With Noah Graff

shop doc

Today's Machining World's "Shop Doc" column taps into our contact base of machining experts to help you find solutions to your problems. We invite our readers to submit suggestions and comments on the Shop Doc Blog at www.todaysmachiningworld.com.

Dear Shop Doc,

We have always performed single point threading for external threads on our CNC lathes, but lately we have been receiving more requests for rolled threads, especially from automotive and aerospace customers. I machine a wide range of materials, including stainless steels. Thread sizes can vary from around 1/4" up to 1", including metric sizes, up to 3" long. I understand that rolled threads are mechanically stronger than cut threads and I also hear the thread-rolling process is considerably faster. I cannot justify the cost of a stand-alone thread-rolling machine and would prefer to drop parts off my machines complete to remain competitive in the automotive sector. What are the options for thread-rolling on CNC lathes?

To roll or not to roll

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Dear To roll or not to roll,

You are correct; thread-rolling improves surface finish, tensile strength and significantly reduces cycle time, with the added bonus of not producing chips (or those bird's nests of stringy swarf familiar to those who perform single point threading). What's more, some of those materials that are sticky and gummy and not fun to machine are often the ones that roll up the best threads you are ever likely to see! It's almost hard to imagine why you wouldn't want to roll all your threads, but of course there are limiting factors to consider; material, component design, quantities, work-holding, machine specification can all influence your decision.

The first obstacle will be the material; in the thread-rolling process, you are effectively cold-working the material, deforming it plastically to the point where it is stressed beyond its yield point, leaving you with an accurate replication of the roll profile on the part. This requires the material to have a minimum five percent elongation and maximum tensile strength of 1700N/mm, which includes most materials you are likely to come across on a day to day basis, including all but the toughest stainless steels, but excluding brittle materials such as cast-iron, hard brasses and hardened materials.

Once you have identified that your material is suited to thread-rolling, you then have to choose how you are going to roll it. Bespoke thread-rolling machines are costly options, best suited to suppliers of specialized fasteners and aerospace components made from high tensile and high-temperature alloys, some of which can be at the extreme limit of rolling and not suited to thread-rolling attachments. The average job shop like yours is looking for a more affordable option that can effectively convert their lathes into thread-rolling machines.

Once you have decided to thread roll, you have three main types of thread rolling heads to choose from. In ascending order of cost, these are Axial, Radial and Tangential, of which the pros and cons of each are detailed below.

Have a technical issue you'd like addressed? Please email noah@todaysmachiningworld.com.
We'll help solve your problem, then publish both the problem and solution in the next issue of the magazine.

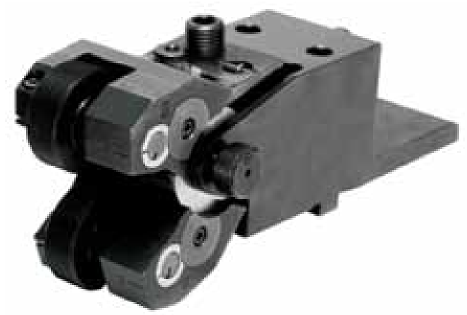
Axial Heads

Axial heads are the easiest to fit onto the turrets of CNC lathes, and most are available with a choice of inch or metric round shanks to suit your tool-holding preferences. As their name suggests, these heads feed axially along the part and at the pre-programmed end-point the Z axis feed is dwelled to allow the head to pull open. The virtue of this system is that it allows long threads to be rolled, often on slender parts, without fear of the side-deflections that can afflict single-point threading. This is achieved by the three-rolls in the head, centralizing the part between them as they traverse along, producing accurate, parallel threads with great repeatability and at considerable speed (typically 1" per second based on minimum rolling speeds of 120 feet/minute). Furthermore, a set of standard rolls can be used in both RH or LH heads, and each set is reversible to allow usage from each end.

Consequently, axial rolling heads tend to represent the first step into thread-rolling by the vast majority of new-comers to the process.

Before you rush out and buy one, be aware of the following limitations of the axial system:

* Axial rolls are normally ground with one or two lead threads and as such cannot roll tight to a shoulder or into narrow undercuts. A rule of thumb is to allow 2 – 2.5 x pitch for the thread run-out, but this can sometimes be reduced to 1.75 x pitch in certain circumstances. Also, as they always approach from the front-end of the part, they clearly cannot roll behind the shoulder.



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* Most (but not all) axial rolling heads operate best by opening at the end of the rolling pass, allowing them to be retracted in rapid without any change in spindle speed or direction. This, however, requires the head to be re-set (closed) before the next part can be rolled. On manually loaded machines this is performed with ease by the operator but on bar-fed machines a method of re-setting the head by means of mechanical or air-trip needs to be configured.

* For threading above **1,1/8 x 12 UNF (M30 x 1.5)**, the size and weight of axial rolling heads often prohibits their use on all but the largest CNC lathes.

* For rolling left hand threads a left hand head is required, although it will take standard rolls bought for RH threads.

Radial Heads

Radial heads, like axial heads, are supplied with inch or metric shanks, suited for mounting directly into standard tool-holders, but are heavier and more complex than their axial equivalent. Designed for rolling short threads close to the shoulder or into tight undercuts, they are particularly suited for high-volume production of fittings and automotive parts. They work by being positioned over the end of part to be rolled, before being tripped. This in turn allows the sprung loaded rolls to engage on the part, whereupon their cam design squeezes down radially on the part, forming a complete thread in one roll-rotation. Typical rolling cycles are 0.1 – 0.2 seconds.

However, this speed comes at a price:

* A radial head is typically 4 times heavier and 3 times more expensive than its axial equivalent.

* Due to the high rolling forces, only short (typically 1/4" – 3/4" OAL) threads can be rolled and normally only on the very front end of the part or just beyond it.

* Mainly finer pitch UNF threads are suited to radial rolling. RH and LH threads can be rolled with the same head, but the correct version of roll needs to be purchased.

Tangential Heads

Tangential heads are traditionally best suited for high volume batch work on multi-spindles machines, having the ability to roll both in front of the shoulder and behind the shoulder, essential for making fittings and similar parts from hexagon stock. However, they can also be used on CNC lathes for certain high volume applications. These heads work by approaching from the side, rather than from the end, with two synchronized rolls on fixed centers in a caliper feeding in tangentially onto the rotating part. This does exert side forces on the parts being rolled, so slender parts or shafts may need to be supported by centers to prevent deflection or breakage.

With no tripping or re-setting of the head to worry about, these heads are very effective and reliable when in continuous use and can roll very close to the shoulder or into narrow undercuts; like the radial head, both RH and LH threads can be rolled without recourse to another head (but LH rolls would need to be ordered). Also, similar to the radial head, tangential heads can only produce short threads up to the maximum width of roll obtainable for each head type.

By themselves, tangential rolling heads are no more expensive than radial heads, but extra cost is incurred purchasing the bespoke holders that are required to adapt them to each and every machine they could be used on.

So, for high volume production of repeating thread sizes, they can represent an ideal option if being commissioned for use on a single type of machine. However, for the smaller job shop who takes on a wide variety of shorter batch work on a range of machines, tangential rolling is not a viable option and the axial head should be used if suited. You mention some threads as long as 3" long, making them the ideal candidate for an axial head, which reinforces the decision to choose such a head in your case.

Size limitations

Whichever system one elects to use, consideration should always be given to the clearance limits of the machine when the turret indexes. Most modern CNC lathes are compact in design, minimizing the distance of the turret and tools from the slides in order to maximize rigidity. The down-side of this can be a turret envelope that restricts the size and/or weight of rolling head that can be mounted. Of the three systems discussed above, the axial represents the lightest heads, with the radial and tangential (inc holder) being the heavier options. For example, to roll a ange of 5/16 x 24 -7/16 x 20 UNF threads, the following heads would normally be recommended:

RA-1 Axial	Weight 2 lb
Dia of head 2,1/2"	Projects from turret face 2.05"
RT-20 Tangential	Weight 10 lb
Effective Dia of head 5.2"	Projects from turret face 2.3"
RE-10 Radial	Weight 10 lb
Dia of head 4"	Projects from turret face 4,1"

Larger turn/mill lathes with Y axis often provide more work-space in the machine to accommodate larger rolling heads.

Smaller Swiss style machines, often with gang-type tool blocks, are mainly suited to small axial rolling heads, as parts being machined are often small and slender and as such are unable to support the side loads generated by tangential rolling, nor the high torque resulting from radial rolling.

Component limitations

There are many variables in a component's features that will determine which type of head one should use. For example, thread rolling behind a shoulder, as explained above, can only be done by a tangential head. Acme or trapezoidal threads, which are coarse, deep forms, can only be done with an axial head, as the rolling forces exceed the limits of radial and tangential heads. A thread close to the shoulder can only be done with a radial or tangential head, whose rolls can be made with minimal edge chamfer to get within a pitch of the shoulder face.

Tubular (thin wall) components are best rolled with an axial head which in certain instances can be fitted with an internal support mandrel to prevent the tube collapsing during rolling. A resume` of component features and the systems best suited to each is shown below.

Component features

Thread to be rolled is behind shoulder T
Acme or Trapezoidal thread A
Thread close to shoulder R, T
Short Thread length R, T
Component has thin wall A
Tools Rotates A, R
Tool Stationary A, R, T
A=Axial R=Radial T=Tangential

As you can see, there are many variables which can decide the viability of a rolling application, but these interact in too many ways to give customers a simple tick-box means of deciding which system is best suited to their shop. The best advice is always to talk to suppliers of thread-rolling heads and attachments, who have a wealth of knowledge to offer customers who are faced with your choice: "To roll, or not to roll?"

Bob Perkins
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RSVP is a North American manufacturer outlet for high quality external thread rolling and cutting systems, and knurling and marking systems.