Phantom
THERE'S NO END TO WHAT YOU CAN DO

Knurling Manual: A Clear Explanation

This manual helps you step-by-step with applying a knurling pattern on metal workpieces using a lathe.

What is Knurling?

Knurling is a technique to apply a pattern (usually for grip or decoration) to a round workpiece. There are two main methods:

- **Knurling by Pressure (Forming):** This involves pressing rollers against the metal, causing the material to be cold-formed. The diameter of the workpiece increases slightly. This is the most common method.
- **Knurling by Cutting (Milling):** This involves cutting away material with special rollers, similar to milling. This often yields a cleaner result and works better on hard or tough materials.

Key Concepts (The Basis for Success)

Before you begin, it's crucial to understand these four concepts:

- **Pre-turning Diameter:** This is the exact starting diameter of your workpiece before you begin knurling. This measurement is extremely important. The circumference of your workpiece must precisely 'fit' the pattern of your knurling wheel. A small deviation here leads to a messy, overlapping pattern. You must therefore pre-turn this diameter very accurately (within ± 0.025 mm).
- **Pitch:** This is the distance between the teeth on the knurling wheel. This value determines how coarse or fine your knurling pattern will be.
- **Knurling Depth:** The depth of the pattern is always half of the pitch.
    - *Example:* For a pitch of 1.0 mm, you set the tool 0.5 mm deeper after it touches the workpiece.
- **Lubrication and Cooling:** This is essential and not optional. Use coolant-lubricant continuously and generously. It prevents overheating, ensures a nicer pattern, and washes away metal particles that could block the rollers.

Method 1: Knurling by Pressure (Forming)

This is the most common method for applying a knurl.

1. Preparation

- **Calculate the Pre-turning Diameter:** Determine the desired pre-turning diameter based on the formulas at the bottom of this document. (The rule of thumb is that the diameter increases by 30-40% of the pitch).
- **Turn the Workpiece:** Turn the workpiece very accurately to the calculated pre-turning diameter. Ensure a smooth surface.
- **Check the Knurling Wheels:** Make sure the wheels in the holder are clean, turn smoothly, but do not have too much play.

2. Setup on the Lathe

- **1 Wheel:** Position the holder so that the knurling wheel is exactly on the center line (center height) of the workpiece.
- **2 Wheels:** Position the holder so that the two wheels clamp symmetrically around the center line. Most holders for diamond knurls are self-centering.

3. Execution

- **RPM (Revolutions Per Minute):** Set the lathe to the correct RPM; consult the forming speed table for this.
- **Lubricate:** Apply coolant-lubricant generously to the workpiece.
- **The Infeed:** Start the lathe. Press the knurling wheels quickly and decisively into the workpiece to the desired depth (approximately 0.5 x the pitch). Do not hesitate, as a slow infeed will result in a poor pattern.
- **Longitudinal Feed:** Immediately engage the automatic longitudinal feed. Let the tool move over the desired length. Continue to lubricate continuously!
- **Retraction:** At the end of the pass, retract the knurling holder from the workpiece and disengage the feed and the lathe.
- **Check:** Inspect the result. If necessary, you can make a second pass. Ensure that the rollers fall exactly into the existing grooves before applying pressure again.

Method 2: Knurling by Cutting (Milling)

This method uses special milling knurl holders for a very clean result, especially on materials that are harder to deform, such as stainless steel or plastics.

1. Preparation and Setup

- **Mount the Wheels:** Place the milling wheels in the holder as indicated in the holder's manual. Use some heat-resistant grease. Make sure they can turn smoothly.
- **Position the Holder:** Adjust the holder to the exact center line of the lathe.
- **Secure the Head:** Set the holder's head (for straight or angled knurls) and secure it tightly with the set screws.
- **Centering (for diamond knurls):** Ensure that both rollers contact the workpiece simultaneously. Do this by rotating the chuck by hand and adjusting the holder until both rollers make contact. Then definitively secure the head.

2. Execution

The process is largely similar to pressure knurling, with the main difference being that this is designed for a single pass.

- **Low Speed and Lubrication:** Set the lathe to the correct RPM; consult the cutting speed table for this, and use coolant-lubricant generously.
- **The Infeed:** Move the holder towards the workpiece. The cutting depth is 0.5 x the pitch.
- **Longitudinal Feed:** Engage the automatic longitudinal feed and move over the desired length. Continue lubricating to wash away chips.
- **Retraction:** At the end, retract the holder from the workpiece. The result should be good after a single pass.

General Tips for a Perfect Result

- **Check the Wheels:** Always ensure that the wheels turn smoothly and are not worn. A worn wheel will produce a poor result.
- **Rigidity is Crucial:** Clamp your workpiece and tool as stably as possible. Use a live center in the tailstock for extra support, especially with longer workpieces.
- **Accuracy:** The pre-turning diameter is the key to success. Measure it twice, rather than once.
- **Material Selection:** Not every material can be easily 'formed' (pressure knurled). Stainless steel, plastic, and copper often yield better results with 'cutting' (milling).
- **Testing:** The recommended speeds and feeds (as in the tables of the original manual) are guidelines. The best results are often achieved by testing on a small sample piece.

Formula for the Perfect Knurling Diameter: A Clear Explanation

The Goal: Why this formula?

To get a neat, clean knurl, the circumference of your workpiece must be an exact multiple of the "pitch" (the distance between the teeth) of your knurling wheel. If it's not, the pattern at the end of a revolution will not align perfectly, and you will get a messy, "double" knurl.

This calculation allows you to adjust your starting diameter slightly so that the pattern aligns perfectly.

The Simple Step-by-Step Method

Use this step-by-step guide with your example: target diameter (D) = 40 mm and pitch (S) = 1 mm.

Step 1: Calculate the circumference of your target diameter

Calculate the circumference you would actually want to have.

- Formula: Circumference = Diameter × 3.14
- Example: 40 mm × 3.14 = 125.6 mm

Step 2: Calculate how many teeth fit on this circumference

Divide the circumference by the pitch of your knurling wheel. The number you get now is the number of teeth that "almost" fit on your workpiece.

- Formula: Number of teeth = Circumference / Pitch
- Example: 125.6 mm / 1 mm = 125.6 teeth

Step 3: Round to the nearest whole number

You cannot have 125.6 teeth. Therefore, choose the nearest whole number. This becomes your target.

- Example: We round 125.6 to 126 whole teeth.

Step 4: Calculate the perfect circumference

Multiply the whole number of teeth (from step 3) by the pitch. This is the new, ideal circumference for a perfect knurl.

- Formula: Ideal Circumference = Whole number of teeth × Pitch

- Example: 126 × 1 mm = 126 mm

Step 5: Calculate your final starting diameter

Divide the perfect circumference by 3.14 to find the final, ideal diameter to which you must pre-turn the material.

- Formula: Final Diameter = Ideal Circumference / 3.14
- Example: 126 mm / 3.14 = **40.13 mm**

Conclusion: To get a perfect knurl with a pitch of 1 mm on a shaft of approximately 40 mm, you must pre-turn the shaft to Ø 40.13 mm.

Summarized in a Formula

If you prefer to use a single formula, it looks like this:

$D_{final} = \pi \text{round}(D_{target} \times \pi) \times S$

Where:

- D_{final} = The final diameter to which you must turn.
- D_{target} = The diameter you originally wanted (e.g., 40 mm).
- S = The pitch of your knurling wheel (e.g., 1 mm).
- π = Pi (approximately 3.14).
- round() = Rounding to the nearest whole number.

Note that for pressure rollers, the outer diameter will increase by 30-40% of the pitch compared to the starting diameter.