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Swiss THREADS

All images: D. Nelson

Finished part with 1⅞" length of ¼-20 threads.

Segmenting can be a way to make threads cost effectively on a Swiss-style lathe.

When Nebraska Machine Products (NMP), an Omaha, Neb., job shop, was quoting a part to make on one of its single-spindle, Swiss-style lathes, it was concerned about how it would make the 1⅞" length of ¼-20 threads. Swiss-style lathes are capable of turning parts with high length-to-diameter ratios, but cutting long thread lengths remains a challenge. The lathe's guide bushing limits the lengths that can be turned when taking multiple passes.

While there are a number of solutions to this kind of problem, switching back and forth between turning and threading in multiple segments is often the best solution for shorter runs. Called "segmenting," this technique is commonly performed on Swiss machines.

NMP services several industries—including hydraulic, agriculture and oil field—and is often asked to make parts with thread lengths that exceed the guide bushing length. "This tends to be a problem on Swiss machines," said Chris Cole, Swiss department supervisor. "Swiss machines are great at cutting long and skinny parts, but long thread lengths are a limitation."

Guide Bushing Challenges

The guide bushing on Swiss-style lathes, which have sliding headstocks, directly affects the way parts are made. For example, a typical fixed-headstock lathe, which does not have a guide bushing, calls tools one at a time and completes a tool's operation before calling for the next one, and a machinist can make as many passes as needed. This type of multiple-pass operation is usually not possible on Swiss-style lathes because after the first pass, the material needs to be pulled back into the guide bushing. If the amount of pull-back is longer than the length of the guide bushing, the material will fall out of the support, a major drawback. So, multiple passes can be made only if the length being machined is less than the supporting length of the guide bushing.

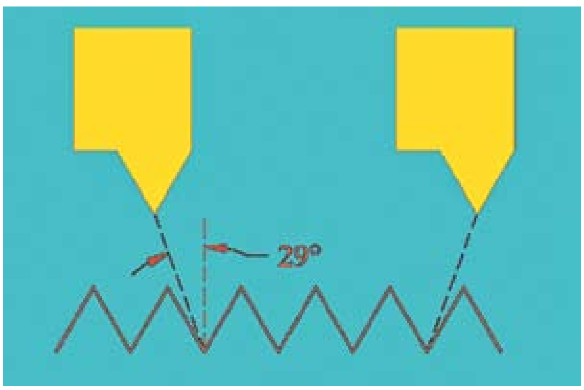
Swiss machining usually overcomes this limitation by removing all the material in one pass. This is typically not a problem because sliding-headstock lathes have high rigidity and usually do not make parts much bigger than 1¼" in diameter.

Chris Cole monitors the Citizen Swiss-style machine as it runs his segmenting program.

"This [single-pass rule] can be one of the more difficult concepts for someone just starting out using Swiss-style lathes," Cole explained. "Once some of the material is removed, there will be no support for the remaining passes."

However, single-point threading requires multiple passes. NMP has tried a few different ways to overcome this problem. "We have cut threads as long as 1¼"," Cole said. "We did that by using left-handed toolholders and shimming them to squeeze just a little more [thread length], but that is about all the room there is with ½"-square tooling."

Using thread rolling dies is another way to produce long threads on Swiss machines. They produce threads quickly and can be used repeatedly. However, thread rolling dies are costly, and the Swiss machine's capabilities may prohibit their use. Tool price is a significant issue, since thread rolling dies typically cost 10 times what single-point thread tools do. Required clearance for large-diameter thread rolling dies is another issue, because the 3.6"-dia. tool takes up so much space in the machine that a neighboring tool location must remain empty. Torque also becomes an issue because rolling threads requires more torque than cutting with a single point. NMP uses thread rolling dies but understands these limits. The shop knows it can use them for sizes that are ⅜" in diameter and smaller.



The angle of entry and exit is critical to the success of thread segmenting. For example, 29° angles must be programmed into each threading pass of the tool.

"Nothing else comes close to how fast a thread rolling die can make threads," Cole said. "But we can't justify the cost when we only cut a few parts." Thread rolling die cycle time per part is faster than segmenting by about 30 seconds in some cases, but the cost per part for segmenting is minimal because it does not require expensive tooling. If a job must include paying for equipping the machine tool with a $2,600 thread rolling die, then a 5,000-piece order would not cover the cost. Also, some Swiss-style lathes just don't have the capabilities required for larger diameter threads. Rolling threads larger than ⅜", depending on the material, can take from 40 to 55 in.-lbs. of torque, which is often more than many Swiss-style lathes can deliver.

Segmenting: A Unique Method

The segmenting method is different, in most cases, than methods typically used on standard lathes. "We use [segmenting] all the time," said Cole, "and not just not for threading." Normally this technique is reserved for turning and grooving.

However, segmenting threads can be difficult. "Each segment must match up with the others, and the quality must be the same for the entire length of thread," said Cole. "If there is a mismatch between one segment and the next, then the two different threads are not quite in sync. This means that the mating part will not thread all the way on the screw."

To accomplish thread segmenting, operators must tightly control placement of the thread tool. Each pass must start its thread in exactly the right place—but that is only one of the process requirements.

"The angle of entry into the thread must allow the tool to follow the flank of the thread," Cole continued. "If the tool enters at an angle that is too wide or too narrow, there will be a small gouge on the sides of the thread every time the tool makes a pass."

Positioning the tool may be exacting, but it is not difficult. Since CNC Swiss lathes have spindle encoders, the threads will line up correctly as long the tool starts at the same positions on the X and Z axes every time. The trick is to always allow for an overlap between the threads, plan each segment carefully and be sure to use the correct angle of entry. In the case of 60° thread forms, an angle of entry of 29°

is required, 1° less than half the thread form for "V" threads.

For the part with a 1⅞" thread length, the thread would be cut in three segments of 0.700" each. This totals 2.1", more than what is required, but there will be an overlap of one thread, or 0.050", for each additional segment after the first. There is also the lead-in at the first thread of about 0.080".

The total minus the overlaps and lead-in equal a thread length within tolerance:

$$2.1 - (2 \times 0.05) = 2.0$$
$$2.0 - 0.080 = 1.92$$

This overall distance is greater than the required length but within the tolerance of one thread. The reason for this is the overlap between the segments. The cutting tool needs to start early to achieve the overlap so that the full travel of the tool is greater than the length of threads created in each segment.

For each segment, the turning tool should cut the major diameter. After the first segment, each subsequent segment will start one pitch before the end of the previous segment. This will add 0.650" to the thread length for each segment.

Note that the turning tool should not turn a length longer than what is required because the unmachined material is needed to provide support for the threading operation.

Using G Code for Segmenting

There are a several types of canned cycles for threading on CNC machines, some of which have the benefit of being easy to use. "Normally, we use the G76 cycle just because it is so easy," Cole said. "The cycle requires only the parameters of the thread form to be included. It figures all the moves for all the passes and produces a perfect thread. We tried using G76 for the segmenting application, but as soon as we cut the threads, we could see there was a problem."

The G76 code only allows for control of the angle of exit from the thread, not the angle of entry. This does not work well when segmenting. If the tool enters the cut at a 90° angle to the part, then each overlapping segment will show an imperfection, a slice into the previous segment's thread.

The Swiss department at Nebraska Machine Products, where many small and complex parts are produced.

Code G32 is a less automatic cycle than G76 and allows for increased flexibility in how passes are programmed. G32 only synchronizes the feed rate to the spindle speed, thus allowing for cutting combinations of angled and straight threads. A more automatic cycle simply asks for the thread parameters, but code G32 requires that every move of the tool be programmed.

While it is clear that this is not the easiest method of cutting threads, segmenting solves the natural limitation of Swiss machines when single-point threading.

"What we didn't realize at first [when segmenting] was the level of calculating that would be required and the length of the program," said Cole. "With seven passes needed for 20 threads per inch and four lines of programming needed for each pass, that adds up to 28 lines just for one segment."

Each pass required four moves. First, the tool entered the cut at the proper angle, next it cut the thread to a given length, then the tool exited the thread, and finally, the tool returned to the starting point.

Programming incremental moves helped keep the program simple. Calculations were made for each pass based on the angle of entry and DOC. The incremental moves made it possible to use the same routine for each segment.

"With all the moves calculated as incremental, it was natural for the threading program to become a subroutine," said Cole. "We started out thinking the program was going to take a long time to calculate and that the program would have 144 lines of code for the threading alone, but it turned out to be fairly easy. Being a subroutine made the length reasonable." Cole was pleased with the results. "With getting the correct angles figured out, the entering and exiting of the thread worked out very well."

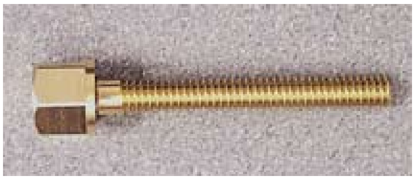
This type of programming requires more calculations to find the numbers needed and if the calculations are not done correctly, the tool will create threads with steps or witness lines—marks that show where tools have entered and exited.

"The first program had a few bad numbers," Cole admitted. "It was not so bad that the gage did not go on or that they looked all that bad, but you could see where the segments crossed over." The problem was corrected and production resumed. "The goal was to have a part that looks like it had been cut in one continuous motion, and I think we achieved that," said Cole.

While it is clear that this is not the easiest method of cutting threads, segmenting solves the natural limitation of Swiss machines when single-point threading. By applying this technique, producing virtually any length of thread is possible.

"We are looking at a part that we might be making soon that has ½-13 threads," said Cole. "Tool manufacturers recommend about 12 passes for that coarse of a pitch. [Compared to using a thread die], that requires almost twice as much programming for the same result, but using a thread die is not even an option for that size thread."

While segmenting threads does tend to require quite a bit of code, there are a couple of ways to shorten the program. One is the use of subroutines. "I found that once I have a program for a certain pitch, I don't really need to write this again for other nominal sizes," Cole explained. "Just to test this theory, I also cut a sample part that has ½-20 threads. The same subroutine works for any size thread that has this pitch."



Unfinished part after three segments of turning and threading.

Cole has discovered that he can shorten the program by using macros. "This will allow me to have one program that will be able to segment any size thread I need.

"The new ½-13 thread will only require two segments," Cole continued. "I'm seeing that this opens up a whole new class of parts for us. We used to pass on a number of parts that had bigger and longer threads."

Segmenting is not the fastest way to build a part with long threads, and it cannot compete with thread dies for cycle time. However for shorter runs, it is an economical method that can be done easily with common tooling, making it useful for many applications on Swiss-style machines. △

About the Author

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