Threaded Fasteners – Torque tightening

To many, fastening parts together with a *bolt/screw/stud and a nut* would seem to be simple and straight-forward. This is far from the truth and much engineering investigation has taken place to understand the nut-and-bolt jointing process.

Factors from varying qualities/tensile strengths of steel, surface finish (e.g. plain or zinc plating etc) and lubrication all vary the correct torque tightness of the joint.

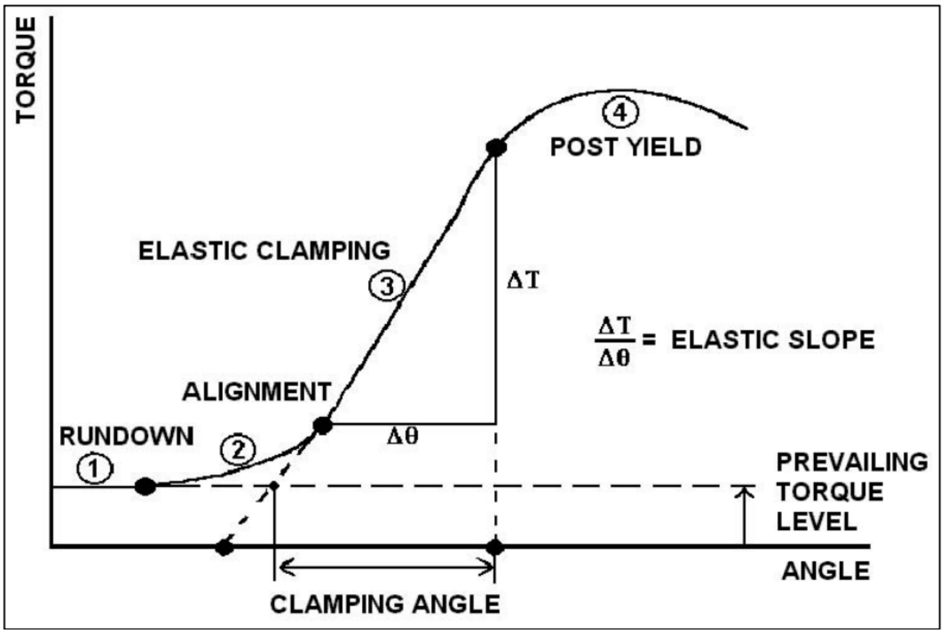
A summary of torque tightening values for various thread types (BSF, Whitworth, etc), thread sizes/diameters, and surface finishes is shown in:
http://www.triple-mregister.org/uploads/retro/Bolt_data.pdf

An idea of the engineering complexity to understand threaded fasteners can be found in Engineering Fundamentals of Threaded Fastener Design and Analysis:
http://www.hexagon.de/rs/engineering%20fundamentals.pdf

As others have indicated the correct torque can be established by a careful measurement of stretch in the bolt when tightening.

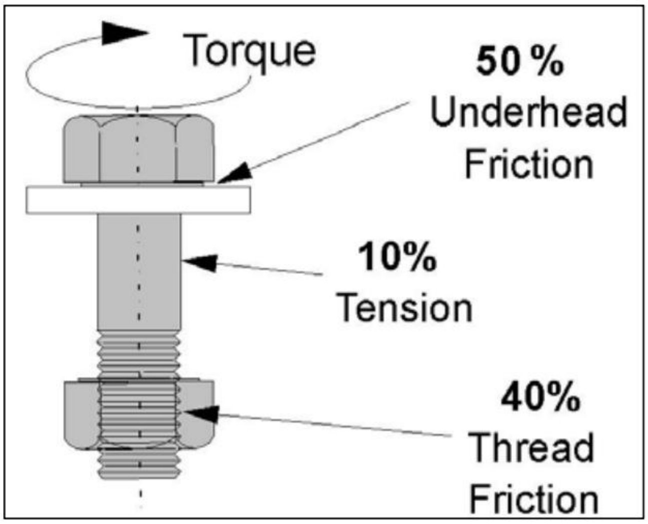
This is explained below, where ***the aim*** is to tighten into the ***elastic clamping*** zone.
Further explanation follows, plus the desirability for threads to be formed by a rolling process.

Figure 2. Four Zones of the Tightening Process
The most general model of the torque-turn signature for the fastener tightening process has four distinct zones as illustrated in Figure 2.



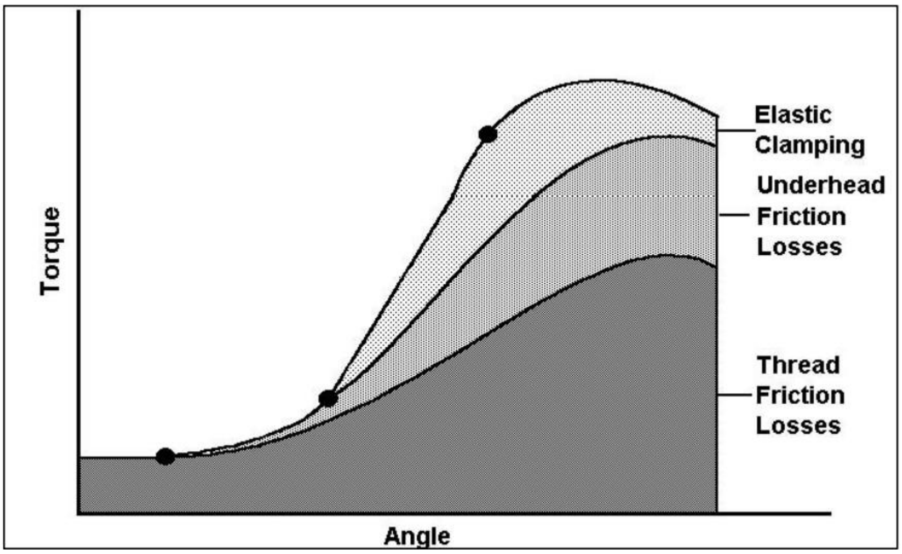
1. The first zone is the rundown or prevailing torque zone that occurs before the fastener head or nut contacts the bearing surface.
2. The second zone is the alignment or snugging zone wherein the fastener and joint mating surfaces are drawn into alignment to achieve a "snug" condition.
3. The third zone is the elastic clamping range, wherein the slope of the torque-angle curve is essentially constant.
4. The fourth zone is the post-yield zone, which begins with an inflection point at the end of the elastic range. Occasionally, this fourth zone *can be due to yielding in the joint or gasket*, or *due to yield of the threads in the nut or clamped components or nut* rather than to yield of the fastener.

Figure 4. Where Does the Torque Go?



As shown previously, the area under the torque-angle curve represents the total energy required to tighten a fastener. As shown in Figure 5, **only the upper 10 percent of the area on the curve represents the elastic clamping energy that is providing the holding power to clamp the parts together.** The elastic clamping energy shown on the torque-angle plot.

Figure 5. **Where Does the Fastening Energy Go?**



Threaded Fasteners – Torque tightening

Differences between threads formed by ‘rolling’ compared to machine-cut threads.

ADVANTAGES OF ROLLED THREADS

Rolled threads have improved physical characteristics, greater accuracy and a high degree of surface finish. They are uniformly produced at high rates of production with no wasting of material. These six major advantages account for the increased use of thread rolling.

PHYSICAL CHARACTERISTICS

The cold forging that threads receive during the rolling process strengthens them in tension, shear, and fatigue.

TENSILE STRENGTH

The cold working of the surface increases the tensile strength of the metal worked, and static tensile test have frequently recorded increases on the order of 10% in the breaking strength of the parts.

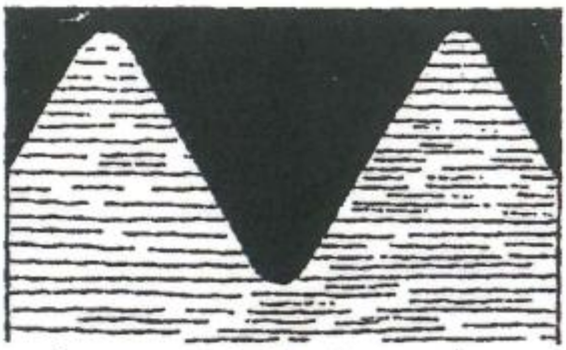
SHEAR STRENGTH

When a thread is rolled the fibres of the material are not severed as they are in other methods of screw thread production, as shown in Fig. 3, but are re-formed in continuous unbroken lines following the contours of the threads, as in any good forging as shown in Fig. 4. Rolled threads resist the stripping because shear failures must take place across rather than with the grain.

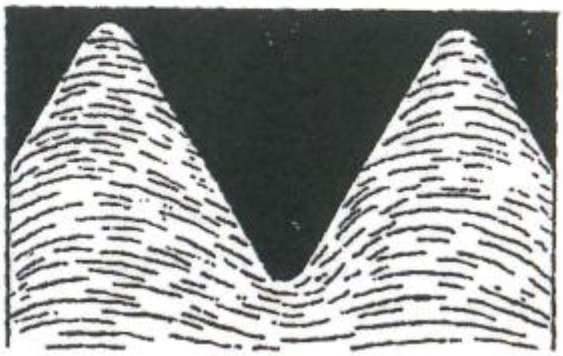
RESISTANCE TO FATIGUE

Thread rolling increases the part’s resistance to fatigue failure in several different ways. Rolling between smooth dies leaves the thread with smooth burnished roots and flanks, free from tears, chatter or cutter marks that can serve as focal points of stress and, therefore, starting points for fatigue failures.

Rolling also leaves the surface layers of the thread, particularly those in the roots, stressed in the compression. These compressive stresses must be overcome before the tensile stresses can be built up, which alone, can cause fatigue failures. This increase in root hardness, up to 30%, adds considerably to the parts resistance to fatigue.



Cut Thread
FIG. 3



Rolled Thread
FIG. 4

It has been repeatedly demonstrated that any fastener that is properly tightened when it is installed, and remains tight throughout its life, is less likely to fail by fatigue than one that is assembled loosely, or that becomes loosed in service.

Threads produced by any of the cutting methods have a surface condition consisting of partly torn-away particles that gradually bear down in service permitting the fastener to loosen. *Rolled threads, on the contrary, which are compacted and burnished during threading, are less prone to loosen, and, thus ordinarily have longer fatigue lives.*

Rolled threads show no loss of fatigue strength when heated for several hours to temperatures up to 500° Fahrenheit; whereas, fatigue strengths of threads produced by other means are lowered by as much as 25% by the same treatment.

Improved fatigue strength, resulting from all the above factors, is reported to be on the order of 50-75%. On heat treated bolts from Rockwell C36 to 40 hardness, that have the ***threads rolled*** after heat-treatment, tests show ***increased fatigue strength of 5 to 10 times that of cut threads***.

THE THREAD ROLLING PROCESS

Thread and form rolling is a simple cold forging process confined almost entirely to external threads. It is referred to as a cold forging process because most rolling is done on cold blanks. However, rolling of threads or heated blanks has been beneficial on some applications. Today, thread and form rolling is accepted by many industries as a preferred method of producing uniform smooth, precise threads of superior physical qualities.

Hardened steel dies are used to roll the threads. The threaded faces of the these dies are pressed against the periphery of a plain cylindrical blanks and reform the surface of the blank into threads as the blank rolls on the die faces

(Fig. 1). The working faces of the dies have a thread form which is the reverse of the thread to be produced. In penetrating the surface of the blank, the dies displace the material to form the roots of the thread and force the displaced material radially outward to form the crests of the thread. The blank has a diameter part way between the major and minor diameter of the thread.

A comparison of cut and rolled thread is show in Fig. 2. Unlike the other threading processes, no material is removed and consequently no chips are produced.

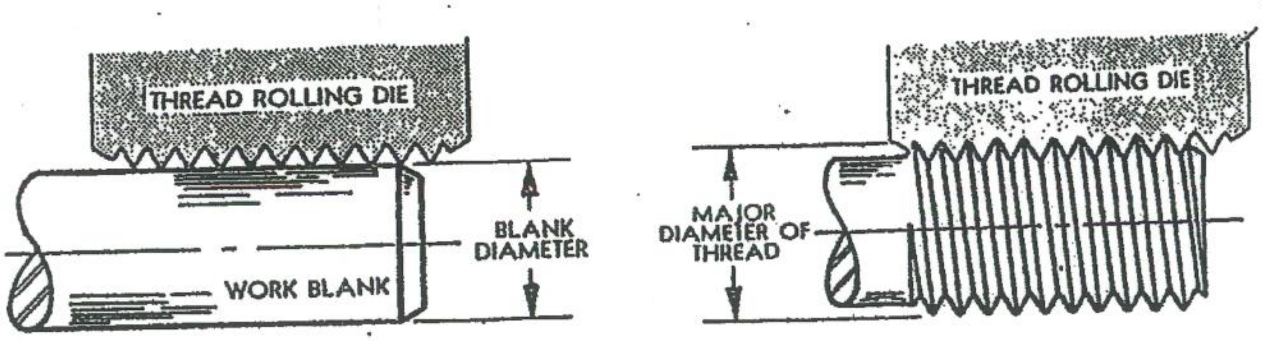
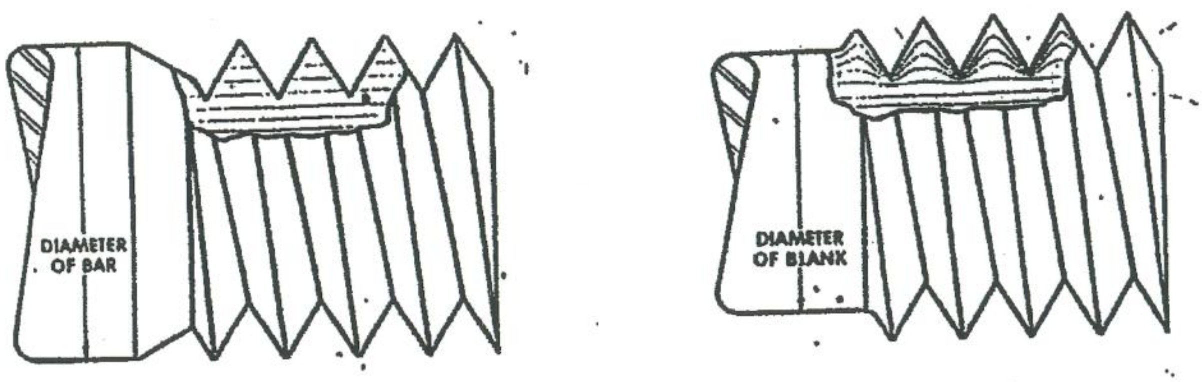


FIG. 1



Cut Thread FIG. 2 Rolled Thread