An Overview of Fastening Tools-Understanding Your Options

鎖固工具概要

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Several days before Christmas of 2016, a truck driver was passing through Chicago on one of the primary expressways. All of a sudden he noticed a large obstruction in his path and swerved his truck to miss it. Unfortunately, in this maneuver he clipped an adjacent vehicle sending him out of control, flipping his truck on its side, breaking through the center concrete divider, and hitting an on-coming vehicle. Sadly, the truck driver lost his life in this tragic accident.

Accident scene investigators would later determine that this accident was triggered by a wheel that had separated off of another truck and was lying in wait on the roadway for an unfortunate victim. In answer to a spate of such incidents, in 1992 the United States National Transportation Safety Board (NTSB) sponsored a study to examine the cause and frequency of wheel separations from large Class 8 trucks. Shockingly the study determined that there are between 750 and 1050 such reported separations on U.S. roadways every year. That amounts to two to three every day. The study went on to find that the leading cause of such separations was improper nut and stud tightening during the installation or reinstallation after maintenance of large truck wheels.

This poignant example illustrates how very important it is to get the proper tension applied to the bolted joint. Now, there are many factors that contribute to successfully doing this, including installing the right fasteners, understanding the right torque-tension relationship, and knowing the right fastening tools to use. This article will take a look at this last point and provide a simple overview of the basic fastening tool options available to an installer.

Why is Fastening Tool Technology Important?

There are a variety of reasons that someone may choose to fasten something together with a threaded fastener. In all but a few cases, one of the primary reasons for such a choice is to take advantage of the screw threads capability to generate large clamping loads. Or put more simply, threaded fasteners have the advantage, when properly installed, to tightly hold things together.

Bolts and screws accomplish this by acting like stiff springs. The more they are stretched the more clamping load they exert on the materials in their grip. Achieving these loads is particularly important when one is fastening a critical joint. Therefore, engineers and designers take great precautions to assure that the correct fasteners are chosen. The goal is to produce a clamping load that is greater than the service loads trying to separate the joint. This is referred to as tensioning the joint or, perhaps, more commonly as achieving the desired "preload". Whatever term might be used, the concept remains the same-achieving the right amount of tension in the joint is extremely important.

Unfortunately it is not easy to measure the tension in the joint. It is certainly not impossible but is difficult or expensive to do in high volumes or where the proper measuring conditions are unavailable. Therefore, we must find an easier way. Fortunately, one exists. Long ago, engineers discovered that there is a direct relationship between torque and tension. Unlike tension, torque is relatively simple to measure in real time. Once a clear understanding of all the factors that go into this relationship are understood, one can pretty confidently rely on the fact that the application of a prescribed amount of torque will result in a desired amount of tension.

The, all too often unspoken, implications of this last statement, however, are that all the influences acting on the joint are understood, that they don't significantly change, and that we have a way of precisely delivering the correct level of torque to the bolt or screw.

Error in Fastening Tools

Like any manufacturing or assembly operation, the installation of fasteners exhibits variation in torque. The variation may come from the fasteners, the elements of the joint, the installer, or the fastening tools. When choosing the fastening tools for a job, it is especially important to consider this. Take for example the scenario where someone grabs a beam style torque wrench from under a pile of other tools in their toolbox, dusts it off, and applies a prescribed amount of torque to a bolt. Will the result be accurate? Perhaps, serendipitously, it will be. However, it is far more likely to be way off the mark, because the torque wrench was not well maintained, never calibrated, and already started out at a disadvantage of having a +/- 25% or 30% error factor. As this example illustrates, one can simply say that not all fastening tools are alike and that to achieve both higher precision (values close to one another) and higher accuracy (values close to the target), one must be willing to invest in better and, often, more expensive technology.

Monitoring Torque During Installation

Because fastening tools that provide some level of "control" rely predominantly on delivering torque, this feature must be monitored and controlled. In the simplest device, a hand torque wrench, the operator must discern the desired torque value by reading a scale or listening for a signal such as a click or a beep that the proper torque level has been achieved. Unfortunately, these hand devices may possess high levels of error and can easily overshoot their desired target. In this industry it doesn't take long before one hears stories about the guy built like Arnold Schwarzenegger who was operating his torque wrench on the assembly line. As instructed he applies torque until he hears the wrench "click", but unsatisfied goes on to give another half turn because it seems natural to assume that if it is tight, being a little tighter is better.

Fortunately, most assembly processes today utilize better technology than hand torque wrenches. In fact, most assembly processes use either manual or fully automated fastening tools, which are either pneumatically or electrically driven. Normally these tools are combined with clutch mechanisms or control units that stop the fastener tools from driving beyond the prescribed torque values. Additionally, many of the higher-end fastening tools combine integrated torque sensors within the tools to monitor torque versus angle (or time.) These are precision sensors that provide levels of accuracy and precision unknown in former times.

Considerations for Driving

When an engineer is designing an assembly process and it includes tightening a threaded fastener, there are many things they must take into consideration.

Precision and Accuracy

Although many consider precision and accuracy to be the same thing, they are not. Accuracy is how close a measurement is to its true value. To think about this in a marksmanship analogy, it is how close the shooter is to hitting the bullseye. Precision, on the other hand, is how close (or repeatable) measurements are to one another. If a shooter positions all of their shots in the upper left quadrant of the target, they would be precise but not necessarily accurate. Our desire is to have a fastening tool which is both accurate and precise.

When considering the fastening tool, therefore, the tool's ability to be both accurate and precise may be very important. This would be especially true for critical joints or where the available margin to over or undershoot the torque target is particularly small. A high strength fastener that is fastened into yield would be one example. If the installer overshoots the torque on such a fastener, the risk and possibility that the bolt or screw will break is high. Likewise, self-tapping screws for plastics often operate under thin margins. If the tension in the joint becomes too high, the female, plastic threads strip out in shear. Thus there are many examples where the assembler must invest in highly accurate and precise equipment to prevent scrap, rework, and downtime. For this reason, manufacturers like Deprag, a well-respected German fastening tool manufacturer, innovate new technology and offer technology in their products such as high-precision, shut-off clutches on pneumatic fastening tools and high-precision controllers to shut-off their servo drive electric units.

Ease of Access

Although it is the dream of most manufacturing engineers to have simple, easy access to every assembly point, many assembly situations are far from straight forward. Assembly locations may be off-angle, hard to reach, or totally blind. Each of these situations may be best suited to specific fastening tool designs such as a straight body, pistol grip, or right angle design.

Drive Bits

Today's fasteners can come with a wide variety of recess drive styles. It would, therefore, not be unexpected for an assembler to desire one work station with the versatility to drive a variety of different fasteners with a variety of different bits all from one fastening tool. To answer such a need, fastening tool manufacturers may offer driver options with either multiple bit interchangeability or quick bit changeover capabilities.

Multiple Torque Settings

When multiple fasteners are driven at a single assembly station, there is often the need to use multiple torque settings. Just like with drive bits discussed above, some drivers may have control units that can store multiple different assembly parameters for use with a single driver. The more traditional approach, however, would be to equip the work station with multiple different drivers, each one dedicated to a specific screw and installation torque.

Drive Speed

Drive speed can be very important depending on the fastening application. For example, self-tapping screws into plastics requires limiting the driving speed. When too high driving speeds are utilized, it can damage the plastic material so that the assembled product may exhibit detrimental effects in the long-term. In the opposite fashion, certain newer fastening technologies for aluminum require very high speed rotation of the fastening tools.

Ergonomics

A few years ago one of the biggest concerns in assembly was ergonomics or the study of operator comfort. Fastening tools that were heavy or had a high torque reaction moment (when the fastening tool reaches its installation torque and stops- usually applying a twist on the fastening tool) were found to be a cause of repetitive motion injuries and operator fatigue. As such, one must specify the right fastening tool or accessory to the fastening tool to limit or prevent such ergonomic issues.

Manual Drivers

When one considers all of the products that are assembled, it is probably fair to say that the majority of fasteners are driven manually. This means that an operator is manipulating the fastening tool into position and manually starting the operation. Although many of these systems are simple with no part feeding or measurement capabilities, others are more advanced and may self-feed the screws or have integrated measurement and control systems.

Although each driver may cover only a limited torque range, most fastening tool manufacturers carry a wide selection of different models that span a broad range of torque values. In other words, if the fastener to be driven is a micro screw, there are fastening tools available that can apply very small torque values. Likewise as screws get larger in diameter fastening tools are available that can handle the torques associated with them. As applied torque values increase, drivers are often fitted with reaction bars and other accessories to assist with safe and ergonomic assembly for the installer.

Manual drivers are energized in one of two ways. The old mainstays, which have been around for many years, are the pneumatic variety, which means they are driven by compressed air. This technology is very mature and provides a compact and usually very convenient and efficient means of energizing the fastening tool. However, to operate properly, they do depend on a strong, reliable source of compressed air. Occasionally this is a problem for some assemblers, especially if their infrastructure is old, “cobbled” together, or has the assembly station located at the end of the airline. Many newer fastening tools are energized by servo driven electrical motors. These generally are very accurate and precise and eliminate some of the variability of pneumatic drivers. They are, however, much more expensive. Therefore, for simple, non-critical, and low volume assembly, they may not be easily justified.

Manual drivers are available in a straight body design for vertical installations, pistol grip designs for horizontal installation and angle head configurations for either confined space or high torque applications.

Of course there are special applications where fastening tools have been uniquely designed. Deprag, for example, offers a line of impulse screwdrivers which are used in high torque applications where torque repeatability and minimal reaction are needed. Screwdrivers have been designed to stop at a prescribed depth rather than a specified torque. These would be useful in applications like applying drywall, and Deprag even has a line of tools, called the VARIOMAT, that can drill and install a screw in a single assembly step. Many other specialty applications exist and an assembler with special fastening needs is wise to speak with fastening tool manufacturers before investing in expensive development. It is possible that a solution or an easy adaptation to an existing solution may already exist.

Automated Drivers

Products that are assembled using automation require many of the same technologies embodied in manual fastening tools, but integrated into the automation so that it requires no human interface. As a result, these units must be both self-fed and operate under some sort of master control. Most such units are fed by blowing a screw through a tube into the nozzle of the driver, although other methods can be employed. These feeding systems are often as sophisticated as the driver units themselves because assemblers cannot afford downtime that is the result of clogged or malfunctioning feeders.

The control units on automated fastening tools can also be quite sophisticated. Not only do these systems need to be integrated into the rest of the automation, but they have to be able to monitor torque, rotational speed, and position of the screw (usually by the angles of turn). It is not uncommon for these control units to be able to store multiple programs for multiple driving tools or different product variations.

Conclusion

Like the products they are driving, fastening tools are continually evolving as new technology is introduced. There always seems to be work underway to make the control systems more sophisticated and versatile yet simpler to use. The precision, even on traditional pneumatic drivers, gets increasingly better year after year. Fastening tool ergonomics is significantly improved so that operators today are safer and more comfortable than their predecessors were even just a few years ago.

Even with these advancements, however, much of the quality of the fastened joint is dependent on the designer to specify the right fastening tool and for the installer to use them correctly. As was illustrated at the beginning of this article, in the example of large truck wheel separations, misunderstanding of how to properly tighten a fastened joint and misapplication in doing so can and often does lead to catastrophic results.