Q&A with Fastener Professor, Dr. Toshimichi Fukuoka

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Basics and Selection of Tightening Method of Screw Threads

Q1: What is the Most Important Point in Tightening Screw Threads?

A: Although threaded fasteners are sometimes used to transfer motion, they are mostly used to fasten parts. Bolt-nut fastening, for instance, is achieved by surely applying the target axial bolt force. The amount of fastening torque in the torque control method and the heating time in the fastening process using a bolt heater are no more than operation guidelines to achieve the target axial force. These guidelines are also related to other questions. Those values are respectively set to attain the target axial force, but bear in mind that they don't completely guarantee the expected axial bolt force.

Q2: What are the Methods for Tightening Screw Threads?

A: The details about each fastening method will be explained in the answers to other questions. Here, I will briefly introduce the outline of widely-used methods. First, the most widely used one is "torque control method". Besides using spanners and torque wrenches to fasten, this method includes the case of turning the heads of small screws by a screwdriver to fasten them. In either method, it is common that a torque is applied around the screw axis, by taking advantage of thread helical geometry, in order to convert the torque into axial force. The torque control method includes the use of motor/air/hydraulic driven torque wrenches and it also includes impact wrenches, which aim to improve workability and fasten large screws. On the other hand, there are tightening methods without applying torque. They are "direct tension method" that uses a hydraulic tensioner by which the axial force is directly applied to the bolt, and "thermal expansion method" that uses a bar-shaped heater to heat and expand a hollow bolt for fastening. Figures 1 and 2 respectively show a hydraulic tensioner and a bolt heater. Each method has a distinctive characteristic, i.e., direct tension method basically has high fastening precision and thermal expansion method doesn't restrict the maximum size of fasteners that can be fastened. Meanwhile, "elastic angle control method" utilizes the principle that the nut rotation angle is proportional to the bolt force to be generated. Its operation is more complicated compared to the torque control method, but it can improve the fastening precision. Note that in the angle control method, the torque is also applied to the nut during fastening.

Fig. 1. Hydraulic tensioner

Fig. 2. Bolt heater

Q3: What are the Important Points in Selecting the Method for Tightening Screw Threads?

A: The main points include the maximum applicable screw size, required fastening precision, workability, the cost of the fastening device, etc. Here, the workability includes the working hours and personnel expenses. First, torque control method is the most extensively used method for ease of fastening, and the situation won't change in the future. Powered torque wrenches, as shown in Figure 3, are commonly used to fasten large fasteners. For even larger fasteners, direct tension method and thermal expansion method are to be used, but recently the market has been selling powered torque wrenches that can fasten substantially large fasteners. The one with the highest fastening precision is the direct tension method. However, it can't be used on a portion with a short grip length or a fastened portion inserted with a gasket whose stiffness is hard to evaluate, because it cannot exhibit the original performance in those cases. In terms of workability, powered torque wrenches stand out for the ability to complete the fastening in a short time, but it needs a substantial cost for the fastening device. The aforementioned direct tension method also requires a hydraulic tensioner and a hydraulic motor that drives the tensioner, so it shares the same problem in costs. The thermal expansion method has advantages in that it can fasten large bolts, spends lower costs, and can simultaneously fasten many bolts. However, the onsite work mostly depends on the know-how of proficient operators because there is not yet an established fastening guideline that is generally recognized. ■

Fig. 3. Powered torque wrench

Reference

1. Toshimichi Fukuoka, "Threaded Fasteners for Engineers and Design – Solid Mechanics and Numerical Analysis –", pp.73-75, Corona Publishing Co., Ltd. (2015)