MANSON PRECISION REAMERS

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How to Reduce Chatter When Using a Manson Reamer

The thought of reamer chatter during chambering strikes fear in the heart of even the most experienced gunsmith. This condition can ruin an expensive barrel and add unnecessary cost to what should have been a profitable job. With many possible causes of chatter; it's not unusual for several to be present at one time.

When discussing causes and cures of chatter, it's essential to realize, up front, that chamber reamers are difficult cutting tools to use. Unlike a chucking reamer, which cuts only on its leading edge and produces a round hole of a certain size, a chambering reamer cuts along most of its length and produces a tapered hole. Think about it—a 30-06 chamber is 2.502" long. Add, say .300" length for the throat ahead of the case, and the length cut by the reamer becomes approximately 2.800". If the case protrudes .150" from the breech end of the barrel, this figure would be reduced to 2.650". Most finish chamber reamers are made with six flutes/cutting edges, so there will be more than 15" (6 x 2.65") of chip generated by the reamer when the chamber is at minimum depth. It takes a fair amount of skill and experience to strike the correct balance between feedrate and rpm in a machining situation such as this.

Other factors enter the "will it chatter" contest: is there a lot of taper in the body of the reamer, how much difference between neck and shoulder diameter is there, is the chamber being cut for 22-cal or smaller?

Chambers with greater taper generally are more troublesome, in terms of chatter potential, than chambers that are fairly straight--cutting 300 Win Mag doesn't give the problems that cutting 300 H&H does. More taper translates into more feed pressure being required to cut a similar depth—this makes it difficult to feed the reamer at the proper rate and means there are no hard and fast speed/feed parameters.

Chambers with large differentials between neck and shoulder diameters also cause problems—cutting a 30/378 Wby chamber will likely be more problematic than one for a 308 Win. It should be noted here that some of the trouble experienced by 'smiths chambering calibers with large neck/shoulder diameter differentials is the result of their allowing the flutes to fill with chips. Don't let flutes pack with chips to the point that the chips have nowhere to go. Besides producing a poor finish, this condition can cause the reamer to break, typically at the neck/shoulder junction. Clear chips before the flutes are filled; a 45-70 reamer can be run in much further before chip clearing than a 300 Win Mag. Watch the amount of chips in the flutes and clear accordingly.

Reamers for 22-cal and smaller are necessarily less rigid than reamers for the larger calibers. Because of this, they're less able to resist any tendency to chatter that might be induced by improper set-up, machine vibration, or other factors. Small-caliber reamers accentuate the aforementioned problems caused by body taper and neck/shoulder diameter differences.

Having covered why chamber reamers can be difficult to use, let's examine how they're designed. Multi-fluted tools, such as chamber reamers, tend to center themselves in the hole into which they're being introduced—your barrel. Nevertheless, chamber reamers are piloted to insure that they do cut concentrically. Further, in our experience, a pilot fitted closely to the bore goes a long way toward reducing any tendency of the reamer to chatter.

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Spacing between teeth on chamber reamers affects the tool's tendency to chatter. If a six-fluted reamer has its teeth spaced evenly at 60-degrees, it will be less stable than one having "staggered" tooth spacing. Many formulas for stagger exist, but the intent is to prevent any two teeth from being directly opposite each other and possibly causing a harmonic (chatter) to build during use.

Odd-fluted chamber reamers would alleviate this problem, wouldn't they? Yes, they would; five or seven-fluted chamber reamers would likely go a long way toward eliminating chatter. But, and it's a big but, they're more expensive to manufacture and are impossible for the user to measure unless he buys expensive 5 or 7-flute micrometers. Spiral, or helical-fluted reamers are chatter-resistant as well and would help as long as there isn't a large diameter difference between neck and body diameters.

Maintaining proper tooth position (rake) on spiral-fluted tools is extremely difficult when milling or grinding flutes on tools with large diameter differentials. Since correct rake is critical to good cutting characteristics, spiral flutes aren't a good option for chambering reamers with shoulders because the variance in rake occurs exactly where you want it to be constant—on the shoulder of the tool. We use spiral fluting on reamers with long, fairly straight tapers—such as shotgun chamber reamers—and they work well. Considering all the options, even-fluted chamber reamers, with staggered tooth spacing, represent the best current option for the gunsmith.

So we're stuck with six flutes and staggered spacing. What else affects a reamer's resistance to chatter. For one, a stronger, more rigid reamer, with thick teeth and large core diameter, is less likely to chatter than one with thin teeth and small core. Reamers with thin teeth/small cores have more chip clearance, but at the expense of tool rigidity. Stronger reamers (of the same caliber, of course) are less likely to chatter, but must be cleared of chips more frequently. This is another of those trade-offs that always seem to be with us.

So far, we've discussed only the reamer in examining the causes of chatter. But the reamer doesn't operate in a vacuum and isn't the only component in a "system" in which chatter rears its ugly head. It is, however, the cutting tool that creates all those ugly marks in the barrel and as such usually gets the lion's share of the blame for the problem. Other factors affect how it performs and we'll examine those next.

The majority of chambering done outside of the larger manufacturers is done in the lathe. Some revolver specialists use a vertical mill to cut their chambers, but we'll limit our discussion to the engine lathe and how it's set up.

Chambering traditionally was done with the breech end of the barrel supported by a steady rest, and the muzzle held in a 3 or 4-jaw chuck. Prior to chambering, the barrel was supported between centers, and the breech end trued and threaded concentric to the bore.

Once a surface true to the bore had been turned on the breech end, it was supported by a steady rest and the muzzle of the barrel was held by a chuck on the headstock. Done properly, the barrel's bore would turn concentric to the axis of rotation of the lathe. All that was necessary was for the reamer to be held in a manner that allowed it to maintain concentricity with this axis of rotation.

Re-read the last sentence in the above paragraph. It implies that all will be well if the reamer is held exactly on the axis of rotation of the lathe. Is your lathe perfectly aligned —side-to-side and up-and-down? And does the tailstock spindle move parallel to the headstock axis?

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Even if lathe alignment is perfect, does the Jacobs chuck hold the reamer co-axial with the headstock? If it doesn't and you lock down the reamer, it will very likely cut oversize at its base. Won't it cut oversize elsewhere, too? Maybe, but it's most likely to cut oversize at the base.

Chamber reamers are made from tough steel and are quite hard to resist wear. They will, however, bend/twist when subjected to sideloadings or excessive torque. In our experience, the front of the reamer will flex to accommodate mis-alignment, but the base diameter—being larger and stronger than the rest of the tool--will not. If the reamer is held rigidly, and the base is out-of-alignment by .001", the base diameter of the resultant chamber will likely be .002" oversize. Essentially, the base of the reamer acts like a boring bar and cuts a chamber that will produce bulged cases every time your customer fires his new rifle. (Bulging of undersize cases in correctly-sized chambers is topic for another discussion.)

This is a good time to introduce the concept of a "floating reamer holder", because the above discussion explains why it helps to have some flexibility in the reaming system. Your "floating holder" doesn't have to be a commercial product, but can be as simple as a long shaft to hold the reamer, that has been reduced to a smaller diameter for an inch or two so as to allow it to flex and the reamer to follow the bore. This type of holder does permit some angularity to creep into the system, but if the shaft is sufficiently long, the effect isn't very pronounced. Arrangements in which one of the 'smith's hands is needed to prevent part of the floating system from turning are, in my opinion, second-rate as well as dangerous. Ever have your fingers crushed against a lathe way by a wrench when the reamer grabbed?

Speeds and feeds are next on the list of chatter-related parameters—what sort of spindle speeds and reamer feeds should be used? It depends on set-up rigidity.

If the 'smith is chambering in a steady rest, we recommend that spindle speed be kept below 100 rpm. This (somewhat) arbitrary speed is because the steady-rest technique is less-rigid, and offers more opportunity for vibration than does chambering with the breech end of the barrel in a 4-jaw chuck and the muzzle held by a "spider" at the opposite end of the spindle. Keeping rpm below 100 minimizes the chance for chatter-inducing vibration—this recommendation would also apply if using a "long-shaft floating reamer holder", as described above.

The steel from which our reamers are made will allow spindle speeds of 300-350 rpm with barrel steel and normal reamer diameters, and we use this as an upper limit for those chambering out of a headstock. If chatter does occur, speeds as high as 350 rpm can be attempted in an effort to remove it. A more realistic figure would be 150-250 rpm because the reamer must be fed fast enough that it remains "in balance" while cutting. Lower RPM means the 'smith doesn't have to feed as fast to keep up with the cutting potential of the reamer.

What does, "in balance" mean? All cutting tools can be said to have a "sweet spot", where the cutting speed, tool flex, sharpness and material removal are optimum. It's true for a pocket knife, a turning tool, a twist drill or a chambering reamer. At some point the rpm, of the barrel relative to the reamer, and the rate at which the reamer is fed into the metal will combine with the flex of the reamer to produce an optimum cutting condition —one in which the reamer is stable and cutting efficiently. Because the cutting profile of the reamer changes as one goes from throat, to neck, to shoulder, to base, the feedrate must necessarily change to keep the cutting conditions "in balance". The reamer may be fed fairly fast when cutting throat and neck sections of a chamber, but must then be fed at a lower rate when going up a shoulder and slower still when fully engaged on the body. As discussed previously, chip accumulation affects feedrate and reamer clearing as does reamer profile--a 45-70 reamer can be fed much faster than one for a 30/378 Wby.

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Types of Chatter:

Different types of chatter? Yep, there are two types that bother the gunsmith—we refer to them as high-frequency and low-frequency.

High-frequency chatter is the type that most often bedevils the 'smith. You know it right away because you can feel it in the tailstock as you're feeding the reamer, likely can see the reamer jumping around in the partial chamber, and may even be able to hear it (unless you've shot too much without hearing protection). Upon withdrawing the reamer from the barrel, high-frequency chatter is also evident in the needle-like shavings on the reamer.

Low-frequency chatter, on the other hand, is more subtle and difficult to detect. Many times a 'smith will chamber a barrel, headspace it to the action and test-fire the gun, only to eject a case that exhibits a series of flats around its body, shoulder and neck. Generally, this type of chatter can't be felt in the tailstock, doesn't make any noise, and generates normal-looking chips. The only hint that something might be amiss is "pulsing" of cutting oil at the entrance to the partial chamber. Low-frequency chatter can also be detected if the 'smith shines a light in the chamber as it's rotating when the reamer is withdrawn to clear chips—he'll see a series of flats reflecting the light as the barrel turns.

A point of interest: If one counts the number of flats, there will usually be 7 or 13—a multiple of the number of cutting teeth, plus 1. If you've ever drilled sheet metal with a 2-flute twist drill, you remember the three-lobed hole. Without any hard-and-fast statistics, high-frequency chatter happens in any type of barrel steel. In our experience, low-frequency chatter seems to occur more often in barrels made from work-hardening grades of stainless steel. We theorize that it starts after feeding the reamer too slowly, so as to allow the development of a "skin" inside the chamber, somewhat harder than the material below it. When cutting through this "skin", the reamer cuts unevenly and low-frequency chatter begins. Keep in mind, it's a theory; we'd be happy to hear your experiences and opinions.

Other factors, of course, include the possibility of a defective reamer, and every manufacturer has let a bad one out at one time or another. The geometry can be bad, tooth-to-tooth height can exceed workable limits, or the pilot and/or shank can be eccentric to the cutting portions of the reamer. The 'smith isn't usually able to check tooth position (rake) but he can check runout (eccentricity) if he has a mag base/dial indicator and a way to turn the reamer between non-rotating centers.

Carefully clean the reamer's centers, place it between centers and locate the pointer of the indicator—with .020" or so preload--on the section of the reamer to checked for runout. Turn the reamer on centers under the indicator and note the difference between the high and low reading. On shanks and pilots, there should be no more than .0005" Total Indicator Reading (TIR); cutting teeth should show no more than .001"TIR. We like to see half of these limits, or less, in our reamers. If you suspect the tool's geometry is bad, or have measured TIR and found it exceeds the limits given above, return the reamer to its maker for repair or replacement. Some faults can be corrected, some can't, but the manufacturer should stand behind his product.

What can you do if chatter starts while you're chambering? This is the crux of it all, because no one wants to cut a chamber with chatter in it. First thing—stop as soon as you suspect there's chatter. Don't continue to cut deeper with the same parameters, thinking it will go away. Unless you're extraordinarily lucky, it will only get worse—can you make a washboard road smoother by driving on it? The following suggestions assume you've checked the reamer as described above and found it in-spec. None of them are infallible, but all have proven to work in *some* instances.

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General machining rule of thumb if something chatters is to reduce the spindle speed, increase the feederate, or both. By doing this, you're loading the reamer more heavily and the tool is less likely to be able to vibrate, ie:chatter. Check your reaming "system" for possible sources of vibration that may be inducing chatter and tighten or eliminate any looseness. Sometimes a little hand pressure on the barrel as it turns can cause the reamer to smooth out—this is a sign you're close to a vibration node that might be eliminated by changing federate and/or spindle speed. When experimenting with different spindles speeds, recall that our reamers can be run as high as 300-350 RPM without damage.

Check the fit of the pilot to the bore, there should be very little play. If using pilot bushings, select one that will fit the bore with a very slight drag. It should turn on the reamer's spindle smoothly, with virtually no play.

If you're lucky enough to have a second reamer in the same caliber, try it—often another reamer will have teeth spaced sufficiently differently that it will remove chatter caused by the first and continue to cut smoothly.

Some 'smiths recommend using a boring bar to remove chatter before attempting to cut the chamber deeper. This removes the chatter, but, if taken too deep, will keep the pilot from being engaged in the bore when the shoulder of the reamer starts to cut.

A technique that works quite well is "the patch trick". This involves using cleaning patches on the reamer to damp vibration while chatter is gradually cut away. Different versions of this technique employ greased paper or other materials, but follow the same concept.

Assuming a 30-cal reamer has chattered, chose a number (6-12) of thick cleaning patches about 1 ¼" square and poke holes in their centers large enough to allow the patch to slip over the neck of the reamer and lay against its shoulder. Note, for smaller bore sizes, use proportionately smaller patches; if patches are thin, use two at a time. Slide a patch on the reamer so it lies against the shoulder and resume cutting the chamber again under power.

While cutting, hold your left hand on the reamer or holder so you can feel when the reamer cuts through the patch and starts to engage the chatter—you'll feel the reamer "tug" when this happens. As soon as you feel the tugging, pull the reamer out of the cut, replace the patch and repeat the process. You may have to repeat this a number of times, but the chatter should slowly be removed from the chamber. Once it's gone, continue cutting to proper headspace; if the reamer continues to want to chatter, keep using patches until the chamber is complete. What you're doing with all this is gradually cutting the peaks of the chatter until the surface of the chamber is the same height. The patches serve two purposes—they damp vibration caused by the chatter and fill the low points of the chatter during reaming.

In conclusion, I'd like to paraphrase an old saying: "There are those who haven't experienced chatter but will, and those who have experienced chatter…..and will again!" It's one of the problems that occasionally needs to be overcome during the chambering process. Hopefully this article has given the reader some insight into the causes of chatter and provided a few tools for dealing with it.

Written by Dave Manson, *Founder of Manson Precision Reamers*
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