stream of electrons has the potential to produce X-rays, a popular carcinogenic. Therefore, the working areas should be heavily leaded to prevent leaking of these rays. Additionally, the application of the vacuum provides additional cost compared to traditional methods of metal casting. The low output volumes attribute to the intricacy of production process involved in the EMB.

## Laser Base Additive Manufacturing Methods

The laser melting technology relies on melting and solidifying metal particles. The metal powder is struck by a laser about 100µm in diameter, melting the particles. The heat on the surface layer conducted to lower layers melting the whole surface together into a melt pool. The molten metal then coagulates fast forming a compacted layer. The laser power varies from 100W to 200W; the beam, therefore, melts the powder bed efficiently.

The heating of the sintered particles by the beam transfers the energy to the neighboring metallic specks. The laser interacts with the powdered particles in the following ways: absorption, scattering, and reflection. The top layer constituents will absorb most of the laser energy; however, some get scattered among the particles. The metal powder having some luster ensures that some energy is reflected too. The laser melting occurs, therefore in layers, serial melting of the un-sintered stratum.

The laser fusion also commonly referred to as selective laser melting, occurs in the following way. Firstly, the application of the metal powder on a construction platform with a roller. Secondly, the laser beam melting operation commences. The fusion repeatedly occurs, a thousand cycles depending on the length of the fabricated part. In summary, the most important parts needed to set up this arrangement will be a powder feeder, roller, and a powerful laser gun. In more advanced methods there are two flows of dust, from the storage tank to roller and from roller to the storage tank. This movement minimizes loss of the particles.

## Three Different Ways of Laser Additive Manufacturing

Laser additive manufacturing occurs in three different ways. These methods are laser sintering, laser melting, and laser decomposition. The establishment of the metallurgical properties and structures one intends to produce need to be clarified before engaging in the previously mentioned processes. However, the powdered materials for the processes are similar ranging from pure metals, alloys, multicomponent metals, and metal matrixes composites (MMCs).

The metallurgical mechanisms applied in laser melting accounts for the various ways of approach. The three all use powdered metal particles, however, the MMCs especially when in ex-situ pre-spread before melting will apply in Laser Sintering (LS). The application of laser beams on the pre-spread powder of pure metals, alloys, and MMCs depicts the use of Laser Melting (LM). The introduction of all coaxial metallic powder in synchrony with laser scanning on a construction table illustrates the use of Laser Metal Decomposition (LMD). The partial melting applied in the LMD allows for the formation of porous substructures (Koptioug et al., 2016).

The Laser fusion also employs the use of CAD. Once the layer of powder gets set on a construction table, the laser beam scans the bed surface to form the structure dictated by the program. The envisioned model formation requires repeated heating and spreading of the powder. Under this extreme thermal energy, the processing speed is rapid, and the reliance on the melting and solidifying methodology ensures quick consolidation of particles into complex parts within short cycles.

## Laser Fusion

The method proves relevant in most industries such as aerospace, energy, education, medical, and automotive. The process plays a significant role in the creation of spare parts, custom products, and medical implants. The ability of the methods to shift material from one position to another on already made parts enables the creation of customized graded quality of the same tool. Moreover, the machines come equipped with a feedback mode solely focused on maintenance of quality and properties of parts created.

The machinery involves in the Laser melting methods are enormous. They rely on significant amounts of energy to operate, even when creating a simple part. Additionally, the requirement of large quantities of powder makes the process expensive. The bigger LM machines aside from assisting in the creation of large compacted automotive parts, for example, the engine pose a threat to the environment. The large amounts of heat created by the machinery, for instance, have pollution capability.

The EBM and LM share certain similarities. They both rely on the effects of high energy on powdered metallic constituents. However, the application of a vacuum in EBM ensures high-density parts compared to those produced by LM. The preheating of particles in EBM inside a vacuum seems to favor production of Ti alloys compared to LM. However, for LM to undertake the manufacture of the same metal composite, individual processing parameters need to optimize. Nevertheless, due to the structural complexity of the EBM machine compared to the LM, the cost of production of the former is higher than the latter (Koptioug et al., 2016).

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