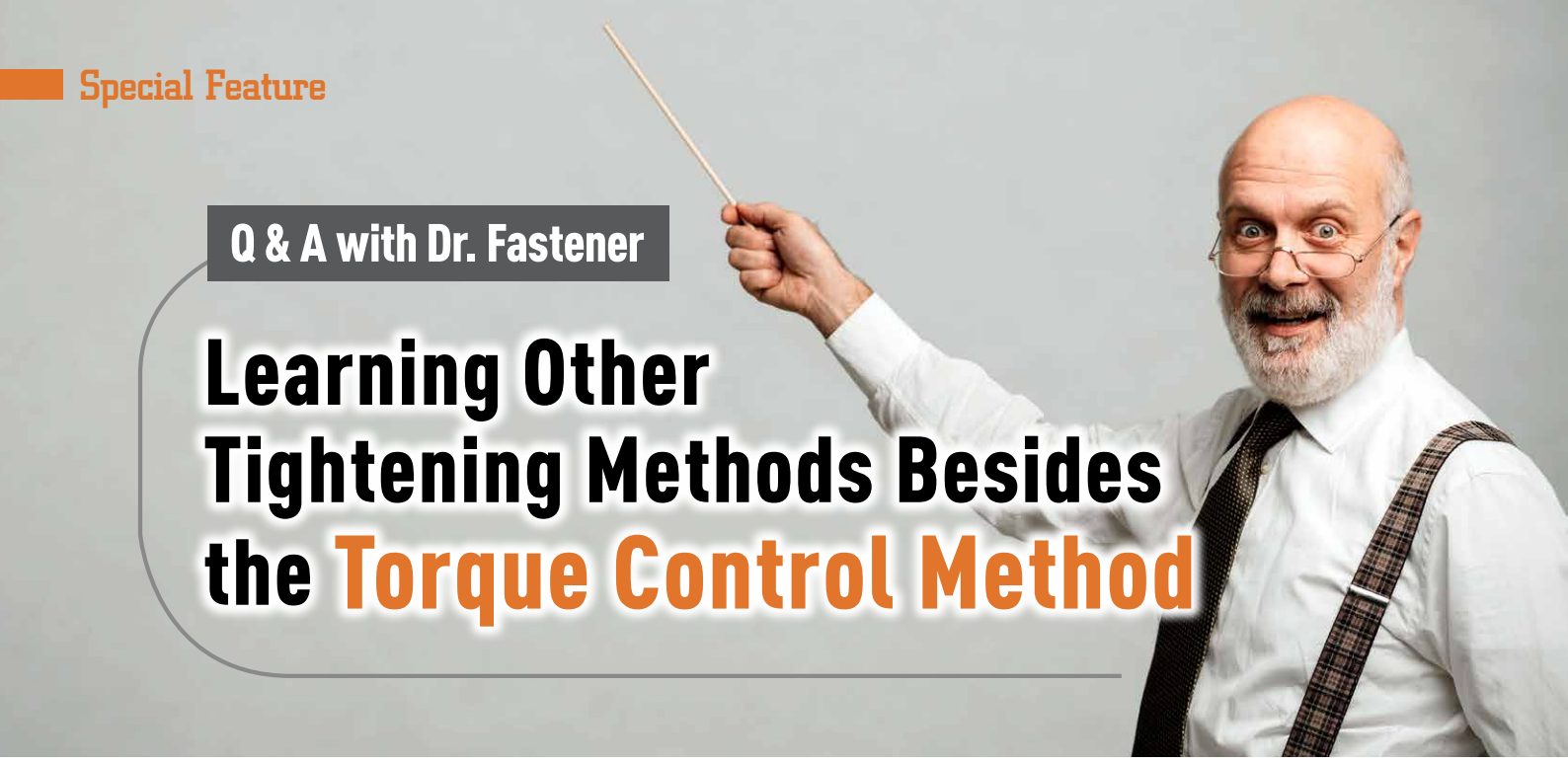

Q & A with Dr. Fastener

Learning Other Tightening Methods Besides the Torque Control Method

Q1: I heard there is a tightening method by pulling a bolt with hydraulic pressure. Please tell me what it is.

A: This is called the **direct tension method**. A hydraulic tensioner shown in **Figure 1** is used to apply tension directly to the bolt. **Figure 2** shows the structure of the hydraulic tensioner, and the tightening process consists of four steps as shown in **Figure 3**. First, the hydraulic tensioner is installed on the fastening portion, and then the grip nut attached to the bolt is lifted by hydraulic pressure in order to apply tension to the bolt. At this point, the nut bearing surface loses the contact with the fastened plate surface, so an appropriate amount of torque is applied to the nut to firmly seat the nut bearing surface. Finally, the tightening operation is completed by removing the hydraulic pressure. **Unlike the torque control method, this method is not affected by the coefficient of friction in the rotation direction of the nut, therefore, if applied properly, the error range of axial force can be kept within a few percents.** On the other hand, the removal of hydraulic pressure causes the nut bearing surface to sink and deform, resulting in some reduction of the final axial bolt force compared to the initial tension. The ratio of the two is defined as the "effective tensile coefficient" in the important working guidelines, and a calculation method using the stiffness of each part of the bolted joint has been proposed.

Figure 1. Hydraulic tensioner

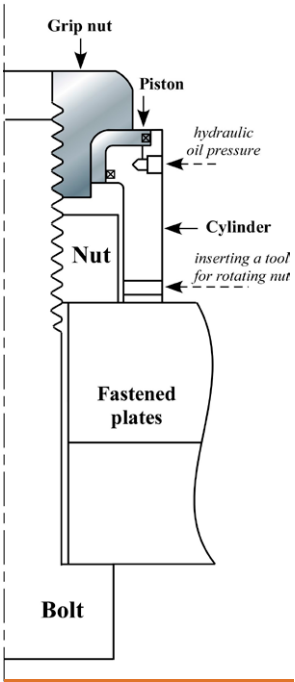

Figure 2. Structure of the hydraulic tensioner

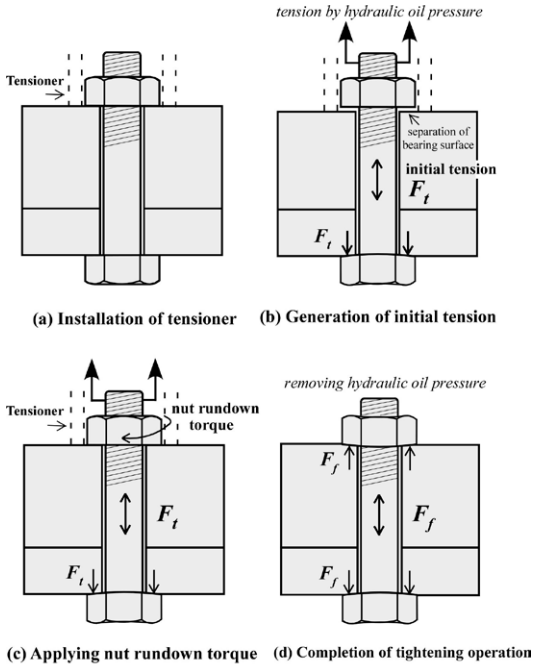

Figure 3. Tightening process of hydraulic tensioner

Q2: Please tell me how to tighten large bolts at a low cost.

A: This is called the **thermal expansion method** using a relatively inexpensive device called a bolt heater, as shown in **Figure 4**. The tightening process of thermal expansion method consists of four steps as shown in **Figure 5**. The bolt is hollow to allow the heater to be inserted, but the diameter of the hole is fairly smaller than the diameter of

Figure 4. Bolt heater

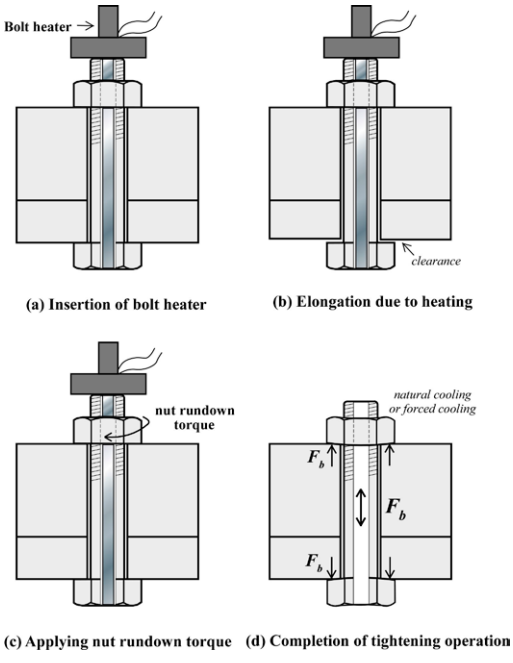

Figure 5. Tightening process of thermal expansion method

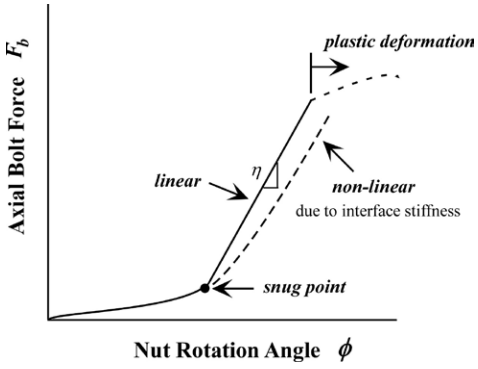

Figure 6. Relationship between the rotation angle of the nut and the axial bolt force

bolt force generated. Once the nut bearing surface is firmly seated, the subsequent axial bolt force increases almost in proportion to the nut rotation angle. In actual work, the nut is first tightened in the same manner as the torque control method until the nut bearing surface is firmly in contact with the fastened plates surface. In this state, a certain amount of axial force is generated. Next, utilizing the fact that the increase in the axial bolt force is proportional to the rotation angle of the nut, the bolt is tightened to the target axial force. The rotation angle required to obtain the target axial bolt force can be calculated using the stiffness of each part of the bolted joint. As is clear from the above discussions, unlike the torque control method, the tightening processes of direct tension method, thermal expansion method, and angle control method are greatly affected by the stiffness of the jointed portions. ■

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the bolt, so there is no problem with strength. **When the heater is inserted into the bolt and heated, the bolt elongates, generating a small gap between the bolt head and the fastened plates. After confirming that the bolt elongation has reached the target value, nut rundown torque is applied.** The process of applying nut rundown torque is the same as in the direct tension method. After that, as the temperature of the bolt decreases, axial force is generated due to contraction. To shorten the working hours, the fastened portion is sometimes forcibly cooled down. If the amount of bolt elongation is known, the magnitude of the axial force generated can be calculated fairly accurately using the stiffness of each portion of the bolted joint. The time required for heating can also be determined by a simple numerical calculation.

Q3: Please tell me how to tighten a bolt using nut rotation angle as an indicator.

A: **The torque method is a very convenient way of fastening, but it is inevitable that the axial force scatters to some extent. In such cases, the angle control method is sometimes used, utilizing the fact that the axial force generated in a bolt is proportional to the rotation angle of the nut. Angle control method is sometimes used to tighten a bolt to the plastic range.** However, in this article I will explain “elastic angle control method” suited for bolts that are reused after routine inspection and disassembly of bolted joints. **Figure 6** shows the relationship between the rotation angle of the nut and the axial

Reference
1. Toshimichi Fukuoka, "The Mechanics of Threaded Fasteners and Bolted Joints for Engineering and Design", pp.101-125, ELSEVIER. (2022)