DMLS – METÓDA PRIAMEJ VÝROBY PROTOTYPOV A NÁSTROJOV

DMLS - METHOD OF DIRECT MANUFACTURING OF PROTOTYPES AND TOOLS

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Abstract

Direct metal laser sintering (DMLS) fabricates metal prototypes and tools directly from computer aided design- CAD data. The process is popular in rapid tooling, since a suitable metal powder can be used to produce the metal parts and tools. The process involves use of a 3D CAD model whereby a .stl file is created and sent to the machine’s software. This process allows for highly complex geometries to be created directly from the 3D CAD data, fully automatically, in hours and without any tooling. DMLS is a net-shape process, producing parts with high accuracy and detail resolution, good surface quality and excellent mechanical properties.

Key words
Direct metal laser sintering, Stereolithography, Direct digital manufacturing.

Introduction

Manufacturing of functional prototypes and high performance artifacts using conventional methods such as machining usually is a time consuming procedure in multiple step route. The pressure to get products on market faster has created several Rapid Prototyping methods. However, potentially one of the most important areas of Rapid Manufacturing technology lies in the field of Rapid Tooling. The aim is to reduce costs and lead-times required for the tooling phase in production cycles. Although more than 20 techniques for rapid tooling have been developed, most of them are indirect, pattern-based approaches. In these methods a mold is made out of a material such as silicone rubber, epoxy resin, or metals using RP models.
However, a great interest exists concerning direct manufacturing methods avoiding multiple step tooling. In fact, great efforts have been made to adapt the existing processes to directly fabricate functional components. On the other hand, the existing material systems are not fulfilling the requirements for manufacturing high performance engineering parts, e.g. injection molding inserts. This implements a great motivation for material developments.[1], [2]

Description of DMLS technology

The SLS technology was developed, like other RP technologies, to provide a prototyping technique to decrease the time and cost of the product cycle design. It consists of building a three dimensional object layer by layer selectively sintering or partial melting a powder bed by laser radiation. The success of SLS as a rapid prototyping and rapid manufacturing technology results mainly to the possibility to process almost any type of materials (polymers, glass-filled nylon, metal and composites) to accommodate multiple applications throughout the manufacturing process, but high density is desired for the production of functional metallic parts. The Selective laser sintering process can be indirect or direct:

1. The indirect SLS uses a polymer coating of about 5 μm in thickness for metal powders and ceramics. The metal powder particles are coated with the polymer and the action of the laser melts the polymer, bonding the metal particles together to produce a green part. It is necessary, therefore, a post-treatment in the oven at high temperature, so remove the polymer and sintering particles by creating a metal-metal link.
2. InDirect SLS (DMLS) a low melting point component is melted and employed as a matrix in which the higher melting point components sit. In this process are used or a single powder with two different grain sizes (a slight and a coarse grains) or binary systems. Typical binary phase systems investigated include Ni-Cu, Fe-Cu and Cu-Pb/Sn. The disadvantage of the above processing routes is that the components produced exhibit the mechanical properties and characteristics of their weakest composite phase, thus lacking the full mechanical functionality required for heavy-duty tasks.[3]

Comparing the RP technologies, the direct metal laser sintering (DMLS) shows the great promise for direct production of functional prototypes and tools. The possibility of successfully sintering metal powders in accordance to CAD data will lead to a major reduction in time for the tool making. Scheme of process is shown on Fig.1. However, regarding the performance of tools it is necessary to expand the range of usable raw materials depending on the application.[4]

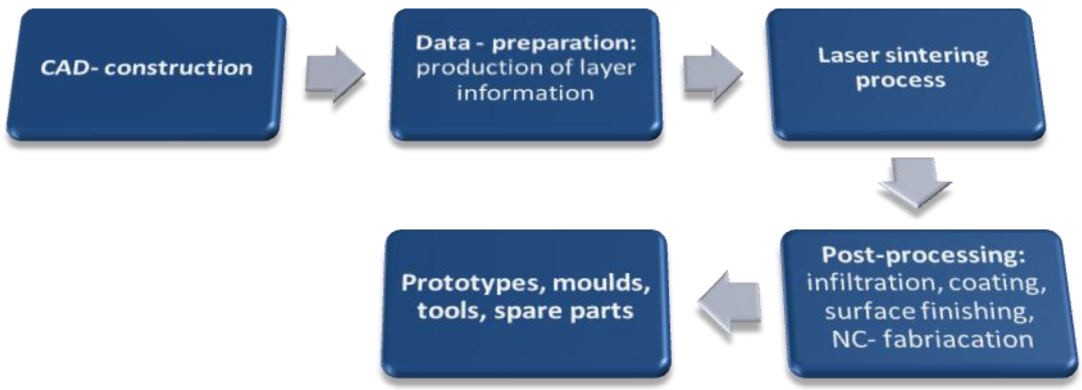

Fig. 1 Disposition scheme of DLMS process

Direct Metal Laser Sintering (DMLS) was developed jointly by Rapid Product Innovations (RPI) and EOS GmbH, starting in 1994, as the first commercial rapid prototyping method to produce metal parts in a single process. With DMLS, metal powder (20 micron diameter), free of binder or fluxing agent, is completely melted by the scanning of a high power laser beam to build the part with properties of the original material. Eliminating the polymer binder avoids the burn-off and infiltration steps, and produces a 95% dense steel part compared to roughly 70% density with Selective Laser Sintering (SLS).

An additional benefit of the DMLS process compared to SLS is higher detail resolution due to the use of thinner layers, enabled by a smaller powder diameter. This capability allows for more intricate part shapes. Material options that are currently offered include alloy steel, stainless steel, tool steel, aluminum, bronze, cobalt-chrome, and titanium. In addition to functional prototypes, DMLS is often used to produce rapid tooling, medical implants, and aerospace parts for high heat applications.

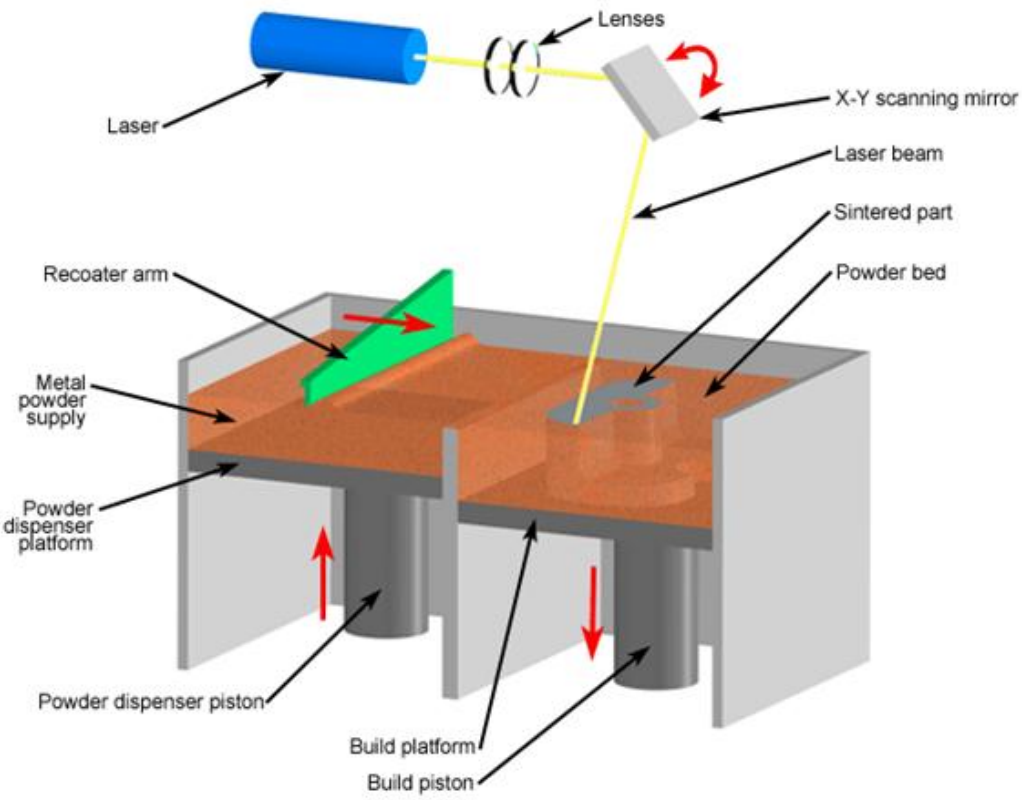

Fig.2 Powder bed method of DMLS

The DMLS process can be performed by two different methods, powder deposition and powder bed, which differ in the way each layer of powder is applied. In the powder deposition method, the metal powder is contained in a hopper that melts the powder and deposits a thin layer onto the build platform. In the powder bed method (shown on Fig.2), the powder dispenser piston raises the powder supply and then a recoater arm distributes a layer of powder onto the powder bed. A laser then sinters the layer of powder metal. In both methods, after a layer is built the build piston lowers the build platform and the next layer of powder is applied. The powder deposition method offers the advantage of using more than one material, each in its own hopper. The powder bed method is limited to only one material but offers faster build speeds.[5]

Fig. 3 depicts the schematic picture of the instrument used for laser sintering. The machine consists of a powder handling system, a continuous wave carbon dioxide laser with related optics and a process computer. In this process, the 3D CAD models of functional parts and tooling inserts are converted to triangulated surface models in the standard STL format. The process computer slices the standard STL format to thick horizontal layers, representing the part into a stack of thin slices. The data preparation step is followed by the laser sintering process. First, a steel base plate is placed on the building platform (XY table) and leveled. Then, a powder layer (about 50 nm in thickness) is spread on the base plate using a moving wiper (mechanical re-coater). The computer scans the laser beam on the powder surface. The laser energy causes the powder particles to bond together. After laser scanning, the building platform is lowered by 50m, and a new powder layer is spread on top of the previous layers.

The process is repeated, and by altering the shape of each scan layer, a part of arbitrary shape can be produced.[7]

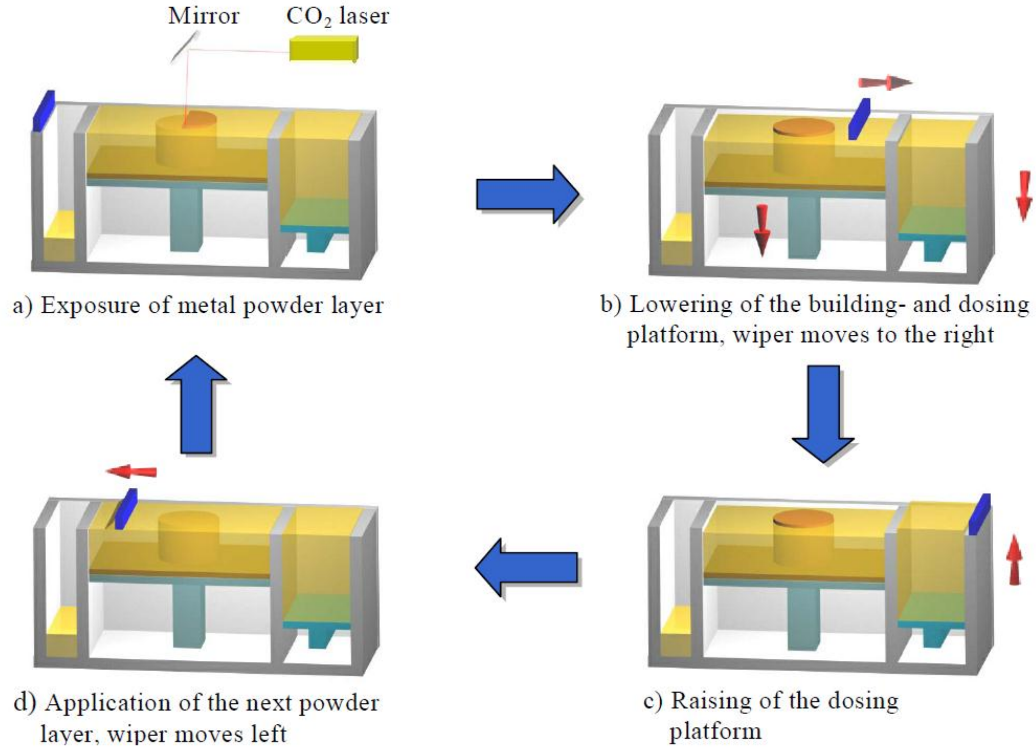

Fig.3 Schematic picture of the instrument used for laser sintering [6]

Conclusion

DMLS has many benefits over traditional manufacturing techniques. Speed is the most obvious because no special tooling is required and parts can be built in a matter of hours. Additionally, DMLS allows for more rigorous testing of prototypes. Since DMLS can use most alloys, prototypes can now be functional hardware made out of the same material as production components.

DMLS is also one of the few additive manufacturing technologies being used in production. Since the components are built layer by layer, it is possible to design internal features and passages that could not be cast or otherwise machined. Complex geometries and assemblies with multiple components can be simplified to fewer parts with a more cost effective assembly. DMLS does not require special tooling like castings, so it is convenient for short production runs.[9]

It would appear that DMLS is currently on a threshold between limited application in prototyping applications and a much larger potential in the areas of series production tooling and in particular part production. The technologies required to open up this potential have already been demonstrated in principle, and the further work necessary for major success in particular application areas is ongoing or still to be done.[10]

For production tooling, material density of a finished part or insert should be addressed prior to use. For example, in injection molding inserts, any surface imperfections will cause imperfections in the plastic part, and the inserts will have to mate with the base of the mold with temperature and surfaces to prevent problems.[11]

Key words
Direct metal laser sintering, Stereolithography, Direct digital manufacturing.

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