Are You Familiar with the Common Failure Modes on Roll Threaded Products?

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If these failure modes are occurring in your thread rolling operation, something is wrong and likely you will "feel it" in more than just the finished product.

I can vividly remember the first time I walked onto the manufacturing floor of a fastener manufacturer. I was not a rookie to a manufacturing environment, having spent the previous two years in a large metal stamping facility, but the "rat-tat-tat" sound of multiple headers banging out hundreds of parts a minute was a big departure from the "ker-chunk" sound of a 2000 lb press forming a car's hood or quarter panel that I had grown accustomed to. Although the headers were center stage and what I would subsequently naturally showcase during hundreds of plant tours in the years afterward, it was the humble thread roller that left an indelible memory during that first plant tour.

I suppose this impression was far less the result of any impressiveness of the machine itself and more on the ingenuity and complete unexpectedness of the rolling process. At that time, my paradigm was shaped from the only experience I had in threading a bolt, and that was using a tap and die set on my garage workbench. I guess I simply assumed that all threaded fasteners employed a tap or die in some fashion. Therefore, I was fascinated to see parts being rolled between two flat plates at speeds so fast that they obscured the parts and transformed them into an unrecognizable blur.

I walked away transfixed and appreciative of the creativity and ingenuity of some long past engineer. It would only be much later that I would fully appreciate the art of this process, but also the multitude of ways that it could produce defects and defective parts. This article is not intended to be an in-depth and detailed look at process, dies, set-up or any number of other factors that play a part in the conditions of the end product, but rather a brief introduction to the common failure modes that can result from thread rolling.

Dimensional Issues:

There are a multitude of dimensional criteria for even the simplest thread form. Three of the more commonly controlled features are the major, functional and pitch diameters. Although it is conceivable that these could be dimensionally off because the tool (roll die) is made incorrectly, these errors are more likely to be a function of improper setup where there is either not enough or too much pressure applied to the blank resulting in under or oversized conditions, respectively. In fact, the most common cause of dimensional issues is related to the blank. A blank that is over or undersized or possessing poorly designed geometry will quickly lead to dimensional issues in either diameter or length.

Years ago, this lesson was very poignantly driven home one day. We were accustomed to pretty much running externally threaded parts, where it is a common occurrence to have to tweak the blank to get the pitch diameter or other features right where you want them. Although we had years of experience with externally threaded parts, we had little experience with internally threaded parts. We had taken on a bolt-like pin, though, that had an internally threaded hole extending about 20 mm into the head. Along with a number of other machining operations, these threads were formed using a roll forming tap on a CNC machine. Unfortunately, at the time we didn't realize that the pre-threaded hole was all important.

As luck would have it, the drill bit that drilled the hole ended up getting a small sliver of material fused onto the end of one of its flutes causing the bit to drill a larger than desired hole. This oversized hole resulted in a minimum material condition and ultimately a severely undersized minor diameter that was not immediately discovered. Even though this lesson resulted in a positive learning experience and significant improvement of control practices, it is testimony to the fact that the blank diameter on an externally threaded part and the pre-threaded diameter of an internally threaded part are critical to the dimensional accuracy of the final resulting part.

Thread Laps:

Thread laps are one of the most common and often unwanted defects in thread rolling. They are the result of minor misalignment of the two opposing die faces or the result of material interaction with the roughed up starting section of the die that create a folding over of material that is then subsequently rolled into the surface without actually welding it in place.

A lap is the thread equivalent of a fold on the outer surface of a part. Like folds, thread laps can be pretty easily discerned using an etching test, which helps bring out the interface or folded-over material, or under low-to-medium magnification on a mounted and polished, etched sample. However, the mounted sample method is likely not included in in-process control plans, and, therefore, usually not the best method for correcting the problem in production.

The consensus is that thread laps generally are not good, although most standards that address thread laps do distinguish between those that are allowable and those that are not. The generally accepted understanding is that laps below the pitch line, in the root, progressing towards the root or on the pressure flank are considered high risk and unacceptable, particularly on parts that may have a fatigue risk.

Thread laps are preventable, but it takes careful and skilled set-up to obtain the optimal alignment between dies. Additionally, there are die manufacturers that have designs available that are claimed to be lap free. Whether they will always provide a lap-free part or not is possibly debatable, but they certainly provide risk reduction and are a good choice for parts where thread laps could be detrimental.

Drunken Threads:

The description of this failure, although quite colorful, is in fact quite appropriate. It is most commonly the result of mismatched dies, but can also result from nonsquare feed into the die or by poor die construction.

The visual effect is that the crest of the thread will have a wavy or uneven appearance, giving rise to the "drunken" description. In many instances, this issue is simply an appearance issue and not detrimental to function. However, it is not a desirable condition and should be something that the operator is vigilant for and corrects immediately upon discovery.

Skidding Through Die:

When a part fails to rotate through all or part of the die, the result is skidding. If it is over a very short area, it may have little or no impact.

However, if this failure to rotate is significant the part will likely be malformed with either threaded grooves on opposite sides of the round blank because the part never rotated or an out-of-round condition where it skidded at some point in the die. This is likely either a set-up issue where the thread is being formed too quickly allowing the part to skid in the later part of the die or the part is presented to the die in such a way that it either does not engage properly in rotating or because the die is "too smooth" at the start doesn't grip and rotate.

Piping:

This is an uncommon and interesting failure mode. It is most likely to occur in parts where the spread between the major and minor diameters is pretty extreme (such as spaced threads), but may also occur in, for example, common machine screw thread profiles.

It is likely caused by "over rolling" or too much pressure applied to fill the threads out to sharp thread crests. In doing this, some of the material gravitates from the center and is packed into the thread crests. This "movement" of material results in a void or "pipe" in the center of the screw. This problem often is discerned after heat treatment as it may cause the major diameter to expand or for the part to possess a barrel shape that gets picked up in inspection.

It is also quite obvious if for some reason the part is sectioned. This condition is detrimental to part function since it may significantly decrease the torsional strength of the fastener.

Run-Ups/Spiral Threads:

When parts are not presented squarely (straight) to the dies, it is possible to produce a condition called a "run-up" or "spiral thread". Because the parts are not square to the die, they end up with an out-of-tolerance helix angle. This results in a part that will not engage the mating nut member, which is why some people refer to them as "spiral threads". These parts are not easy to discern visually once they have been made and are intermixed with other parts. However, they do have a tendency to start rising out of the die, which is why manufacturers refer to them as "run-ups".

Many of today's thread rolling machines have detectors that are able to detect these parts in-process and halt production until the operator can assess the situation and make changes.

Rabbit Ears/Volcano Cone Appearance:

Although not normally an area of concern, when one closely examines many formed threads, it is quickly obvious that some or all of the threads have raised edges and a slightly depressed middle giving the cross section an appearance of "rabbit ears" or a "cone of a volcano". This is normal and, in fact, expected with most formed threads. Unless very severe, particularly on internal threaded parts, this condition would be considered normal and benign.

I have included rabbit ears/volcano-like appearance here not because it is a true failure mode, but rather because this condition is commonly misunderstood and mistaken for being a defective situation.

These items do not constitute every possible issue from thread forming. However, they serve to highlight most of the more common possibilities. It is safe to say that if these failure modes are occurring, that something is wrong and likely the manufacturer will "feel it" in more than just the finished product. In fact, most of these issues have consequences on the die life.

Thread rolling has long been as much "art" as repeatable science. The good news is that there continue to be innovations from both the machine producers and control system providers that are increasingly providing repeatable solutions that will one day hopefully eliminate some of these more common failure modes.

For additional discussion on becoming familiar with common failure modes in the roll threading process, contact the author via email at *lsclaus@sbcglobal.net*. FTI