# Practical SPC for external rolled threads

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The growing concern about fastener thread quality by major fastener users such as the federal government and several automotive companies will necessitate the use of Statistical Process Control (SPC) in fastener manufacturing threading operations in the future. This article will hopefully provide some helpful ideas about the most practical approach to employing SPC in the production of external threads. A future artiele will address the same subject regarding internal threads.

There is a growing recognition that the key to greater overall product quality is the minimization of variation in all manufacturing processes. SPC provides the tools for measuring process variation so that meaningful analysis of the process can be made. In implementing SPC two common errors are frequently made. These are the attempt to control too many product characteristics and/or the selection of the wrong characteristics to be controlled. The logic to use in selecting characteristics to control statistically is:

1. Select characteristics which have a direct bearing on the product's final function.

2. Select characteristics which affect the quality of subsequent manufacturing processes.

3. When possible select one characteristic that is indicative of the machine's operation and one characteristic which is indicative of the tooling's performance.

4. Control the minimum number of product characteristics which will indicate the performance of each manufacturing process.

5. The controlling of four product characteristics or fewer per operation is ideal. Never control two or more product characteristics which will vary together in the same operation because this is wasteful and redundant.

Keeping these suggestions in mind, let us look at what are the logical product characteristics to control to minimize process variations in rolling external threads.

## Fastener heading process

The fastener blank diameter must be controlled in the heading and/or blank grinding processes to ensure good thread quality. In the production of most commercial fasteners threads are rolled on the "as headed" blanks, whereas many aerospace parts require the grinding of the blank diameter prior to rolling.

Blank diameters should be controlled within 0.001" in most cases to obtain consistent rolled threads, Figure 1. This will probably require many manufacturers to tighten control on their heading die inside diameters and lead them to change dies more quickly than previously thought necessary. This is necessary to minimize thread variation.

This concept will logically lead the manufacturer to the elimination of all steel heading die inserts for the thread portion of the fastener blank. The relatively quick die wear in steel inserts is a source of heading variation which must be eliminated. Carbide inserts are the obvious choice to minimize this problem. It is much better for a tool to chip or crack after an acceptable number of pieces are produced rather than have a tool wear out. Wear results in variation. Die fractures provide a clear determination of "good" versus "bad."

Fig 1-Measuring blank diameter

## Fastener rolling process

At the thread rolling operation the major diameter and functional diameter should be the charted characteristics. The reasons these should be charted are as follows:

1. Major diameter

Major diameter should be selected because it affects both the final function of the part and it indicates process variation immediately, Figure 2. A major diameter must always be within specification to ensure that the appropriate depth of thread engagement is maintained with its mating internal thread in order to prevent thread failure due to stripping.

Fig 2-Measuring major diameter

Anyone who has been involved in thread rolling realizes that fluctuating major diameters signal problems like blank slipping, loose rolling dies, loose machine ram, and/or blank diameter variation. The major diameter is by far

the easiest external thread characteristics to measure. For these reasons, charting the external thread's major diameter for statistical and process control of the thread rolling process is a must.

2. Functional diameter

The thread's functional diameter is that measurement which indicates the thread's pitch diameter plus any effect of variatiou in its lead, flank angle, straightness, roundness, and/or taper,

**Fig 3-Measuring functional diameter**

Figure 3. This measurement is made with an indicating gage having multiple thread engaging elements at either 120 or 180 degrees. The configuration of these elements are defined in ANSI/ ASME B1.2-1983 on page 138, Figure 26. This measurement must fall within the pitch diameter size tolerance indicated in the appropriate thread standard such as ANSI B1.1-1982.

A thread's functional diameter is a must to chart because this is the only thread characteristic that by itself indicates that it will assemble with an internal thread of the appropriate size which also has an acceptable functional diameter. This characteristic will also indicate almost every process variation that can occur in the external thread rolling process.

The use of SPC in thread rolling does not relieve the manufacturer of the requirement to inspect other thread characteristics which are required by the thread specification being produced. All of the thread characteristic requirements should be measured at the process setup. If all characteristics are within specification at set-up they will all generally vary in concert with or follow any variation in the thread's major diameter and/or functional diameter.

Single element pitch diameter should be measured at machine set-up and die changes to insure that it is within the specified tolerances if it is a required measurement, Figure 4. More importantly, when the thread's single element pitch diameter and functional diameter measurements are within 40% of the

**Fig 4-Measuring single-element pitch diameter**

total pitch diameter tolerance of each other the operator knows that the thread rolling dies are in proper match. If rolling dies are in proper match the thread rolling process cost goes down. This is a result of the dies lasting longer and the pressure on the machine's ram being minimized, which makes the machine last longer. These savings are particularly significant for the producers of aerospace fasteners where the rolling dies generally cost several hundred dollars per pair and last a relatively short time.

Actually, the closer these two dimensions are the greater these cost benefits. What many manufacturers will find is that the blank diameter standards they have been using will not produce threads that will allow them to adjust the process to center it in the tolerance. They will find that operators have always been mismatching the rolling dies to make the threads enter a Go ring gage and stay out of the NoGo ring gage. Blank diameter standards should be adjusted so that dies can be consistently run in match as indicated by the comparison of the pitch diameter and functional diameter and produce acceptable threads.

As beneficial as the measurement of single element pitch diameter is in the above mentioned regard it is not a thread characteristic to be charted. It varies in concert with the functional diameter and does not have any significant effect on the final function of the external thread.

Some people are proponents of the charting of the "differential" as it is called. This is that difference between the pitch diameter and functional diameter measurement. This is inappropriate because as stated above single element pitch diameter is redundant when functional diameter is controlled. Only directly measurable characteristics are appropriate to chart because of the potential for mathematical errors and the additional and unnecessary complication that this imposes on the operator. An operator is going to be more cooperative if his measuring and charting requirements are kept simple.

The minimization of manufacturing process variation as monitored by SPC is a key to providing consistently good quality in general, Figure 5. The proper use of SPC in the heading and rolling processes can ensure consistently good fastener thread quality. From the most practical standpoint, the product characteristics which should be charted and controlled are the blank diameter before the thread rolling process and the major diameter and the functional diameter during the thread rolling operation. Process variation is the manufacturer's biggest enemy in the fight for continuing product improvement. SPC is a major tool in identifying degree and source of variation in a process, but to be effective it must be utilized and implemented logically and practically.

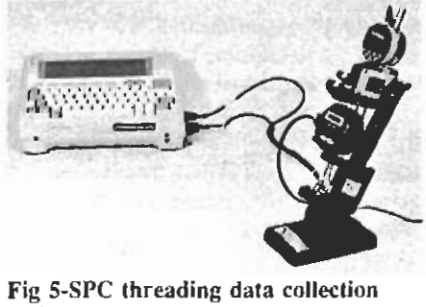

**Fig 5-SPC threading data collection system**

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