



3D printing

# Made to measure

In just a couple of hours, 3D printing systems from voxeljet can create complex molds and models for cast metal components, or even custom movie sets and architectural models. Beyond the high levels of precision and unprecedented design complexity that 3D printers offer, what users really appreciate is the tremendous time savings to be gained with small production runs, prototypes and models. All of this is supported by a versatile, integrated automation and control solution based on high-performance BSR technology, which ensures that even large print jobs can be handled reliably, precisely and true to detail.



"In addition to our primary customers in the automotive and aerospace industries, as well as machine manufacturing, shipbuilding and heavy industry, we are seeing new customers in an expanding range of other industries discover the potential of 3D printing," explains Björn Matthes, responsible for electrical planning at voxeljet. "This is particularly true when it comes to producing prototypes, small production runs and models quickly and without special tools. We have responded to this trend by drastically expanding our range of printing services, while at the same time developing a full spectrum of devices to handle workpieces of virtually any size."

#### **Largest 3D printing system in the world**

The printing technique used by voxeljet is quite similar to that used by traditional ink-jet printers. The difference is that the company's specially developed print head uses a liquid binder instead of ink. The binder is applied selectively in the shape of the workpiece to be created on top of a thin coating of particles on the printer's platform. In this way, the VX4000 – which voxeljet claims to be the world's largest 3D printing system – builds shapes of sand layer by layer on a platform measuring up to 4,000 x 2,000 x 1,000 millimeters (LxWxH).

First produced by voxeljet in 2009, the VX4000 prints each layer in just 75 seconds with a resolution of 300 dots per inch and a thickness of 300 micrometers. The spacious platform allows the VX4000 to produce large individual components or several smaller parts simultaneously. By using the CAD data directly, it ensures accuracy down to the smallest detail.

The printer's software places the 3D CAD model in a virtual workspace and then breaks it down into print layers. In order to process



The largest 3D printer in the world has a print chamber measuring 4,000 x 2,000 x 1,000 millimeters (LxWxH). With its high-quality components, it is designed for continuous operation.

the large volumes of data involved, the voxeljet system uses an industry-grade PC featuring an SSD system disk and an additional hard disk with at least 1 terabyte of storage to hold the data.

#### A seamless product portfolio without rival

"On all the 3D printers we built prior to the VX4000, the PC was also responsible for controlling the entire system via a CAN bus connection," says Matthes. In developing the VX4000, voxeljet introduced an additional level of abstraction in order to further simplify the control architecture and relieve some of the burden from the PC. They also needed to develop a gantry system to drive the two portal systems on which the print head and particle recoater are mounted.

"We've learned from experience that if different suppliers are involved in producing the drive system, problems can arise due to miscommunication and unclear responsibilities," explains Matthes. "That's why we were looking for a partner who could handle the entire automation system, from the gears right through to the control system and HMI." Matthes notes that voxeljet quickly con-

cluded its selection process with a clear favorite. "B&R's seamless portfolio, which includes integrated safety and a universal development and configuration tool, really convinced us that we had found the right partner. The B&R system gives us everything we need as well as plenty of room for future innovations."

The decision was sealed in a meeting with application engineers from B&R, where voxeljet was able to see firsthand just how easy it is to build a gantry system using B&R technology.

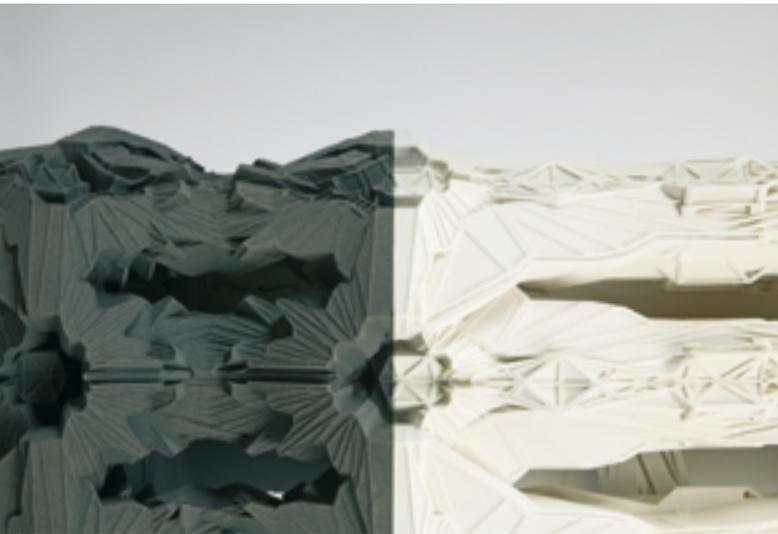
#### Flexible architecture

In the automation solution for the VX4000, which uses B&R technology for everything except the PC, a PLC from B&R's X20 series functions as the motion controller. Movement commands generated by the PC are transmitted via standard Ethernet to the CPU module, which converts them into corresponding motor movements. In addition to the 4 servo motors controlling the Z axis of the two portals of the gantry system, the VX4000 uses up to another eight servo motors which are partially synchronized (2 x X1 and 2 x X2).

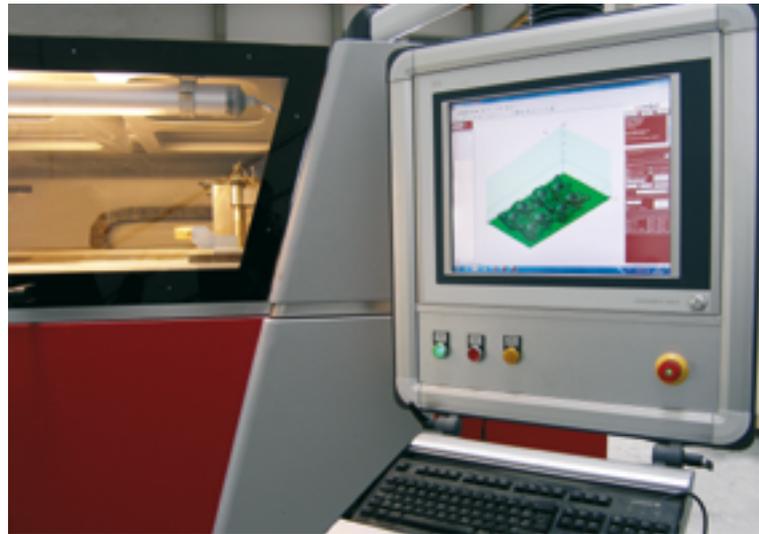


**Björn Matthes**  
Electrical Planner, voxeljet AG

"From the very first training session, it was clear that B&R really thinks ideas through from start to finish to ensure that they are implemented right. The level of support at B&R is outstanding and has helped us many times to answer questions quickly and develop our engineering skills."



Artwork produced using 3D printers from voxeljet. These printers can create items of virtually unlimited complexity (including undercuts) from all types of raw material, including molding sand and plastic.



The operator terminal of the new VX2000 from voxeljet is based on a Power Panel with touch screen from B&R. The HMI application runs on the same PC that prepares the print data for the 3D printer.

voxeljet uses exclusively servo motors in order to keep the architecture flexible, respond quickly to future requirements and optimize inventory. All motors are powered by ACOPOSmulti drives, which communicate with the controller via POWERLINK. These drives are used for more than just motion control. They are also used to coordinate the sequence of lower-level functions that regulate tasks directly related to printing, such as moving the print head (Y) and filling the recoater.

"The prototype VX4000 that was built using this architecture is still working efficiently and reliably at our service center," says Matthes. "Of course, the architecture has continued to evolve since then."

#### Effortless setup with openSAFETY

The automation solution now incorporates the Safe Torque Off (STO) and Safely Limited Speed (SLS) safety functions. Both functions were implemented by voxeljet developers using ACOPOSmulti inverter modules with integrated SafeMOTION safety technology and Safe I/O modules from the X20 system. "Even with the large dimensions of the printer, which measures 20 meters long and 7 meters wide, service and setup are much easier because personnel can safely move around inside the printer and monitor the processes without having to hold down an enable switch," says Matthes. "The hardware and time needed to integrate the safety functions was minimal thanks to the openSAFETY communication protocol."

The system was designed with the I/O modules split into two strands. While the safety I/O channels are connected directly to the CPU, the non-safety-related I/O channels are isolated via POWERLINK. Originally this separation didn't exist. "By separating the channels we've made it easier to expand the system. Another bonus is being able to disconnect the power supply for the stand-

ard slices without affecting the safety-related areas," continues Matthes. Automation Studio offers a number of clear benefits for voxeljet. It provides a single tool that unifies the entire range of B&R automation components, including control software, HMI and safety functions. The comprehensive diagnostic functions make analyzing software and troubleshooting errors much easier. Of particular value is the clear structuring of the engineering environment and the ability to synchronize hardware configurations thanks to the integrated EPLAN interface. All new automation projects from voxeljet are created using Automation Studio 4.

#### Virtual master axes simplify reuse

In addition to the integrated safety functions, voxeljet has since also incorporated the concept of virtual axes into the system's architecture. Now all master axes are implemented as virtual axes. For voxeljet this means that, when developing the control software, it doesn't matter which drive will later be connected to a particular axis or how the axes should work together. "This allows us to simulate the drive hardware and test the automation solution even before the system is completed," explains Matthes. "What's more, using virtual axes makes it much easier to reuse the automation architecture for other systems."

Matthes speaks from experience – voxeljet has already reapplied the B&R-based automation solution to its VX2000 with only minimal modification.

"We received excellent support from B&R when introducing this and other technologies," says Matthes. "From the very first training session, it was clear that B&R really thinks ideas through from start to finish to ensure that they are implemented right. The level of support at B&R is outstanding and has helped us many times to answer questions quickly and develop our engineering skills." ←