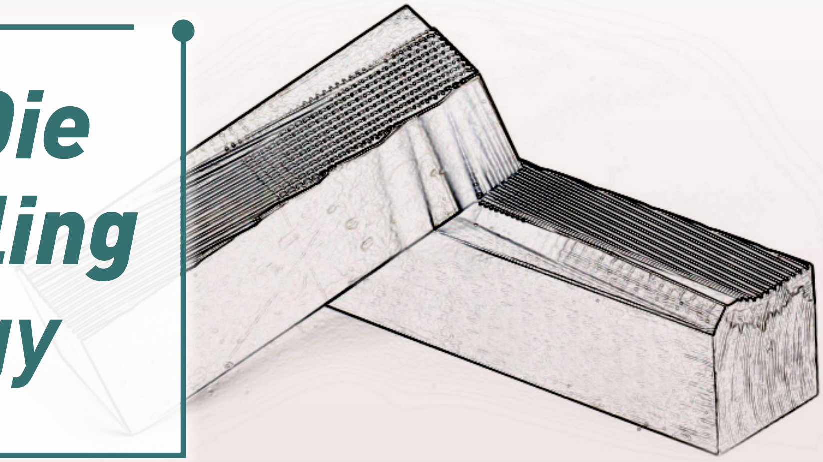
New Flat Die Thread Rolling Technology



by Laurence Claus

One of the delights of being an independent consultant is the wide assortment of people I meet and projects I get to review. Over the last ten years the two problems that I am most commonly approached about include skills development and thread rolling. In fact, I have written many articles in the last ten years and the one that I most frequently have inquiries about years later is related to problems in thread rolling. This is truly a step in the fastener manufacturing process that is ripe for innovation.

Last fall I was introduced to a new technology that, interestingly, addresses both of the problems mentioned above, accelerating thread rolling skills development and providing a way to develop a reproducible thread rolling set-up. I was so impressed with this solution that I wanted to dedicate an article into looking at how companies address the thread rolling conundrum. This article will therefore, explore the way that manufacturers approach flat die thread rolling.

Let us rewind briefly to my encounter of this new technology. I was speaking with the inventor, Mr. Ken LeVey, President of Mule Technology LLC of Chicago, Illinois. Mr. LeVey is a long-time member of the fastener industry and holds multiple patents on specialty fasteners and fastener manufacturing methods. For many years he oversaw design and manufacturing engineering in a large fastener manufacturing plant and was always vexed by the challenges experienced by traditional flat die thread rolling processes.

As I discussed this subject with him, he would point out the challenges of traditional flat die thread rolling methods. In particular, Mr. LeVey expressed the inherent inconsistency experienced by manufacturers because of the existing or traditional methods of set-up. In essence, operators are provided a wrench and some shims and expected to get the die oriented and the machine squeezing "just right" to produce the desired threads to specification. It has been done this way for years and, **although operators eventually get jobs set-up, more often than not the speed and degree to which they are successful is partly attributed to good luck and partly to their experience.**

The problems resulting from this very capricious set-up method include the following:

- **It is not repeatable**
- **It is not measurable**
- **It is not transferrable**

It is not repeatable:

If you have never set up a rolling machine, it may seem pretty simple, but operators that do this every day will tell a different story. First the dies have to be properly aligned in the die space. This is accomplished by strategically placing shims underneath and behind the die to get it located where the operator wants it. Adding or moving the location of these shims creates a new situation with each readjustment. Additionally pressure is regulated by turning Pressure Adjustment Screws one way or the other. This is done by feel with no objective way to regulate precisely how much the screws have been turned. As such, **it is impossible, even for the best operator to exactly repeat a previous set-up.**

It is not measureable:

Normally an operator will have a selection of shims and simply place them by trial and error. Even if the thickness of each shim used is tracked, the exact placement and potential overlapping interactions make it impossible to quantify a measureable value. Likewise, since there are no adjustment settings on the Pressure Adjustment Screws to enumerate how much it has been turned clockwise or counterclockwise, and **since the Pressure Adjustment Screws do not always apply pressure evenly across the Die, the actual extent of adjustment is unknown and not measurable.**

It is not transferable:

These adjustments are successfully completed as a function of the skill of the individual setting up the machine. **Although a seasoned veteran can instruct a pupil in how to perform these functions, it is impossible for them to precisely transfer their knowledge to that individual.** In other words, they can say, "turn that adjusting screw a little to the left", but what does this mean to someone listening and trying to repeat the instruction. What is "a little" to the instructor may be more or less to the pupil.

Therefore, these limitations reveal two significant shortcomings with the current system. First, traditional flat die rolling requires skilled set-up personnel. Each individual learns at a different rate, but it is safe to say that most individuals will not become truly accomplished until after they have been doing the job for a while, perhaps several years. Secondly and directly related to the first, today a universal problem throughout worldwide manufacturing is that older personnel are leaving faster than new, younger personnel can become proficient and replace them. This has become known as the “Skills Gap” and is resulting in many manufacturers placing higher demands on a few key personnel. This leaves them with little margin should those key personnel become unavailable and increases their risk of quality spills due to operator set-up error.

How do Manufacturers Address the Problem?

Let us first refresh our understanding of the Flat Die Thread Rolling process. An unthreaded fastener blank is fed between two matched flat rolling dies. One of the dies is shorter and resides in a pocket on the stationary side of the machine while its partner is longer and is located in a pocket in the ram on the moving side of the machine. When the ram is retracted all the way back, a blank is fed into the gap between the dies and the ram strokes forward, grabbing the newly introduced blank and squeezing it between the dies as it rotates. The spacing between and orientation of the dies triggers material to flow into the die grooves developing a little more of the thread with each rotation until it is complete and rolls off the end. As already explained getting all the inputs just right can be tricky and requires skill and expertise.

Doing it the way it has always been done

Unfortunately, with very few available options for improvement, most manufacturers resign themselves to do it the way it has always been done. That means they have a team of individuals, possessing varying degrees of experience to set-up and run the machines to produce an initial part to a print or standard requirement. Experience is passed on exclusively by on-the-job training and often takes several years and many set-ups to thoroughly develop. Unfortunately, under these conditions, even the “best” operator can have a “bad day” and wrestle with getting a job set-up or producing quality parts. For these reasons, manufacturers may be really handicapped if they experience high turnover or have a younger, less experienced set-up team.

Gaging>>

Although this added step to the manufacturing method does not really solve the challenges related to skill or development, gaging does provide a way for operators to better control quality over the course of the manufacturing run. I should mention here that I am not referring to the common practice of gaging parts for first piece approval or regular checks of the major diameter. These practices are common and expected. The gaging I am referring to is variably measuring both the Pitch Diameter and the Functional Pitch Diameter and conducting Statistical Process Control methods on the result. If a thread is “perfect” its Functional Pitch Diameter will be equivalent to its Pitch Diameter. Therefore, if the difference between these two measured values starts to increase beyond an established acceptable value, it is a good sign of the process starting to get out of control. Unfortunately, because of the added time, cost, and operator training required to do this gaging process, few manufacturers do.

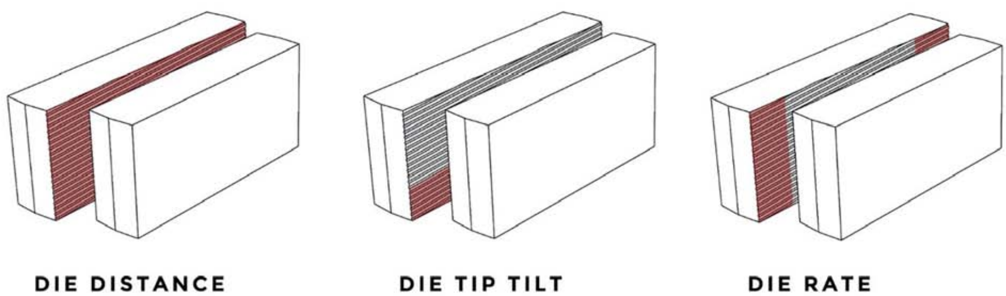
In a similar vein, both initial and on-going monitoring for thread laps is an excellent way of measuring the quality of a set-up. The most common, although not only, reason for thread laps is due to misaligned dies in the set-up. Checking for thread laps is one way to expose a poor set-up. Once again, however, few manufacturers do this check unless required by their customer because of the time and expense to equip themselves to do the test. Sadly, even fewer conduct on-going evaluation for thread laps.

In-Process Monitoring>>

Thirty years ago, a revolution in the cold heading industry was occurring. Manufacturers were beginning to equip heading machines with in-process monitors that could alert an operator when something went wrong in the process. Although it took many years, this same technology has been gaining steam for flat die thread rolling. If properly set-up and used, in-process monitors are an effective method of identifying a part anomaly or potential changes to tools or set-up.

Unfortunately, this powerful technology does not really address the challenges I have spoken of in this article. It will not prevent a bad initial set-up, nor will it accelerate the learning curve of a new rolling operator. In fact, it is another device that the operator must learn how to use properly, and, likely, adds to their already steep learning curve.

Figure 1. Die Orientations Set by Varying Bar and Disc Size



New Technology

At the beginning of this article I mentioned a new technology for flat die thread rolling that I was introduced to late last year. It is the only method I have encountered that creatively addresses the majority of the challenges outlined at the beginning of this article. In fact, it is the only one that provides a reproducible set-up solution.

So, how does this technology accomplish this? The cleverness of this solution is that it removes the "guess work" and replaces it with four recordable and repeatable adjustment points. **The technology requires a retrofit to the rolling machine. Usually this is just the Stationary Die Pocket but on Hartford machines requires a change to both die pockets. The new die pocket comes with a set of numbered bars and lettered discs which increase in size. By varying the combination of bars and discs one uses to align or fit the die in the pocket, the dies can be precisely oriented to provide different alternative configurations of what the inventor calls Die Distance, Die Tilt, and Die Rate (See Figure 1). These three measures define the pressure pattern applied to the part.** The bars and discs are uniquely identified so that experimentation with differing combinations of Bars and Discs can provide the optimum set-up condition. The Bar and Disc combination can be recorded and saved in an accompanying APP to provide what the inventor calls a "Mule Recipe". Once saved, these can be repeated and used time after time to produce uniform results on future manufacturing runs.

I hope that it is obvious at this point how this technology addresses the problems of repeatability, measurability, and transferability.

- **Repeatability:** Once a Recipe is established the Bar numbers and Disc letters and their respective positions are recorded. It is simple for the operator to recreate this combination. Not only is repeatability accomplished, but it is simple enough that even an operator at the beginning of their learning development cycle can recreate a good set-up.
- **Measurability:** Since the Bars are numbered and the Discs given letter identification, each combination can be precisely measured. This measurability function also comes in handy when preparing a new Recipe, as each change can be recorded in precise, measurable increments. To my knowledge, no other method allows for the quality of the part to be related to a recordable combination of set-up variables. The value in being able to optimize a set-up should not be overlooked or discounted. This is an incredibly powerful tool to any proactive, continuous improvement minded manufacturer.
- **Transferability:** Once the Recipe is fixed, the information is easily transferred to any individual with a little bit of training or know-how in operating flat die thread rollers. There are no logistics constraints on the Recipe, meaning that a Recipe for the same model machine will work at different sites. This is a nice benefit for multi-site companies that may perform process development engineering in one locale and transfer it to other satellite locations, nearby or far away.

Summary: In summary, thread rolling has always posed a vexing problem of sorts, a creative and unique way to efficiently produce external threads, but highly dependent on the set-up with no guarantee of reproducibility from one set-up to the next. Any technology or method which either reduces the dependence of long-term training of an operator or gives the operator tools to make his or her job easier should be interesting to any proactive fastener manufacturer. Not only will adopting such methods potentially address the Skills Gap problem but it will also lead to continuous improvement in part quality and manufacturing efficiency. Adopting such methods provides significant potential to continuous improvement minded companies and may be a means by which they could leap frog their competition. I hope that I can look back in another ten years and see that the thread rolling steps included in manufacturing threaded fasteners has really evolved into a more scientific, uniform, and reproducible process than it is today. ■