



Industrialization of Additive Manufacturing

With unique seamless PLM software and scalable automation solutions

[siemens.com/additive-manufacturing](https://www.siemens.com/additive-manufacturing)

Siemens industrializes Additive Manufacturing

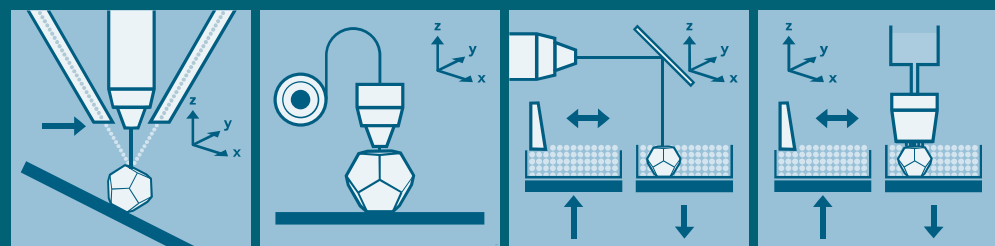
Individualized mass production, functional design, high energy and resource efficiency as well as shorter innovation cycles – the advantages of Additive Manufacturing are being leveraged more and more in the industrial environment. Whether powder bed fusion, directed energy deposition, material extrusion or jetting – all these techniques build up workpieces layer by layer based on digital 3D design data. These techniques allow extremely complex structures to be created, which are both light and stable – in fact, finally, parts can be cost-effectively created with batch sizes of just 1. And digitalization offers the best possibilities of covering the requirements associated with Additive Manufacturing.

Unique seamless software and scalable automation solutions

Siemens is the only company that offers seamless software and automation solutions for Additive Manufacturing – where the advantages of digitalization fully come into their own. With the PLM software, designers, engineers and companies operating machines have a seamless process chain

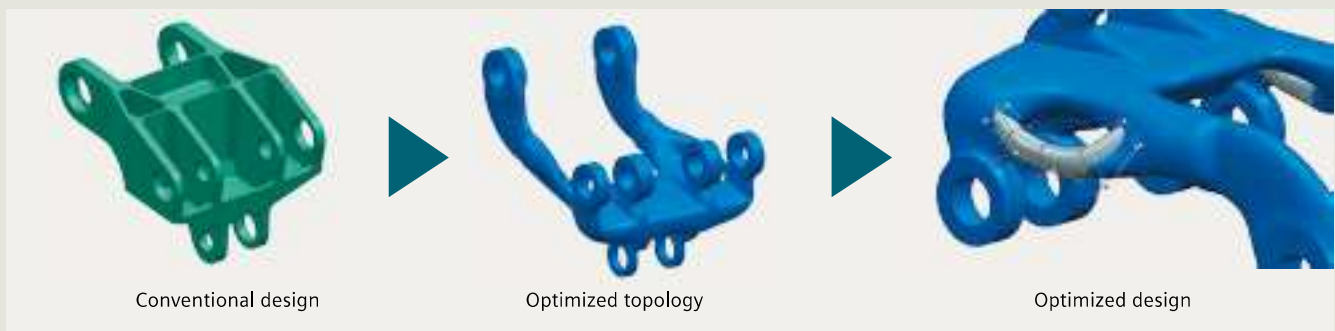
available that extends from development and design up to data preparation for components for 3D printing. Siemens is offering machine builders solutions for equipping industrial 3D printers based on its automation solutions firmly established in the market.

Layer by layer to the finished part or component – all the additive techniques are based on this principle.



	Directed energy deposition	Material extrusion	Powder bed fusion	Jetting	
				Binder	Material
Metal	●	○	●	○	●
Plastic		●	●	●	●
Ceramic		○	●	○	
Sand		○	○	○	
Composite		○		○	

● = Build platform material ○ = Material that can be optionally added



Workflow for converting a conventional product design to one optimized for Additive Manufacturing.

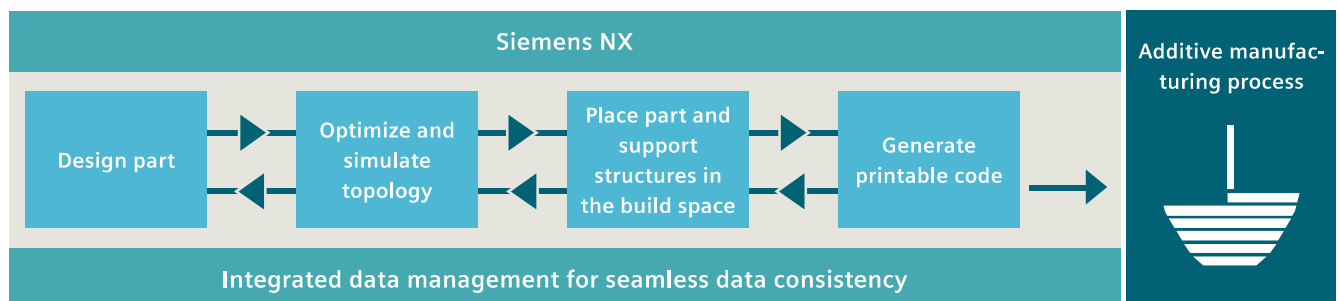
Seamless workflow from development through to the finished part

Within the context of digitalization, industry is using seamless software tools in all product development phases. Siemens offers the ideal solution with its PLM software NX having functions specifically for Additive Manufacturing applications, which provides a seamless workflow. NX covers the complete process – from development and design through preparing the build job – up to generating machine code for the 3D printing system. More specifically, the complete digital process chain is emulated in a single, integrated associative software environment – allowing it to be operated from a standard user interface. Tools for developing, simulating, manufacturing preparation and 3D printing are embedded in one seamless and

integrated system. This means that data conversion processes – prone to errors with possible loss of information – are not required. This is how NX ensures high process reliability and efficiency.

Mature for series production: NX for Additive Manufacturing

The completely seamless NX solution for Additive Manufacturing facilitates a seamless process chain, even when it comes to complex printing techniques. As a consequence, high-quality products can be produced in series on Additive Manufacturing machines.



Totally Integrated Automation – where all automation components interoperate efficiently



The intelligent automation of production systems plays a decisive role in the industrialization of Additive Manufacturing. Totally Integrated Automation, the industrial automation from Siemens, ensures that all the automation components interoperate efficiently. The open system architecture covers the complete production process and utilizes a standard approach across the board: consistent data management, global standards and unified hardware and software interfaces. This common approach minimizes engineering costs, shortens time to market and increases flexibility.

PLC-based automation solutions with SIMATIC

With SIMATIC, the core of Totally Integrated Automation, users can depend on the highest degree of integration and seamlessness. The basic automation based on SIMATIC, the SINAMICS drive system and SIMOTICS motors to move the mechanical units of the machine for powder bed fusion and jetting techniques offer some unique advantages:

- As a result of its scalability, solutions can be extremely flexibly and cost-effectively adapted to address the actual requirements
- Shorter time to market is achieved through integrated engineering and efficient programming in the TIA Portal
- Diagnostic functions are simply configured and do not have to be programmed

SIMATIC highlights

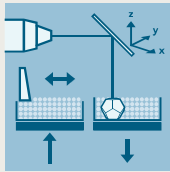
When it comes to industrializing Additive Manufacturing, manufacturers of 3D printing systems especially profit from the following SIMATIC highlights:

Safety technology embedded in the controller

SIMATIC S7-1500 is the only software controller with Safety Integrated available in the market. The integrated safety functionality helps save space and reduce costs as an additional safety controller is not required.

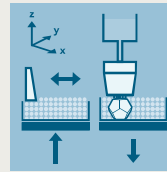
OPC UA and PROFINET – open standards for communication concepts

With PROFINET, Siemens uses the Ethernet standard for automation. OPC UA has established itself as the open, non-proprietary communication platform linking control systems to the ERP level and to the Cloud. Combining the individual strengths of both standards facilitates secure and seamless vertical communication in the complete automation and IT environment.



Powder bed fusion

With the powder bed fusion technique, the powdered material – i.e. metal, plastic or ceramic – is applied to a build platform, the powder bed. The laser beam precisely melts the powder and fuses defined points to the layer below. The laser repeats this process until the part to be created has been completed.

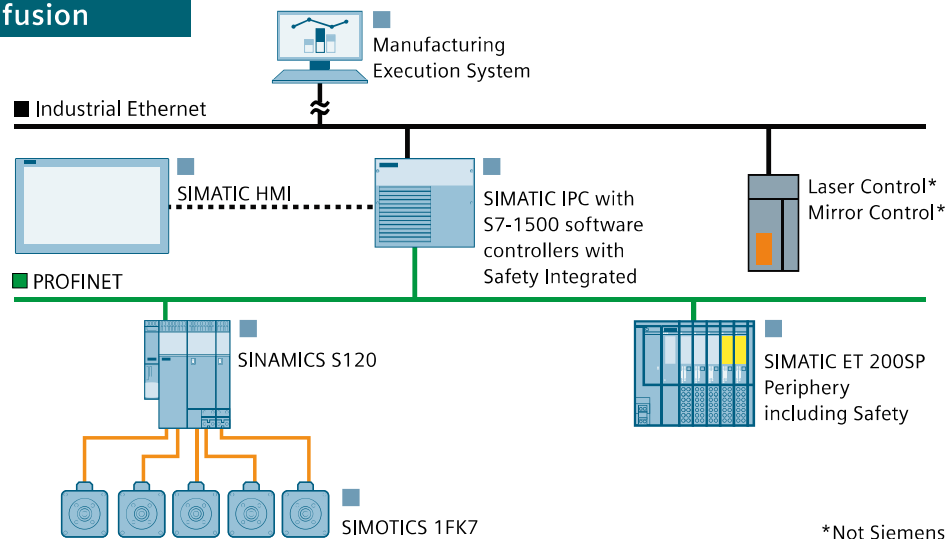


Binder jetting

In the binder jetting process, the powder-based material is applied to a build platform. When lowering the build platform, a print head applies adhesive (the binder) gluing the powder layer by layer. This allows parts and components to be built without requiring any support structures.

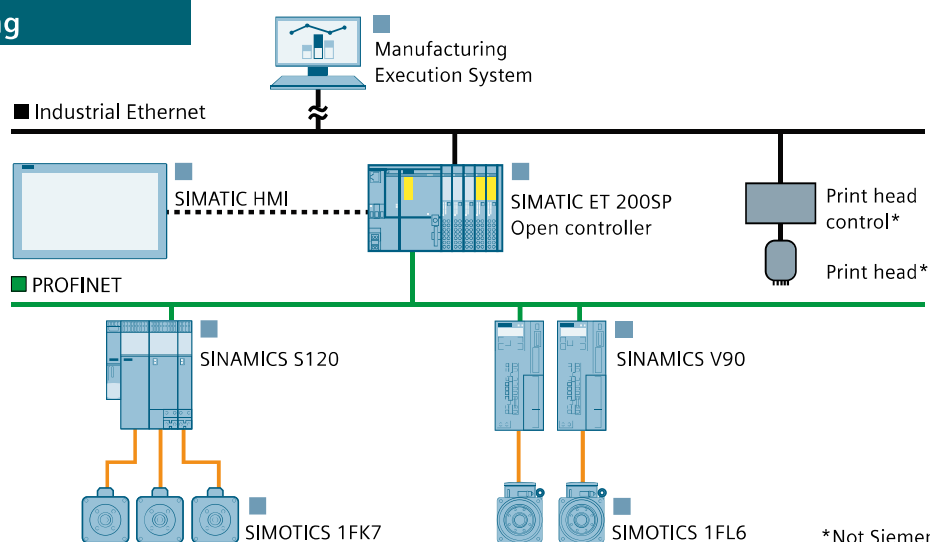
Two possible configurations are shown here as examples. Customized automation solutions can be configured to address the specific requirements of the machine.

Powder bed fusion



*Not Siemens components

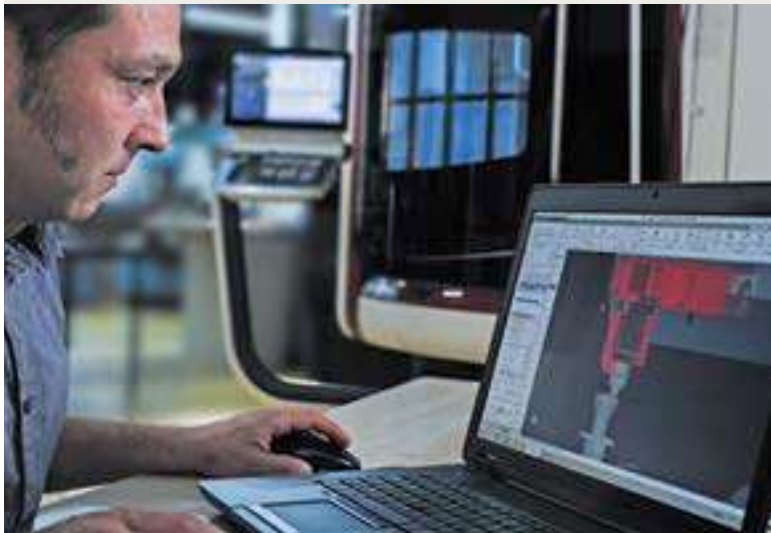
Binder jetting



*Not Siemens components

CNC-based automation solutions with SINUMERIK

The 5-axis technology of SINUMERIK 840D sl provides a high degree of flexibility in the Additive Manufacturing domain. Whether material extrusion or directed energy deposition – the SINUMERIK 840D sl CNC together with the SINAMICS S120 drive system and SIMOTICS motors facilitate precise and dynamic multi-axis motion control.



Seamless CAD/CAM-CNC chain from NX through to the SINUMERIK-controlled machine at Hoedtke GmbH & Co. KG

SINUMERIK highlights

When it comes to industrializing Additive Manufacturing, manufacturers of 3D printing systems especially profit from the following SINUMERIK highlights:

Seamless and integrated CAD/CAM-CNC chain

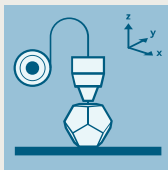
Based on the CAD model of the component, the material deposition strategy for additive techniques can be generated in NX by applying 5-axis motion control. The path is calculated for the production process in NX in the same way as for conventional machining processes, generating runnable CNC programs. After encrypted data transfer to the machine (to protect intellectual property), this data can be directly processed by the CNC.

Support structures can be reduced thanks to 5-axis motion control

For machines with 5-axis motion control, in addition to the three linear axes, there are two rotating and/or swiveling axes. This creates the basis for multi-dimensional motion control strategies, and allows the nozzle to be moved relative to the build platform. The material can be optimally deposited for the build process by appropriately orienting the print head as well as the part itself. For instance, for material extrusion, this allows most of the support structures and special support materials to be eliminated. Higher build rates, more efficient material utilization and, last but not least, a better surface quality can be achieved as a result of the high dynamic performance and precision of SINUMERIK.

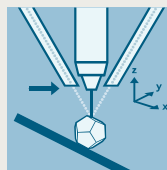
Maximum technology in the machine

The high level of system openness of SINUMERIK 840D sl gives machine builders the opportunity of integrating technological functions that are precisely tailored to address their specific machine requirements. These extend from their own machine-specific user interfaces up to compile cycles – this is all made possible by the open CNC kernel and drive architecture, which is absolutely unique in the market. Packed with these innovative features, SINUMERIK 840D sl guarantees the highest degree of technological expertise in high-performance Additive Manufacturing production systems.



Material extrusion

Material extrusion is a technique frequently used in the plastics domain. This process involves melting and applying a very fine stream of plastic.

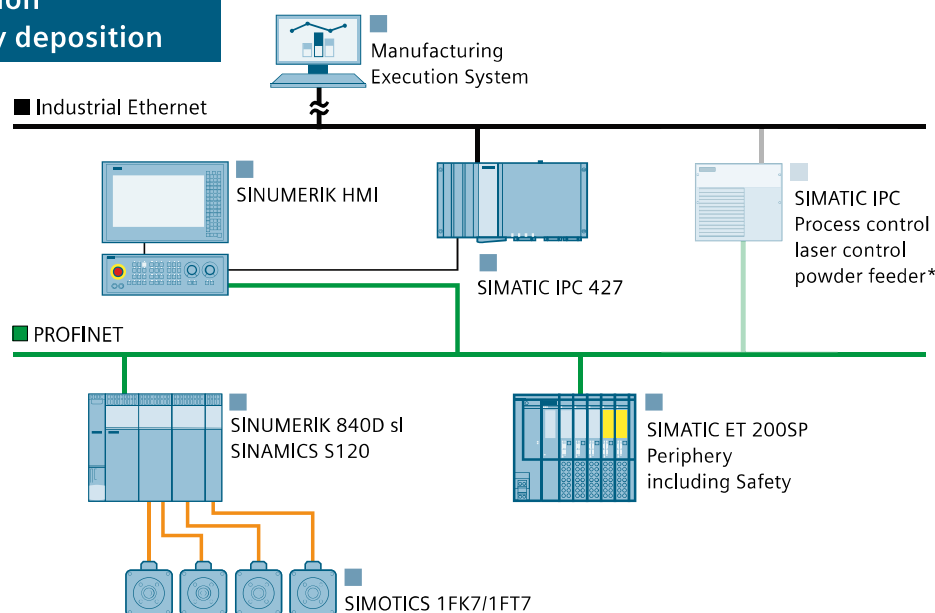


Directed energy deposition

In the directed energy deposition technique, the metal powder is directly fed to the weld location and melted using a laser.

One possible configuration is shown here as example. Customized automation solutions can be configured to address the specific requirements of the machine.

Material extrusion Directed energy deposition



*optional

Control cabinet solutions that are certified worldwide

The comprehensive portfolio of automation technology allows the control cabinet equipment to be standardized. Siemens can provide the complete range of automation and drive technology as well as the low-voltage controls (SIRIUS, SENTRON). Siemens products comply with IEC-UL/CSA regulations and have the associated approval, which means that they can be used globally with mostly identical design.



**More about Additive Manufacturing
in the web:
[siemens.com/additive-manufacturing](https://www.siemens.com/additive-manufacturing)**

**Find out more about Siemens solutions for the
Additive Manufacturing domain for industrial
production that can help you increase your market
potential – from the software up to the automation.**

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