Desktop Metal

CASE STUDY

Replacing Brass Lost Wax Casting with Metal 3D Printing

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EAC Innovation & Métal advances stainless steel production with binder jetting

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Industrial lost wax casting

3D-Printing Service Bureau
EAC Innovation & Métal

Location
Bourg-de-Péage, France

Machine
Shop System™

Material
316L Stainless Steel

Website
www.eacswimsource.com

Customer
INSEAD The Business School for the World

Location
Fontainebleau, France

Industry
Education

Application
Salamander statuette for donors

Website
www.insead.edu

Lost wax casting: An ancient metal manufacturing method

Lost wax casting, also known as investment casting, precision casting, or 'cire perdue', is a traditional process for creating metal parts by pouring molten metal (such as silver, gold, brass, or bronze) into a mold made from a wax model.

Lost wax casting has a long history, dating back more than 5,000 years. It was developed independently in some ancient cultures to visually capture their stories and religions in the form of small figurines, sculptures, tools, and jewelry.

This ancient method is known as a highly versatile process that achieves detailed results. Today, despite the development of industrial casting methods, the lost wax process is still used to create metal objects, jewelry, and industrial components.

Although lost wax casting is still used today to produce metal objects, the significant limitations of this traditional method, such as its inconsistent results, inefficient use of materials, and design limitations, have encouraged manufacturers to look for a better way to produce complex metal parts.

Binder jetting: A modern additive manufacturing approach

Binder Jet Technology (BJT), one of the seven additive manufacturing technologies recognized by ASTM, is the key to a better way of making metal. Binder jetting quickly produces metal parts without the need for tools like those used in lost wax casting, which add cost and lead time, or lasers like those

used in other 3D printing technologies, which can be expensive to acquire and maintain.

EAC Innovation and Métal, a renowned 3D printing service bureau in France, was one of the earliest adopters of metal binder jetting in the European Union. The company has designed and produced numerous metal accessories for swimwear, lingerie, luxury leather goods, luxury packaging, cosmetics, and interior design.

Marouene Zouaoui, Chief Additive Officer at EAC Innovation and Métal, commented on the many advantages of metal binder jetting over lost wax casting:

"EAC is committed to regulatory compliance, prioritizing the protection of human health and the environment by adhering to strict chemical safety standards. This commitment aligns with our sustainable practices, ensuring responsible production and minimized environmental impact. Binder jetting technology is an excellent choice that aligns with our strategy. Printing with 316L stainless steel has a lower environmental impact due to more energy efficient processes, reduced emissions from raw material extraction, and the ability to reuse material. Lost wax casting with brass requires more energy and results in higher emissions. Besides, binder jetting provides repeatability and greater operational flexibility."

Customer success story: Salamander statuette

This strategy of eliminating brass lost wax casting and using stainless steel production with binder jetting was key to delivering a customer job – salamander-shaped statuettes for the donors to INSEAD, the business school in Fontainebleau, France. The school wanted a manufacturer that could ensure consistent quality and no delays in the delivery of the statuettes. It found EAC Innovation and Métal, which proposed to change the production to metal binder jetting and to switch to 316L stainless steel.

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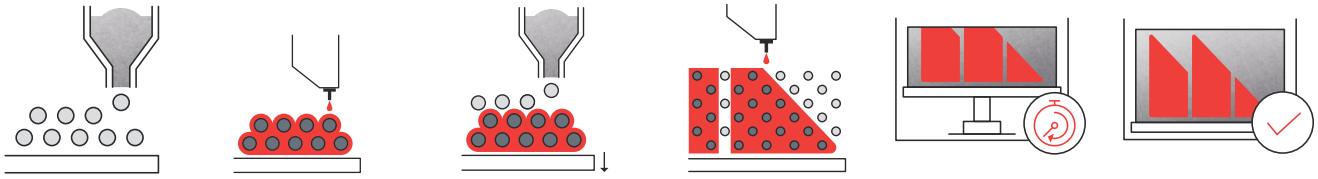
A batch of the salamander statuettes for the donors to INSEAD, the Business School in France, are made from 316L stainless steel and printed on the Desktop Metal Shop System using the binder jetting process. Various finishes were applied. INSEAD owns the copyright of the 3D model of the salamander statuette.

Binder jetting process

Metal binder jetting is an efficient and flexible production process where an industrial inkjet printhead rapidly deposits a binder onto a thin layer of powder particles. This high-speed process is repeated layer–by–layer using instructions from a digital design file until the object shape is complete. For metals, this process creates “green” parts from bonded metal powder that are then cured, or dried, in an oven. The printed part is then removed from the powder bed - a process called “depowdering” - and cleaned before final sintering in a high-temperature furnace, where the particles fuse together into a final metal object that is dense, accurate, and machinable.

Digital File Prep
Machine & Material Prep
3D Printing



Powder Layer

The recoater applies the first thin layers of metal powder in the print area or job box. specific materials

Liquid Binder

A gantry of inkjet industrial printheads selectively applies binder to the powder to bind particles together where desired. Different binders work with different materials to achieve desired results.

Lower & recoat

After each layer, the bed lowers for the next layer to be applied. Recoating is a critical step in binder jetting, as the consecutive powder layers must be precisely and compactly applied to deliver a high-quality precision part. Whether using coarse or fine particles, powder handling is a critical element of successful binder jetting.

Repeat steps

Once the next powder layer has been applied to the print area, the stage has been set for the next layer of binder to be selectively deposited. This recoatingand-binding sequence is repeated until the part is complete.

Fast layer speed

With a full sweep of printheads, a binder jet 3D printer can complete a full layer very quickly. This is one of the core benefits of binderjetting compared to other additive manufacturing methods.

Printing complete

Once the print job has finished, parts can be removed from the print area or job box. Depending on the material and binder used, additional curing and post-processing steps may be necessary. Metal parts typically require curing and sintering.

Next steps depend on application and specific materials

Metals

- Curing
- Depowder
- Debind & sinter

Preparing the print job

EAC Innovation and Métal uses Desktop Metal Live Build™ MFG software to generate and optimize binder jetting production for printing and sintering success. The company also uses the software to generate sintering setters that ensure safe handling and optimal nesting, as well as to protect geometric details and avoid distortions.

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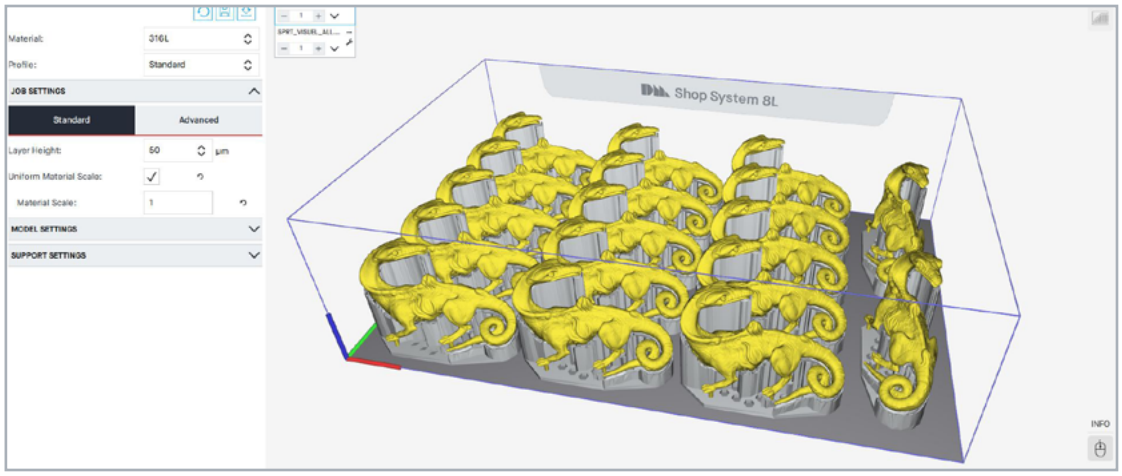
EAC Innovation and Métal uses Desktop Metal Live Build™ MFG software to generate and optimize binder jetting builds for printing and sintering success, and to generate sintering setters.

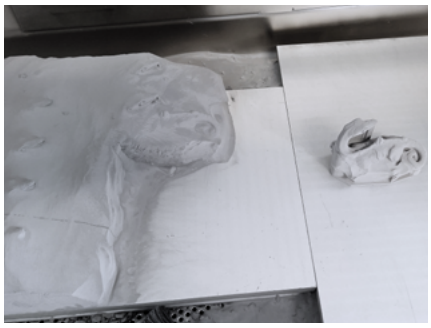


- Print time: 8 h 40 m
- Number of nested parts: 17
- Setter design: Desktop Metal Live Build MFG software
- Layer resolution: 50 µm
- Build height: 65 mm
- Number of layers: 1,300
- Binder volume required: 170.6 mL
- Material: 316L stainless steel
- Average labor time per build (depowdering and preparation for sintering): 3.5 h
- Powder loaded into printer: 65 kg
- Scrap during depowdering: < 3 %

Depowdering

After printing, Zouaoui of EAC Innovation and Métal argues that depowdering is a very important step, especially for the salamander-shaped statuettes. Quality control is important to ensure that no powder residue remains and that all details are properly cleaned. “The craftmanship of the depowdering operators is paramount in the binder jetting process. Depowdering requires a high level of 3D awareness to ensure safe handling and efficient powder recovery,” argued Zouaoui, who has more than 250 hours of depowdering under his belt.

EAC Innovation and Métal confirms that the same print job has been used for almost two years and that the print resolution has been maintained. Currently the parts are produced on demand and finished according to the customer’s requirements.



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Green parts during depowdering.

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Ruthenium-finish salamander showing all the details reproduced from the 3D model.

Process-based advantages of binder jetting over lost wax casting

The benefits experienced by EAC Innovation and Métal in replacing lost wax casting with metal binder jetting are as follows:

Higher repeatability and precision

Metal binder jetting is a digital and automated process that delivers consistent, repeatable results with every print. The process eliminates the manual variability that can occur with traditional casting, ensuring that intricate designs and fine details are accurately reproduced every time. With metal binder jetting, the skin pattern of the salamander statuette is repeatable.

In contrast, lost wax casting is subject to variation due to the manual nature of wax modeling, mold degradation, and metal flow during casting. Each casting can have small differences, especially in fine details, resulting in lower repeatability compared to binder jetting.

Greater design flexibility

Additive manufacturing, such as binder jetting, enables complex geometries and designs that are difficult or impossible to achieve with traditional methods. This flexibility can also result in lighter and more cost-effective parts. [1] Lost wax casting, on the other hand, has limitations when it comes to design complexity. Fine details or thin structures can be difficult to cast reliably, and intricate geometries may require post-casting machining, adding complexity and cost.

Another excellent example of the exceptional quality and high precision of binder jetting is a stunning piece of décor featuring a majestic lion head surrounded by intricate patterns which EAC Innovation and Métal printed using the Desktop Metal Shop System. The system features an advanced printhead with more than 70,000 nozzles that ejects 1.2 pL droplets at nearly 10 kHz, ensuring high-resolution parts.

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This antique decorative piece, featuring a majestic lion head and intricate patterns, is printed on the Desktop Metal Shop System, a binder jet 3D printer that allows for design freedom and delivers high precision and repeatability. This piece is made of 316L stainless steel and finished with antic copper to showcase the depth of detail. Layer resolution: 50µm. Diameter: 65 mm.

"The same level of detail can be maintained because a 3D digital model is used. If you were to use lost wax casting to make this decorative piece, you would have to make a lot of wax models that would vary in detail and quality," argued Zouaoui of EAC Innovation and Métal.

Zouaoui of EAC Innovation and Métal highlights specific design features where metal binder jetting is also strong: "Interlocked parts and complex lattice structures cannot be cast because they require very specific casting channels. These channels require additional labor to remove. To be fair, a 3D printing technology like Wax Jet allows to overcome similar problems by numerically generating these channels attached to the wax model. However, metal binder jetting surpasses such limitations and ensures more detail consistency. Internal channels and surfaces are also a strong point for metal binder jetting."

Faster prototyping and production [1]

Binder jetting enables rapid design changes without the need to create new molds or tooling, improving operational flexibility. Manufacturers can quickly adapt to changes or custom requirements, resulting in shorter lead times and increased efficiency.

In contrast, lost-wax casting requires multiple steps from wax modeling to mold making, which slows production, especially when design changes are required. New molds must be created for each new part or design iteration, limiting operational flexibility.

Zouaoui of EAC Innovation and Métal is very pleased with the much faster prototyping and production process that metal binder jetting offers compared to lost wax casting: "In lost wax casting, a wax model must be fabricated, sometimes even 3D printed. This wax model is manually prepared and usually welded to a main casting channel. Then we can proceed to creating the mold. In metal binder jetting, we can go directly from a digital model to a physical object. We can nest hundreds of parts by simply duplicating the digital file. However, in lost wax casting, each mold cavity requires a wax model and that cavity can only be used once because it will be destroyed to the metal cast part."

More efficient material usage and less waste

Metal binder jetting is a resource-efficient additive process where material is used only as needed, layering metal powder until a solid object is formed.

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Marouene Zouaoui, Chief Additive Officer, EAC Innovation and Métal

Unbound powder can be recycled for future prints - 316L stainless steel powder is fully recyclable without quality loss. [2, 3] This method reduces material waste as it doesn‘t require molds, unlike lost wax casting, which depends on disposable wax models and ceramic molds, leading to significant material waste and unrecoverable metal.

Lower energy requirement

Unlike lost wax casting, binder jetting doesn’t require melting large amounts of metal. Instead, it uses sintering at lower energy levels to bind the powder. This results in lower energy consumption and a reduced carbon footprint. Lost wax casting, on the other hand, requires wax modeling, mold making, and melting brass at high temperatures (~1,100 °C/2,012 °F), which consumes a lot of energy.

Binder jetting allows for the reuse of stainless-steel powder that is not used in the printing process. This reuse directly reduces the high energy required to mine or refine fresh copper and zinc, the primary components of brass.

Because 316L stainless steel is often made from a high percentage of recycled material, and the binder jet process requires less energy than lost wax casting, CO_2 emissions are significantly lower. Copper and zinc mining is associated with significant carbon emissions and environmental degradation, contributing to a higher carbon footprint. [3]

Zouaoui of EAC Innovation and Métal pointed out: “With metal binder jetting, there are no emissions. All the material can be reused and there is no waste.”

The comparison between metal binder jetting and lost wax casting*

	Metal Binder Jetting	Lost Wax Casting
Repeatability and precision	▪ High (digital control, consistent output)	▪ Average (manual model making, mold degradation)
Design flexibility	▪ Freedom in design, complex designs (e.g. intricate thin decoration patterns. Engravings)	▪ Limited design complexity
Production time	▪ Fast	▪ Lengthy
Production flexibility	▪ High (through digital, tooling-free prints that enable rapid responses and custom designs)	▪ Low (hard tooling limits design possibilities and lengthens production timelines)
Material usage and waste management	▪ Efficient. Minimal waste (recyclable powder, no molds)	▪ Inefficient. High material waste (disposable wax models, non-recyclable molds)
Energy consumption and CO_2 emissions	▪ Low	▪ High

* Note: This comparison is based on EAC Innovation and Métal’s evaluation of metal binder jetting and lost wax casting.

Material comparison between 316L stainless steel and brass

In addition to the many benefits of using metal binder jetting instead of lost wax casting to produce the salamander-shaped statuettes and other complex parts such as the Infinity Gauntlet, EAC Innovation and Métal also found that 316L stainless steel offers several advantages over brass:

Increased durability and lower maintenance

316L stainless steel is known for its excellent corrosion resistance, also in harsh environments, making it ideal for long-term use with less maintenance. [2] Although brass is also resistant to corrosion, it can tarnish and degrade faster, resulting in a shorter service life for parts exposed to certain conditions. Brass also requires regular cleaning and polishing to maintain its appearance and prevent tarnishing. “The stainless steel salamander statuette made with the metal binder jetting process is more durable than the brass lost wax statuette,” confirmed Zouaoui.

Less harmful mining

The raw materials for 316L stainless steel, such as iron, nickel, and chromium require mining, but the high recycling rates for stainless steel reduce the need to mine virgin materials. [3] Brass requires copper and zinc, both of which are resource intensive to mine. [4] Copper mining and processing, in particular, is associated with various environmental and social impacts. [4, 5, 6. 7]

The comparison between 316L stainless steel from binder jetting and brass from lost wax casting*

	316L Stainless Steel in Binder Jetting	Brass in Lost Wax Casting
Durability	▪ Excellent/more durable	▪ Moderate (prone to dezinfication)
Maintenance	▪ Lower	▪ Higher
Impacts of mining	▪ Lower (due to high recycling rates)	▪ Higher (due to the more resource-intensive nature of mining, environmental, and social impacts)

* Note: This comparison is based on EAC Innovation and Métal’s evaluation of both materials, which is supported by several publications.

Demo part: Infinity Gauntlet

Another brass application that EAC Innovation and Métal has experimented with producing in stainless steel using the metal binder jetting process is the Infinity Gauntlet, a powerful glove used by Thanos, a character in a Marvel movie, to hold six Infinity Stones, each of which controls an aspect of the universe such as time, space, and reality. With all of the stones, the gauntlet gives Thanos god-like power, allowing him to wipe out half of all life with a snap of his fingers.

EAC Innovation and Métal printed the glove using a digital 3D model that is freely available online for non-commercial use. Metal binder jetting allows the precise placement of rhinestones carved directly into the 3D model, intricate thin décor patterns and engravings.

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Thanos Infinity Gauntlet

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A 3D digital model of the Infinity Gauntlet

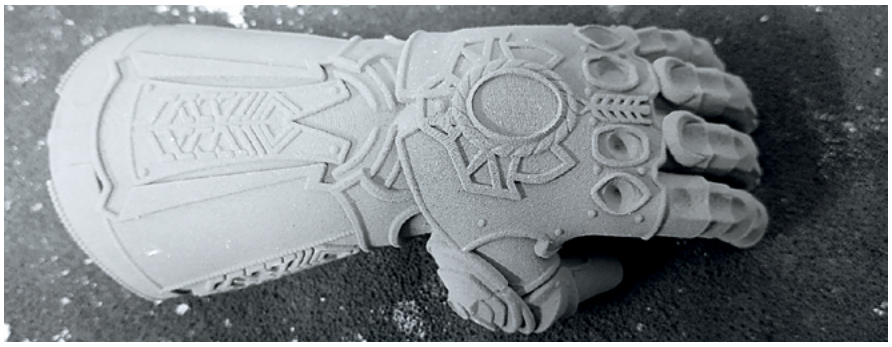
Below are some tips from EAC Innovation and Métal on how to handle certain processes:

Setter design and part orientation

- Ensure integrity and protect geometric details (placing the hand on the back reduces the volume of the setter, but puts some features at risk)
- Safer handling (especially for the fingers)
- Optimal nesting (since the setter takes up less space in the build volume)

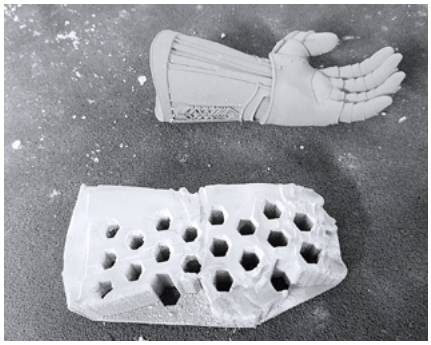
Depowdering

Control the quality to make sure that no powder residue remains and all details are properly cleaned.



Sintering preparation

Apply your ceramic powder to all the surfaces where the part will be in contact with the setter.



After sintering

Simply remove the part from the setter. Sometimes, a gentle tap on the floor can help.

Post processing

The Infinity Gauntlet features an antique brass finish. This finish is more durable and resistant than the equivalent brass part. Rhinestones are added to the gauntlet.

Personalization is a strength of binder jetting

While lost wax casting is a mature and effective process for producing high-quality metal parts in bulk, it struggles to match the speed, flexibility, and cost-effectiveness of metal binder jetting for personalized or small-batch production. These strengths make metal binder jetting a powerful choice for industries that prioritize customization, such as the jewelry, fashion, and luxury industries.

Because metal binder jetting only needs digital 3D models, each printed part can be unique, unlike lost wax casting where a wax part must be made for each design. The two different designs of the Infinity Gauntlet holders are a good example of the personalization power of binder jetting," said Zouaoui of EAC Innovation and Métal.

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Various designs of Infinity Gauntlet holders: "OH SNAP" and "Baby Groot"

References:

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[2] Worldstainless. Stainless Steels and CO_2: Industry Emissions and Related Data. https://www.worldstainless.org/about-stainless/environment/stainless-steels-and-co2-industry-emissions-and-related-data/

[3] Worldsteinless. Stainless Steel Recycling. https://www.worldstainless.org/about-stainless/environment/recycling/

[4] Metal Wars: Comparing Stainless Steel with Iron, Copper, and Brass. https://www.pat.org.uk/construction/11/2024/metal-wars-comparing-stainless-steel-with-iron-copper-and-brass/15289/

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[7] Bureau of International Labor Affairs. From Mines to Markets: Exposing Labor Exploitation in Critical Mineral Supply Chains. https://www.dol.gov/agencies/ilab/supply-chain-research/from-mines-to-markets-exposing-labor-exploitation-in-critical-mineral-supply-chains

Read also:

The Additive Manufacturer Green Trade Association (AMGTA). Comparison of Greenhouse Gas Emissions: Casting vs Binder Jetting of an Industrial Part. Additive Sustainability, Volume III, July 11, 2023. https://amgta.org/wp-content/uploads/2024/03/AMGTA_Vol3_BinderJettingIndistrialComponent_ES.pdf

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About EAC Innovation and Métal

Founded in 1992, EAC Innovation and Métal is a 3D printing service bureau based in Auvergne-Rhône-Alpes, France. Originally focusing on manufacturing metal accessories for the footwear and leather goods markets, the company is now increasingly repositioning itself in designing and manufacturing metal accessories for swimwear, lingerie, luxury leather goods, luxury packaging, cosmetics, and interior design. EAC Innovation and Métal is part of the Éphies Industries Group based in Bourg de Péage, France, specializing in electroplating and manufacturing of plastic and metal parts for luxury goods.

Learn more: www.eacswimsource.com
www.ephie-industries.com

About Desktop Metal Inc.

Desktop Metal is driving Additive Manufacturing 2.0, a new era of on-demand, digital mass production of industrial, medical, and consumer products. Our innovative 3D printers, materials, and software deliver the speed, cost, and part quality required for this transformation. We're the original inventors and world leaders of the 3D printing methods we believe will empower this shift, binder jetting and digital light processing. Today, our systems print metal, polymer, sand and other ceramics, as well as foam and recycled wood. Manufacturers use our technology worldwide to save time and money, reduce waste, increase flexibility, and produce designs that solve the world's toughest problems and enable once-impossible innovations.

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