Malbec, Ornament and Rustication

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Abstract

The digital fabrication tools used in project *Malbec* included the digital modeling tools Autodesk Maya and McNeel's Rhino 3d, the manufacturing software MasterCAM, and a 3-axis CNC machine. The project was part of fabrication seminar held at Texas A&M University, Department of Architecture. The concept, as depicted in the name *Malbec* is of a wine splash on a gallery wall.

Malbec, the physical manifestation of the study (see figure 4), addressed material experimentation produce expressive form: we strove for minimal design sacrifice by developing innovative fabrication techniques and assembly procedures which allowed us to find a way around the machine's 3-axis limitations.

Design Intent

Malbec was designed to be a prototype for ornament-rusticated digital storefronts. It was designed and constructed for the Storefront exhibition through The Neighborhood Design Center at The Ohio State University Urban Arts Space on Nov. 4 2009.We were interested in how to create certain surface effects and increase material performance by combining the foam with additive materials including films, lacquers, and coatings. Its primary intention was not to be representational of an actual façade but rather an engage the scale of the human body in an architectural way and conjure certain emotional, sensational responses through its form, surface articulation and material expression. The design consists of an approximately 8' by 8 ½' area of wall consisting primarily of panels and a 10' by 3' completely 3-dimensional "branch" structure. The panels were designed to be flat on one side, where they attach to the wall, while the branch structure is suspended above an opening in the wall and must be hung from above.

Materials

The material of choice was poly-urethane foam, a common material which has been used for CNC milling in the past. Poly-urethane is more expensive than other materials, but is preferable because it comes in a variety of different densities, typically in 2 pound increments per cubic foot (pcf) of material - the higher the density of the foam, the higher the strength. It also comes in 4' by 8' sheets with varying thickness, which allowed us to eliminate the step of laminating sheets together. We decided to use primarily 2 pcf density foam for the wall panels but 10 pcf density for the "neck", or beginning of the suspended element.

Sectioning Technique

Before beginning the actual fabrication process, we had to decide how the model was going to be broken up and the location of joints because the overall design was much larger than a single sheet of foam (8' x 4' x 4"). The wall panels were designed such that each panel could each fit within a sheet of foam as shown in Figure 4 on the left. The branch structure of the design that extends to the right of the paneled wall pieces was designed to be completely 3-dimensional, a total sculpture with curvature and perforations on each side. Since a 3-axis mill does not have the ability to make undercuts, the biggest challenge was to develop technique that allowed the piece to be articulated on both the front and back of the construct. A sectioning technique was used to split the piece into separate horizontal sections as shown in Figure 1. It was then further sectioned vertically with each piece not being thiner than 4 inches, due to the height of the foam stock. With this technique, it was possible to mill many small pieces of the overall form that fit together much like a giant jigsaw puzzle. The red lines in Figure 1 show where the form was cut in both elevation view and plan view. Undercuts were not completely unavoidable but we tried to avoid them as much as possible via sectioning, and the parts where undercuts could not be avoided had to be sanded by hand to approximate the geometry. Figure 2 shows an exploded axonometric of the overall branch structure and the separate pieces that make up the whole. By organizing the horizontal sections alpha-numerically, it was possible to assemble the pieces of each section separately before combining the separate sections.

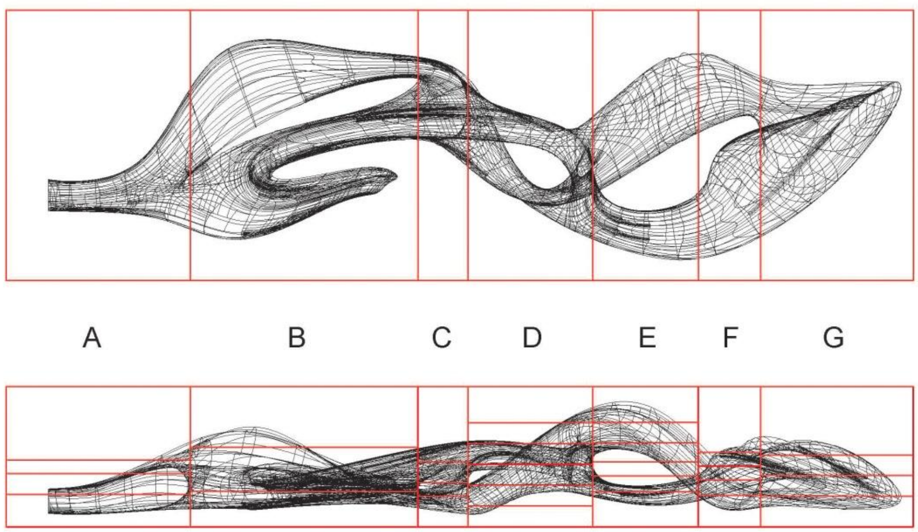

Figure 1. *Elevation and plan view of branch structure. Red lines indicate cuts in the form to allow for fabrication.*

Cut-File Set-Up

Since the size of our material stock was given, a 4’ x 8’ plane in Rhino was drawn central to the piece of the object that was to be milled: this ensured that the edges of the form would not be slightly cut off due to inevitable inaccuracies when the foam was aligned on the cutting bed of the machine. It was important to make sure that the modeled form did not extend below the plane in the *z* direction, as the machine would read that and try to cut below the bottom of the material into the bed of the table. The trim command in Rhino was used to trim off the model that was below the level of the plane. Each “cut-file” was imported into MasterCAM, which in turn converted the data from the digital model into a language that the CNC mill could understand and accurately produce. While 3-axis CNC machines come in a variety of different types, this particular machine had a stationary work-table with a carriage and gantry that move the tool in the *x*, *y*, and *z* axes only above the work. While this machine type allows for any number of complex geometries to be carved out, it is limited to 3 axes of movement, and does not allow for material to be removed from the sides, or undercuts. [1]

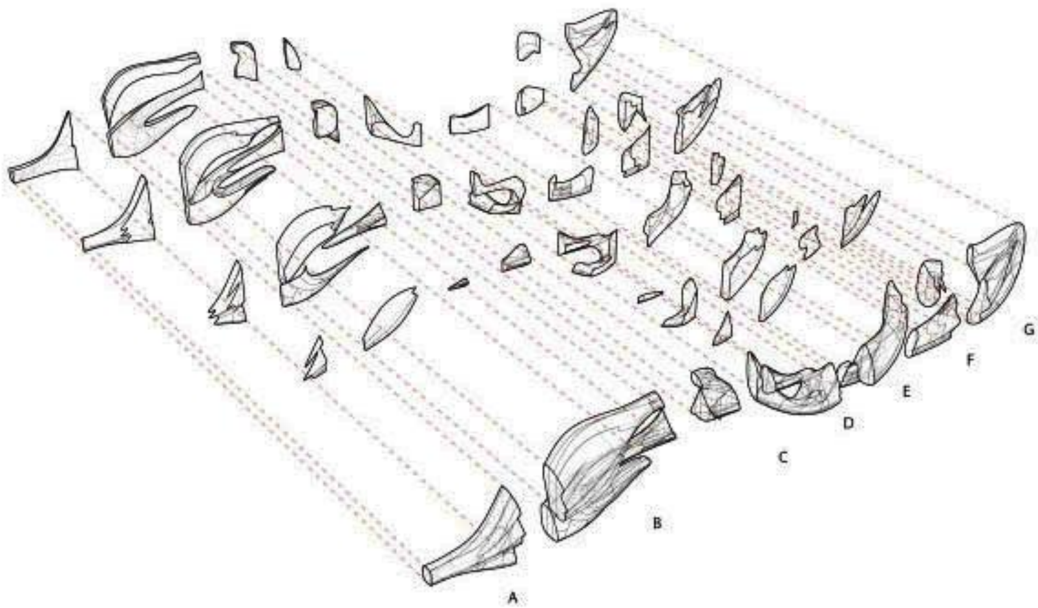

Figure 2. Exploded axonometric of overall branch structure. Shows sectioning technique of splitting branch into 7 sections horizontally (A-G) and then slicing those sections into 4 inch high pieces.

Material Set-Up

Before starting the milling process it was necessary to set up the actual material stock (4'x8'x4" foam) on the cutting table, secure the specified bit, and calibrate the machine to an origin 0, 0, 0 by allowing the machine to "touch down" the bit at that 0, 0, 0 point in space. Below the foam was a layer of smooth composite "sacrifice" board to protect the bit if for some reason it was to go below our material stock. Because the foam used is extremely light-weight (2 pcf density) tape was used to keep the foam from moving during the milling process. The chosen tape was double-sided carpet tape, which was stronger and worked the best. Strips of the tape were laid down length-wise on the composite board with 3 inch to 4 inch spacing between the strips and placed the foam on top. Scrap polystyrene "holders" were secured around the perimeter of the foam to keep the foam from moving as well.

Milling

Depending on the size of the form to be milled, the actual milling process usually took about 3-4 hours per 4' x 8' x 4" sheet of foam for the rough-cut and about 2 additional hours for the finish-cut using a 3/8" round-tip bit with 2 flutes. It was extremely important that the foam not move during the rough-cut, which the first round of cutting that carves the rough overall form out from the block of foam. This may take several passes, as the machine typically has ½" to 1" step-downs during the rough cut. The finish-cut is where the machine goes back and refines the surface of the form with much smaller step-downs and results in the smooth finished form.

Figure 3. *Photographs showing the first, second step-down of the rough cut, a detail of the rough-cut and the finish-cut The complete installation required a total of 8sheets of 2 lb. foam and 2 sheets of 10 point foam were employed depending on structural requirements inherent to each segment, see figure 2.*

Assembly

Once each piece was milled, we sanded them to smooth out any irregularities, adding three coats of drywall compound after each sanding pass. Since the entire length of the branch was over 8 feet long, we decided to join all of the pieces into two separate branches rather than one large one to allow for easier transportation, and installation. Because this sculptural piece would be suspended over an opening by wires, the connections needed to be very strong so that the branch would not break at the weak joints. For the weaker joints, especially those where the 10 pcf density foam had to be joined to the 2 pcf density foam, we used metal dowel rods to hold the pieces together. At this point we prepared the piece for paint by using two coats of an oil based primer. A professional automotive paint shop did the painting of the wall panels and branch structure completing the assembly. This was the final finishing technique used and was successful in giving the foam the glossy effect as seen in the close-up of the surface in Figure 4.

Figure 4. *Final piece as installed*

References

[1] Schodek, D., Bechthold, M., Griggs, K., Martin Kao. M. *Digital design and manufacturing CAD/CAM applications in architecture and design*. Hoboken: John Wiley & Sons. 2005