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MANUFACTURING OF FORMS FOR INJECTION MOULDING TECHNOLOGY BY RAPID PROTOTYPING METHOD

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ABSTRACT: Article briefly describes SLS (Selective Laser Sintering) and DMLS (Direct Metal Laser Sintering) Rapid Prototyping processes, which allows creation of metal parts that is used by manufacturing of forms for Injection Moulding technology. In article are mentioned also advantages, which manufacturing of above mentioned forms by Rapid Prototyping method offers beside to conventional way of manufacturing forms for Injection Moulding technology.
KEYWORDS: SLS, DMLS, Rapid Prototyping, Injection Moulding, Form

INTRODUCTION

Rapid Prototyping is suit of technologies for manufacturing of prototypes using 3D printing. These prototypes (in dependence on technology) are usually inappropriate for bigger loads and generally serve just for imagination about appearance (design propositions) and build-up in machine, or for smaller loads. Virtual 3D model of part is "sliced-up" on thin layers, which are created by miscellaneous technologies from different materials and put in layers, whereby final prototype is created. The Rapid Prototyping method includes several processes:

- SLA (Stereolitography),
- FDM (Fused Deposition Modeling),
- SLS (Selective Laser Sintering),
- DMLS (Direct Metal Laser Sintering),
- LOM (Laminated Object Manufacturing),
- 3D Printing,
- Inkjet Printing,
- Jetted Photopolymer.

For manufacturing of forms for Injection Moulding technology are from above mentioned technologies suitable only SLS and DMLS technologies, which allows creation of metal prototypes.

SLS - SELECTIVE LASER SINTERING

The basic concept of SLS is similar to SLA and is shown on Figure 1. It uses a moving laser beam to trace and selectively sinter powdered polymer and/or metal composite materials into successive cross-sections of a three-dimensional part. As in all Rapid Prototyping processes, the parts are built upon a platform that adjusts in height equal to the thickness of the layer being built. Additional powder is deposited on top of each solidified layer and sintered. This powder is rolled onto the platform from a bin before building the layer. The powder is maintained at an elevated temperature so that it fuses easily upon exposure to the laser. Unlike SLA, special support structures are not required because the excess powder in each layer acts as a support to the part being built. With the metal composite material, the SLS process solidifies a polymer binder material around steel powder (100 micron diameter) one slice at a time, forming the part. The part is then placed in a furnace, at temperatures in excess of 900°C, where the polymer binder is burned off and

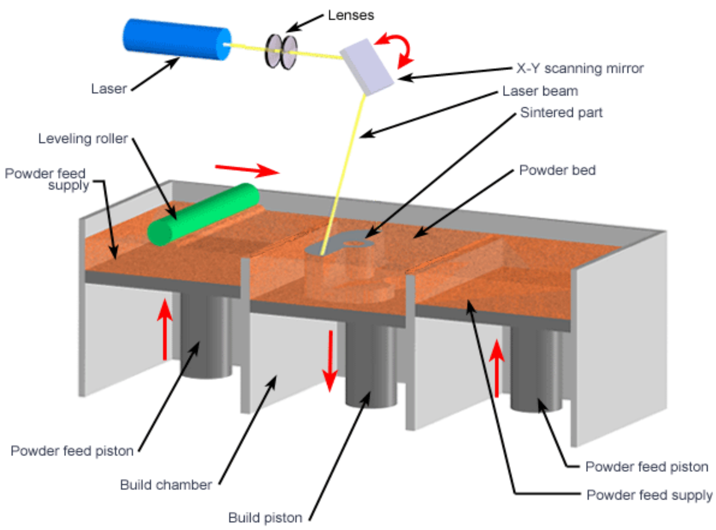

Figure 1. Principle of SLS [3]

the part is infiltrated with bronze to improve its density. The burn-off and infiltration procedures typically take about one day, after which secondary machining and finishing is performed. Recent improvements in accuracy and resolution, and reduction in stair-stepping, have minimized the need for secondary machining and finishing. [3]

DMLS - DIRECT METAL LASER SINTERING

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 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.

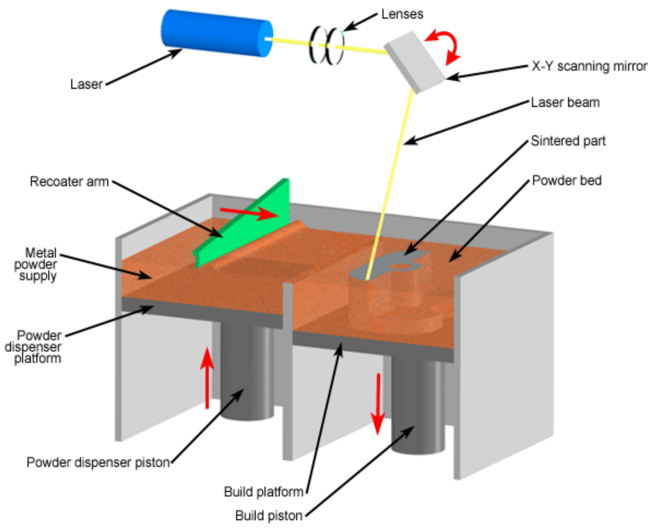

Figure 2. Principle of DMLS [2]

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 Figure 2), the powder dispenser piston raises the powder supply and then a recoated 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. [2]

ADVANTAGES

With conventional forms for Injection Moulding technology, where cooling channels are usually led in a parallel way, is by manufacturing of parts with multiple surface very difficult to achieve desired cooling or heating conditions, those breach or slight may lead to extension of production times or in worst-case, to damage of final product.

Manufacturing of forms for Injection Moulding technology by Rapid Prototyping method offers in contrast to conventional way of manufacturing these forms several advantages:

- *Possibility of tracing cooling channels by contours of moulding which ensure faster heat removal,*
- *Possibility of utilization by cooling of hardly accessible places, where cooling by conventional way is impossible,*
- *Reduction of production times by pressing up-to 35%.*

Other advantages, disadvantages and technical specifications are mentioned in Table 1, which briefly describes SLS and DMLS methods.

Table 1. Comparison of SLS and DMLS method

Abbreviation:	SLS	DMLS
Material type:	Powder (Polymer)	Powder (Metal)
Materials:	Thermoplastics such as Nylon, Polyamide, and Polystyrene; Elastomers; Composites.	Ferrous metals such as Steel alloys, Stainless steel, Tool steel; Non-ferrous metals such as Aluminium, Bronze, Cobalt-chrome, Titanium; Ceramics.
Max. part size:	560 x 560 x 760 mm	255 x 255 x 220 mm
Min. feature size:	0,127 mm	0,127 mm
Min. layer thickness:	0,1016 mm	0,0254 mm
Tolerance:	0,254 mm	0,254 mm
Surface finish:	Average	Average
Build speed:	Fast	Fast
Common applications:	Form/fit testing, Functional testing, Rapid tooling patterns, Less detailed parts, Parts with snap-fits & living hinges, High heat applications.	Form/fit testing, Functional testing, Rapid tooling, High heat applications, Medical implants, Aerospace parts

CONCLUSIONS

Based on above mentioned statements result, that parts manufactured by SLS Rapid Prototyping method can be produced in bigger dimensions than parts manufactured by DMLS Rapid Prototyping method. On the other side, parts manufactured by DMLS Rapid Prototyping method can be created from wider range of metal materials as are steel alloys, stainless steel, tool steel, aluminium, bronze, cobalt-chrome, titanium or ceramics, what is big advantage, however forms for injection moulding are manufactured usually from non-ferrous metals due to their excellent thermal conductivity facilities.

Parts manufactured with SLS or DMLS Rapid Prototyping method have an exceptional surface finish ranging from 5 - 10 µm Ra from the process, and may require little additional post-processing to achieve impeccable surface facilities. Post-processing can be performed just like traditional metals: can be machined, EDM processed, polished, etched, textured and more.

Last but not least it is necessary to highlight technical and technological benefits, which have forms for injection moulding process manufactured by SLS or DMLS method against moulds manufactured by conventional way.

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