In recent years a new addition to public school curriculum has taken the US by storm. This addition is known as STEM, which is an acronym for "Science, Technology, Engineering, and Mathematics". One of the foundational subjects of the STEM curriculum is education about the "Seven Simple Machines". As a student of technology, each of these simple machines is an interesting subject, but perhaps none of the seven is more elegant than the screw thread.

Since its first inception and surely its first recorded uses, the screw thread has been faithfully serving mankind in many ways. One of the first recorded deployments of the screw thread was when Archimedes used it to move water from one level to another, and today it's uses for holding things together are almost limitless and span from the very mundane to the very important and critical. In fact, today many in our society are thankful for screws that hold bones and other body parts together, enabling revolutionary remedies to common health and mobility problems.

Screw Threads- Different Designs and Where They Are Utilized

by Laurence Claus

So what is it about a screw thread that makes it such an engineering marvel? The answer to this is primarily the thread's ability to generate high levels of mechanical advantage with relatively low levels of input energy. In simpler terms, the screw thread is a powerful force multiplier.

Screw threads have several common attributes. Although they have many universal features, the most commonly used features that describe threads of all types are major diameter, minor diameter, pitch diameter, flank angle, thread pitch, lead, and helix angle. **Figure 1** illustrates most of these principles on the diagram of an actual screw. The definitions are:

- ***Major Diameter:*** The largest diameter on the thread (on an external part this is the outermost diameter and on an internal thread it is the innermost diameter.)
- ***Minor Diameter:*** The smallest diameter on the thread (on an external part this is the innermost diameter and on an internal part it is the outermost diameter.)
- ***Pitch Diameter:*** Pitch diameter is exceptionally important because amongst other things manufacturing control and validation is based off of this diameter. It is, however, conceptually difficult to understand. The pitch diameter represents the diameter of an imaginary cylinder that is defined when the distance measured across the thread flank profile is equal to the distance between the threads.
- ***Flank Angle:*** This is the angle defined by the thread in profile.
- ***Thread Pitch:*** This is the linear distance from a point on one thread to the same point on the next adjacent thread.
- ***Lead:*** The linear distance that a part moves with one full rotation of the part. In a single lead thread this distance is equivalent to the pitch. In a multiple lead thread, the distance moved is equal to the number of leads multiplied by the pitch. In other words, if one has a double lead thread, one rotation of the part advances it the distance of two pitches.
- ***Helix Angle:*** The angle that the thread ramps up the cylinder it is wound on. Helix angle is an important factor as it is interrelated with the thread pitch, lead, and ability to multiply force.

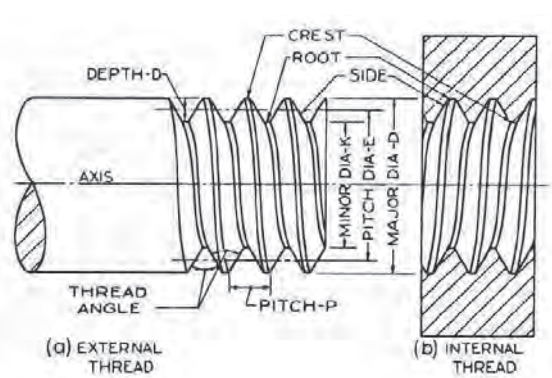

Figure 1- Thread Nomenclature

Although threads come in many different varieties and are used in many different ways, I categorize them into three primary families; threads with 60° profiles (commonly referred to as machine screw or metric threads), threads with greater than 60° profiles (power threads), and spaced threads. Even the most infrequent user likely recognizes that the most common of all these thread forms are the 60° profile threads. These are used in all sorts of screws, bolts, and other threaded joints and are usually, although not always, paired with pretapped holes or with nuts. Spaced threads are divided into two different categories. Low profile flank screw threads which are designed with flank angles lower than 60°, most being somewhere between 45° and 30°. Because these flank profiles do not carry the requisite strengths needed for high load applications or thread forming into "stronger" materials, they are most commonly employed in thermoplastic, wood, and other building material applications. More often than not, these are thread forming screws, meaning that in addition to magnifying load they function to cut or form their mating threads. The second category would be spaced threads with flank profiles of 60° or greater. These have historically been utilized on thread forms like Type AB used to fasten thin metal sheets. Spaced threads have been given the name because each subsequent thread does not begin where the preceding thread ends. As a result of this purposeful "spacing", thread pitches on these screws are greater than their nearest non-spaced equivalents. Finally are the screw threads with flank profiles greater than 60°, many approaching an almost horizontal profile. These are commonly known as Power Threads because these configurations translate into higher axial force components. Higher axial force components mean that the screw is able to generate extremely high loading or to carry heavy loads.

Threads are used to perform several important functions. Although usually the design purpose is singular, there are cases where the thread exhibits multiple functionality. The most common examples are thread forming screws where the thread first acts like a tap to generate its mating threads and then as a force multiplier to generate the desired clamping load. Fastener threads generally are used to accomplish one or more of the following five functions:

- Generate clamping load
- Adjustment
- As a tool to create its own mating threads
- To generate and/or hold exceptionally high loads
- Facilitate reversal (disassembly)

With this basic understanding of what a product designer may be attempting to accomplish through their choice of screw threads, let us take a closer look at each of the three families, common thread forms in each family, and where they are commonly used.

60° Profile Thread Flanks

Users most commonly refer to these types of screws as "Machine Screw Threads", "Unified Thread Series" and "Metric Threads". These are the thread forms defined by ASME standards like B1.1 for inch UNC, UNF, and UNR products and by ISO standards like ISO 68 for metric "M" products. Although slightly different in form and definitively different in pitch, pitch formats, and size, these products are comparable to one another in the sense that they are similarly designed but one defines inch product and the other metric product (See Figures 2 and 3).

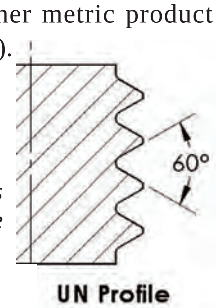

Figure 2- Unified Series Thread Profile

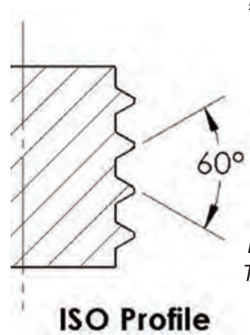

Figure 3- ISO Metric Thread Profile

These thread forms are the most extensively used throughout the world and are found almost everywhere and in almost every application. Normally they can be found on fasteners that are intended to be paired with pre-existing threaded mates; however, there are also a wide selection of thread forming fasteners (primarily for metal thread forming) that employ these same thread forms. One of the advantages of this is that if the screw needs to be replaced for some reason, it can be accomplished with a readily available machine screw replacement.

Again, these thread forms are used liberally throughout all fastener using industries and applications. In fact, some industries almost exclusively deploy threaded fasteners with these thread forms. The highest profile examples of such industries include structural bolting and aerospace.

Greater than 60° Profile Flank Threads

These are commonly referred to as Power Threads. They have thread flanks that are nearly flat and low helix angles so that the resultant force components are almost all pointed in the axial direction. As such, they are able to multiple high forces and hold heavy loads. These types of threads are commonly used in applications such as automobile jacks, automobile power seat adjusters, and on mechanical presses and tensile load generating equipment, just to name a few. They are also commonly used in construction and can be found on the ends of posts used to support beams in houses and other structures (See **Figure 4**).

Figure 4- Example of a Power Thread in Action

The most common of these thread forms are Square, Acme and, Buttress Threads. Figures 5, 6, and 7 illustrate these threads forms, respectively.

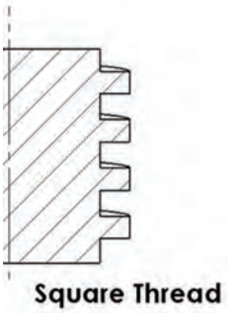

Figure 5- Square Thread Profile

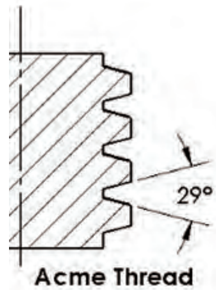

Figure 6- Acme Thread Profile

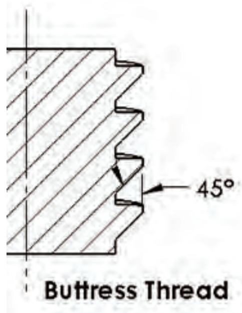

Figure 7- Buttress Thread Profile

Spaced Threads

Of the three families, spaced threads easily incorporate the widest variety of forms. They are often referred to as "Specialty Threads". Calling them spaced threads, however, is an apt description because instead of one thread terminating and the next thread immediately beginning at that point, there is a gap or space between the conclusion of one thread and the start of the next. This gap is normally embodied by the flat surface of the cylinder that the thread is rolled on, but some specialty products actually have a depressed or profiled root. These are usually incorporated on thread forms for applications where the screw is forming its mating threads in soft material that has the proclivity to extensively "flow". These relief areas provide additional space for soft materials to flow into, preventing damage from disrupted material flow. One of the best examples of this type of fastener is EJOT's patented Delta PT® screw (See **Figure 8**).

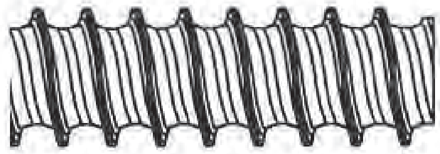

Figure 8- Delta PT® Thread Profile

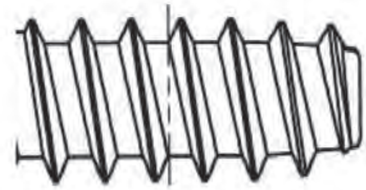

Figure 9- Plastite ® Thread Profile

Many of these spaced threads have profiles less than 60˚ and are used for thread forming soft materials such as thermoplastic, magnesium, and, in some cases, aluminum. There are many varieties, but perhaps the most common go under the tradenames, Delta PT®, PT®, Plastite®, Remform®, and HiLo® to name just a few. **Figures 9 and 10** illustrate a couple of these representative thread forms.

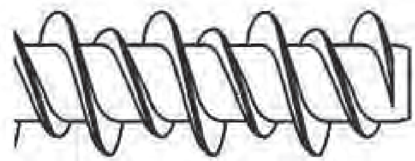

Figure 10- HiLo® Thread Profile

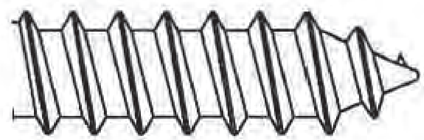

Figure 11- Type AB Thread Profile

There are also many varieties of spaced threads with 60˚ flank profiles. More often than not these are used in construction and for fastening thin metal sheets. Common varieties include Type A, Type AB, Type B, Type 17, and Type 25. **Figures 11, 12, and 13** illustrate a couple of these representative thread forms.

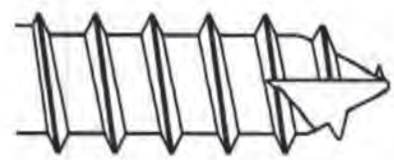

Figure 12-Type 17 Thread Profile

Figure 13- Type 25 Thread Profile

Summary

Screw threads come in many different varieties and are liberally employed throughout all industries and applications that require joining. Not all thread forms, however, are the same or universally applicable to be used in every application. Therefore, designers and users have to be "smart" about choosing the thread design or profile that best meets their needs and requirements. The best designers will educate themselves in the different nuances of each thread design so that when confronted with inevitable design challenges they are able to make the best decision. Fastener manufacturers and distributors alike should also be aware of such things so that they can steer their customers to the best choice of fastener. ■