The Manufacture of Bourbon Barrels

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**Summary**

Using barrels to age various liquors is a practice that has been commonplace for many centuries. This paper describes the methods which produce barrels specifically for bourbon whisky, from the initial stages of material selection to forming and sealing.

**Discussion**

The first step in the process is selecting the appropriate wood. Oak is used for almost all liquor aging, due to its unique chemical and physical characteristics. Unlike many other trees, such as pines and maples, oak is considered a “pure wood,” which has no resin-filled channels flowing through it. Besides this, the components of the wood have been shown to produce flavors which are beneficial to the final product. More specifically, the hemicellulose provides caramelized aromas and flavors, as well as providing the dark brown color bourbon is known for. The lignin content of the wood accounts for the presence of vanillin, which gives the spirit its sweet smell and taste. The wood also possesses tannins which enable oxidation within sealed containers, as well as having a preservative effect. There are three oak species used in barrel making, but bourbon uses only American White Oak.

After settling on the appropriate wood type, the actual construction begins. The lumber is dried for one year, then aged outdoors for another six to nine months to enhance the natural flavors. A final kilning ensures that no residual moisture remains. Next the wood is planed to reveal the fresh color and to protect it from outside contamination. The quarter cut then produces wide and narrow staves. Following this cut, the staves are hand-milled into a convex curve. The staves are wider in the middle than at the ends, as the mouth is narrower than the overall diameter, and the cross-section of a board is trapezoidal to allow the inner circumference to be smaller than the outer. These staves are arranged by hand in a temporary steel ring frame, alternating wide and narrow boards to evenly distribute the internal forces. Each barrel requires 31 to 33 staves. The assembly is then heated by steam, to soften the polymers in the wood and allow it to be bent without breaking. The staves are held in their final position by the addition of another temporary steel ring about the opposite end. The lids of the barrel, called ‘heads,’ are produced by pinning planks together into a square, then using a milling machine to cut it into a perfect circle. This disc’s edge is then beveled to allow smooth contact with the body of the barrel.

The next, and perhaps most important, step in barrel production is the heat treatment. Some barrels undergo a preliminary toasting step, wherein the interior is heated to a specific (and secret) temperature for a prolonged time. This toasting phase is said to bring the sugars in the wood to the surface, and therefore be more easily absorbed into the whisky. The step which cannot be skipped, however, is the charring stage. The interior of the barrel as well as the heads are exposed to open flame for a brief time period, which creates a layer of charcoal coating the barrel’s entire inner surface. The amount of time and the heat of the flame both can have an impact on what flavors are produced by any one particular barrel. This layer of charcoal acts as a filtration system, siphoning out the harsher immature flavors of young whisky. It also absorbs unwanted sulfur compounds, which produce a most unwelcome taste. Most importantly, the charring creates a thin layer of caramelized wood between the unburnt section and the charcoal, which contributes the most to the eventual flavor of the spirit.

The final stage of construction requires that the barrels be cooled, so that the rings do not later fall off when the wood shrinks and loses tension. The six final hoops are then formed into three pairs of different diameters, to account for the barrel’s taper. Segments of steel are cut from a coil, bent into circles, then riveted together. Rivets are stamped by the cooperage to indicate the barrel’s provenance. Next, trenches are milled about the barrels for the final hoops to fit snugly into. The temporary ring-frames are removed, and the hoops are placed into position. A specially designed concentric press called a ‘hooper’ is used to press the hoops into the barrel. The entrance and exit for the liquor, known as a bunghole, is drilled in the midpoint of the barrel where the wood is widest. It is placed in the midst of a wide stave to minimize the risk of leaks or splitting. The heads are secured onto the ends with a thin line of paraffin wax about the edge, to ensure water-tightness. At this point the barrel is partially filled with water and soaked throughout, before air pressure is applied. If any leaks are present, the water bubbles out and reveals their position. After passing this final test the barrels are shipped out to the distillery to be used in the maturation of whisky.

**Economics**

Bourbon whisky barrels have become more widely used across the globe relatively recently, only becoming popular in the 1930s when the Spanish Civil War made the sourcing of sherry casks economically unviable. An estimated 350,000 barrels are sent abroad each year for the maturation of Scotch whisky. Recently demand for bourbon in the United States has increased greatly, as much as 36% in the past five years alone. In 2016 Kentucky distilleries filled a record-breaking 1,886,821 barrels of whisky, surpassing a highwater mark from the mid-60s. This uptick in demand is proving difficult to keep pace with, particularly due to the manual nature of barrel production. This, of course, means the barrels which are produced are being sold quickly and for great profit. This is an industry which is ripe for a new method of production, whether that comes in the form of automation or some other time-saving mechanism. Wherever there is money to be made, innovation is surely not far behind.

**Engineering Relevance**

The significance of this topic for a beginner engineer is to show them that while automation is often the hallmark of manufacturing, there are many fields where humans do the vast majority of the work. This teaches that while machines are useful, sometimes flexibility is the most important component of manufacturing equipment.

The significance of this topic for an experienced engineer is to expose them to a process which was developed decades ago and is still operating today relatively unchanged. This demonstrates that a lack of modernization in one step of a production process can throttle the entire business, making rapid expansion nearly impossible.

**Learning**

I learned a great deal about the manufacture of a simple product which I rarely, if ever, considered. Of particular interest to me was how much human inspection was required to produce functional parts, and that a great deal of barrels require retooling to be ready for storage. I believed that all barrels, for whisky or wine or flour, were all produced in the same manner, but I discovered that there is a great deal of material selection that goes into the process, and is critical to the quality of the eventual product.

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