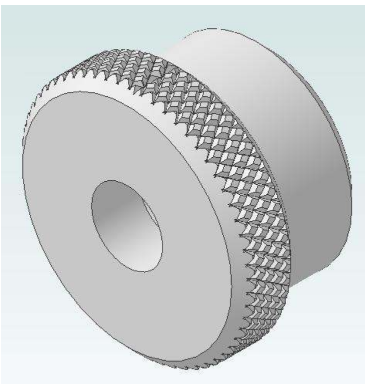
Knurling, Version 2

By R. G. Sparber



Knurling involves mostly[2] the deforming of metal which produces a surface pattern. This pattern can be just decorative or can be precisely controlled to change the outside diameter.

The extremely odd thing about knurling is that it works at all. When done correctly, it works every time on any diameter and on any material. Yet, if you look at a simple model of the process, it becomes clear that knurling cannot work except for very special cases.

Many people tell me they can't ever get a decent knurl. Others vent their frustration saying that it sometimes works yet they don't know why. And then there are a few that say that it works every time.

Clearly the simplified theory is incomplete. In fact, even the information in Machinery's Handbook is, gasp, incomplete. The book talks about the relationship between characteristics of the knurling wheels and the diameter of the work piece. In particular, that the work piece diameter must be a whole number multiplied by a parameter calculated from the outside diameter of the knurling wheel and the number of teeth it contains. If you start with an "approved" diameter, your knurl will come out right. What they fail to say is that if you start with an unapproved diameter, your knurl may also come out right.

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2 An inspection of the knurling wheels and surface of the work piece show a film of oil saturated with particles of metal. So some material removal does take place.

The factor not addressed in my simple theoretical model is that the work piece is in a "plastic" state. In other words, it squishes around under the pressure of the knurling wheel. You may be able to see this by knurling aluminum and then steel. The much softer aluminum will knurl correctly more often than the steel given the same technique.

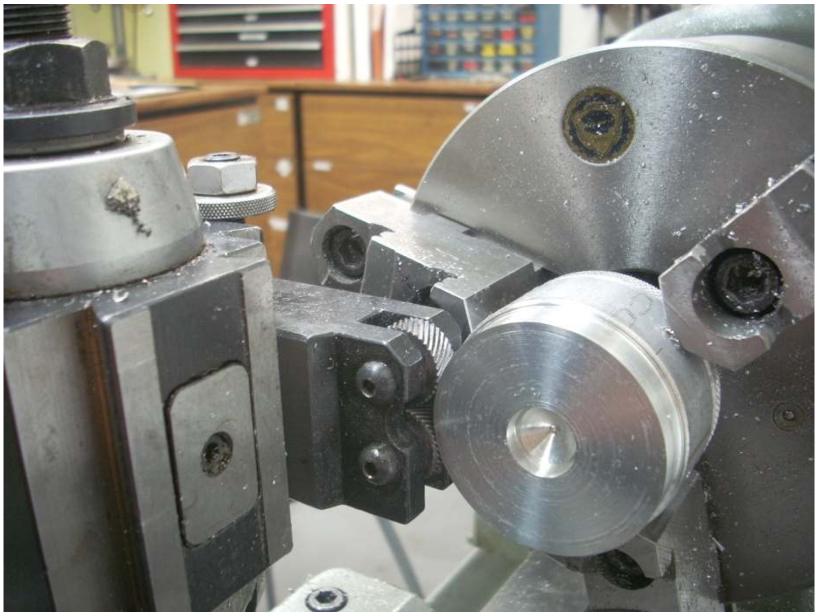
Here you see three test passes in aluminum. The one on the right and middle match the guidelines in Machiniery's Handbook. The one on the left is as far from the correct value as it physically possible. Yet they all came out looking the same.

This sample was formed in 12L14 leaded steel. After many attempts to find the exact diameter that will give a screwed up knurl, I decided to cut a 2.5° taper and then run the knurling tool along that taper. If the dominant variable in knurling was the diameter of the work piece, then I expect the pattern to vary from poor to perfect and then back to poor.

Instead, I see that the pattern looks fine across the entire range of diameters. Only when the tool jumped up to the uncut diameter did I start to see one of the knurling wheels jumping around and generating a fine structure. The other wheel stayed in sync.

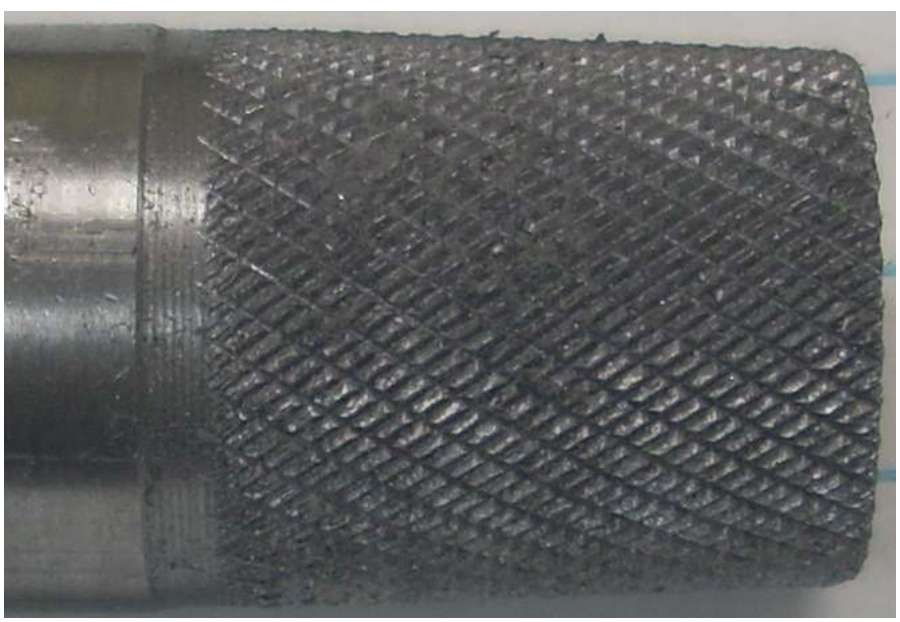
Factors that Effect Knurling

The biggest factor I found was the knurling tool design.



I was using a knurling tool that came with my Phase II Quick Change Tool Post.

It has at least two design flaws. The first is that all force is applied from one side. This puts a lot of stress on the lathe's apron and could cause damage. Second, it is very hard to get the two wheels to apply the exact same force on the work piece. The tool must be exactly on center. If it is a little off center, one wheel will dig into the work piece while the other just grazes it. The wheel with the deeper imprint will lock into that pattern and reinforce it. The other wheel could form multiple other imprints and jump between them.



This is, at least, one explanation for my odd dual pattern I generated on this tapered work piece.

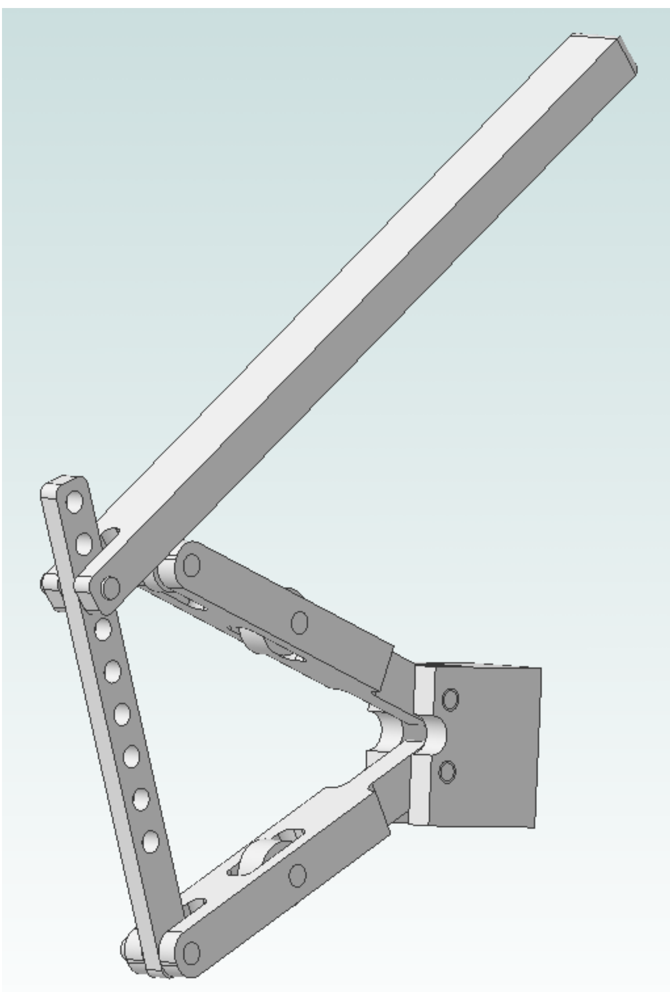
The lines going from upper left to lower right are at the same spacing as the knurling wheel. The lines going from upper right to lower left are at half of the spacing. In other words, this wheel imprinted at twice as many places.

“Doc”, from the metal_shapers Yahoo group, described his knurling tool which “has never failed him”. It took about 10 minutes to rig up a test of his idea.

My proof of concept machine used the existing knurling wheels and the body of the QCTP knurling support. I added a few bits from my scrap bin and screws. My first attempt at knurling was on 5/8” diameter 12L14 and it worked perfectly. I then tried it on some 2 ¼” 12L14 and got the same great result.

So what does this arrangement have that is good? First of all, there is very little stress on the apron of the lathe. As I pull down on that wide, thin plate at the top, it squeezes the knurling wheels together in a scissor action[3]. The QCTP and apron must withstand my downward force but that is a lot less than the infeed of the wheels with the old arrangement. Second, the knurling wheels are close to being on opposite sides of the work piece. The downward force from the top wheel matches the upward force of the bottom wheel. There is no possibility of misalignment.

What didn't work so well? The bars were a very loose fit to the QCTP tool holder so the assembly did twist from the knurling force. The design corrected this problem.



Here is a rendering of my finished design. Details will be given in a later article.

I set the width of the knurling arms at the QCTP tool holder to be a close fit.

The top pin that joins the lever arm to the vertical bar is easily removable. That is how I adjust the tool for different diameters of work pieces.

If the arms bind on the work piece, I can back the QCTP block away from the part. The knurling wheels will then be off of the diameter which is not ideal. But it is still much better than having them both pushing on the same side.

I have only used this tool to knurl at a fixed place. Moving it along the work piece does cause the QCTP to rotate. An additional support on the arms will be necessary.

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[3] There is nothing new here. Plenty of good knurling tools use this arrangement of knurling wheels.

Having the right knurling tool is just the first step. I had to learn how to correctly use it.

I adjust the knurling arms so they are perpendicular to the axis of rotation of the lathe. This seems to minimize twist of the tool. Some prefer to set the wheels on an angle in order to minimize the total force applied.

Before each use, wash out any metal particles coating the knurling wheels and area around these wheels. Then apply spindle oil to the knurling wheel axles. Just before starting the knurling process, coat the work piece with cutting oil. For aluminum I prefer WD40. On steel I use commercial cutting oil.

I tried various RPMs and didn't see much difference. In the end I ran at around 200 to 300 RPM. Some will say to run at the lowest possible speed. Others say run at the same speed as for normal single point turning.

This next step appears to be critical to repeatable knurling. You need to get the knurls to bite into the work piece and stay synchronized as it turns. I do this by pushing down on the knurling handle before starting the lathe. The knurling wheels bite into the work piece. Then I start the lathe and apply more pressure. Once a clean pattern has been established, I can turn off the lathe, swing the knurling wheels out of the way and inspect the result. If I want to knurl a bit more, it is easy to drop the wheels back into the pattern where they will stay put.

So far I have not formed a single poor knurling pattern using my new scissors tool plus the procedure shown above. May you have the same happy experience.

Acknowledgements

The outpouring of help on this adventure has been amazing. I need to thank “doc” from metal_shapers for many bits of essential wisdom. Neil and Gene from valleymetal provided facts that have been of great help in seeing what is important. JR Williams, Gordon Long, Alan Lapp, and Ian Newman of metal_shapers have provided many practical tips which I will use in subsequent versions of this article. Steve from metal_shapers provided a few links to huge bodies of information on knurling. I’m still working through it. Thanks to L. Garlinghouse of atlas_craftsman for his advice on lubrication.

I must also acknowledge the authors of Machinery’s Handbook for a well written section on knurling.

These generous people again demonstrate that “all of us are smarter than any one of us”.

I welcome your comments and questions.

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