Demonstration 03 – Chairs

Printed by: Savonia University of Applied Sciences
Design: Niilo Herlevi & Sampsa Ylönen

This demonstration part is a coffee table chair that was printed in two separate parts. The chair frame was printed in horizontal orientation and the printing process was straightforward without complications. The seat was printed in a 45-degree angle on top of a 3D-printed mold and had more challenges.

The mold was printed with Sulapac Flow 1.7 and the surface was milled smooth. Programs for 3D-printing and milling paths were generated with Sprutcam Robot X. All of the chairs were printed with different material using the same process steps and geometry. Materials were: Brightplus Loimu C73, Brightplus Loimu D55, Sulapac Flow 1.7 and KCL biocomposite. Some of the materials required external cooling.

The frame was sliced with both Sprutcam Robot X and Adaxis AdaOne. The final printed part was sliced with Sprutcam Robot X, because it handles the point reduction slightly better with curve commands. Seat slicing was done in Adaxis AdaOne and tested with both planar along curve and 45-degree settings. The final printed version was sliced in a 45-degree setting as it worked better with the geometry.

Link to video: <click to open link>

Figure 1. 3D-printed mold of the seat after printing and after milling

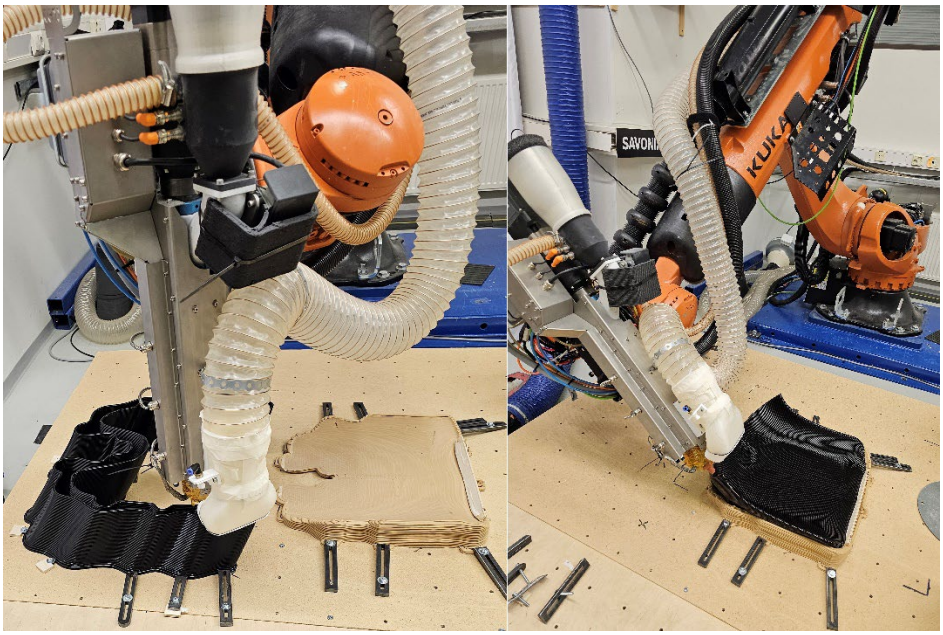

Figure 2. Frame was printed in horizontal orientation, seat in 45-degree angle.

Chair 1: Brightplus Loimu C73 Transparent

Brightplus Loimu C73 transparent is a rigid bioplastic with 99.5% biobased content. More information can be found from https://brightplus.com/bioplastics/.

C73 flows quite well and has a melting temperature of 178 °C. Heat dissipation of the material is somewhat slow. It is typically not a problem with single wall structures, but with thicker print geometries significant external cooling may be required to avoid excessive melting and layer collapse. The seat part of the chair required several separate cooling units to prevent collapse during the printing.

Material is also susceptible to warping when cooling down during the printing process in typical industrial hall conditions without chamber. When printing large structures, it is important to ensure good adhesion to print bed, preferably with mechanical fastening.

Warping issues were mostly avoided by using significant cooling and adjusting the printing speed to keep the process in constant layer time regardless of the path length.

Print info

Material: Brightplus Loimu C73
Dimensions: 500 x 730 x 500 mm
Weight: 17 kg
Print time: ~5 h 32 min
Frame: 3 h 12 min
Seat: ~2 h 20 min
3D-modeling: Rhinoceros
Slicing: Sprutcam Robot X & Adaxis AdaOne
Extruder: CEAD robotextruder
Robot: KUKA KR-120 R2700

Nozzle size: 6 mm
Layer height: 3 mm
Wall thickness: 7 mm
Print speed: 15 - 40 mm / sec

Figure 3. Chair printed with Transparent Brightplus Loimu C73

Chair 2: Black Loimu D55

Loimu D55 Black is semi-rigid bioplastic with 80% biobased content. Chair was printed with D55M2 version of the material, which is better suited for 3D-printing than the regular version. More information can be found at: https://brightplus.com/bioplastics/.

Similar to C73, heat dissipation of the material is slow and can be a problem with thicker print geometries, especially if external cooling is not used. Molten, semi-rigid material can be little wobbly at the deposition point, especially on sharp corners, requiring good adhesion to the print bed and previous layers.

The seat part of the chair required several separate cooling units to prevent collapse during the printing. Despite that, there were challenges with the material heating due to the excessive melting that caused quality problems with layers in some areas of the seat.

Print info

Material: Brightplus Loimu D55
Dimensions: 500 x 730 x 500 mm
Weight: 17 kg
Print time: 5 h 30 min
Frame: 3 h 12 min
Seat: 2 h 18 min
3D-modeling: Rhinoceros
Slicing: Sprutcam Robot X & Adaxis AdaOne
Extruder: CEAD robotextruder
Robot: KUKA KR-120 R2700

Nozzle size: 6 mm
Layer height: 3 mm
Wall thickness: 7 mm
Print speed: 15-40 mm / sec

Figure 4. Figure 3. Chair printed with Brightplus Loimu D55

Chair 3: Sulapac Flow 1.7

Sulapac Flow 1.7 has 72% USDA certified biobased content with wood from industrial side streams and biodegradable biopolymers. It also meets EU and US FDA requirements for food contact materials. More information can be found from https://www.sulapac.com/3d-printing-material/.

The material reacts quickly to humidity and is susceptible to warping when cooling down during the printing process in typical industrial hall conditions without chamber. Generally speaking, when printing large structures with Sulapac Flow, it is important to ensure good adhesion to print bed, preferably with mechanical fastening.

There were no challenges printing the geometry. Sulapac flow 1.7 also has good post-processing properties.

More information can be found at: https://www.sulapac.com/3d-printing-material/

Print info

Material: Sulapac Flow 1.7
Dimensions: 500 x 730 x 500 mm
Weight: 17 kg
Print time: 4 h 35 min
Frame: 2h 35 min
Seat: 2h min
3D-modeling: Rhinoceros
Slicing: Sprutcam Robot X & Adaxis AdaOne
Extruder: CEAD robotextruder
Robot: KUKA KR-120 R2700

Nozzle size: 6 mm
Layer height: 3 mm
Wall thickness: 7 mm
Print speed: 40 mm / sec

Figure 5. Chair printed with Sulapac Flow 1.7

Chair 4: KCL biocomposite

KCL biocomposite, formerly known as UPM Formi 3D/2019, contains 20% cellulose fiber. Material is well suited for 3D-printing in large scale applications, and it is one of the easiest materials we have worked with in robotic printing applications. It also has good, wood-like post-processing properties.

There were no challenges printing the geometry. The cellulose fibers in the material enhance the stability of the print and help to keep the material in extruded shape. They also reduce the possible warping issues.

More material can be found at: https://kcl.fi/kcl-biocomposites/additive-manufacturing/

Print info

Material: KCL Biocomposite
Dimensions: 500 x 730 x 500 mm
Weight: 17 kg
Print time: 4 h 29 min
Frame: 2h 43 min
Seat: 1h 46 min
3D-modeling: Rhinoceros
Slicing: Sprutcam Robot X & Adaxis AdaOne
Extruder: CEAD robotextruder
Robot: KUKA KR-120 R2700

Nozzle size: 6 mm
Layer height: 3 mm
Wall thickness: 7 mm
Print speed: 35 - 50 mm / sec

Figure 6. Chair printed with KCL biocomposite