The refinement is characterized by low solidity, the cracks or the decarburization of the surface caused by inappropriate constitution of the protective atmosphere. During cementation or inductive hardening, the small thickness of the hardened surface layer or material overheating in the area of sharp edges are the most often occurring problems. Austenitic stainless steel (A2, A4) are characterized by the fact that their increased solidity is not reached by heat treatment but by mechanical cold surface firming. It quite often happens that the declared strength valued at 700 or 800 N/mm^2 does not correspond to reality. All the mentioned cases of the screws and nuts production are unacceptable in practice.

Fig. 8

Surface treatment

It is often mistakenly supposed that surface treatment serves only as the protection against corrosion (Fig. 8) or to improve the appearance due to the higher credibility and marketability of products. However, the fact that the character of screws and nuts surface significantly determines the friction of coefficient, is marginalized. As it is shown in Fig. 3, different surface treatment influences the final pre-stressing force FV. Therefore, the constructor should have at disposal the correct data on surface characteristics in order to prescribe the right parameters of tightening. The bolted joint in Fig. 8 is a typical example of the incorrect combination of galvanized and untreated surface.

Conclusion

The security of products and the whole construction units is a difficult process in which the constructor has the most significant role. The constructor is responsible for construction security and whether it meets all technical requirements, economic and ecological criteria, etc. Naturally, that is true if the assembly fully respects the construction prescription. Unfortunately, it is not rare that correctly calculated and precisely dimensioned bolted joint is finally tightened manually, i.e. in an uncontrolled way. It is one of the persisting bad habits of the current technology of mechanical joining.

The Importance of Controlling Joint Tightening 緊固接合控制的重要性

by Laurence Claus

On December 23, 2016 a fatal crash occurred on a busy Chicago highway. A large tractor trailer truck hit a car, flipping over, and crashing through the center median hitting on-coming traffic. What could have been a horrendous holiday tragedy was limited only to the driver of the truck. Unfortunately, even one fatality is too many, especially if it is due to an entirely preventable cause.

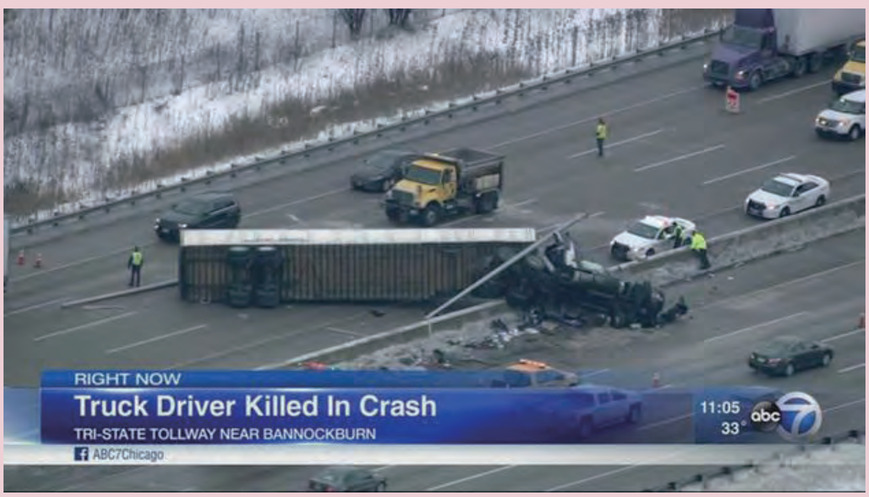

Figure 1: December 23 Chicago Truck Crash Linked to Separated Wheel

Early reports claimed that the crash was caused by a wheel separating from the truck. It was believed that this caused the driver to lose control resulting in the subsequent chain of events. After accident reconstruction, however, it was determined that the truck driver actually hit a wheel (tire and rim) that had separated from another truck and was lying in the roadway.

Now what does this accident have to do with fasteners? Perhaps nothing, and likely we will never know for certain anyway, but wheel separations are often fastener related. About twenty-five years ago the United States' National Transportation Safety Board conducted a study of wheel separations from large and medium duty tractor-trailer trucks. The study declared that anywhere between 750 and 1000 wheels separate from large trucks every year on United States roadways. That works out to be about 2 or 3 every day. More remarkably, the study concluded that as many as 75% of these wheel separations were the result of improper fastener tightening. In other words, the lug nuts holding the wheels in-place had either been over or under tightened. Considering these statistics, it's amazing that more people aren't injured or killed each year due to large truck wheel separations.

Although conducted a long time ago, the NTSB study spotlights the criticality of proper tightening, both at original installation and during maintenance activities. Most original equipment manufacturers are very deliberate and careful about determining the proper fastener tightening parameters and overseeing assembly methods that assure those parameters are met. Unfortunately once in service, control becomes much sketchier. In fact, most readers can probably relate to their own personal experience that human nature leads us to use a "tighter is better" philosophy when tightening screws and bolts. Regretfully with no real control being exerted, this strategy can leave screws, bolts, and nuts under tightened, over tightened, stripped, and broken. Joints in these conditions often lead to failures, sometimes with disastrous consequences.

This article will explore why the tightening process is so critical and, thus, why assembly parameters and the equipment used to assemble the joint must be thoroughly considered every time a joint is tightened.

Tension is All Important

Although it may be counterintuitive to many, bolts and screws act like stiff springs when tightened. Like a spring, the more it is stretched, the greater the tension in the joint becomes. This is particularly advantageous because it is this axial tension load, often referred to as the "clamp load", which holds the joint together. It is understood among fastener engineers that a properly tensioned joint, one that the tension load generated by the tightening of the screw or bolt exceeds any service load acting to separate the joint, should remain intact indefinitely.

Over the years I have been amused by debate as to whether the torque or tension is more important. A fastener engineer would quickly and clearly reinforce the idea that joint security is all about achieving the proper tension. Why then is torque even introduced into the discussion?

The answer to this is simple, tension is difficult to measure without specialized and usually very expensive equipment. This makes it difficult or even impossible for both the high volume assembler and the individual to know whether they have achieved the desired tension. The fastener engineer's saving knowledge, however, is that there is a direct relationship between torque and tension, and torque is easy to measure. Therefore, when designing a tightening strategy to achieve a desired tension, most rely either partly or entirely on controlling the torque.

Unfortunately applying some derived value of torque is not that simple. In fact, there are two significant challenges remaining. First, although torque and tension have a direct relationship, this relationship is dramatically influenced by the frictional characteristics of the joint. Small changes in surface conditions, geometry, or environment can significantly impact these frictional factors, often in ways not obvious to the assembler. Therefore, unless very well controlled, the actual tension generated may be greater or less than expected due to the actual frictional conditions at assembly. The second challenge is related to the equipment used to measure the applied torque. Simple torque wrenches are not especially accurate, with repeatability error factors as great as +/- 30%. For installations that are designed on thin margins or require greater tightening control, simple torque assembly methods may not be sufficient.

There are a variety of different methods, often referred to as strategies, to tighten screws and bolts. These strategies range from relatively simple methods that even the novice mechanic can employ to very sophisticated methods employed by highly trained and expensively equipped technicians. Although there are many others, this article, will only explore the methods known as "torque control" and torque-angle control".

Torque Control

The most common method of tightening control is known as the torque control method. This method simply depends on using a torque wrench (or other torque measuring or sensing device) and an understanding of the torque-tension relationship to achieve the proper tension. This method is universally incorporated for joint design and is revealed when the assembly instructions or service manual instructs the assembler to tighten the screw, bolt, or nut to a specified torque value. As an example, a service manual may instruct that the "Bolt Part Number XX should be tightened to 10Nm".

The most basic approach to this method is to use a torque wrench to set the joint to the specified value. Most often, this is the approach that will be taken in the field, as a torque wrench is a simple and relatively inexpensive tool for a mechanic or technician to have in their tool kit.

Torque wrenches come in several different varieties. The most basic is a beam torque wrench. When using a beam torque wrench, after the screw or bolt is seated, the load exerted on the drive cause the cantilever beam on the wrench to deflect and move a pointer along a scale to provide the torque reading. Of all the torque wrench varieties, beam torque wrenches are the least accurate. Dial torque wrenches are more popular and slightly more accurate. They act on a similar principle as a beam wrench except their mechanism moves a needle inside a dial to provide the torque reading. For higher volume applications, "clicker" style torque wrenches are commonly utilized. A clicker wrench has an internal clutch or mechanism that will detect or slip when the desired torque is reached. Normally these wrenches will emit a beep or clicking sound when the desired value is obtained.

Figure 2: Beam Style Torque Wrench

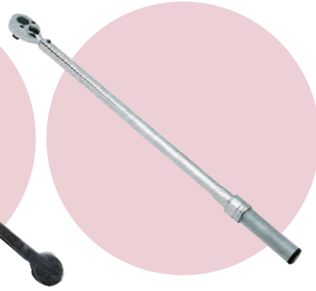

Figure 3: Adjustable "Clicker" Style Torque Wrench

Figure 4: Dial Style Torque Wrench

Torque wrenches provide a simple and inexpensive means of measuring or applying a desired torque value, however, they may possess a significant amount of repeatability error and are designed for manual, one-at-a-time, assembly. Essentially this makes them impractical for applications requiring high volume or high precision. For this reason, most original equipment manufacturers invest in driver units with integrated torque control devices. These units can be integrated in both pneumatic or DC electric drivers and are available from all suppliers of such equipment. In addition to enhancing speed and ergonomics, these drive units significantly enhance accuracy and may have repeatability errors as low as +/- 5%.

Torque-Angle Control

As mentioned earlier in this article, small variations in friction can have a significant impact on the achieved tension. In instances where the tightening is very critical or has little margin for error, such as when tightening a part into yield, a better method is required. The most common "better method" is known as torque-angle control. The relationship between torque and tension is still a factor with this strategy but now it also includes the added factor of angle of rotation.

From an engineering perspective, threaded fasteners are elegant in many ways, including the consistency and predictability of thread spacing. Taking advantage of this the engineer can very closely predict axial movement or stretch by controlling the amount of rotation the part makes. Therefore, in the torque-angle strategy, torque is applied to achieve a baseline position and then rotated a specified number of degrees to provide "fine tuning". This is typically the strategy employed to tighten a fastener into yield.

Although in original equipment manufacturing torque-angle strategies employ sophisticated and expensive assembly equipment, which consistently achieves repeatability errors of +/-5% or less, this method also can be and is often employed with relatively simple tools in the field. In fact, most structural bolting assembly employs a variant of this method known as "turn of nut" or "turn of bolt" assembly. In this case, structural assemblies are brought to what is known as the "snug tight" position. Reference marks are made to indicate the position of the nut or bolt head relative to its surroundings. The nut or bolt is then turned, usually only ¼ to 2/3rds of a turn, per a relevant tightening specification such as the structural bolt tightening guidelines published by the Research Council on Structural Connections. Similarly, this method is often employed in auto racing and by some mechanics by using a combination of a torque wrench and an angle guide tool to tighten critical joints.

Impact Wrenches

Anyone desiring control of the tightening process should eliminate any usage of impact wrenches from the assembly. An impact wrench combines rotation with an impact blow. Favored by many for its speed and ability to tighten at levels above what one could normally accomplish by hand, it possesses no level of tightening control. Users that blindly wield an impact wrench to tighten a joint have absolutely no idea how tight it really is. For this reason, a critical joint, such as the ones used for truck wheels, can be over or under tightened with no one knowing it. The consequences of such a loss of tightening control can be disastrous, especially when the joint is critical in nature.

Conclusion

Although the fastener engineer's goal is really all about achieving the desired tension in the joint, attention is often focused on the torque that is applied because it is through the applied torque that the tension is achieved. The torque-tension relationship, however, can often be tricky, so that how torque is controlled and applied becomes a critical factor. Torque can be applied with a variety of different methods using a variety of different devices. These devices can vary in cost, sophistication, and accuracy. The user must define what is required and make the proper choices. Failure to do so, as illustrated at the beginning of this article, can have horrific consequences. Therefore, properly engineering the "lowly fastener" and understanding and controlling tightening takes on a new level of importance and significance.