Functional Diameter Measurement ...Recommended For SPC in Threading

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Based on my 25 years of experience related to the fastener manufacturing industry, I recommend the "functional diameter" of both external and internal threads be monitored for the purposes of statistical process control.

There continues to be a lot of unnecessary confusion about thread technology regarding the importance of the various thread characteristics as they relate to fastener production and fastener performance. As explained in my last article, the major diameter of external threads and the minor diameter of internal threads are the most critical thread characteristics related to thread strength and load carrying ability.

The functional diameter of threads is always important because this is the characteristic that ensures the external and internal threads will mate without interference. The size of a thread's pitch diameter has no value as a predictor of strength or performance of threaded components.

An objective review of the following points should eliminate some of the confusion about the significance of various thread characteristics during the manufacturing process.

Point #1: No process can be turned on for manufacturing until the proper setup is achieved so that all required product features are within their specifications. This means when a thread manufacturing process is being setup, all of the required thread characteristics are of equal value and must all conform before production begins.

The predominate thread quality level required is ASME System 21. This requires the thread's functional diameter to lie between the upper and lower limits of the pitch diameter size; the major diameter of the external thread and the minor diameter of the internal thread must lay between their respective upper and lower limits. If Statistical Process Control (SPC) is to be employed, ideally, the setup will be worked at until these characteristics are very close to the center of their tolerance band.

Point #2: The purpose of using SPC is to eliminate all possible waste and variation in each process in order to achieve consistent output at the lowest possible cost. Toward this end, one should seek to control the least number of process characteristics that provide sensitive indications of process variation. It is wasteful to monitor two, three, or four characteristics if one will always indicate process variation before, or simultaneously, with one or more of the others.

In threading processes, I contend the most sensitive thread characteristic for detecting process variation is the "functional diameter."

Common causes of threading process variations are blank inconsistencies, tools wearing or loosening, or looseness in machinery components such as the ram. These process variations can lead to inconsistencies in the thread's lead, flank angle, or pitch diameter. All of these thread elements are component parts of the functional diameter. Therefore, functional diameter of the thread will show variation simultaneously with variations in any of these other thread elements.

Following is the definition of the functional diameter in the ASME B1.7M standard for screw thread nomenclature:

> ***Functional diameter*** *- the pitch diameter of an enveloping thread with a perfect pitch, lead, and flank angles and having a specified length of engagement. This includes the cumulative effect of variations in lead (pitch) flank angle, taper, straightness, and roundness. Variations at the thread crests and roots are excluded.*

Point #3: Process monitoring for use in SPC can only be accomplished using variable/indicating gages with readout resolution no more than 10% the total tolerance band of the characteristic being controlled. Gage Repeatability & Reproducibility (GR&R) should be no greater than 20%.

This means that thread ring gages and plug gages are not suitable for process monitoring and control. Parts should pass ring or plug gage inspection before the setup operation is complete, and the process is turned on for production, but these gages do not provide indications of actual size as required for process control evaluation.

I suggest use of a tri-roll or segment style gage with functional size measuring elements for external thread process control and segment style gages with functional size fingers for internal threading process control.

The use of "thread differential analysis" gets a lot of discussion. This is the procedure of measuring and comparing a thread's pitch diameter to its functional diameter to determine the magnitude of the cumulative effect of the deviations in the individual thread elements. It is my opinion that this procedure has one, and only one, valuable use: to use this procedure during the setup of the threading process to determine threader die match.

It should be a standard setup requirement that the process will not be turned on until the difference between these two measurements is less than 40% of the thread's total pitch diameter tolerance.

The value of this procedure is that it provides the operator with an empirical means of determining perfect or near-perfect die match. The closer the measurements of pitch diameter and functional diameter are on a given thread, the closer the dies are to perfect match. The more perfect the die match, the lower the pressure on the die plate faces. The lower die face pressure, the longer the dies will last and the longer the threader's rams will go without adjustment or replacement. Longer die and machine life results in substantial operation savings, over time.

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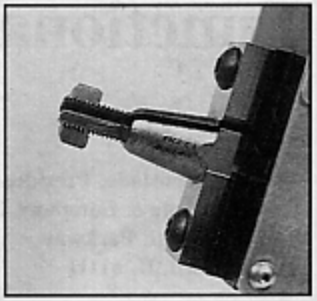
Functional Diameter Measurement...Continued

I consider the use of "differential analysis" for process control or for final acceptance to be a misapplication of the procedure. After a threading process is properly setup, measuring both pitch diameter and functional diameter is wasteful. Measurement of only functional diameter will show variation before or at the same time as variation in pitch diameter.

The threading process operator must stop the process when excessive variation is detected and determine the source of that variation. Once determined, the source of the variation in the process must be eliminated to get the process back into control. The operator has no more information about the variation's source, whether monitoring the "thread differential" or whether monitoring the "functional diameter" alone.

Since making two thread measurements, pitch diameter and functional diameter, and subtracting one from the other does not provide any more information about the process than measuring the functional diameter alone, why go to the extra effort of performing differential analysis? I believe performing differential analysis for thread process control is a wasteful operation and should not be used for this purpose.

I believe in the concept and economic benefits of the use of SPC in all fastener manufacturing operations. My understanding of ways to achieve the most consistent output at the lowest cost is to simplify processes as much as possible, eliminating as many potential sources of variation as possible.



Instruments for measuring function diameter of both external (left) and internal (right) threads.

Measurement, charting, and analysis are elements of the "control process." I believe the control process should be made as simple as possible without losing its effectiveness. This is why I advocate that only the functional diameter be monitored for SPC purposes. The setup of a threading process is not complete and must not be turned on until all required thread characteristics meet their specifications. After setup, the functional diameter provides a very sensitive, comprehensive indicator for detecting variations within the threading process.

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