Even bulky objects such as a chair can be manufactured rapidly with Colossus, one of the largest transportable 3D printers in the world.

"Transparent production" in a container allows a free view of the 3D printer from IMA and is intended to give the public a clear idea of the way it works.

TwinCAT 3 Plastic Processing Framework for extruder control and TwinCAT CNC in additive manufacturing

"Colossal" 3D printer benefits from high-performance data processing

Colossus is a start-up enterprise in Limburg, Belgium, whose name says it all: the company possesses one of the largest transportable plastic 3D printers. It was developed by the Colossus team in cooperation with machine builder IMA from Houthalen in Belgium. The printer's trailblazing controls come from Beckhoff and not only control the traversing axes in the machine, but also the temperature of the extruder in the print head.

Colossus plans to manufacture large functional or decorative objects such as outdoor furniture and ornaments with a new 3D printer that processes recycled plastics as the raw material, which creates further special requirements. In addition, the 3D printer will be installed in a container and transported to trade shows and festivals as an "eye-catcher." To ensure that visitors of such events are able to experience and follow the fascination of 3D manufacturing live, the products must be created quickly – much faster than standard technologies currently allow. In short, Colossus tasked machine manufacturer IMA with a very ambitious project.

The recycled materials are processed using the Fused Granular Fabrication (FGF) process, in which a plastic granulate is melted in an extruder and the end product is created by applying layer after layer of the material. In this application, the extruder's print head is moved through space by a special linear portal.

Large 3D objects require large quantities of data

The drive control data for the linear portal are determined in two steps: First, G-code is generated from the 3D model of the end product. The controller processes the G-code and computes the movement of the print head in space. Both of these computing procedures require high processor power.

The team at IMA, including Project Engineer Dries Daniels, Senior Automation Engineer Chris Briers and Hardware Engineer Thomas Voets, developed an XYZ portal as the drive for the 3D printer. Toothed belts drive both the

XYZ portal as the 3D printer's drive: Toothed belts drive the X and Y-axes; an additional computing procedure converts the desired X and Y coordinates for correct toothed belt drive control.

X- and Y-axes so that the Y-axis does not require a motor. The goal was to save weight, because the extruder alone weighs 70 kg. Because of this, however, an additional calculation procedure is required to convert the correct X and Y coordinates into the corresponding data for the toothed belt drive.

The XYZ portal itself is mounted on four spindles, each equipped with its own drive. In this way, the printing plane can be kept in perfect parallel to the plane of the X and Y-axis.

Using open control platform benefits

As an open platform, PC-based control from Beckhoff was chosen for the control of the printer. "It was clear from the very start that we needed system openness so that all components can communicate with one another," says Chris Briers, putting the decision in a nutshell. One of the components is the heating zone control of the extruder. IMA utilizes the TwinCAT 3 Plastic Processing Framework software for this purpose. Briers explains: "The extruder has six heating zones with 3-point control. Each zone has a heater band and a fan for cooling. To achieve a stable process, these devices need to be precisely controlled. A shut-off nozzle is used to start and stop the melt flow. This is a motorized valve, which is used to control the flow rate. The operation of this valve represents a disturbance variable for the temperature controller, which has to be compensated for."

The extruder operates with a constant throughput. This means the movement of the print head must be controlled in relation to the geometry of the end product. The users must be able to adjust the corresponding parameters themselves.

Extrusion and CNC software libraries simplify implementation

The solution developed by IMA is based on a C6030 ultra-compact Industrial PC as well as three double actuators and one single actuator implemented via AX5000 Servo Drives. The visualization program is written in .NET so that the visualization layout can easily adapt to suit the customer's wishes.

The control software can read in and process large quantities of data in G-code format. TwinCAT CNC takes care of the interpolation and kinematic transformation of the virtual X and Y-axis to the A and B-axis of the XYZ portal. G-code processing is a typical CNC function and, like the heating control of the extruder, is available as a library built into TwinCAT. With these libraries, the implementation of extremely complex tasks can be reduced to the parameterization of available functions. The temperature of the extruder is controlled with the TwinCAT 3 Plastic Processing Framework (TF8540). The control parameters are determined automatically (auto-tuning). With the help of these optimized parameter settings, fast heating with low overshoot is possible.

In order to read out the temperatures of the individual zones and to control the heating and cooling elements, the extruder was equipped with IP67-protected EtherCAT Box I/O modules. A TwinSAFE Terminal is used to monitor the pressure in the extruder to ensure safe operation.

The operators panel employed is regarded as highly important to optimally convey the exciting possibilities of 3D printing to the public. IMA chose the CP2912 multi-touch Control Panel with 12-inch display as the visually appealing hardware for that purpose.

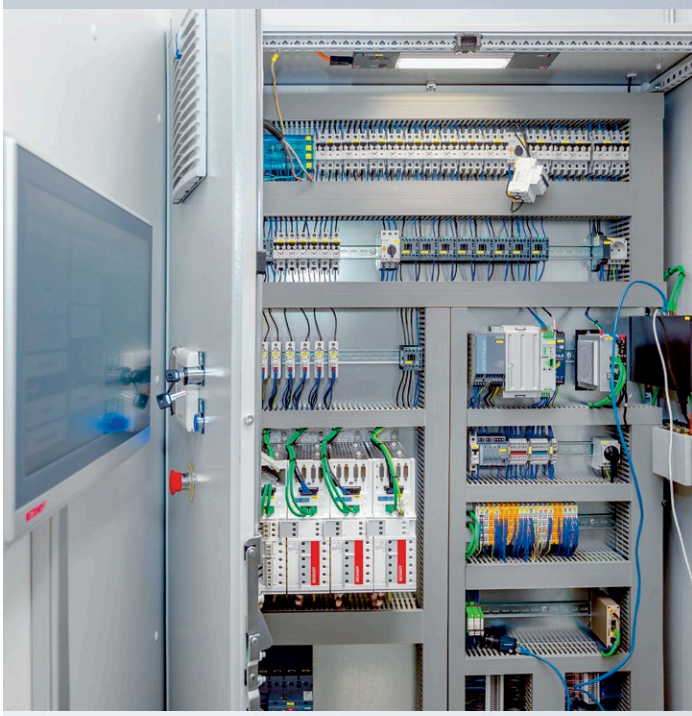
Impressive printing speed

The 3D printer from Colossus is a superlative device in every respect and delivers astounding results. Its creative design allows the best-possible use of available space inside the shipping and display container. 3D printed parts with dimensions of up to 2.72 × 1.25 × 1.5 m can be manufactured. The printer also boasts an impressive output capacity of up to 15 kg per hour. A sufficiently high resolution can be achieved with a nozzle size of 2 to 8 mm. The printed products are ready-for-use right away, depending on the desired finish. If necessary, various postprocessing techniques can be used to create different surface qualities.

Colossus presented the first printer – delivered in April 2018 – at multiple events and trade shows. Attendees at these events showed great interest in the 3D giant and its new method of recycling. It is therefore intended that more of these printers will be implemented to manufacture different products on an industrial scale in the future.

Further information:

www.madeinlimburg.be/bedrijven/colossus
www.machinebouw.be
www.beckhoff.be



The view inside the control cabinet shows the Beckhoff C6030 ultra-compact Industrial PC and the inline connected EtherCAT Terminals (center right) as well as the AX5000 Servo Drives (center) and the 12-inch CP2912 multi-touch Control Panel (left).

At a glance

Solutions for the plastics industry

– extruder controls for mobile 3D printers

Customer benefit

– Control system processes large quantities of data.
– Additional computing procedure makes motor for Y-axis unnecessary.

Applied PC Control

– Due to its system openness, PC-based control offers all options for communication between the most diverse machine components.
– A C6030 ultra-compact Industrial PC enables processing of large data quantities.
– The TwinCAT 3 Plastic Processing Framework (TF8540) offers all functions required for extruder control.
– TwinCAT CNC takes care of the interpolation and kinematic transformation of the virtual X and Y-axis to the A and B-axis of the XYZ portal.
– AX5000 Servo Drives ensure dynamic and precise print head movements.