Desktop Metal

CASE STUDY

TECNALIA Research & Innovation

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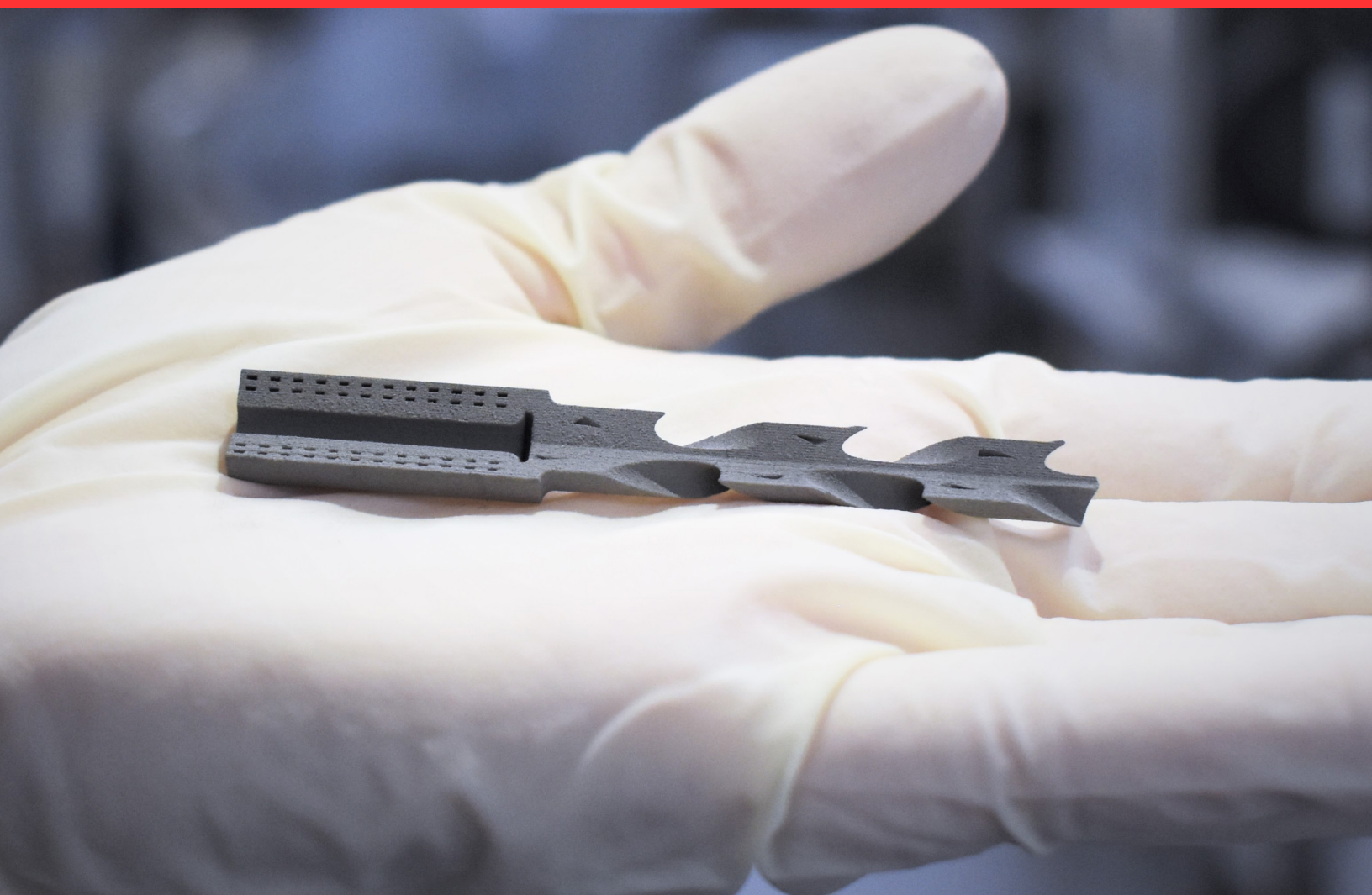
Binder jetting of hard metal and tool steels for cutting tools



tecnalia

MEMBER OF BASQUE RESEARCH
& TECHNOLOGY ALLIANCE

Customer
TECNALIA Research & Innovation

Location
San Sebastián, Spain

Industry
Tooling

Application
Cutting tools; inserts and drills

Machines
InventX®

Material
Hard Metal (WC-Co) and Tool Steel (M2)

Website
www.tecnalia.com

About TECNALIA

TECNALIA Research & Innovation is a private, independent, non-profit applied Research Centre of international excellence. Legally a Foundation, TECNALIA is the leading private and independent research and technology organization in Spain and one of the largest in Europe, employing over 1,400 people, including 248 PhDs, with income of near €110 Million in 2019.

The team at TECNALIA focuses on one goal: to transform technological research into prosperity, meaning wealth to improve people's quality of life by generating business opportunities for industry. TECNALIA is committed to generate major impacts in economic terms, by means of innovation and technological development, addressed by 6 business divisions, covering economic sectors of Energy, Industry, Transportation, Construction, Health and ICT. TECNALIA has been granted over 396 patents and promoted more than 30 spin-off companies. Learn more at www.tecnalia.com

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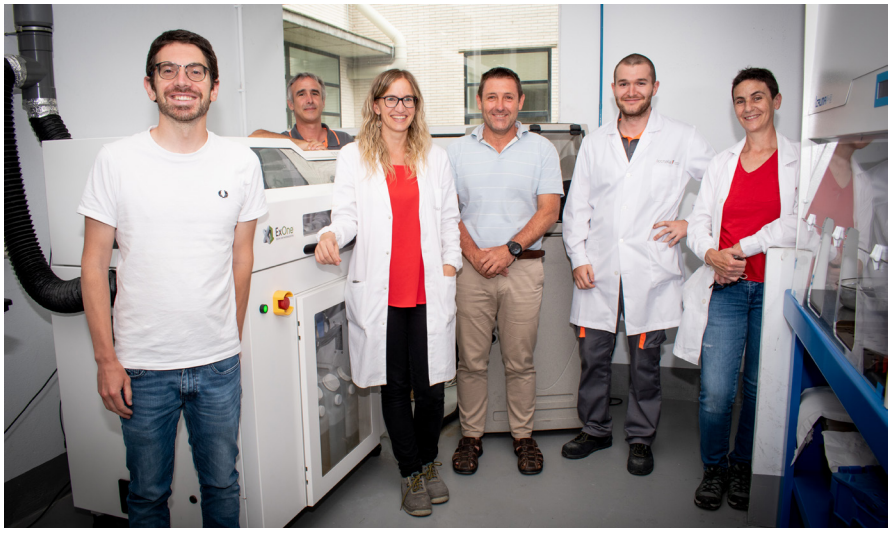
The TECNALIA team uses its material and manufacturing expertise on the InnoventX binder jetting system to develop applications that transform knowledge into business opportunities for companies and GDP growth for society



Transforming knowledge into business opportunity

Dr. Iñigo Agote, Project Manager and Group Leader at TECNALIA, explained the role his team plays in advancing additive manufacturing, saying, “With our concentration of PhDs and materials knowledge we can be early adopters and implement the technology relatively easy. The companies we partner with, however, are still surveying the process and not sure where it fits, so we help fill that gap with our expertise to advance their applications.” Agote’s team is part of TECNALIA, a benchmark research and technological development center focused on transforming knowledge into business opportunities for companies and GDP growth for society. Recognizing the importance of additive manufacturing (AM), the institute purchased its first binder jetting machine, an InnoventX®, in 2017 to develop its expertise in sinter-based AM processes.

Through various projects TECNALIA has acquired the knowledge to help companies be more successful with disruptive binder jetting technology. The Materials for Extreme Conditions research group, belonging to the company’s Industry and Mobility (I&M) division, focuses on the design, manufacturing, maintenance, and end of life of industrial products and services. With over 25 years of experience in developing materials for extreme conditions, the team helps improve competitiveness in a variety of strategic sectors. The knowledge and technological capabilities of the group cover all stages in powder metallurgy: from raw materials to the final component, complemented with design, characterization, and failure analysis capabilities.

A new way to process metals for tooling

The TECNALIA team has collective knowledge in materials for extreme temperature, wear, abrasion, and corrosive environments, making them

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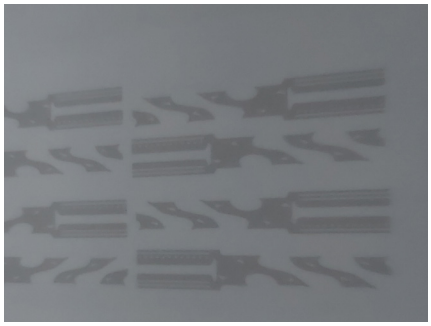
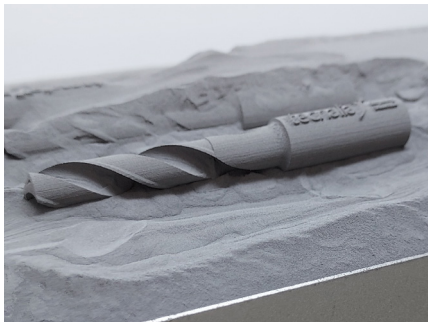
the natural partner for companies in the tooling industry looking to investigate new manufacturing options to optimize tool production.

The harsh conditions of modern machining operations require tools with excellent mechanical properties such as hardness and fracture toughness, together with high expectations for wear resistance, surface quality, and dimensional tolerances. Hard metals such as tungsten carbide cobalt (WC-Co) and tool steels such as M2 are ideal for such applications because of their excellent and well-balanced hardness/fracture toughness, high temperatures resistance, and wear resistance.





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Conformal cooling channels that cannot be manufactured any other way are easily integrated into binder jet 3D printed WC-Co tooling like this drill produced with on the InnoventX® by TECNALIA

“The tooling sector is always looking for better performing tools, decreased lead times of special tools, and increased customization of tools” said Agote. Binder jet 3D printing can bring great benefits and deliver on these requirements. Other additive manufacturing process such as laser-based 3D printing are not capable of obtaining good quality tools made from these desirable materials, he explained, stating that the M2 alloy has a tendency to crack during the high heating and cooling rate of laser-based processes, while hard metals like WC-Co pose a challenge with decomposition while only obtaining a limited density.

Binder jet additive manufacturing overcomes the limitations of the beam-based additive manufacturing processes. Since binder jet 3D printing does not use heat sources to melt material during printing, rather selectively deposits binder from a printhead onto the powder bed without thermal fluctuations, heating and cooling related defects such cracks and compound decomposition are eliminated.

In addition, the post processing used in binder jetting is analogous to the conventional process - pressureless sintering after cold pressing or MIM for M2 alloy and a sinter-HIP (hot isostatic press) following the typical CIP (cold isostatic pressing), cold uniaxial pressing, extrusion, or MIM manufacturing of WC-Co. Parts obtain full density in the post-printing sinter process, an important requirement for materials used in tooling applications, but the die-less binder jetting gives the TECNALIA team extraordinary design freedom.

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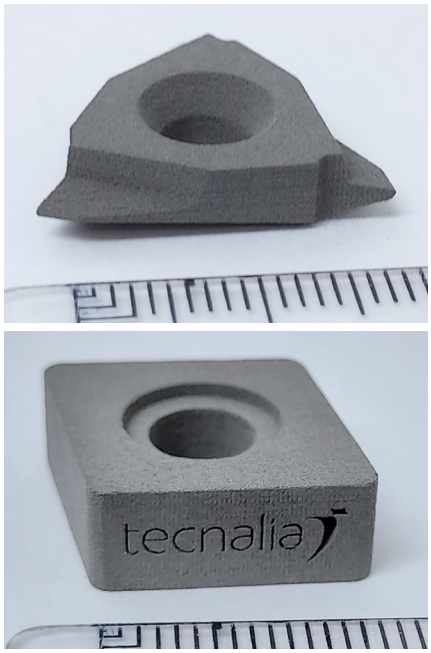

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M2 tool steel cutting tool inserts produced with binder jet 3D printing by TECNALIA

Binder jetting also provided a near net shape part, reducing the machining and polishing post-processing steps. The freedom of design of 3D printing also enables new functional tool geometries, such as cooling channels, without any cost increase. The optimized cooling channels provided positive impacts on the tool temperature and thus the tool material degradation. The integrated cooling system allows manufacturers to machine at higher speeds, preserving tool lifetime, thus increasing process productivity and the decreasing coolant consumption.

Furthermore, binder jetting substantially decreases the lead time of special-order tools and allows for mass customization without additional cost increments. Agote points out that these abilities are especially relevant in the tooling market where unique tooling solutions enable innovative "traditional" production with CNC machine tools.

However, the processing of these desired tooling materials still required tailored development, as Agote explained. "WC-Co is a composite material made of a ceramic, tungsten carbide (WC), and a metal, cobalt (Co). A 12% cobalt composition was used but the commercial ready-to-press (RTP) powders used nowadays for WC-Co are not adequate for the binder jetting process because of their large grain size, low tap density, and other various issues related to the binders involved in the process. Obtaining high density in binder jetting M2 is challenging because it's so new, it hasn't yet been well studied." Thus, TECNALIA focused on the raw materials development and the optimization of the printing and sintering steps that are crucial for their industry partners to obtain products with properties comparable to their counterparts manufactured by conventional processes.

So the TECNALIA team got to work identifying suitable WC-Co material and powder treatment methods as well as defining the best parameters for the printing and sintering processes. Ready-to-press powders optimized with specific treatments and plasma spherodize WC-Co powders sourced from

> "After sintering, parts with **densities comparable to traditionally manufactured commercial parts** were obtained. In addition, the **hardness and fracture toughness for the material was also comparable.**"
>
> **Dr. Iñigo Agote, Project Manager and Group Leader, TECNALIA**

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Global Tungsten & Powders (GTP) were found to be adequate for the binder jetting process while MIM grade M2 powders sourced from Sandvik provided satisfactory results. The sinter-HIP and sintering cycles were optimized for heating rates, holding times, and temperatures for WC-Co and M2, respectively. “After sintering, parts with densities comparable to traditionally manufactured commercial parts were obtained. In addition, the hardness and fracture toughness for the material was also comparable,” Agote said.

The flexibility of the InnoventX machine to customize parameter settings combined with the process and materials expertise of the TECNALIA team to tailor the properties for this application led to the breakthrough that delivered final parts with the required properties. Parts with tailored cooling channels and unique geometries unmanufacturable with other methods were realized. Even more, parts could be produced in less than 1 week with Desktop Metal binder jetting technology, compared to 4 weeks required for conventional process, allowing the manufacturer to start production faster and while running more efficiently.

Ongoing material development for binder jetting

TECNALIA supports the needs of regional, national, and international industries, making its extensive knowledge of manufacturing materials and processes available to the market. As members of EARTO and EUROTECH, TECNALIA play an important role in linking together European research

3D printing technical ceramics

The flexibility of the InnoventX binder jetting machine allowed the TECNALIA team to print the challenging materials after an exhaustive selection and powder conditioning process optimized for the binder jetting process. The final parts provided were near net shape, reducing difficult and expensive machining and cutting lead times by 75%. The new functional designs enabled by additive manufacturing allowed embedding cooling channels to optimize the tools‘ temperature during operation.

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X160 Pro binder jet system ramps up applications developed on the innoventX or X25 Pro to mass-production volumes

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centers. Through EU Framework Programmes they have participated in over 700 projects, coordinating nearly 150.

To date, TECNALIA has been granted nearly 400 patents and promoted more than 30 spin-off companies. During the past year the Materials for Extreme Conditions research group worked with different sinter based additive manufacturing processes, such as binder jetting.

The InventX system affords the team the flexibility to work with a range of materials, ceramics and metals. “The team is eager to work with any powder they can get,” Agote says. While they continue developing WC-Co and M2, they also work with copper, silicon carbide, and alumina, and are gearing up to tackle aluminum and titanium to continue bringing the most advanced innovations into both niche and mass markets.

Binder jet 3D printing was identified as the most adequate additive manufacturing process to create **unique designs and shorten lead times of advanced cutting tools** because of the absence of cracking in tool steels, preservation of tungsten carbide (WC) without decomposition, and the obtained good densities.

Desktop Metal

About Desktop Metal Inc.

Desktop Metal, Inc. is accelerating the transformation of manufacturing with end-to-end metal 3D printing solutions. Founded in 2015 by leaders in advanced manufacturing, metallurgy, and robotics, the company is addressing the unmet challenges of speed, cost, and quality to make metal 3D printing an essential tool for engineers and manufacturers around the world. In 2017, the company was selected as one of the world’s 30 most promising Technology Pioneers by the World Economic Forum, and was recently named to MIT Technology Review’s list of 50 Smartest Companies. For more information, visit www.desktopmetal.com.

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