Vacuum Kiln Wood Drying

I am new to woodturning having started about 7 years ago. After scurrying around and collecting a pile of local wood I decided that I'd have to dry it. I have mainly Birch, Manitoba Maple (aka Box Elder), Aspen and Balsam poplar, and a variety of berry woods. My research led me down the usual paths of air drying, alcohol soaking, small warm kiln drying and microwaving. I decided that the rule of thumb of 1 year of air drying per inch of thickness, plus a year was just too slow. I nearly built a small warm kiln complete with light bulb to do the job in several months. However, I was wondering if a vacuum could be used. I discovered Joshua Salesin's book called "Vacuum Kiln Drying for Woodworkers" and my question was answered. My research into the subject began.

It turns out that drying wood in a vacuum kiln is old news. The Swedes started working on it in the 1920's. A lot of research was done worldwide in the '80's and '90's and the physics and math have generally been worked out. Some commercial companies have been building vacuum kilns for large volumes of wood but economically it doesn't work out very well. It is hard to beat a couple of trainloads of wood parked in a hot kiln and cooked for a while versus having to carefully layer slabs of wood with heat mats and sealing a decent sized vacuum kiln. As for the sizes of wood turners use, there really isn't a very big market. Exit the commercial guys generally unless they use a vacuum kiln as a secondary unit. Woodmizer no longer manufactures them. Dehumidification kilns are more popular now but pricey and slower.

Fortunately, for the average hobbyist a vacuum kiln is a dandy device. Small blocks of wood (relatively speaking), can be dried Very quickly. For example, a friend and I cut down a good sized Balsam Poplar in mid December 2015. It was the middle of winter and the tree was frozen. We slabbed it on a bandsaw mill to various thicknesses. I took two slabs roughly 16" x 18" x 3" thick, still frozen and put them in my vacuum kiln January 1, 2016. They were much more than 50% water typical of poplar. I also chose pieces adjacent to the heartwood on purpose. I started the run and checked the moisture readings remotely every 6 hours or so. From time to time I drain my collection tank and keep track of volumes. When the moisture readings hit about 10% I took the slabs out. That was January 4th, 2016. In those three days I drained about 3 ½ gallons of water from the kiln. The wood never heated to more than 40 Deg Centigrade (that's 104 deg Fahrenheit) so just above body temp. The checking or cracking was minimal such that I could turn almost all of the slabs. January 6, 2016 I turned a 15" platter from one of the slabs and it is still fine months later. Green, frozen, really wet wood to less than 10% moisture content in 3 days and turned a couple of days later. I don't know about you, but that works for me!

I've been drying out wood with my kiln over the past year since I built it and have always had similar results. I don't have access to the fine hardwoods that warmer places have, but the porosity of wood is similar from what I understand, even if the density is different. I don't need to wait years. Hurray!

So how does it all work you ask. Wood dries almost entirely from the end grain; about 99% I've read. In Air dried wood I believe a very steep gradient of wet versus dry wood is created at the ends with the consequent forces putting a significant strain on the wood. Naturally it is going to check and crack. People generally coat the ends with something to slow the process down and that works to some degree.

Hot kiln drying accelerates the evaporation process but the lignin holding the wood together is weaker at high temperatures so wood can check or crack more easily. It is also possible to severely damage hot kiln dried wood if the temperatures are not managed properly so there are exacting timing and heating schedules developed to prevent this. A 'case hardened' piece of wood can look fine on the outside but can be shattered inside I've read.

Microwave drying is very quick but needs very close attention so as not to overheat the wood. Sometimes a piece can be overdone and found to be burnt on the inside if it hasn't already caught fire.

Enter Vacuum drying at temperatures below 120 degrees Fahrenheit or 48 degrees Centigrade. At these temperatures the lignin is still strong and evaporation from the end grain is accelerated. However there is one additional factor not present in Hot kiln drying and that is vaporization of the water within the wood. Water boils at a lower temperature in a vacuum. In my area 2600 ft above sea level water will boil at about 36 degrees C or 98 F. The maximum vacuum I can pull is 27.3 inches of Mercury but I generally manage at 26.5 In Hg. At sea level you can get 29 inches Hg but that's just because of altitude. So if I heat the wood to 36 to 40 C with rubber heat mats, and draw a good vacuum, the water in the wood vaporizes and leaves the wood quickly. My kiln walls are cool so the water condenses, runs to the bottom and out to a collection tank that I can drain while maintaining a vacuum. I also try to condense the moisture from the air stream running to my vacuum pump since there is a lot of water involved. I overflowed my pump several times before I figured out a cheap condenser. That is cheap, not perfect.

I can monitor the moisture content of the wood remotely using a couple of small nails hammered into the end or side grain and connected to the outside via a USB cable. I can remotely monitor the wood temp with a probe inserted into the end grain of a slab. I can measure the amount of water coming out via my collector tank and condenser tank. It is easily automated to maintain a decent vacuum. Best of all it is relatively cheap to build!

Joshua Salesin estimates in his book that it costs in the region of $500 to build and that is my experience as well. The major costs are the used vacuum pump he recommends, and the pipe I suppose. Here in Alberta there is relatively easy access to large diameter pipe so that didn't figure in my cost. I can also weld and that helps.

The bits of monitoring equipment and plastic tubing are pretty cheap I figure so in the context of expensive turning tools and purchased wood, this is a bargain.
What is my setup you may ask. I have a piece of steel pipe, 18 inches in diameter and 40 inches long (because that's how far I can reach in). The walls are 3/8" thick. The end plates are ¼ inch thick plate steel with the corners trimmed to a nearly octagonal shape. What other pipe sizes could you use? I honestly don't know. Josh Salesin suggests you consult an engineer. He uses a piece of 12 inch diameter plastic schedule 80 pipe and Corian end caps. It has very thick walls. I think plate steel end plates would be easier to get. I decided 12" was too small for my needs so 18" it was.

I welded one of my end plates on so there is one less place to leak. I bought an 8 inch long, threaded ½" ID pipe nipple and cut it in half. I drilled ¾ inch holes at the top and bottom of one end of my big pipe and welded the pipe pieces in. I painted the whole thing with rust paint. I built a wooden stand for it with a shelf below for the various pumps and tanks I would need. I sourced a used Welch vacuum pump as recommended by Joshua Salesin in his book, off EBay. In my area I can get gas rated ball vales for ½" steel pipe for 8 bucks so I bought a few. In time I built a condenser tank and collector tank out of 4" pipe with 1/8" plate end caps and the usual ½" pipe nipples welded on. I also found an inexpensive temperature sensor that would also control my 110v heat mats. I got Heat mats from Amazon and a mechanical timer from my local hardware store. To complete my automation I found a solenoid valve that worked off a used 12V transformer (although they are also available for 110V). For the gasket on the open end of the kiln I decided to use an 18" bicycle inner tube cut around it's circumference and stretched over the pipe end. I made sure the pipe ends were smooth and flat. I ran a 110v extension from inside to outside maintaining the sealed, manufactured end inside the kiln to minimize leaks. Likewise with the temp probe and USB cable. USB cable has 4 wires and a ground so five potential monitor points with a common ground. I sealed the holes for the wires with SealAll commonly available in hardware stores. I discovered Silicone type sealant doesn't work very well for this.

When all was assembled I tested the kiln seal with a small vacuum pump I already owned and was pleased to hold the vacuum pretty well for 24 hours. After all that it has just been a question of learning how to use the new tool.

In general shorter is better. Planning to build a vacuum kiln for 8 foot boards is probably not a good idea because wood dries from the ends. No one I know turns 8 foot boards anyway. The longer the board, the farther water has to go to get out. That said, it would still be much faster than other methods. I will do various sized bowl blanks (unturned) or rough turned, or slabs up to 16 inches in width routinely. Similar thicknesses make it easier to get even heat. Logs split in half don't heat as well as the same pieces flatted in the outside. That part is generally turned off to make a foot anyway. Laying similar sized spindles together also works well. The thickest slabs I've done so far is 7 inches with the only problem being getting enough heating to the core of the wood. My stiff rubber heat mat would not wrap around the curved outside of the wood very well so I had poor heat transfer. I have

found that thicker pieces do still have a moisture gradient from outside to inside. For example they might be at zero moisture on the ends and still 12% in the center but I don't worry too much because they will equilibrate in a couple of weeks, the center is turned out anyway, and it's only three or four days to dry them in the first place. Checking or cracks can happen but in my experience they tend to be much smaller and less of a problem than wood dried with other methods. I keep the wood away from the kiln walls because a lot of water condenses there and will easily wick back into the wood and stain it on the way down the wall. My shelf inside the kiln is about 6" off the bottom to maximize the diameter wood I can put in and to keep the wood out of the water that collects at the bottom. I did have a drain hole plug once and could hear the water sloshing around inside. I do a second wood layer at times with a smaller, narrower heat mat on top and that works well too. Vacuum leaks whistle quite loudly and you won't be able to keep a decent vacuum. If I need a piece of crotch wood I will split the crotch on the band saw and have it available and dry a few days later. I rarely use commercially available woods other than for accent at this time. I have found that the barrier of time to get dried wood doesn't exist. At this point in my woodturning career turning a piece of green wood and watching it warp and or crack makes me nuts. Maybe one day I will appreciate that part of turning, ha, ha.

I hope this short description is helpful to other turners. No, I don't do custom work.

Disclaimer: I am not an engineer. Building this device as I have works for me. I believe it's worth building your own for the cost and convenience. Turners tend to be scroungers in my experience, that's why so many make their own tools and jigs. Don't build one with walls too thin. I calculated something like 31000 lbs total pressure on the outside of my kiln at my altitude, hence the thick wall pipe. Since my ¼" end plates deformed 1/16" under full vacuum I would guess ¼" wall pipe would be too thin. Asking a qualified engineer for advice is a good idea, otherwise you build it at your own risk as I did.

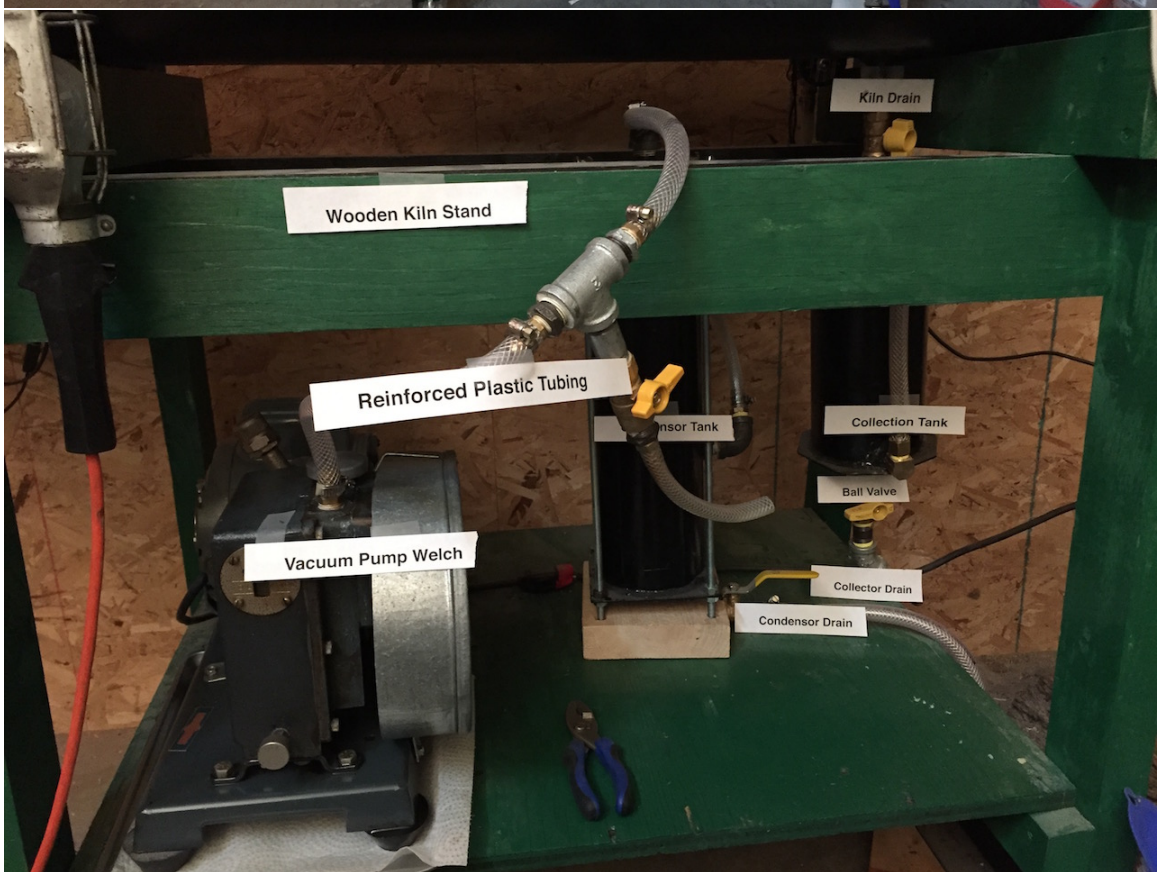
I've attached some photos below.

A Vacuum Kiln could be Magic or just plain Physics but it works.

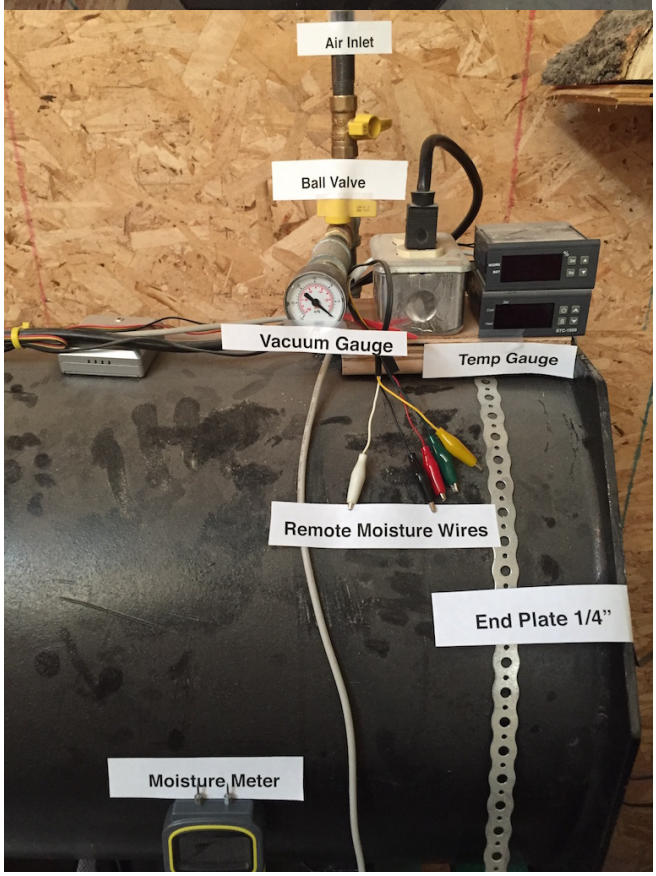
Many Thanks to Joshua Salesin for getting me started on saving time and wood. He answers many common questions in his book so it is worth a read. A new edition is planned for later this year I believe. I found it originally on Amazon.com

Happy turning, Jeff Hankinson


Ball Valve
Humidity Gauge
Vacuum Gauge
Temp Gauge
Remote Moisture Wires
End Plate 1/4"
Rubber Gasket 18" dia
Vacuum Kiln
18" dia x 40" long x 3/8" wall
Moisture Meter
Pipe Clamp (4)
Wooden Kiln Stand
Collection Tank
Reinforced Plastic Tubing
Collector Drain
Vacuum Pump Welch
Condensor Drain


Kiln Drain
Wooden Kiln Stand
Reinforced Plastic Tubing
Collection Tank
Ball Valve
Vacuum Pump Welch
Collector Drain
Condensor Drain


USB Cable
110V Connector
Heating Mat
Wood Slab
Wood Slab
Temp Probe
Moisture Pins
Heating Mat
Sheet Metal reflector
Shelf
End Plate 1/4"
Shelf


Air Inlet
Ball Valve
Vacuum Gauge
Temp Gauge
Remote Moisture Wires
End Plate 1/4"
Moisture Meter


USB Cable
110V Connector
Heating Mat
Wood Slab
Wood Slab
Temp Probe
Moisture Pins
Heating Mat
Sheet Metal reflector
Shelf