RAPID PROTOTYPING

Following the new market trends, starting from 2007, **ACAD** began a research/development project based on the different rapid prototyping systems in order to satisfy all customers' needs combining both cost saving and parts validation.

As it follows, the result of about 10 years of experience in the research of the best rapid prototyping methods:

1- Cold press

Using silicone, resin or aluminium moulds, it is possible to obtain a little range of objects with mechanical and aesthetic characteristics 95% equivalent to the final product.

2- Mechanical engineering with 3/5 axis CNC machine

The mechanical engineering directly applied to different material drawings allows obtaining parts with the same characteristics of manufacturing process and high dimensional precision

Aluminium / Steel - mechanical parts
Brass - mechanical parts
Wood – demonstrative models
Ureol – aesthetical models
ABS, **Polycarbonate** - aesthetical models and serviceable prototypes
Delrin - Pom - mechanical parts
Methacrylate – transparent prototypes and models (*after polishing*)

3- 3D Printers (in cooperation with a brand leader in the field such as STRATASYS)

Currently, **ACAD** offers every rapid prototyping 3D printing type to its Customers using different raw materials:

A-FDM

B-Stereolitography

C-Sintering

Today **ACAD** is one of the two Italian companies able to print monolithic parts of dimensions 1800 x 850 x 400 mm.

A-FDM Fused Deposition Modeling

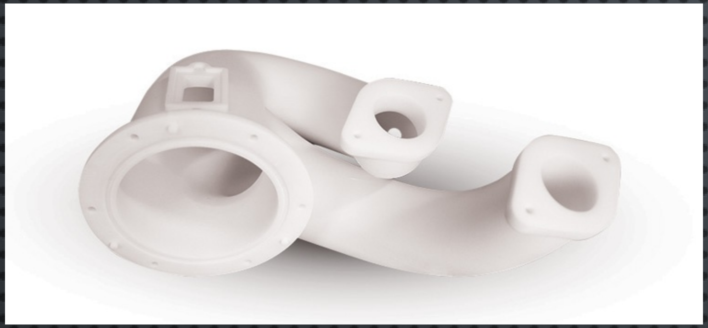
The machine builds the prototype setting down various overlapped layers made of molten plastic material. The main peculiarity of this technology is to use a real thermoplastic material rather than a resin with similar characteristics. The same material is then utilized by manufacturing plants. This process allows getting prototypes with a resistance to thermal characteristics in a range of 80° to 220°C and with mechanical characteristics 95% equivalent to the relative manufactured part.

The available materials are:

- **ABS Acrylonitrile-Butadiene-Styrene**

The thermoplastic material used in automotive industry (bumpers/covers/oil caps) is at affordable costs in order to let designers and engineers work in a repetitive way, make and fully test many prototypes. Furthermore, the material is also so solid and sturdy that new concept models and prototypes will behave like the final product.

-POLYCARBONATE (PC)



Making polycarbonate (PC) parts lets engineers and designers combine speed and agility of 3D printer with reliability of the most common industrial thermoplastic present in the market. Thanks to the possibility to insource the production of solid PC parts as well as to the reliable FDM technology, now the manufacturers of equipment used in automotive, sales and other sectors, can explore new opportunities.

-PC+ABS

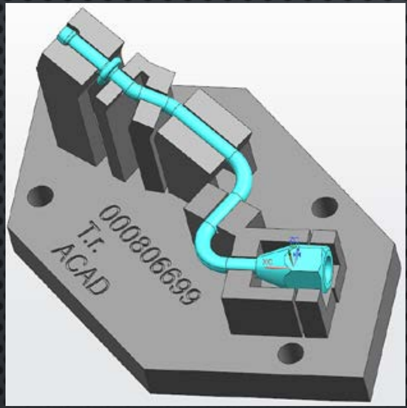
For prototyping, tool construction and manufacturing of little functional volumes of parts that require a greater crash test, the FDM technology works with PC-ABS thermoplastic material. This material merges the best characteristics of two FDM thermoplastics: the resilience and the thermal resistance of the polycarbonate and the flexibility of the ABS. Furthermore, the PC-ABS material shows a great element definition and an excellent finishing.

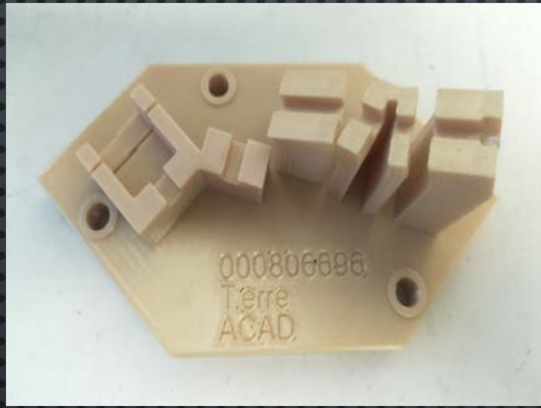
- **PPSF/PPSU (poly phenyl sulfone)**




Performances have been tested in fire conditions. For printed 3D parts able to afford temperatures up to 220° and chemical exposure, the FDM technique - Fused Deposition Modelling – is used with high-performance PPSF/PPSU thermoplastic materials, for the insource production of engine prototypes or sterilisable medical devices.

- **ULTEM**





1
Design of piping control gauge

2
Manufacturing of a gauge for testing made of Ultem

3
Manufacturing of a steel pipe with a tube nut made of Aisi 304

4
C.T.R. Test of a pipe in a gauge

The reputation is strictly related to reliability. This thermoplastic material, renowned for its exceptional performances, has thermal, mechanical and chemical properties that make it better than all other materials in the most of categories. ULTEM 9085 is a FDM (fused deposition modelling) thermoplastic perfect for aerospace, automotive and military applications thanks to the FST classification, to the high resilience/weight rate and to the existing certifications. It allows designers and engineers printing advanced functional prototypes and final parts in 3D

B-SLA – Stereolitography – Photopolymerization to solidify a liquid resin

Among all the rapid prototyping techniques, stereolitography has been one of the first ones as well as the most known; it uses a laser ray able to solidify, through polymerization, a liquid resin contained in the build chamber of the machine.
The first objects obtained using this technology were very fragile and their main use was the production of silicone moulds. Currently there are many resins able to simulate the characteristics of the various thermoplastic materials. The final objects are very well defined and can be made of transparent resins, resins similar to **ABS** and ceramic materials for high temperatures.
The con is represented by the scarce mechanical resistance of prototypes that tend to deform over time due to the action of ambient light.

C-SLS – Direct Laser sintering of dusts

The sintering machine is able to build prototypes using nylon dusts aggregation. Inside the machine is present a laser that sinters nylon dust which is laid down layer over layer.

The final prototypes are highly resistant and very well detailed. They can be made of the following materials:

PA	Pure Nylon
PA/GF	Glass filled nylon
PA/Al	Aluminium filled nylon
PA/ CF	Carbon filled nylon

OBJET

The printer Objet is the last one appeared in the market. Its functioning is very similar to the one of an inkjet printer. The machine overlaps layers of photosensitive resin polymerized by a UV lamp.

The parts obtained with this technology are very well defined and all the available resins allow getting transparent prototypes, similar to ABS and to PPSF/PPSU. It is possible to build rubber-like objects with different hardness as well as “co-printed” prototypes made of one part of rigid material and another one of rubber material.

An **ACAD** team of greatly experienced designers manages the different **3D rapid prototyping** techniques realized with latest generation machines.

The final model (the first element of the series, the prototype) allows the manufacturing company that required it to verify its layout and every other characteristic useful to assess feasibility and quality of the final product, before organizing and planning the whole manufacturing. The visual analysis and the ergonomics study of every single part is for sure fundamental to avoid, as far as possible, substantial errors.

SINTERING PRINTING - Methods
SLM (Selective Laser Melting) fully melts the material (metal dust) selectively using high powered lasers.
DMLS (Direct Metal Laser Sintering), very fine powder granules of metal, layered with layers up to 0,02 mm.

Dusts are made using spray nozzles that allow having a **very subtle grain size** useful to produce SLM/DLMS. The production starts from **a 3D file re-designed** for the **additive manufacturing**. Optimizing the file is crucial to **exploit** plant and material **characteristics at their best** in order to obtain a high quality result.

Companies, such as **ACAD**, that work with industrial **metal rapid prototyping** must guarantee:

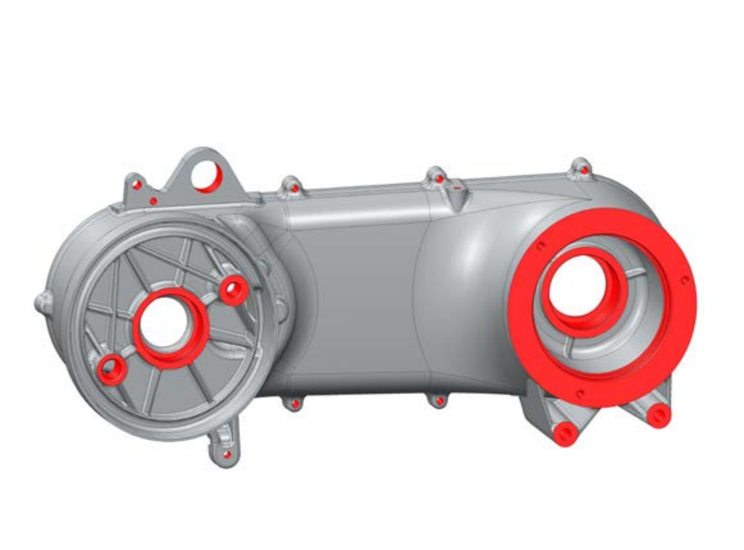
- **speed** during commissioning
- the best **quality**;
- **confidentiality**

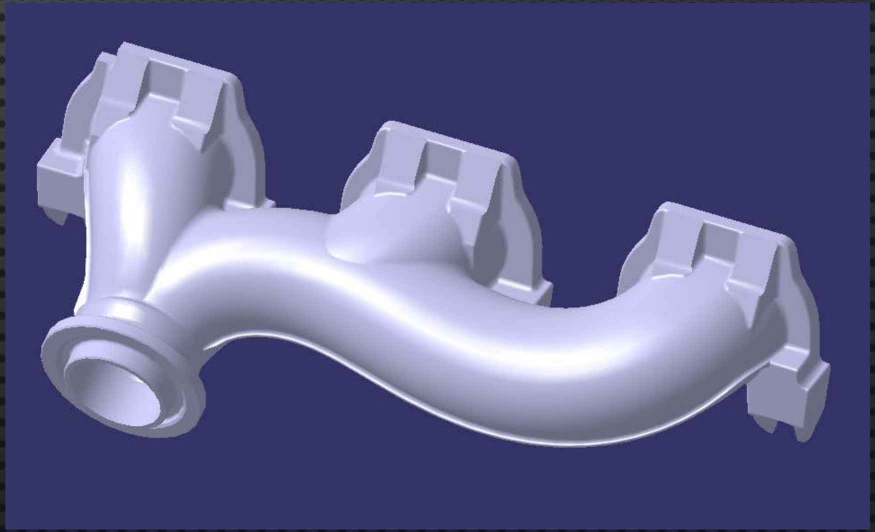
Materials for metal 3D printing

Metal 3D printing may use a very wide number of materials with different mechanical and preciousness characteristics according to its intended use. **Titanium Ti6Al4v**, AlSi 10 Mg **Aluminium**, **AISI** 316 L **Stainless Steel**, **Chromium Cobalt** as well as **Bronze** and **Silver** 925.
Every type of material works in the same way; the difference is the process that leads to the best performance of a design in the machine.

The **additive manufacturing** with metal dusts allows calculating layouts with the aim of substantially lightening the product, keeping the same resistance. The physical and mechanical characteristics will be the same of the ones result of a traditional manufacturing but the pre-production flexibility brings a lot of decisive advantages in many **sectors** such as **avionic, racing and extreme sport ones**.

Parts - DMLS/SLM Method





Thermoforming

Thermoforming is a manufacturing process where a vacuum or under pressure plastic sheet is heated to a pliable forming temperature, trimmed to create a usable product.

It is a great alternative to injection technology, above all when the following conditions are satisfied:

- Little number of parts to manufacture (in this case a manual thermoforming machine is used).
- High number of parts to manufacture in a short time.
- The best manufacturing flexibility (parcels of different finished parts).
- A very thin thickness of part walls.
- The requested precision is above 1 mm.
- The part has undercut areas that cannot be eliminated.

Material used to create moulds for thermoforming:

- MDF (Medium-Density Fibreboard), to print prototypes up to 1000 pieces.
- Wood (stone pine etc.) for small parcels.
- Epoxy resin tables such as E^u-tool or Ciba-tool to print prototypes (however it is very expensive). Polyurethane resins (Thermal compound).
- Moulds in aluminium melted in foundry with copper coils to cool the mould itself, used only for high volumes to print and high quality finishing.

Thermoforming can be obtained:

- Vacuum. The pre-heated sheets stretch over a mould by suction (vacuum) acquiring the same shape of the mould, male or female one based on the best and most suitable part for printing.
- Under pressure

The plastic film is pressed on the mould at high pressure caused externally by the air, that facilitates the cooling too.

The separation of the printed model from the rest of the frame mainly occurs in two ways:

- using shaped dies, sometimes heated, only in case of material that vitrifies i.e. PVC(polyvinyl chloride); this method is the most used but less precise due to machine wheelbase that cuts out.
- using the technique of metal flat cutting, where the separation occurs inside the mould thanks to blades that activate when it is still closed or, in any case, when the material is already formed. This is the most common method used for Polypropylene (PP).

Materials used for thermoforming

ABS	Acrylonitrile-butadiene-styrene
PS	PolyStyrene
PC	Polycarbonate
PVC	Polyvinyl chloride
PP	PolyPropylene
PET	Polyethylene Terephtalate
PMMA	Polymethyl methacrylate (plexiglass)

Pros of thermoforming

- Possibility to print very thin parts, not likely to be made by injection technology, because, with this last method, the liquid plastic is shot at a long distance from the injector but, due to the thin thickness, the plastic itself cools down before completing the whole distance required.
- Likelihood to print a mould in different shapes/figures – depending on machine worktable dimensions – linked with production times optimization If compared with injection printing, as well as great balance between production costs and number of produced parts likely to reach economical target.

Micro-fusion or lost wax casting

Micro-fusion or lost wax casting uses concepts identical with the metal part to produce.
These concepts, usually known as WAXES, are realized in peculiar materials studied to be liquefied or burnt at relatively low temperatures without releasing ashes or residuals.
WAXES or test concepts are used to create, if possible based on dimensions, a structure known as grape bunch – obtaining as many details as possible all together.
This WAX structure is drowned in an inert material - liquid gypsum in case of Aluminium casting, or liquid ceramic in case of steel casting).
With casting method it is possible to use both aluminium and steel.
The ceramic shell (for steel) has a great strength but the process is longer. The test concept is dipped in the liquid ceramic for many times, making a subtle layer of ceramics dry and harden.
Because of the high number of layers, micro-fusion ceramics tend to be very expensive, especially for parts above 130 mm height and with a maximum dimension up to 350/600..

MATERIALS

- Micro fusion in Aluminium alloy (GAl Si 10 -A 357)
- Micro fusion in steel (Aisi 316 L)

Not only Automotive

Biomedical industry

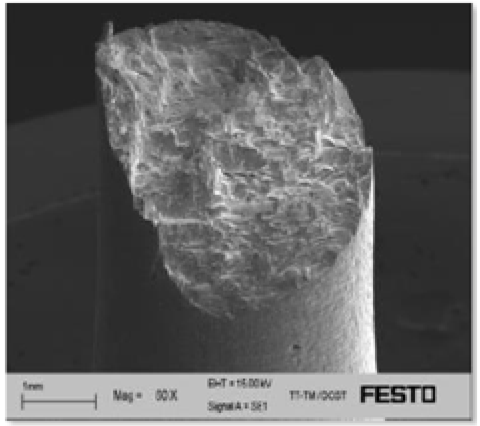
Metal prototyping is also appropriate for medical sector use. The department MEDICAL DIVISION is fully dedicated to this sector and makes **prototypes for dental** and **medical use**, realizing a wide range of customized, biocompatible and **certified** models. **ACAD** enlarged its machinery inventory with a laser fusion system for metal dusts introducing a Concept Laser Mlab Cusing R. This machinery is perfect to make parts with a very complex and elaborate structure that can guarantee an extreme-quality finishing also for very small parts. The medical and dental sectors are the ideal intended use, especially with Remanium Star CL chromium cobalt material by Dentaurum.

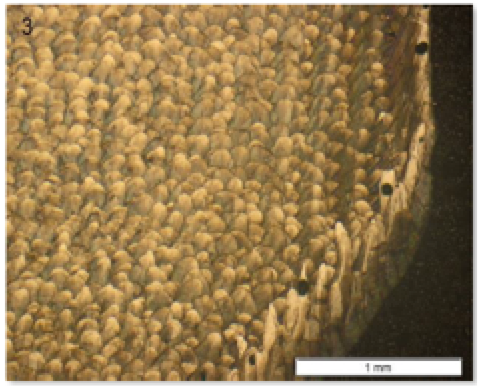
The Machinery inventory for metal rapid prototyping is shared with our partners

The machinery inventory is made of three system for metal **ADDITIVE MANUFACTURING**: **M2 CUSING**, a smaller one that is **MLAB CUSING R** and the **Xline 200R** - 800 x 400 x 500 mm – for big components.

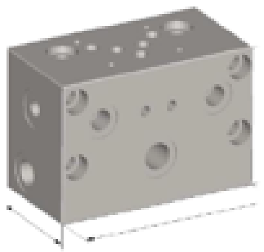
In addition they are available EOS and Renishaw machines.

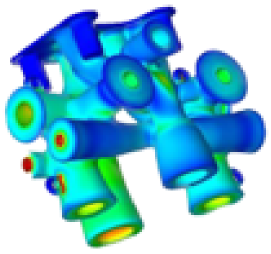
- 20s: Stainless Steels
- 30s: Aluminium Alloys
- 40s: Titanium Alloys
- 50s: Steels for Plastic Injection Dies
- 60s: Steels for Aluminium Die Casting
- 70s: Steels for mechanical parts
- 80s: Copper Alloys
- 90s: Steels for Stainless Dies
- 100s: Nickel-based Alloys
- 110s: Chromium-Cobalt
- Special materials on demand





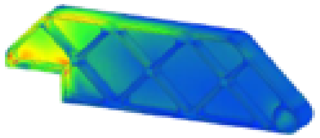
Traditional	Bionic design for additive manufacturing

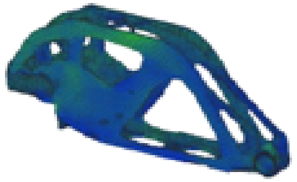




- Weight reduction: 80%
- Reduction of power loss: 50%
- Functional integration: sensors, cooling, etc.

Traditional	Topological optimization for additive manufacturing

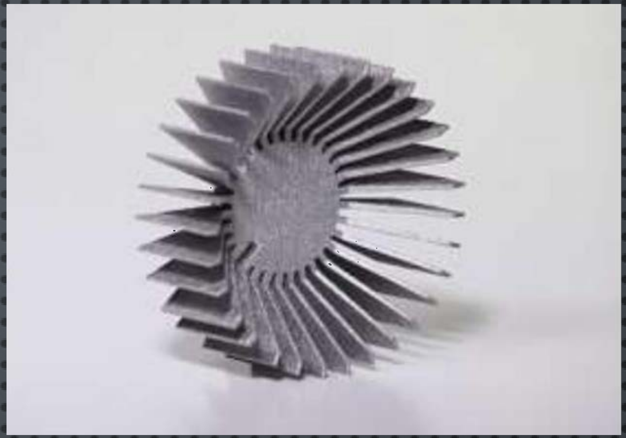




- Double load capacity
- Quite quadruplicated Stiffness
- Weight reduction about 8%

RSC Engineering GmbH

Parts of DMLS/SLM Method



Fusing activity - Cold-Box molding -
Mixture of sand and two-component binder.
3d Polymerization of synthetic resins are utilized to produce cold pressed shapes and cores that are used as binders after the transit of a gaseous catalyst at ambient temperature