Additive manufacturing technologies for industry

Processes, materials, pros and cons of the technologies most used by the manufacturing industry
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Introduction

The goal of this e-book is to have a complete overview of the technologies most used in the industry to make prototypes.

We have not included details on CNC machining because they are not part of the additive rapid prototyping technologies.

We will dedicate a special eBook to this process as it remains a technology to produce prototype parts used to test a project under development.

For each technology we will illustrate the pros and cons, bearing in mind that there is no better technology in an absolute sense.

Each project is different, and the most suitable technology is chosen according to the specific needs and tests to be carried out.

With our machinery we can satisfy all the typical needs of the various industrial sectors, also following co-design and consultancy activities to optimize the design according to the chosen technological process.
## Additive Rapid prototyping technologies

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<td>Stereolithography (SLA)</td>
<td>Thermoplastic photopolymers</td>
<td>From 0.051 to 0.152 mm</td>
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<tr>
<td>Selective laser sintering (SLS)</td>
<td>Nylon, Nylon PA+30GF, Alumide</td>
<td>About 0.102 mm</td>
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<td>HP Multi Jet Fusion (MJF)</td>
<td>Plastic</td>
<td>About 0.102 mm</td>
<td>Rough, Waterproof</td>
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<td>Fused Deposition Modeling (FDM)</td>
<td>ABS, PC, Ultem, PEEK</td>
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**Stereolithography (SLA)**

**Additive manufacturing process.**

The piece is made inside a tank containing a resin sensitive to UV radiation. With a computerized laser the product is polymerized, building it section by section on the surface of the liquid resin. The process is repeated until the detail is completed, making each new polymerized layer adhere to the underlying layer.

Stereolithography was the first additive rapid prototyping technique.

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Stereolithography (SLA) Pros and cons

Pros

- Excellent, smooth surface finish ideal for aesthetic prototypes
- Easily paintable; also ideal for surface finishes such as metallization
- Suitable as a master for silicone mold replicas.
- Suitable for manufacturing complex geometries
- Delivery time 2-3 days
- Available transparent material with mirror or matte finish

Cons

- Prototypes are more fragile than those made with other processes, therefore they are not suitable for performing functional tests.
- As the resin cures with UV light, exposure to sunlight causes the resin curing process to continue and over time the pieces become more brittle.
- Useful for producing parts with complex geometries but cannot provide information on the final feasibility of the project.
Selective Laser Sintering (SLS)

The laser sinters the powder material layer by layer, from bottom to top.

The finish is grainy and sandy to the touch.

Suitable for functional prototypes.

The powder can be filled with glass or aluminum.

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<td>Nylon, also with the addition of glass or aluminum fibers</td>
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</table>
### Pros

- The pieces are precise and demonstrate greater durability and resistance than those made with stereolithography.
- The process allows to produce parts with complex geometries.
- The sintering prototypes are very performing from a mechanical and heat resistance point of view.
- This technology is generally chosen for assembly checks and mechanical tests.
- The PA12 and PA12 + 30GF materials have USP Class VI certification.

### Cons

- The surface of the pieces is grainy / sandy and therefore not very suitable for aesthetic applications.
- Prototypes absorb moisture and liquids.
- To make the surface smooth and paintable, it is necessary to sand and fill.
Multi Jet Fusion is a powder-based technology, but it does not use a laser.

The powder bed is initially heated evenly.

A fusing agent is then deposited at the points where it is necessary to selectively melt the particles.

A finishing agent is deposited around the contours to improve the resolution of the parts.
<table>
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<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology suitable for mechanical tests</td>
<td>The surface finish of the piece is slightly rough</td>
</tr>
<tr>
<td>Prototypes can be used for usability, ergonomics, manufacturability and testing tests.</td>
<td>If a smooth finish is required, the prototype must be grouted</td>
</tr>
<tr>
<td>Parts are printed in very thin layers up to 80 microns, so the prototypes have a high density</td>
<td>Only grey color.</td>
</tr>
<tr>
<td>Low porosity such as to be waterproof</td>
<td></td>
</tr>
<tr>
<td>Suitable for high temperature testing up to 175 °C</td>
<td></td>
</tr>
<tr>
<td>The performance of the models is particularly suitable for functional tests</td>
<td></td>
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**Fused Deposition Modeling (FDM)**

It creates the pieces from bottom to top thanks to a computerized print head.

The raw material of the process is an extruded resin filament, which the machine re-melts selectively and deposits on the previous layer for each section of the desired piece.

The FDM process produces parts in ABS or PC, which are therefore more resistant than parts made with other additive processes.

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However, it can happen that porous pieces are obtained, with evident effects of scaling or graining on the external surface, particularly at the junctions between the layers. Additionally, tight tolerances can be difficult to achieve with this process.
# Fused Deposition Modeling (FDM) Pros and cons

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</table>
| - The pieces are quite resistant and suitable for some types of functional testing.  
- The process is capable of producing parts with complex geometries. | - The surface finish of the piece is poor, with a pronounced grain effect and layers almost always visible to the naked eye  
- Compared to SLA and SLS, it has longer lead times.  
- It is useful for producing parts with complex geometries, but does not provide information on the final feasibility of the project. |
Direct laser sintering of metals (DMLS) is an additive manufacturing method that builds prototypes and production metal parts using a laser to selectively melt a fine metal powder.

With this technology it is possible to produce fully functional parts of metals such as cobalt chromium, stainless steel, titanium, inconel and many others.

To appreciate the benefits of this technology compared to conventional processing, it is necessary to design the detail according to this process.

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Direct Metal Laser Sintering (DMLS) Pros and cons

**Pros**

- Possibility of creating complex geometries impossible with conventional processes
- Mechanical properties comparable to pieces made by mechanical processing
- No setup costs
- Less waste of material
- Compatibility with almost all alloys

**Cons**

- It usually requires expensive secondary machining processes
- Expensive
Like a classic DLP (Digital Light Processing) printing process, the geometry is created by projecting the layers onto liquid photopolymers loaded with ceramic particles.

The green obtained is subsequently subjected to heat treatment during which the organic matrix is removed by pyrolysis and the particles are densified during sintering to create the final product: a dense ceramic body.

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Lithography-Based Ceramic Manufacturing

Pros and cons

Pros

- Exceptional characteristics of thermal and electrical insulation and high resistance to high temperatures.
- Smooth ceramic surface effect
- Suitable for food use and biocompatible

Cons

- Possibility of making small pieces
- It could be expensive
- Limited geometric freedom, as it must be possible to remove the support structure
- Maximum wall thickness limited due to thermal processes
- High specialization on the process and related engineering
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