Vacuum Chucking for Woodturners

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By Dave Smith April 21, 2011 Late Breaking Story: Woodturner & Lathe Never Heard From Again!

There was a woodturner named Dean Whose vac chucking system was mean His pump weighed a ton Was as vile as a Hun Sucking Dean and his lathe in for fun





My Experience with Vacuum Chucking for Woodturning

- I've been actively woodturning for 5 or 6 years and vacuum chucking for probably 4 of those.
- I was already aware of vacuum chucking being used in many industrial manufacturing applications so it just made sense to me that it could also work well for certain types of woodturning
- I'm a scrounger and already had a used vacuum pump (I have no idea where I got it) as well as an assortment of electrical and plumbing fittings so I had most of what I needed to put a system together.
- Now that I've been using it for a few years, I really like it and find that it makes some operations much, much easier (at least for me), especially when I'm turning bowls and plates / platters
- Vacuum chucking has no application to spindle turning that I aware of. As you'll see in my talk, it is most commonly used on wood faceplateturned objects at least a couple inches in diameter.





What I Am I Trying to Do and Not Do With This Talk

- <u>I am not</u> trying to sell you on vacuum chucking! There are lots of ways to hold turnings and if you have tools and methods that work for you, you may well want to stick with them. "If it ain't broke, don't fix it."
- What <u>I am</u> trying to do is convey facts and some of my experiences so you can decide whether vacuum chucking is something you want to explore.
- A few weeks ago, I was talking to Ralph Mosher and describing to him what I liked about vacuum chucking - to which Ralph replied that he already had tools and techniques for doing all the same things. But......
- A week or so later, Ralph told me that I had said something that really appealed to him when I said I liked being able to cut a round disc on my bandsaw and take it over to my lathe, vacuum chuck it and start right in turning the top of a plate.
- Are there other ways to turn a plate? Of course. But vacuum chucking has certainly made it both convenient and enjoyable for me!
- Finally, I've tried to make these slides complete enough that if you want to refer to them later, you'll be able to understand what I'm talking about.



Briefly, What I'm going to Talk About

- · What is vacuum chucking
- Components of a typical vacuum chucking system for woodturning
- Common woodturning applications
- How much holding force does vacuum chucking provide
- Advantages / disadvantages
- Typical costs for functional systems, both high and low \$
- Types of vacuum chucks
- Some problems with vacuum chucking and solutions
- 3 types of vacuum pumps I would recommend
- Web and magazine resources



What is Vacuum Chucking?

- Vacuum chucking works by holding the piece being turned via a vacuum applied to flat or cup-shaped chuck, which is mounted on the lathe headstock. It is commonly used for cutting, sanding and applying finishes to woodturned pieces.
- Almost always, there are multiple ways to hold pieces on the lathe and vacuum chucking is just one of them. Some alternative ways are:
 - Scroll chucking using conventional or Cole Jaws
 - In a jamb chuck
 - On a screw chuck
 - Between headstock and tailstock centers





Common Applications for Vacuum Chucking

- Cutting and sanding bowl bottoms (especially useful for natural edge bowls)
- Cutting and sanding plates & platters
- Cutting and sanding other pieces which have at least a few square inches of area on the vacuum chuck, i.e., where the chuck diameter is at least a couple of inches.







Except for its foot, this natural edge bowl is finished and ready for mounting on a vacuum chuck for completion

Vacuum Chucking for Finishing Foot of Natural Edge Bowl



Unfinished foot. With vacuum chucking, there's no tailstock to interfere with cutting the bead and finishing the bowl foot.

Bead and foot are cut, sanded and ready for Behlen's Salad Bowl Finish











Using a vacuum chuck made it easy to hold this platter for fluting, giving an otherwise ordinary looking platter some "Pizazz"

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Vacuum Chucking Made it Easy to Enhance an Otherwise Ordinary Looking Platter

I finished several of these platters, which all looked rather ordinary. Struggling to think how I could improve them, I held this one on a vacuum chuck and sanded flutes in it's rim. Vacuum chucking gave me lots of room for my fluting equipment. I hope you'll agree that the fluting added some "Pizzazz" to this otherwise ordinary looking platter.











My Vacuum Chucking Setup at My Lathe

This hose comes goes to the vacuum pump, which, with a cyclone dust collector, resides in a sound deadening room about 20 feet from my lathe

The home made Vacuum Control Module is next to the lathe for easy access & adjustment







- If you look at a barometer, you'll find that our air pressure readings are usually around 30 inches of mercury, i.e., the air is pushing down on the mercury enough to make it rise about 30 inches in an evacuated tube.
- This corresponds to an air pressure of about 15 pounds per square inch, which pushes on everything exposed to it
- If your pump can pull a vacuum of 25 inches of mercury on your vacuum chuck (and the backside of your work piece), (i.e., its pulling a pretty good vacuum), then the air on the outside of your piece will be pushing about 12.5 pounds harder on every square inch of the piece over the chuck.





Chuck Dia. (In.)	Chuck Area (Sq. In.)	Approx. Holding Force @ 20 in. Mercury (Lbs)	Approx. Holding Force @ 25 in. Mercury (Lbs)
2	3	31	39
3	7	71	88
4	13	126	157
5	20	196	245
6	28	283	353
7	38	385	481
8	50	503	628
10	79	785	982
12	113	1131	1414

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Vacuum Holding Force as a Function of Chuck Diameter

Note: I calculated that my Powermatic 3520A tailstock would generate over 6,000 lbs of force if I "cranked hard" on it. So it's probably fair to say that most tailstocks can exert considerably more holding force than even a 12 inch diameter vacuum chuck. What this means is that the following are still best held with a tailstock in place:

- Pieces being roughed out or "hogged"
- Very heavy pieces
- Off-center and unbalanced heavy turnings
- Pieces being cored

Some Advantages of Vacuum Chucking

- For many operations, it's convenient
- Permits turning parts without using the tailstock, giving you better access to the piece. This often let's you add details that you otherwise couldn't easily add, e.g., a bead
- Provides easy chucking of pieces such as natural edge bowls that are difficult to chuck other ways
- Sometimes permits turning wood with no chucking tenon, thus saving wood or eliminating the need for a glue block. E.g., platters can be turned with no tenon.
- Can minimize chatter and piece deflection because a vacuum chuck can support bowls and platters out near their edges. (Scroll type chucks usually provide support nearer the center of the piece)
- Because no chucking tenon or internal dovetail is required for platters, you don't have to deal with it later when finishing your piece
- Permits you to re-chuck work once external chucking tenon or internal chucking dovetail has been removed





Some Disadvantages of Vacuum Chucking

- Setting up a system can be relatively costly in terms of \$, time and space, ٠ especially for woodturners who already have other tools and methods for holding their work
- Generally, not good for roughing or "hogging" cuts, or heavy or unbalanced pieces. • I.e., it's generally more appropriate for lighter cuts and finishing operations.
- Some woods are guite porous and require the application of a sealer such as ٠ wax to secure a good vacuum
- Too much vacuum can distort or collapse a piece, especially large, thin pieces
- Out of round / distorted pieces may be impossible to vacuum chuck
- Generally, it doesn't work well for small pieces •
- Pieces will fall off the lathe in case of power failure (or, if like an idiot, you turn off your vacuum pump forgetting that your piece is still on the vacuum chuck)
- Doesn't work for pieces with large holes or perforations ٠



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Not a great candidate for vacuum chucking!

Approximate Costs for a Lower Cost, Fully Functional System¹

Component		Supplier
Vacuum Pump (used)		eBay or Industrial Surplus Store
Vacuum Gauge		Grainger, Ebay
Vacuum Filter		Harbor Freight
Long Electrical Wire & On/Off Switch		Home Depot, Lowes
Compressor Hose (50 feet, 3/8 inch)		Harbor Freight (Goodyear Brand)
Easy Vacuum Adapter (Rotary Union & Pipe Assembly) ²		Packard
Quick Coupler Sets (quantity 2)		Harbor Freight
Misc. Brass Valves, Fittings, Hose Barb Adapters & Clamps		Harbor Freight, McMaster Carr, Lowes, Home Depot
PVC Pipe, Plywood or MDF for Vacuum Chucks		Home Depot, Lowes
Contact Cement		Home Depot, Lowes
1/8 inch to 1/4 inch Thick Neoprene Foam Rubber or Equiv.		McMaster Carr, Michaels
Grand Total		

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- 1. This will require some work on your part: shopping, wiring, plumbing, making vacuum chucks, etc.
- 2. You can save the majority of this expense by purchasing a ball bearing and making vacuum adapter components out of wood. (See "Building a Vacuum Chuck System for Woodturning" by William Noble, Section 4.3, "How to Make Your Own Rotary Fitting."

Approximate Costs for a High Cost System, Where You Buy Everything From a Woodturning Supplier

Component	\$ 1	Supplier
Gast Vacuum Pump (4.5 Cubic Foot Capacity & Pulls 26 inch Vacuum)	\$429	Craft Supplies
Vacuum Control Kit with Gauge	\$93	Packard
Easy Vacuum Adapter (Rotary Union & Pipe Assembly)	\$83	Packard
Wireless Transmitter / Receiver for On/Off Control	\$69	Woodcraft
Vacuum Chucks (Oneway 5 1/2 and 8 Inch)	\$310	Craft Supplies
Vacuum Hose , Quick Disconnect and Other Misc. Fittings	\$50	Harbor Freight
Grand Total	\$1034	

1. Does not include tax or shipping

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Some Critical Things to Look For When Setting Up a System

- Be sure to purchase a vacuum pump with enough capacity to accommodate leaks and wood porosity, which are inevitable. I recommend a pump capable of a minimum of 2 cubic feet per minute (CFM). 3 - 5 CFM is better yet!
- If purchasing a used pump, be careful it's single phase and rated for 115 volts (or 230 volts if you have this in your shop) and not a 3 phase or low voltage DC pump. (Pumps on eBay and at surplus stores are sometimes cheap because of their oddball electrical requirements).
- I recommend purchasing a pump which can pull at least 20 inches of vacuum (readily available) or better yet, 25 inches (also readily available).
- Do not attempt to use a vacuum cleaner. It can't pull enough vacuum and it's not designed to run without a constant air flow to keep it cool
- Ensure that your Vacuum Controller is located close to your lathe and includes a vacuum gauge. A gauge here tells you how much vacuum you have where it matters - at your lathe. A gauge at the vacuum pump, especially if the pump's located some distance from your lathe, will give you misleading readings!



Closed cell Neoprene foam provides both seal and work piece support. It should have non-slip properties to prevent piece movement during cutting.

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Cup Type





Commonly Used Forms of Vacuum Chucks



Non-slip router pad material provides support for flat work piece surfaces

Closed cell neoprene foam strip fits in faceplate groove and provides seal





Some Solutions for Common Problems with Vacuum Chucking

Problem	Solution	
My vacuum pump is so noisy it's driving me crazy	 Buy and install muffler on pump output Build sound absorbing housing Locate pump far from lathe. "Pipe" vacuum to lathe via compressor hose and switch pumpvia remote wired or wireless switch. 	
Leaks and porous wood prevent getting sufficient vacuum	 Identify source of leaks and seal via Teflon thread tape or other tape / sealant as appropriate Seal turning with a coat of finish or paste wax 	
I'm afraid I'll collapse or distort my piece if I apply full vacuum	 Follow the upcoming guidelines regarding how much vacuum to apply 	
It can be difficult to get a turned part running true on a vacuum chuck	 If piece was previously turned using a four jaw chuck, thread chuck onto tailstock via taper-to-thread adapter and then push piece up to vacuum chuck For platters, put center points on both sides of blank 	





Ash Platter Blank



Center point of compass when I drew circle of platter blank (I always circle it so I can find it Later)



Tip for Locating Center Points on Both Sides of a Platter Blank

Once blank is centered and squared up against faceplate, tailstock center is brought in to make a center point on the other side of the blank. Now both sides have a center point.



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Compass center point on the platter blank is positioned flat against this faceplate so the sharp centered pin locates in the compass hole



Some Solutions for Common Problems with Vacuum Chucking

Problem	Solution
My Piece has scratches or scuff marks on it after vacuum chucking	 Clean gasket material thoroughly before using Apply a sheet of Saran Wrap (with hole in it) over gasket material before applying vacuum to the piece Reduce or turn off vacuum and align piece gently by hand, i.e., using a sledge hammer to align a piece under full vacuum is asking for scuff marks.
Part slips on vacuum chuck while I'm turning it	 Ensure you have maximum vacuum Take lighter cuts Use a larger vacuum chuck if possible Ensure gasket is high friction type such as neoprene foam rubber
Piece has holes in it so it won't hold a vacuum	• It is sometimes possible to apply tape over holes such that a vacuum will hold.





Guidelines for How Much Vacuum to Apply

- This is a very complicated subject since the strength of turned pieces depends on the wood species, rate of growth, geometry of the piece including diameter, form (spherical shapes such as bowl are inherently stronger than flat pieces) and thickness, grain orientation, and number and nature of inclusions
- A retired Boeing Engineer, Bill Marx, has written an excellent paper on this topic entitled "Allowable Vacuum for Wood Turning" in which he calculates the maximum vacuum assuming a 3/16 inch thick uniform plate. His paper analyzes this for a couple dozen wood species and chuck diameters from 2 to 8 inches.
- Virtually all species could withstand a vacuum of 25" on chucks up to 4 inches in diameter. Above this, it gets very interesting! E.g., on a 6" chuck, Ash can withstand 25" of vacuum but Western Red Cedar only 11".
- The problem with this analysis is that you will rarely if ever be turning and vacuum chucking a 3/16" uniformly thick plate.
- While I have cracked 2 bowls of the many dozens I have vacuum chucked, I was using an 8 inch cup chuck and the bowl walls were turned quite thin
- **Bottom Line**: My advice is to refer to my chart that shows vacuum holding force as a function of the chuck diameter and try to envision if your piece would survive that much weight being placed on it. If not, cut the vacuum and take lighter cuts.





My Recommendation of Three Types of Vacuum Pumps

Rotary Vane Pumps

- Type offered by major turning suppliers
- CFM ratings from 2 10 CFM
- Generally maintenance free

Diaphragm Pumps

- Ideal for vacuum chucking but fairly low CFM ratings: 1-3 CFM
- Relatively low cost
- Relatively quiet

Piston Pumps

- Not as quiet as diaphragm pumps
- Typically 2 5 CFM

Two vacuum pump brands I've had good experience with are Gast & Thomas







On Web

Web & Magazine Article Resources

- Allowable Vacuum for Woodturning by Bill Marx
- Vacuum Chuck System How I Built Mine by Steve Schlumpf (Sawmill Creek)
- Making a Vacuum Chucking System on a Shoestring Budget An Adventure by Sy Plonsky
- Building a Vacuum Chuck System for Woodturning by William Noble
- Basics of Vacuum Chucks / Pumps by Bill Hrnjak
- Vacuum Chucking, The Bruised Brothers by John Solberg & Peter Tkacs
- Making MDF Type Chucks by Johnny Tolly <u>www.turningwood.com/mdfchucks.htm</u>
- Gast Vacuum and Pressure Systems Handbook (downloadable from website)
- Thomas Vacuum Pumps Standard Product Catalog (downloadable from website)

Magazine

- American Woodturner (the Journal of the American Association of Woodturners, Feb 2011, Vol 26, #1, "Understanding and Improving Vacuum Chucking Systems"
- Please note that there are many other vacuum chucking articles in the American Woodturner besides the one shown above. Here's another reason to become a member!



The End



