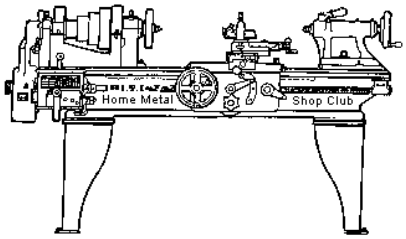
November 2015
Newsletter

Volume 20 - Number 11



http://www.homemetalshopclub.org/

The Home Metal Shop Club has brought together metal workers from all over the Southeast Texas area since its founding by John Korman in 1996.

Our members' interests include Model Engineering, Casting, Blacksmithing, Gunsmithing, Sheet Metal Fabrication, Robotics, CNC, Welding, Metal Art, and others. Members enjoy getting together and talking about their craft and shops. Shops range from full machine shops to those limited to a bench vise and hacksaw.

If you like to make things, run metal working machines, or just talk about tools, this is your place. Meetings generally consist of ***general announcements***, an ***extended presentation*** with Q&A, a ***safety moment***, ***show and tell*** where attendees share their work and experiences, and ***problems and solutions*** where attendees can get answers to their questions or describe how they approached a problem. The meeting ends with ***free discussion*** and a ***novice group*** activity, where metal working techniques are demonstrated on a small lathe, grinders, and other metal shop equipment.

President	Vice President	Secretary	Treasurer	Librarian
Vance Burns	*Norm Berls*	*Joe Sybille*	*Emmett Carstens*	*Ray Thompson*
Webmaster/Editor	Photographer	CNC SIG	Casting SIG	Novice SIG
Dick Kostelnicek	*Jan Rowland*	*Martin Kennedy*	*Tom Moore*	*Unfilled*

This newsletter is available as an electronic subscription from the front page of our website. We currently have 905 subscribers located all over the world.

About the Upcoming December 2015 Meetings

The next scheduled general meeting will be held on 12 December at 12:00 PM (Noon) at "Roll Formers of Texas" (Gene Rowan's shop). There will be demonstrations plus talks. Please bring your show & tell items. Also, come with safety gear! If you plan to touch anything - you'll need gloves, safety glasses, etc, etc. If you would like to demonstrate (we so seldom have a place like this to do it) let Vance or Norm know and they will run it by Gene for an OK. Gene has also kindly offered to provide a Bar-B-Que lunch at the meeting.

Visit our website for up-to-the-minute details, date, location maps, and presentation topics for future meetings.

General Announcements

Videos of recent meetings can be viewed on the HMSC website.

The HMSC has a large library of metal shop related books and videos available for members to check out at each meeting. These books can be quite costly and are not usually available at local public libraries. Access to the library is one of the many benefits of club membership. The club has funds to purchase new books for the library. If you have suggestions, contact the Librarian *Ray Thompson*.

We need more articles for the monthly newsletter! If you would like to write an article, or would like to discuss writing an article, please contact the Webmaster / Editor *Dick Kostelnicek*. Think about your last project. Was it a success, with perhaps a few 'uh ohs' along the way? If so, others would like to read about it. And, as a reward for providing an article, you'll receive a free year's membership for the next renewal cycle!

Ideas for programs at our monthly meeting are always welcomed. If you have an idea for a meeting topic, or if you know someone that could make a presentation, please contact Vice President *Norm Berls*.

The Battleship Texas is looking for docents for the metal shop located inside the ship.

The annual swap meet is scheduled for 5 December 2015 from 9:00 A.M. to noon. The location is 3119 Jensen Drive, Houston, Texas. This is your opportunity to sell or trade items which no longer hold your interest. This is also your opportunity to acquire a tool or two that you have been contemplating.

Recap of the 14 November 2015 General Meeting

By *Norm Burls*

The Home Metal Shop Club had an exhibit at the recent Mini Maker Faire (November 14, 2015) held at the GRB convention center. HMSC had a banner and stand as well as numerous displays. The displays included a Stirling hot air engine fan by Dick Kostelnicek and an array of measuring and other hand tool by Norm Berls.

Vance Burns, Emmett Carstens and Norm Berls staffed the booth throughout the day. They handed out an entire box of business cards on behalf of HMSC. They had numerous visitors and answered a lot of questions.

The Maker Faire seemed to be well attended despite the road construction going on in front of GRB convention center. There had to have been thousands of attendees there. Many of the other exhibitors dealt with 3D printing and robotics. Other exhibitors were there to publicize various "maker barns" and facilities around the Houston area. These included George Carlson, an HMSC member and one founder of the Woodlands maker barn.

The HMSC exhibit was the only one dealing with metal working. Several HMSC members showed up, spent time at the exhibit, and helped answer questions. The attached photograph shows Vance Burns, Emmett Carstens and a fellow traveler at the HMSC exhibit.

Articles

Making Gear Cutters with Buttons

By *Alan May*

A couple of model engines I have built required gearing to reduce the RPM by half to accommodate valve cams and ignition. Both designs called for 48 pitch gears. Pitch is approximately the number of teeth per inch of circumference. I found pricing gear cutters a sobering experience.

There are two main flavors of gears 14 ½ ° and 20° pressure angle. The 14 1/2° pressure angle is said to be obsolete, but also is said to have less backlash. More importantly, I found that 14 1/2° cutters could be obtained from Traverse Tool Co. for $41, while 20° cutters are $78. And of course I need two cutters, as each cutter is limited in the number of teeth it is designed to cut. A total of eight cutters are needed for each pitch to cover gears from a small number of teeth through rack or flat gear.

I bought 14 1/2° cutters #2 (55 – 134 teeth) and #3 (35 - 54 teeth) for the first engine, and then made do using a #3 to cut 20 teeth for the second engine, ignoring good practice. It seems to work OK, and long term wear is not an issue. Of course it would be better to have a proper gear.

I also have need of a pinion for a small metal shear / bake that I use mostly for cutting circuit boards. I made a replacement with the Mototool method of making a fly cutter type gear cutter, and it worked out *sort of*. It needed a lot of filing to get it to work at all. I had been stumped because it is a metric gear.

Making Gear Cutters with Buttons

Recently, I focused for the first time on making gear cutters using hardened small disks or buttons, which are said to come very close to the involute curve required for a proper tooth. The buttons are small hardened disks with stems like a flower. Machinery's Handbook has a table giving inch dimensions for metric gears. (Page 2220 of my computer copy.)

The main publication on buttons for gears is a book by Ivan Law, who apparently invented the button process. His book will tell you more than you want to know about gears, but it also has a good section on making a cutter using buttons. The book gives dimensions for the diameter of the buttons, the center distance between them, and the stock advance to get a proper tooth shape. The tables give numbers for a DP or diametric pitch of 1" (inch) or Module #1 (metric). To find the inch based numbers for the pitch you want, divide the table amounts by the pitch number you need. To find mm dimensions, multiply the table numbers by the module number.

Law's book has a couple of gaps, for me anyway. First, Mr. Law has no use for gears of less than 20 teeth, so his tables stop at 20. He also gives nothing regarding a 14 1/2° pressure angle gear. Unlike other authors, he suggests that the buttons have an installed 4° top rake, which means 9° stand alone slope, as the top of the holder should have a 5° forward slant to provide front rake.

The internet provides articles by D. J. Unwin, John Stevenson. and Mike's Workshop. All three have button tables which are close to the same, and yet are quite different from Law's tables, as much as 70% in some cases. Mike goes into considerable detail to support his calculations. The others are silent for the most part. I decided to go with the majority. Copies of Mike's Workshop tables are attached to this article.

Interestingly, Stevenson and Unwin provide infeed from the first contact with a blank with the exactly prescribed width, exactly centered between the buttons. Law and Mike measure infeed from the front of the button. That's much easier to accomplish. You can set the starting place by taking a light cut on the blank with one of the buttons and with the blank a little wider than necessary. It does not have to be exactly centered.

Buttons for Metric 1.5 Module Cutter

I determined the module for the metric pinion to be #1½ by measuring the diameter of the old pinion in mm, and dividing it by the number of teeth plus 2. (Machinery's Handbook p2219.) Machinery's also told me that the inch based Diametric Pitch for a 1½ Module is 16.933. (p 2220).

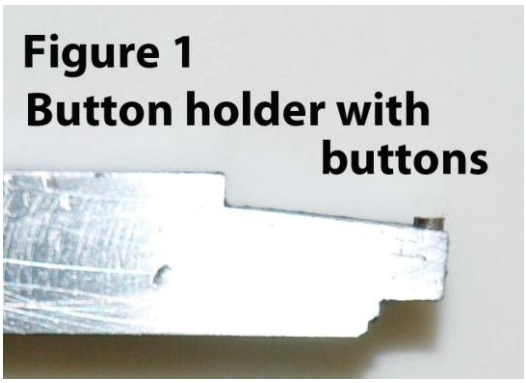
I need a 12 tooth gear, so Law's tables were out no matter what as they stop at 20 teeth. Going with Mike's table for a 20° - 12 tooth gear, I divided the 20° pressure angle numbers by 16.933. This resulted in a button diameter of 0.242", center distance of 0.308", an infeed of 0.131" from the front of the buttons, and minimum tool width 0.236". I even remembered to double the infeed distance on the cross slide. For this gear, I added 4° top rake. However, I am not persuaded that it helped. Law says the highpoint of the button should be turned half way to the center. Positive top rake at an angle pretty well eliminates grinding after hardening and mounting.

Stevenson, Unwin, and Law all give guidance as to mounting the buttons. They suggest that the button holder be tapered 5° forward, which gives the buttons 5° front rake. Stevenson and Unwin suggest no top rake on the buttons. This I like, as you can grind the button tops with a cup wheel on a mill, getting them sharp and of equal height after hardening and mounting. Since they are mounted with a 5° degree forward slant, the tops must be ground flat anyway. Otherwise, there would be negative top rake. I may try straight forward top rake next time. The buttons should be hardened, and according to all authors, tempered.

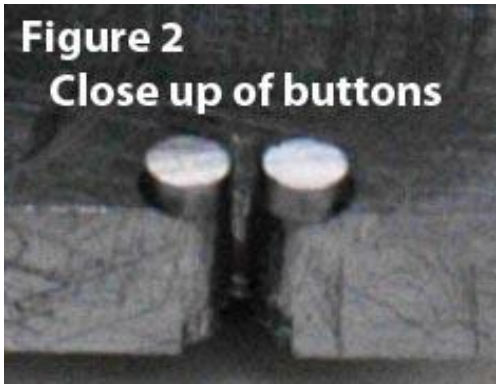
Button Holder

If making a circular cutter, the total height of the holder and buttons must be less than the tooth gap. If too big it will be stopped by the front of the following tooth. There is no such problem for a fly cutter type cutter.

Important! Drill the holes for the button stems at the same time with the same setup as when the 5° forward slant is milled on the holder, so the stem holes will square with the slanted top. The stem hole edges need to be relieved a bit so the buttons will sit flat on the holder. Small button stems need to be fitted to the holder by trial and error. Small drills drill oversize. I fixed the buttons to the holder with Locktight.

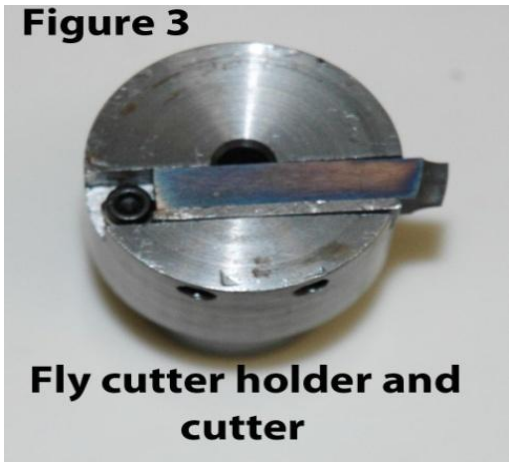


The smaller the stem compared to the button, the easier it is to relieve the holder to expose the button while leaving as much support as possible. I found that the easiest way to cut a path between the buttons is with a slitting saw. The rest is file work. Mark the holder with layout blue, temporarily mount the buttons, and mark their outline on the holder. See figures 1 and 2.



Fly Cutter Type Gear Cutter

Law's book provides dimensions for a fly cutter type gear cutter, and I made a similar one to cut a metric gear for the small metal shear/ brake. Note the 1/16" spacer in the slot shown in figure 3. You put the spacer above the ¼" blank when forming the tool, and below it when cutting a gear. I added the #4 cap screw in the slot to keep the blank from retreating into the holder when forming and relieving. The



holder is about 1.5" in diameter. The top of the cutter slot intersects the tool's center. The cutter can be shaped with the lathe running, but very slowly with very light cuts. It is necessary to shape the end of the cutter with a square tool or a button so the tip of the cutter, which passes between the button will be the right depth. If this process is done with a button, the starting place to measure infeed is set.
I think the gear cut with the fly cutter came out rather nicely. See old and new gears in figure 4.

Old and new metric gears
Figure 4

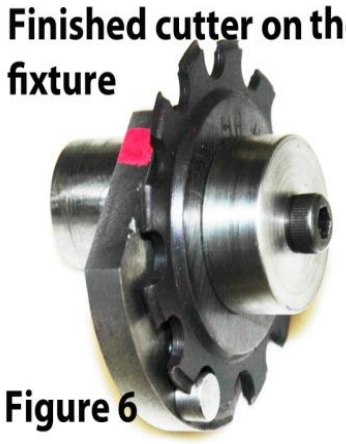
DP 48, 20 Tooth Pinion Cutter

For the 20 tooth engine gear, I went with Mike's table again, the only one for 14 1/2° pressure angle gears. I used 14 1/2° because that is what I used for the large gear made with a purchased cutter. The pitch for that gear was 48, about as small as you get outside of a watch. Applying 48 to the table, I got button diameter of 0.089", center distance of 0.116", and infeed of 0.053" from the front of the button. Also, the minimum cutter width is 0.083".

I decided to make a circular cutter. I have some A2 ¼" x 2 ½" air hardening steel not being used, so I cut off a piece. I elected a 7/8" bore because I have a nice 7/8" keyed arbor to mount the finished cutter. About a 5° front rake will result from a ¼" slot milled square on the radius of the blank. From a quick and dirty trial run, I learned that the gap between the teeth needs to be wide enough to allow the entire button assembly to enter, or it is stopped by the following tooth, so I milled a 5/16" gap. It helps if the blank is reduced in width so slot can be cut with one pass. I thinned the outer 1/2" to about 0.100" taking equal amounts from each side. I decided on 12 teeth as about right for 2 ½" cutter. Once the blank rim was thinned, I profiled the entire blank with the button tool. Then I cut the gaps 5/16".

Top rake is cut by mounting the blank ¼" below center and manually rotating the blank in the lathe. This might be accomplished using a 4 jaw chuck or with a fixture. Cutting starts at the trailing end of the tooth and continues to just reach the cutting edge. A 4 jaw chuck could work, but it would hard to center all the teeth the same. The tip of the cutter blank will not be relieved with the button tool because it will pass between the buttons, so it needs to be relieved separately with a square tool. Do this first because it leaves burrs on the sides. I made a fixture, really the only way to go. It has a pin on chuck side shaft to keep it from slipping, which can be a problem. If it slips, the offset will no longer be 90° from the buttons. There is a short pin that fits the slot in the blank so all teeth are held the same.

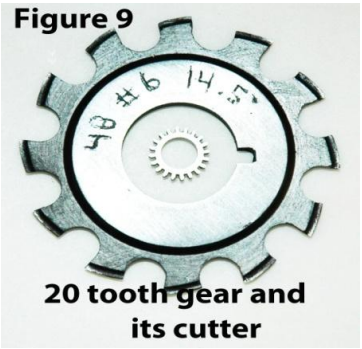
The pin is threaded so it can be moved around for other blanks or replaced with a different size. I used a bar stuck in a key hole to turn the chuck. See figures 5, 6, 7, and 8. The extra threaded hole in figure 5 shows that I first put the pin in the wrong place.



Procedure for 48 Pitch 14 1/2° Pressure Angle, Gear Cutter #6 17-20 Teeth:

- Bore an accurate hole in the blank, mount it on an arbor, preferably keyed and make it circular.
- Reduce the width of the blank to about 0.100". Remove stock from both sides. Thin the outer ½" of the disk.
- Profile the tooth shape for the whole disk with the button tool. Run the work dead slow. (The first time I did this with tempered buttons, stock removal between the buttons and the work was a tie. I may have run the lathe too fast.)
- Mount the blank on a rotary table and cut the gaps between the teeth with a 5/16" mill 3/8" deep. Provide for 12 teeth.
- Mount the blank on a fixture centered ¼" below the center of the lathe spindle.

- Turning the lathe chuck by hand, with a square tool, relieve the tip of each tooth. Mark the tooth tip with a red marker (more visible than black) and stop when the mark is just barely removed at the cutting edge of the tooth. Mark the cross slide and cut each tooth the same. Do the tooth top first because there will be a burr on the sides of the tooth from this procedure.
- Using the button tool, and turning the lathe by hand, cut the tooth profile relief. Mark the sides of the tooth with red and stop when the cutting edge is reached. Note the reading on the cross slide. Cut all the teeth to the same depth.
- Check carefully and remove any burrs.
- Sharpen any teeth that appear dull.
- Mark the cutter with its DP, pressure angle, and cutter number.
- Harden and temper.
- Check the leading edge of each tooth and sharpen as necessary.



See figure 9, the finished cutter, and the gear it made. I tested the new gear with one I cut with a purchased gear, and it seems to be just fine. See figure 10. I made the little fixture to check the practical center distance of gears before I drilled holes for their shafts. There are imprecise settings in gear making, like centering the cutter, which will effect the gears if a bit off. I have had some unpleasant surprises relying on theoretical dimensions.

Final thoughts:

The smaller the diameter of a circular cutter, the closer the gear blank can be mounted to the dividing head or rotary table, and the shorter the feed to cut each gear tooth, an advantage. The commercial cutters I have are 1.75", and have 16 teeth with gaps of 3/16". There is a lot of stress on the holder, so it is best to thin the buttons rather than the holder. Next time I will try to make the cutter as small as possible. The fly cutter approach is probably more efficient for only one gear, and it has a smaller diameter. Only a few of the teeth on a circular cutter do all the work anyway, just like a slitting saw. Not as satisfying as producing a circular cutter though.
A couple of tables follow, button data from Mike's Workshop, and a gear dimension spreadsheet based on data from Machinery's.

Fig. 10

Questions for the author? Contact Alan May - almay@swbell.net or the Tinkering newsletter site.

Button Tables from Mike's Workshop

Mike's Workshop

14.5°		Base DP=1" or Module = 1			
No.	Teeth	D Button D	C Cen. Dis.	E In Feed	W Blank
1	135 - R	33.801	34.195	13.631	4.000
2	55-134	13.771	14.799	6.118	4.000
3	35 - 54	8.763	9.947	4.235	4.000
4	26 - 34	6.510	7.762	3.384	4.000
5	21 - 25	5.258	6.547	2.910	4.000
6	17 - 20	4.256	5.574	2.528	4.000
7	14 - 16	3.505	4.842	2.240	4.000
8	12 - 13	3.005	4.352	2.045	4.000

E measured from front of button.
Divide by DP to get dimensions.

Mike's Workshop

20 °		Base DP=1" or Module = 1			
		D	C	E	W
		Button	Cen.		
No.	Teeth	D	Dis.	In Feed	Blank
1	135 - R	46.173	44.772	16.091	4.000
2	55-134	18.811	19.056	7.083	4.000
3	35 - 54	11.971	12.624	4.827	4.000
4	26 - 34	8.893	9.727	3.809	4.000
5	21 - 25	7.182	8.116	3.242	4.000
6	17 - 20	5.814	6.825	2.786	4.000
7	14 - 16	4.788	5.855	2.442	4.000
8	12 - 13	4.104	5.207	2.210	4.000
9	10 - 11				

E measured from front of button.
Divide by DP to get dimensions,

The following table is a copy of my Excel spreadsheet I put together for calculating gear dimensions. I have shown the data for the metric gear described above. Of course, on my computer the calculations are automatic, but the formulas are given in the table. All that is really needed to make a gear is the outside diameter and the tooth depth. The center distance is helpful in assembly.

Gear Cutting Calculations - English – Inch

Fill in Blue Cells			Pressure Angle			
Calculated amounts			14.5°		20° & 25°	
DP	**diametrical pitch***	**16.933**				
	desired ratio (gear/pinion)	**1**				
Gear						
N1	**number of teeth #1**	**12**				
Do	**outside diameter**		(N+2)/P	**0.827**	same	**0.827**
Ht	**whole depth of tooth:**					
	Old obsolete 1932		2.157/P **	**0.127**	1.800/P	**0.106**
	Current: 1968					
	Fine P>20		(2.2/P)+ .002 **	**0.132**	same	**0.132**
	Coarse P<20		2.250/P **	**0.133**	same	**0.133**
D1	Pitch diameter		N/P	**0.709**	same	**0.709**
Pinion						
N2	**number of teeth #2**	**12**				
Do	**outside diameter**		(N+2)/P	**0.827**	same	**0.827**
Ht	**whole depth of tooth**					
	Old obsolete 1932		2.157/P **	**0.127**	1.800/P	**0.106**
	Current: 1968					
	Fine P>20		(2.2/P)+ .002 **	**0.132**	same	**0.132**
	Coarse P<20		2.250/P **	**0.133**	same	**0.133**
D2	Pitch diameter		N/P	**0.709**	same	0.709
Center distance			(N1+N2)/P X 2	**0.709**	same	**0.709**
	also		(D1 + D2) / 2			

* The number of teeth per inch of pitch circle diameter - Pitch "P"

** Per Machinery's Handbook