Lean Manufacturing and Environment

Apollo Hardwoods Company Case Study

Background

The start-up of Apollo Hardwoods in 2003 provides a unique example of a business enterprise designed and launched with lean principles in mind from the beginning. The company is applying lean production techniques to manufacture custom "cut-to-size" cherry plywood for cabinetry made from fine northwestern Pennsylvania cherry wood.

Ed Constantine founded Apollo Hardwoods in Pennsylvania after leading numerous lean implementation efforts at HON INDUSTRIES and with Simpler Consulting (a lean consultancy which he also founded) and Lean Investments LLC.

Apollo Hardwood's founders and investors saw the wood products manufacturing industry as an industry ripe for the successful application of lean techniques:

- Veneer manufacturers typically have significant capital tied up in large "monument" processes and equipment (e.g., slicers, dryer ovens).
- Wood products manufacturers generally carry large inventories of wood which requires substantial space and can result in damage or spoilage to inventories.
- The manufacturing processes typically result in significant amounts of wood scrap and waste, which is often burned for energy recovery.

It became apparent that because the 12-foot slices produced by the conventional process and equipment were ultimately trimmed down to a usable (less than 6-foot) size, using a veneering process that is "right-sized" to more usable dimensions would not only require smaller, less expensive equipment, but also will allow the business to use a much wider variety of logs all while obtaining similar quality end-results.

Conventional Veneer Manufacturing

The conventional veneer panel manufacturing process typically consists of six main steps:

1. *Slicing.* The log is cut into a square and left to soak in 160°F water for up to several days. The log, up to 12 feet long, is then held horizontally in a vice-like fixture. A razor sharp blade then vertically slices the log into veneer.
2. *Drying.* Veneer is fed into large dryer ovens designed to reduce the moisture content of each piece to facilitate a strong, permanent adhesive bond.
3. *Lay-up and Gluing.* When the veneers have been dried to their specified moisture content, they are conveyed to a lay-up operation, where a urea-formaldehyde adhesive is applied. The pieces are then glued to a plywood core.
4. *Pressing.* The laid-up assembly of veneers is then sent to a press designed to press the glue into a thin layer. After being unloaded from the press and after cooling, panels are trimmed to precise sizes.
5. *Sanding.* To smooth raised grains and/or remove glue from the surface, the panel product is often sanded using manual or automated sanders.
6. *Grading.* After sanding, the plywood is graded and prepared for storage or shipping.

A conventional veneer manufacturing process typically relies on large pieces of equipment (e.g., hot water soaking tanks, veneer slicers, drying ovens) that typically cost several million dollars. For example, conventional wood dryers typically cost $1.5 million for a 20-foot by 100-foot oven that blows 180°F forced air on the wood.

The primary environmental impacts from conventional veneer manufacturing include air emissions, energy use, and run-off.

- The primary source of air emissions are organic compounds from the drying process. The type and quantity of emissions depends on the wood species and type of dryer, but are typically ducted through separate stacks (for heating zones and cooling sections).
- Hot pressing operations also release some volatile organic compounds (VOCs), but these emissions typically remain uncontrolled.
- Particulate emissions (PM) typically result from log debarking, cutting and sanding, and drying and pressing.
- Organic compound emissions (formaldehyde and other hazardous air pollutants) can also result from gluing and hot pressing.
- Sawdust and other small wood particles are generated by cutting and sanding operations, which are typically controlled and collected to use as fuel.
- Wood storage piles can also be a source of PM and VOC emissions.
- Uncontrolled runoff can also result from large inventory piles, because unused logs need to be sprayed with water to prevent cracking.

Another environmental dimension of cherry veneer manufacturing is the deteriorating supply of black cherry trees in Pennsylvania. Although the Allegheny Plateau contains some of the highest quality black cherry trees in the world (particularly well suited for high quality veneer), their supply is limited. In part, this is because conventional veneer manufacturing practices require high quality, defect-free logs that can produce 12-foot veneer slices. This length requirement, in turn, frequently requires companies to harvest large diameter mature black cherry trees.

Applying Lean Principles to Veneer Manufacturing

Apollo Hardwood's founders see an opportunity to significantly reduce the amount and cost of capital required for veneer manufacturing. This opportunity stems from lean principles that emphasize making capital investments only where necessary and when necessary, allowing for the highest possible return-on-investment. This strategy is particularly relevant to start-up companies, where one of the quickest routes to profitability is minimizing capital costs while producing a quality product.

Conventional manufacturing wisdom might lead a company to buy larger equipment, so that the plant can accommodate production increases. Lean thinking, however, suggests that the company may be better served by investing in capital needed for current production, and adding additional capital incrementally to meet growth needs. This lean strategy relies heavily on the availability of "right-sized" (and sometimes mobile) equipment that can be easily replicated (and improved) at significantly lower cost when compared with large, conventional equipment (e.g., "monuments").

Conventional debarking, cutting, slicing and drying equipment have many attributes of monuments, and these processes were targeted by Apollo Hardwoods. The goal was to find a less capital intensive process for slicing and drying veneer that would also address other business needs such as product quality, flow time, and cost.

Since such a process and associated equipment were not available, Apollo Hardwoods sought to develop them in-house using the lean method typically referred to as 3P (pre-production planning). The 3P method was initially developed as part of the Toyota Production System, and it focuses on optimization and waste elimination at the product and/or process design stage.

Apollo Hardwoods recruited a team to assist in a series of 3P events to design a lean veneer slicing and drying process and associated equipment. Team members were carefully selected to ensure that the team did not have too much familiarity with conventional veneer manufacturing methods, which could limit creativity during the 3P events. Success parameters were set for the 3P events that articulated the desired takt time (i.e., the rate at which product must be turned out to satisfy market demand) and a dollar limit for building the process equipment.

The 3P team assembled for a week-long event to work through the following steps:

1. The team described and mapped the steps necessary to produce veneer, and brainstormed key words to describe each step, such as "shave" and "cut."
2. The group went through a "back to nature" step in which they considered where in the natural world these processes took place. For example, they identified that beavers' tree gnawing activity resembles the slicing activity that they were trying to mimic in the plant. Research at the local library revealed useful information about beaver cutting "techniques." The team found that beaver teeth have a harder enamel layering on the front sides of their teeth than on the back, enabling their teeth to self-sharpen and to therefore be "built to wear."
3. The group engaged in a "try-storming" exercise in which they developed prototype equipment to test various approaches and techniques identified through earlier brainstorming activities. For example, the team mocked up a slicing tool, with the metal on one side of the blade harder than on the other, mimicking beavers' teeth. The team tested and evaluated the various prototypes, and eventually selected those that appeared to be most promising for meeting the success criteria defined at the beginning of the 3P event.

Following the 3P event, the process of building actual production equipment from the 3P prototypes began. The 3P method was also applied to the drying process with similar results.

By applying lean principles and methods to veneer manufacturing, Apollo Hardwoods has achieved significant results. Production is arranged in one-piece flow cells, where production operates in a continuous flow with no piling of inventory in-between process steps. The equipment comes in at approximately half the capital intensity of the industry's conventional machinery, has much lower energy demands, and fits into small production cells that can be easily replicated to accommodate production increases.

The machines also work with smaller pieces of wood that require less trimming to meet customer size specifications. This means that Apollo will use less logs to deliver the same amount of finished product. The right-sized equipment and smaller veneer pieces also significantly reduce the amount of wood scrap generated. Whereas most veneer companies burn their wood scrap for energy recovery, Apollo sees high quality cherry wood as an expensive energy source. By reducing wood scrap and energy use through lean implementation, the company is creating a highly competitive business model that significantly lessens the environmental impacts of veneer manufacturing.

Apollo Hardwoods indicated that future lean improvement events will likely target other aspects of the production process, such as the gluing process. In particular, the company is interesting to finding ways to reduce formaldehyde emissions by exploring alternative adhesives in the future.