Chapter 2: Sawdust

Sawdust

Sawdust is comprised of tiny particles that come from sanding or cutting wood. It is largely an industrial byproduct generated by the wood industry in sawmills, furniture factories and onsite in building construction. [Figure 23] Sawmills have historically been the largest producers of sawdust. They have been in operation since the middle ages, and were often constructed adjacent to salt and iron works in order to produce fuel. In the early Eighteenth century in North America forests were so abundant that settlers moving across the country would construct sawmills in the wilderness as one of the first acts when establishing a town. The first frame house in a community, built with the lumber from the sawmill, was notable, perhaps momentous, because frame construction in early America was entirely different from roughhewn log huts that were commonplace and stood out as a revolutionary new paradigm in building.[[1]](#footnote-1) Houses using the lumber from the sawmill and the “balloon” frame technique replaced heavy timber hewn by hand houses because they could be erected more quickly. Balloon framing quickly became the standard technique of mass housing construction in the nineteenth-century. At that time, the United States was still a forest rich region, and because of the availability of wood, manufacturing became even more prodigious and industrialization brought new technology and advances in the quick and cheap processing of wood in sawmills on a massive scale. This rapid industrialization created extremely high levels of waste. In fact, by the mid twentieth century it was said that sawmills were in reality “sawdust factories, with a by-product of lumber”[[2]](#footnote-2).

Eventually the realization that the perception of the limitless forest was a misconception prompted engineers and inventors to speculate on how to be more efficient with these limited resources. Whereas previously, as much high-quality wood as possible was sent to the mill, new innovations would exploit ‘wood waste’ or sawdust. Eventually, sawdust became the driving force of the construction industry through engineered building products such as plywood, fibreboard and chipboard. However, in addition to continuing to generate large quantities of sawdust during the manufacture of lumber and engineered building products today, the construction industry also generates tons of wood waste during the construction and demolition of buildings. In 2013, in the United States alone, over 42 million tons of wood waste was generated on construction sites.[[3]](#footnote-3) If necessity is the mother of invention, then necessity demands that the world’s continuing supply of wood waste be transformed yet again.

Wood waste is frequently incinerated for the production of energy at large factories but it can also be ground into very fine wood flours. Wood flour has major industrial markets in the construction industry, for example, epoxy resins, felt roofing, floor tiles, wood fillers, caulks, putties, and a vast array of wood plastics are all made of wood flour that are frequently used in the construction of buildings, boats and furniture. Additionally, wood scraps and shavings are used to make building materials such as chipboard, fibreboard and particleboard.

Pykrete is one of the most interesting and novel uses of sawdust as a building material. Freeze a combination of 14 percent sawdust with 86 percent water and the cellulose fibers from the wood dramatically increase the strength and durability of ice. Upon freezing, pykrete is up to 14 times stronger than regular ice and melts much more slowly than regular ice and outperforms concrete in compression. This novel process was invented by Max Perutz during World War II, who proposed its use as the material to construct large unsinkable ships and mobile offshore bases upon which airplanes could take off and land. A small-scale prototype of a pykrete ship was fabricated in Alberta, Canada in 1943, but the idea was scrapped due to the invention of long-range fuel tanks for fighter and patrol airplanes. In 2014, students at the Eindhoven University of Technology built the largest ice dome in the world out of pykrete.

Sawdust can also be used to make wood pulp, which is used to make paper. In building construction, paper is used for sheathing, roofing, and for insulation in laminated building products, and, of course, as wallpaper. Using wood waste materials to make new wood products has contributed to a wood renaissance. One of the current most visible uses of recycled wood flour in building can be found in wood plastic composites used for decking materials. The wood flour used in wood plastic composites can be locally sourced reclaimed wood that would otherwise end up in a landfill. By using reclaimed sawdust, additional trees need not be harvested to make more wood products. Wood plastic composites are very strong and easy to shape and mill. By adjusting the species, size and concentration of wood particles in the formulation, different properties, such as color and strength, can be achieved.

3D Printing with Sawdust

3D printing with sawdust has some similarities to recycled engineered wood products, but in many ways, it is also quite different. Whereas many current applications for upcycling sawdust into building products use equal parts sawdust and polymers, our 3D printed sawdust begins with nearly 85% of the recycled wood and cellulose particles. The remaining percentage is comprised of powder-based glues that are activated by water. It is only after a 3D printed object emerges, that a polymer coating is applied, which gives the printed object a materially rich texture and surface in addition to its strength. The color and texture is ultimately a product of the wood species that is printed. Pine flour produces objects that are lighter in color, and softer, compared to hardwood fillers such a maple or walnut, which can appear almost like rusted corten metal. Surprisingly, the layers that are a product of the additive manufacturing process impart a grain similar to natural wood, as if the wood wanted to return to it’s original state and express its internal growth. Sawdust isn’t the only material that can be used to 3D print wood-like objects. Nutshells, husks and seeds are all agricultural byproducts that can be ground into fine powders and flours and used to make 3D printed objects that have similar colors and properties.

The *Sawdust Screen*, for example, is made of pulverized walnut shells and sawdust, and, retains the layering effect from the additive manufacturing process, simulating natural wood grain. [Figure 24] The screen is comprised of individual 3D printed wood components that are affixed together to form a variably dimensional enclosure and surface. Its porous pattern is inspired by the vessels found in a microscopic analysis of wood anatomy in hardwoods. [Figure 25] When viewed from the end grain, vessels demonstrate the porosity of wood. In a live tree, vessels serve as the pipelines within the trunk, a transportation system for water and sap. In the *Sawdust Screen*, the vessels serve as an opportunity for visual porosity. [Figure 26] The subtle curvature of each vessel accentuates the openings as convex or concave apertures making the screen both a visual and haptic experience. The *Sawdust Screen* is evidence that 3D printing with sawdust and other agricultural by-products have the potential to transform the inherently subtractive process that begins with trees and ends with dust, into an additive process that upcycles this widely available material into architectural components. [Figure 27]

Objects:

*Poroso*

*Poroso* is an experiment in block aggregation using a specially formulated walnut shell material combined with wood fibers in the form of sawdust. *Poroso* is unique in that it is a double-sided block that has a hollow interior. There is no front or back, both faces of the *Poroso* wall assembly are unique in their design, allowing for a rich layered effect when one looks through the wall. The blocks are designed using the karakusa method of patterning in which, the pattern employed along the surface of one tile connects to the pattern in every adjacent tile, making a labyrinthine and uninterrupted motif across the surface that can expand with continuous variation. [Figure 28]

*Burl*

A burl is a tree growth in which the grain has grown in a deformed manner. It is commonly found in the form of a rounded outgrowth on a tree trunk or branch that is filled with small knots from dormant buds. Burls usually result from a tree undergoing some form of stress, such as an injury, virus or fungus. In this case, the burl is a product of the 3D printing of wood, exploring the forms and thickness that is possible with wood waste as an emerging material in additive manufacturing. Like a burl found in nature, this *Burl* contains cracks, deformations and dense layers of growth rings—a product of the layers of manufacturing. [Figure 29]

*Lamprocyclas Raelsanfratellis*

The *Lamprocyclas Raelsanfratellis* light fixture is made of 3D printed maple sawdust. The pores, or openings, in the fixture exhibit a play of brilliance or sparkle because of their small size. The 3D printed wood portion of the light fixture is translucent and glows, giving off a softer luminescence. Both the design and the materiality of the fixture contribute to the dual nature of the overall lighting effects. [Figure 30] [Figure 31] [Figure 32]

*Burst Tiles*

The *Burst Tiles* demonstrate the potential for variation and ornamentation within 3D printing. In this particular tile design the flower on the surface of the tile can have varying degrees of openness. The petals on the surface of the flower are parametrically constrained to 30-degree increments of openness but may just as easily be constrained to 1 degree for 90 unique possibilities. The petals in their most open and most closed positions develop undercuts and geometries that would make it challenging to carve these tiles using traditional methods. Because of the complex form and potential for unlimited variation, 3D printing is the best method for producing these designs. [Figure 33] [Figure 34] [Figure 35] [Figure 36]

*Wood Block*

The *Wood Block*, designed by Anthony Giannini, is an example of 3D printed cellulose powder as a building material that can be mass customized. The additive layer manufacturing of the binder jet printing creates a grain similar to natural wood that is expressed in the curvature. The wood material is composed of recycled agricultural waste. The texture and subtle translucency of the 3D printed wood material gives the material a warmth, texture and luminosity under certain lighting conditions, but also similar to rusted corten steel. The *Wood Block* can be used as a curtain wall or as a customized masonry unit.

[Figure 37] [Figure 38]

*Haeckel Bowl* in Wood

The *Haeckel Bowl* shown here is 3D printed in walnut shells. Nylon fibers have been added to the powder matrix to increase tensile strength.

[Figure 39] [Figure 40]

Newsprint

Sawdust, in addition to being a byproduct of the construction industry, is also the byproduct of certain animals, birds and insects that live in wood, such as the [woodpecker](https://en.wikipedia.org/wiki/Woodpecker), wasp and [carpenter ant](https://en.wikipedia.org/wiki/Carpenter_ant). It is said that the idea of using wood to make paper was inspired by observing wasps. Paper wasps scrape away small particles of wood, and mix it with their saliva when making their geometrically complex paper nests.

Paper, specifically newspaper, today is made of ground up wood pulp. For 3D printing, the newspaper is shredded, mixed with water, dried and ground up into a fine powder mixture much like paper mache. [Figure 41]The final product has a velvety, granular appearance and is soft to the touch. [Figure 42]

1. Joachim Radkau, *Wood: A History* (Wiley, 2013), Kindle Edition. [↑](#footnote-ref-1)
2. Bryan Latham, *Timber: Its Development and Distribution: A Historical Survey*. (G.G. Harrap, 1957) [↑](#footnote-ref-2)
3. EPA (June, 2015), Advancing Sustainable Materials Management: 2013 fact sheet. [↑](#footnote-ref-3)