A Woodturners Guide
To
Designing, Building & Using Vacuum Chuck Systems

There are a number of reasons a woodturner might consider a vacuum chuck system. Perhaps you are a professional turner and you're simply looking for ways to increase production or improve efficiency. Maybe you are a hobbyist turner and want other options for holding a work piece for final finishing or repairs. On the other hand, like so many of us, perhaps you simply need another tool to enhance your woodturning experience and enjoyment. Whatever the reason, once you have decided to get into the vacuum chucking business there are two important things to consider and this applies to either buying or building a system. They are,

- The type of equipment to use
- How to use it safely

I will address each of these in their proper order.

The Equipment

If you are considering building or buying a vacuum chucking system you will need to have 6 distinct and important pieces of equipment.

1. Vacuum source – i.e. a vacuum pump or a venturi/eductor type device
2. A filter for vacuum pump protection
3. A bleeder valve for pressure control
4. A pressure gauge to monitor vacuum level and troubleshoot problems
5. A vacuum adapter for your specific lathe
6. A vacuum chuck to hold the work piece

This is one of those situations where you can spend a lot of money on a commercially manufactured system or spend a very modest amount of money on a self-built system. If you decide to purchase all pre-made components from normal retail outlets, expect to pay as much as $1,000 for a complete system. If you are a frugal person, you can build a system by judiciously purchasing good used and surplus equipment for as little as $150. I will address both ends of the spectrum.

Vacuum Sources

There are several different ways of generating a vacuum to hold turned objects on the lathe. They can generally be classified as venturi/eductor type systems or mechanical vacuum pump type systems.

The venturi type systems consist of a specially designed tube and compressed air to generate a vacuum. The advantage of the venturi systems is their simplicity and compact size. The disadvantage is that they require an outside source of compressed air and they generally will not pull as high a vacuum as other mechanical type vacuum pumps. The new Powermatic 4224

lathe comes with a built-in venturi vacuum system. Holdfast™ makes a vacuum generator based on venturi principles. It is shown below in Figure 1.

Figure 1 - Holdfast™ Vacuum Generator

Historically, mechanical type vacuum pumps have been the most popular with woodturners. Two of the more common types are diaphragm and rotary vane. Without going into technical design details, each type pump is well designed, mechanically reliable and will serve the purpose intended. However, each has their advantages and disadvantages. The diaphragm type pumps tend to be quieter, handle more air flow (i.e. leakage), but may only pull a vacuum of 22-23" Hg. Rotary vane type pumps tend to be nosier, handle less air flow, but will pull a vacuum of 26-27" Hg in a "tight" system. Gast™ and Thomas™ are two manufacturers of mechanical type vacuum pumps. There are now a number of imported pump options.

The vacuum pump can be the most expensive component of your vacuum system if purchased new and through normal retail channels. However, low cost options are available. For example, I purchased a Gast™ Rotary Vane vacuum pump several years ago on E-bay for $65 including shipping.

Below are pictures of a typical diaphragm and rotary vane type vacuum pump.

Figure 2 – Imported Diaphragm Vacuum Pump

Figure 3 – Gast™ Rotary Vane Vacuum Pump

<u>Vacuum System Protection</u>

It is absolutely necessary that you have a good filter between your vacuum pump and lathe. Otherwise, fine wood particles and dust can be sucked into the vacuum pump and over time

damage the diaphragm or carbon vanes. Currently you can buy excellent Donaldson™ filters, specifically designed for vacuum systems, from www.surpluscenter.com Item # 4-1565 for about $6.00. Below is a picture of the Donaldson™ filter.

Figure 4 - Donaldson™ Filter

Vacuum Bleeder Valve

Most vacuum pumps operate at constant speed and will generate between 20-28" Hg vacuum. This is often more vacuum that needed to securely hold a piece on the vacuum chuck. In almost any vacuum system, there will be some leakage, either through hose connections or the wood itself. However, most all efficient vacuum pumps can handle nominal leakage and it will be necessary to allow a controlled amount of air to "bleed" into the system to precisely control the vacuum. The best way to control the amount of air entering the system is through a small needle valve. You can buy inexpensive valves at your local hardware or home improvement stores, but these will generally be gate, ball or globe valves. You will get better and more precise control by using a needle valve. You can generally find 1/4" NPT Brass needle valves on E-Bay, Graingers, Enco, etc. for less than $10. A picture of a typical 1/4" NPT needle valve is shown below in Figure 5.

Figure 5 – Typical Brass Needle Valve

Vacuum Gauge

It is important to know precisely how much vacuum (or negative pressure) you have in the system. You can measure this negative pressure with a vacuum gauge. Why is this so important? One reason is safety! If the piece you are trying to hold is large and heavy, too little vacuum may not safely hold the vessel in place. Also, if you have a light, fragile vessel, too much vacuum could destroy your bowl. A gauge is necessary in order to properly adjust and maintain system vacuum. You should look for a 2" vacuum gauge with a ¼" NPT fitting that has a range from 0 to 30"Hg. Alternatively, look for one whose pressure ranges from 15 psig to 30" Hg. www.surpluscenter.com is a good, inexpensive source for vacuum gauges. They currently have 0 to 30" Hg vacuum gauges for about $6. They are also a good source for miscellaneous ¼" NPT brass fittings such as tees, crosses, ells, hose barbs, etc. Figure 6 on the next page shows a vacuum gauge that would be suitable for any system.

Figure 6 – Typical 0 to 30” Hg Vacuum Gauge

Vacuum Adapter

Every vacuum system must have some type of adapter that allows the vacuum generated by the pump to be transmitted through the hollow spindle and to the chuck which holds the work piece. A common feature of every vacuum adapter is a bearing which allows the hose from the vacuum pump to remain stationery while the lathe spindle is turning. There are several different designs made by companies such as Oneway™, Holdfast™, E-Z™, JT Turning™, etc. You can find most of these adapters in the woodturning catalogs we are familiar with such as Craft Supplies USA and Packard. Manufactured vacuum adapters can be pricey, ranging from $70 to $100+. With a bit of skill and ingenuity, you can make your own adapter. Shown below in Figure 7 is an adapter I made about 10 years ago from Nylon, O-rings, a bearing and miscellaneous fitting. My shop made adapter cost about $15. Also shown is a commercially available adapter manufactured by JT Turning™.

Figure 7 – Examples of Shop Made (L) and Commercially Available Vacuum Adapter (R)

Miscellaneous Materials

You will need a few miscellaneous fittings, hoses, hose barbs, etc. Most of these materials can be bought at your local hardware or home improvement store. The connecting hoses can be simple, inexpensive braided vinyl tubing. If the tubing and hose barbs are reasonably well fitted, hose clamps are generally not needed. Since you are dealing with a vacuum, the hose/barb joints will tend to close when vacuum is applied instead of opening when under pressure. Examples of such fittings you might also need are shown on the next page in Figure 8.

Figure 8 – Examples of fittings you may need (L-R): Cross, Elbow, Bushing, Hose Barb, and Tee

Assembly

Now that you have everything except the vacuum chuck, it's time to assembly the system. For simplicity, I try to have as much uniformity as possible in sizing all components. For example, I like to use only ¼" NPT brass fittings, 3/8" braided vinyl hose, ¼" NPT x 3/8" hose barbs, etc. This just minimizes the need for additional hardware such as reducing bushings, adapters, etc. Figure 9 below shows schematically how the system should look when it is all hooked together.

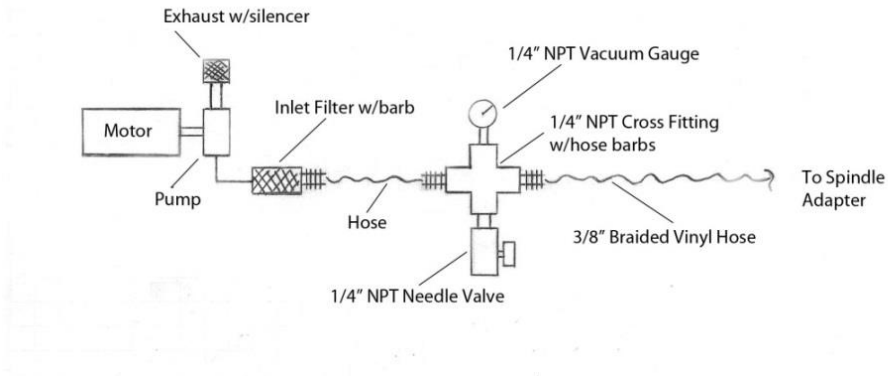

Figure 9 – Schematic of a Typical Vacuum System

Vacuum Chucks

The final piece of the equipment puzzle is the vacuum chuck. The vacuum chuck is attached to the inboard end of the lathe spindle and is designed to hold the work piece securely when the appropriate amount of vacuum is applied. Generally, a vacuum chuck consists of three parts, 1) a threaded base to fit the lathe spindle, 2) a hollow body made from wood, plastic or metal and 3) a gasket seal on the outside edge of the body to minimize air leakage.

Several manufacturers make high quality vacuum chucks to fit most popular spindle sizes. These chucks will cost from $70 to over $200 depending on the size and manufacturer. Shown on the next page in Figure 10 are examples of chucks made by Oneway™ and Woodfast™. These are available from most of the common woodturning equipment catalogs.

Figure 10 - Oneway™ (L) and Holdfast™ (R) Vacuum Chucks

Another option is to make your own vacuum chucks. This can be done easily and cheaply with common materials. Here's how I've made several vacuum chucks using spare faceplates, a piece of hard/dense wood, a PVC pipe coupling and some inexpensive foam gasket material. More detailed steps of the process follows:

1. **Faceplate** – Many of us have spare faceplates that are seldom or never used. If not, used faceplates are often easy to find and reasonably cheap. You need a faceplate whose threads match your lathe's spindle threads. Generally a 3"-4" faceplate is sufficient.

2. **Wood Base Material** – You need a piece of hard/dense wood on which to mount the faceplate on one side and the PVC coupling on the other side. I like to use Hard Maple, but glued-up pieces of MDF also works fine. The advantage of MDF is its flatness, uniform thickness and high density. The size of the base will be dictated by the size of the PVC coupling you wish to use. If you are using a 3" faceplate, a 5-6" piece of wood should be sufficient.

   Fasten the wood on the lathe with a screw chuck, etc. and carefully flatten the exposed side. Remove the wood from the lathe and drill a hole through the middle that is the approximate size of the faceplate hole. Mount the faceplate on the wood base with sturdy screws. You may wish to put a small amount of Silicone sealer under the faceplate to prevent any air leakage. Next, mount the faceplate on the lathe, round the corners and flatten the outside face of the wood. At this point you may want to give the wood a of couple coats of lacquer to seal the end grain.

3. **The PVC Chuck Body** – Determine the size chuck you want. PVC couplings are available in sizes ranging from less than 1" to over 6" diameter. They are inexpensive and readily available from your local hardware or home improvement store. For the first one, I would choose a smaller size; say a 2" or 4" coupling. Next, cut a groove in the face of the body with a parting tool to accept the PVC coupling. This groove should be cut precisely so the outside edge of the PVC coupling will fit very snuggly in the groove. Do this operation in small steps and "sneak up" on the outside groove size. After the groove has been sized properly, take the faceplate off of the lathe, stand it upright and partially fill the groove with your favorite epoxy. Firmly seat the PVC coupling in the groove and let the epoxy harden.

After the epoxy has hardened, remount the faceplate and see if the PVC coupling is running true. If there is a slight amount of "wobble" use your scraper and true-up the coupling. Next, round over and smooth the outer edge of the coupling with a scraper. You now have a vacuum chuck almost ready to use.

4. **Gasket Seal** – The last step in making your own vacuum chuck is installing a suitable gasket seal. You can use a variety of commonly available materials or buy gasket material from our well known woodturning catalogs. Many types of material can be used, but as a common feature they should be dense, readily conform to shapes they will contact, be thick enough to provide a cushion, yet thin enough that the piece being held will not rock back and forth with pressure. My favorite material is the 2mm foam sheets that are available at most any craft supply store or Wal-Mart. One product brand name is "Foamies".

   To install the gasket seal, cut a piece that is about ½" larger that the diameter of the chuck body. Spray one side with an adhesive material such as 3M Super 77™. Stick the foam gasket on the edge of the chuck body and apply pressure for a couple of minutes to get a firm set. With the chuck mounted on the lathe, turn up the speed and trim the gasket material with the long point of a sharp skew.

You're done! Now you can start enjoying the advantages of a vacuum chuck. Also, these vacuum chucks make excellent jam chucks. Shown below in Figure 11 is an example of a shop made vacuum chuck.

Figure 11 – Shop Made Vacuum Chucks

Note: If you need more vacuum chucks than you have faceplates, you can make multiple wood bases with different size PVC couplings and reuse the same faceplate. Just make sure you put an index mark on both the faceplate and body so it can be reinstalled in its original orientation.

Important Safety Considerations for Using a Vacuum System

As with any piece of equipment there are some important principles that should be understood and followed for safe operations. Listed below are a few important safety considerations.

1. **How Much Vacuum Should I Use** – This will depend on many factors such as the size and weight of the piece, the size of the chuck, speed of the lathe, etc. I seldom use more than 15" Hg vacuum and often less.

   The holding power of a chuck will be a function of the vacuum pressure applied and the surface area of the chuck. We all remember from high school that the area of a circle is $A = \pi r^2$ where r is the radius of the circle or chuck. If you apply a vacuum of 15" Hg, this is roughly equivalent to a negative pressure of 7.5 lb/in^2 or psi. So, if you have a chuck made from a 2" PVC coupling with a 15" Hg vacuum applied, the holding force would be,

   Holding Force = Area (square inches) x pressure (#/in^2)

   Holding Force = π $(1)^2$ x 7.5 = 23.5 lbs.

   If you doubled the chuck size to 4", the holding force would be

   Holding Force = π $(2)^2$ x 7.5 = 94 lbs.

   Taken one step further, if you again doubled the chuck size to 8", the holding force would be

   Holding Force = π $(4)^2$ x 7.5 = 377 lbs.

   So, as you double the chuck diameter, at constant vacuum, the holding force will increase by a factor of 4. This is an important concept to remember.

   In general, it's best to use the largest chuck available that will easily fit the work piece.

2. **Safe Area of Operation** – A vacuum chuck is neither designed nor intended for aggressive wood removal or power sanding of a partially completed item. This is best left to traditional holding methods. The best use for vacuum chucks is to provide complete, unobstructed access to the bottom of a vessel for final foot preparation, sanding and finishing. As a general rule, it is best to confine all work within the area covered by the chuck body. This is illustrated in Figure 12 below.

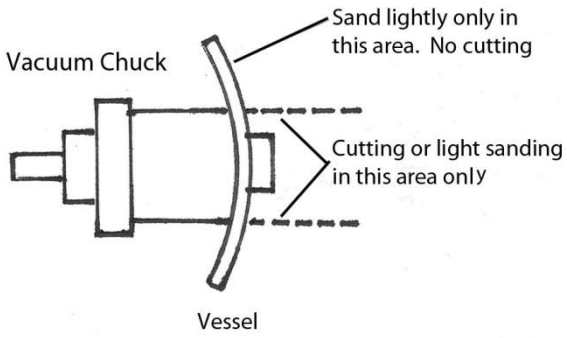

Figure 12 – Safe Area of Operation

With a significant catch, you can pull the vessel off of the chuck. Be careful and always take light, well thought out cuts. It is a good practice to maintain tailstock support as long as possible and when you need to take anything other than very light cuts. Remember, vacuum chucks also make wonderful and efficient jam chucks.

3. **Speed** – There is seldom any need to use high speed when holding a piece with a vacuum chuck. A vacuum chuck will normally be used to refine the bottom of a vessel, perform final sanding on the bottom, or apply your favorite finish. With any of these operations, there is no need for high speeds. Sanding is typically done at speeds less than 300- 400 rpm. Applying a final finish on the lathe is often done at low speed or no speed. If you find a need to crank the speed up over 400 rpm or greater, you should seriously consider using tail stock support

4. **Loss of Power** – Much has been written and discussed about the hazards of losing electrical power while using your vacuum chuck. Some people have installed vacuum reservoirs between their vacuum pump and lathe vacuum adapter. The theory being that the extra vacuum reservoir will give extra time to safely shut off the lathe before the piece falls from the chuck. While perhaps it is possible, I have never experienced a power failure while using a vacuum pump. It's my general belief that if you lose power to your shop, you will probably lose power to your lathe also. While the vacuum pump will certainly stop quickly, the lathe will also begin slowing down. If you are observing all other safety issues, especially speed, the worst case scenario would be the work piece would fall from the chuck and be dinged. If you feel the additional insurance is worthwhile, by all means install a vacuum reservoir in your system. This could perhaps give you an additional few seconds of time to control the situation.

5. **Remote On/Off Switch** – Incidents can happen at the lathe with blinding speed. It is a good safety practice and a nice convenience to have a remote on/off switch located near the lathe so the vacuum pump can be quickly turned off if needed. Shown in Figure 13 below is a shop made on/off switch made from inexpensive electrical conduit fittings. It has a magnet so it can be attached to the lathe at a convenient spot.

Figure 13 – Shop Made Remote On/Off Switch

Final Thoughts

Vacuum chucking capability is not necessary for your woodturning enjoyment, but it is a nice convenience. Once you have an operable system, you will quickly discovery many ways to put it to good use and you'll wonder how you ever lived without one. For the professional

woodturner who would use a vacuum system on a daily basis and wants sturdy, commercial quality materials, sourcing off-the-shelf materials would perhaps be the best option. For the hobbyist woodturner, whose demands aren't as rigorous, a shop built system should be more than adequate.

Joe Johnson

Disclaimer – Throughout this document, there is mention of numerous companies that produce or have equipment available for the woodturner interested in building a vacuum chucking system. The author has absolutely no financial or commercial interest in any of these companies or products. They are mentioned only as a reference source for the interested reader.