# The Morse Tapers

When I started turning and heard about the Morse 2 taper (MT2) in the spindle and tailstock, I thought, well that's an interesting name. I thought Morse was a guy who invented a telegraph code. Let's take a close look at Morse's invention.

The Morse Taper was invented in 1864 by Stephan A. Morse, following his invention the same year of the twist drill. Recognizing the need for a way to drive his twist drill, Morse created the taper shank series. A machine taper is a simple, low-cost, highly repeatable, and versatile tool mounting system. It provides indexability, as tools can be quickly changed but are precisely located both concentrically and axially by the taper. It also allows high power transmission across the interface, which is needed for milling. After patenting, two sets of master gages were made up; one, sent to the Bureau of Standards in Washington, D.C., was accepted as a National Standard. The other remained with the Morse Company.

Machine tool operators must be able to install or remove tool bits quickly and easily. A drill press, to which an operator may want to mount a bit directly, or by using a drill chuck was Morse's inspiration. Another example, a lathe, has a rotating spindle in its headstock, to which one may want to mount a spur drive or work in a collet. Virtually all milling machines, from the oldest, manual machines up to the most modern machines use tooling that is guided on a tapered surface. The machine taper is a simple, low-cost, highly repeatable, and versatile tool mounting system that uses tool bits (or holders) with gradually tapered shanks and a matching hollowed-out spindle.

For light loads (such as encountered by a lathe tailstock or a drill press), tools with self-holding tapers are simply slipped onto or into the spindle; the pressure of the spindle against the workpiece drives the tapered shank tightly into the tapered hole. The friction across the entire surface area of the interface provides a large amount of torque transmission, so that splines or keys are not required. For heavy loads (such as encountered by a milling machine spindle), there is usually a key to prevent rotation and/or a threaded section, which is engaged by a drawbar that engages either the threads or the head of a pull stud that is screwed into them.

All machine tapers are sensitive to chips, nicks (dents), and dirt. They will not locate accurately, and the self-holding variety will not hold reliably, if such problems interfere with the seating of the male into the female with firm contact over the whole conical surface. Machinists are trained on keeping tapers clean and handling them in ways that prevent them from being nicked by other tools

There are other taper standards besides Morse tapers. Jacobs Tapers, commonly abbreviated JT are common in drill press arbors. There are also Jarno Tapers and Brown and Sharpe Tapers among others.

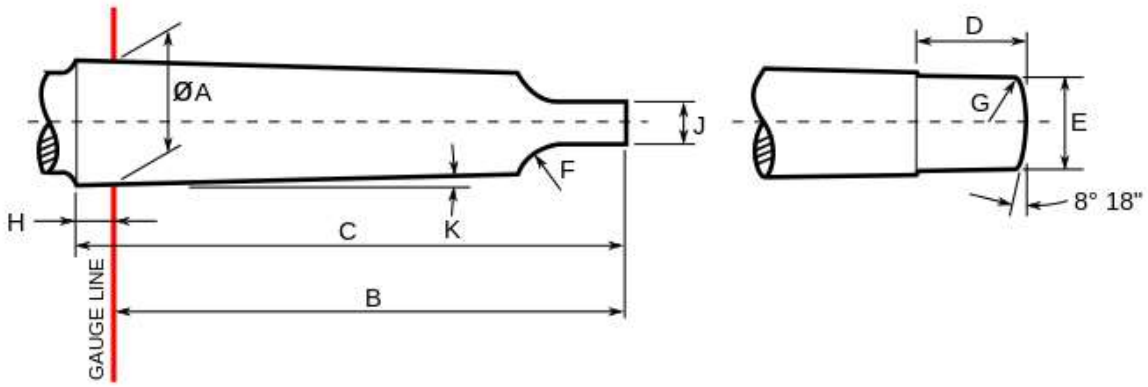
Morse tapers are of the self-holding variety, and can have three types of ends:

- tang (illustrated) to facilitate Positive drive, preventing slippage
- threaded to be held in place with a drawbar
- flat (no tang or threaded section)

Most of my lathe accessories have a flat end, although the MT2 drill chuck I bought has a tanged end.

Self-holding tapers rely on a heavy preponderance of axial load over radial load to transmit high torques. Problems may arise using large drills in relation to the shank, if the pilot hole is too large. The threaded style is essential for any sideloading, particularly milling.

Morse Taper Dimensions




**Morse taper dimensions (mm)**

| Morse taper number | Taper | A | B (max) | C (max) | D (max) | E (max) | F | G | H | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1:19.212 | 9.045 | 56.5 | 59.5 | 10.5 | 6 | 4 | 1 | 3 | 3.9 | 1° 29' 27" |
| 1 | 1:20.047 | 12.065 | 62 | 65.5 | 13 | 8.7 | 5 | 1.2 | 3.5 | 5.2 | 1° 25' 43" |
| 2 | 1:20.020 | 17.780 | 75 | 80 | 16 | 13.5 | 6 | 1.6 | 5 | 6.3 | 1° 25' 50" |
| 3 | 1:19.922 | 23.825 | 94 | 99 | 20 | 18.5 | 7 | 2 | 5 | 7.9 | 1° 26' 16" |
| 4 | 1:19.254 | 31.267 | 117.5 | 124 | 24 | 24.5 | 8 | 2.5 | 6.5 | 11.9 | 1° 29' 15" |
| 5 | 1:19.002 | 44.399 | 149.5 | 156 | 29 | 35.7 | 10 | 3 | 6.5 | 15.9 | 1° 30' 26" |
| 6 | 1:19.180 | 63.348 | 210 | 218 | 40 | 51 | 13 | 4 | 8 | 19 | 1° 29' 36" |
| 7 | 1:19.231 | 83.058 | 285.75 | 294.1 | 34.9 | – | – | 19.05 | – | 19 | 1° 29' 22" |

Converting to inches we have for MT2

**Morse 2 taper dimensions (in)**

| Morse taper number | Taper | A | B (max) | C (max) | D (max) | E (max) | F | G | H | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 1:20 | 0.700 | 2.953 | 3.150 | 0.630 | 0.531 | 0.236 | 0.063 | 0.197 | 0.248 | 1° 25' 50" |

The key takeaway is the taper angle is 1:20 or 1 inch in 20 inches, or 0.05 (five hundredths) of an inch per inch. When Bob Eberhardt said you could easily make one by turning a 5-inch spindle where one end is 1/2" and the other end is 3/4", the difference being 1/4". Well the 5 inches is equivalent to 20 (1/4" lengths) in that 1/4" change in diameter resulting in a taper of 1 in 20. Bob shared a Morse taper worksheet that looked like this.

Morse taper worksheet

| **Morse Taper** | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| **Taper** | Large End | Small End | Length | Taper/ Foot | Taper/ Inch | Angle From Center |
| **#2** | 0.7000 | 0.5720 | 2.56 | 0.5994 | 0.0500 | 1.4307 |
| | 0.75 | 0.5 | 5 | | | |
| | 3/4 | 1/2 | 5 | | | |

Sources:
https://en.wikipedia.org/wiki/Machine_taper
https://littlemachineshop.com/reference/tapers.php
https://beautifuliron.com/mttaper.htm
Bob Eberhardt handout

# Making a Wooden MT2 tapered spindle

Bob gave me a pre-drilled Christmas Ornament blank that needed a 1/4” jamb chuck to drive it properly.  To do that I needed to make a wooden MT2 taper with the 1/4” jamb chuck on it.

I started with turning a cylinder from a piece of maple and marked it with a 5” span.

Next, I used my parting tool to make a 1/2” channel on the left side and a 3/4“on the right staying on the same side of the line in each case.

Next I used my roughing gouge to begin to taper the shaft to the guide lines, finishing with a spindle gouge and then a skew.

After sanding with fine sandpaper glued to a flat board, I was ready to test fit into the lathe's tapered spindle and then twisting it to produce shiny patches that needed further sanding. This is a sand and repeat situation until the taper fits in the spindle solidly, and centers nicely. I found on my Rikon mini lathe, I had to remove over an inch of the taper on the narrow end to have it fit properly. As it said in the specs, the length of the taper must be under 2.953" with a tang and only 2.56" with no tang as measured from the gauge line which is a diameter of 0.70" for MT2.

I reversed the spindle in this picture to shape the thin end, and eventually to shorten it.

After that it is finishing both ends how you desire them.  Then I could mount the taper in the spindle and turn the 1/4“ male jamb chuck on the end to work with the ornament blank. That worked nicely and I could reproduce the ornament similar to the one Bob had made.

I’ll be making more of these MT2 spindles with either unfinished ends or of various sizes to have on hand for future projects.