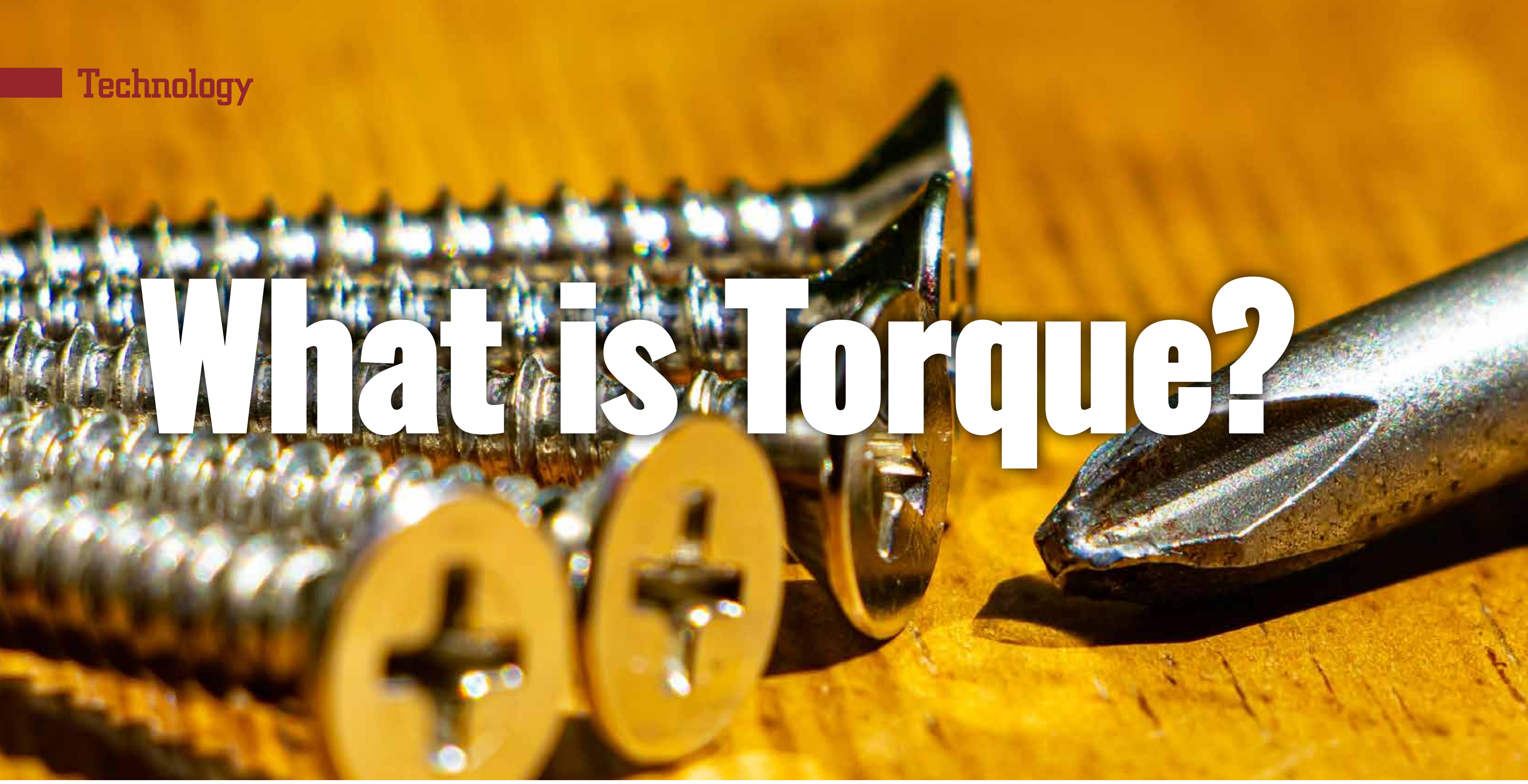

What is Torque?

So, what really is torque? Torque is frequently thought of as the critical force when tightening a joint together, but there are many other factors to consider when using torque as a measurement.

Torque is a combination of forces. In physics, torque is a vector that measures the tendency of a force to cause an object to rotate about an axis while applying a tension to the axis. With a fastener, we are rotating either a nut or the bolt head about the axis of the bolt.

Torque is the force applied to a lever (wrench), multiplied by the length of the lever rotated perpendicular about a fulcrum: the fulcrum being the axis of the bolt. The force is measured in pounds, or Newtons. The lever is measured in inches, feet or meters. Therefore, there is the pound-inch (lb-in), pound-foot (lb-ft) or Newton-meter (Nm) units of measurement.

Torsion is the amount of twisting performed due to an applied torque. When we stop turning the wrench, or twisting the bolt, the torsional forces dissipate. All forces are at rest. However, it should be noted that in many cases, joint relaxation will occur due to the 'spring-back' effect of the bolt as it equalizes the twist. Normal 'spring-back' of the bolt results in an average loss of clamping force of about 10%.

Torsion occurs during the tightening of the bolt as it applies a twist to the bolt's body while the bolt is being elongated by the advancement of the nut along the helical threads (tension). This twist occurs due to the friction created between the threads of the nut, or tapped hole, and the threads of the bolt as the flanks of the mating threads engage under the pressure of tension.

Therefore, torque is a function of friction. In essence, we are only measuring friction, not clamp load, which sets us up to be influenced by many variables.

Friction is that resistance we feel as we rotate the wrench during tightening, no matter if we use a torque wrench or a box wrench. We feel the joint becoming tighter with each degree of rotation as the nut is literally being crushed against the joint surface. This is the friction at the interface of the nut and joint surface.

We have two sources of friction: There is friction at the nut's bearing surface, or at the washer-face of the bolt's head, while the mating threads grind against each other at the same time in an attempt to apply enough strain on the bolt to carry it into its proposed elastic region and produce a clamp load upon the joint.

The approximate torque value is calculated using the universally accepted formula:

$$T = \frac{kDW}{12}$$

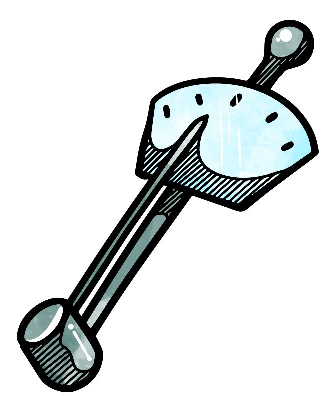

Fig. 1. Beam type torque wrench

To calculate a torque value for a specific grade, diameter and thread pitch bolt, the Diameter (D) of the bolt is multiplied by its projected work load (W). Clamp load can be any predetermined desired load for the joint or, more commonly, it is a value that is 75% of that bolt's proof load (with respect to Grade, Property Class and thread pitch). The product of which is then multiplied by a factor of 'k', then divided by 12 to convert inches to feet. The value of 12 is not used in Metric calculations.

The value of 'k' is the critical variable. In mathematics, 'k' is a constant, but with fasteners, it is a constant variable. This represents the coefficient of friction between the moving parts while under pressure. This includes under the bolt head or at the nut interface and between the threads.

The value of 'k' is usually determined experimentally. This can be done using a load cell or by placing a bolt and nut into a solid fixture. When tightening against a fixture, use a beam type torque wrench (**Fig. 1**). Turn the nut against the fixture while observing the beam deflection. At some point, the beam will stop advancing. Make note of this torque value as this is the point the bolt has gone into yield. Any further rotation of the nut and the beam will begin to drop downwards.

These methods will determine the 'k' factor for the particular conditions of that bolt and nut; different types of plating finishes, oils, wax coatings and anti-seize lubricants and in different combinations. Once the 'k' factor has been determined, it may be used on other sizes of bolts with the same surface conditions.

Because of 'k', a torque wrench's accuracy can be ± 150%. In fact, torque is only accurate under one condition, which only accounts for less than 50% of its use, and that is with using a lubricant.

The torque formula is just to show that friction variables can interfere with producing any clamping force that is close to being consistent and predictable. It demonstrates that a lubricated fastener will require less torque than a non-lubricated fastener.

Using a high speed power tool can cause an elastic rebound effect upon the bolt. The joint compresses greater than normal under the high speed pressure which advances the nut further than normal. When the tightening stops, the joint rebounds back to normal exerting a greater force against the nut that produces more tension on the bolt than expected. In some cases, this could be close to yield.

A common saying in the racing community was that horsepower is how hard you hit the wall and torque is how far you move it. This is exactly what happens when the high horsepower of a power tool is applied to the assembly of a fastener; the force and torque on a nut being driven onto the bolt threads by the power wrench and into the joint surface can cause damage.

Speed, whether by hand or power tool, is not as affected by friction because of a builtup of momentum that would overcome any burrs or thread inconsistencies. In some cases, though, this would cause thread stripping of the bolt or nut. Low torque power tools are used for assembling multiple bolt joints but most of the surface variables are consistent with new parts. Maintenance assemblies are quite different and have many variables.

Torsion will destroy a bolt if there are not enough threads in the grip. That is, if the bolt breaks with only one or two threads left on the body of the bolt or one thread outside the nut, there were not enough threads or basic material to absorb the torsional twist of the assembly. Always try to maximize the number of threads in the grip. This will also help reduce the chance of metal fatigue.

Small screws are especially susceptible to head failure due to excessive torsion and speed. The head is against the joint surface and there is not enough material to absorb the twist. Slow application of low torque will help the life of the screws.

A torque number does not mean anything to an impact wrench or most power tools. Torque values are meant to be used as a guide, and then consider the associated variable(s). However, it is the technique of applying that torque which will go a long way to making the connection a safe connection.

The key to avoiding failures in any bolted joint is to be consistent. ■

Article by Guy Avellon *Copyright owned by Fastener World*