

# QA

# Strategies to Suppress the Variations in Axial Force

## Q1. Is there an easy way to improve the accuracy of Torque Control Method?

The biggest cause of the variation in axial bolt force is the scatter in the coefficients of friction on the thread surface and the nut bearing surface. The mechanism was explained in the article "Reviewing Torque Control Method" before the previous one. As a measure to improve the accuracy of Torque Control Method, the author has proposed "the use of flat washers with the same surface treatment that is applied to bolts and nuts" in the relevant academic society. Since bolts and nuts have usually undergone the same surface treatment, the variations in the coefficient of friction on the thread surface are considered relatively small. In contrast, the coefficient of friction on the nut bearing surface varies greatly depending on the material and surface treatment of the fastened object in contact. Then, the use of a flat washer described above can reduce the variation because "the surfaces with the same surface treatment are in contact." Experiments conducted by use of a large number of bolts and nuts have shown that the variation in axial force can be reduced to about 10%, as shown in Figure 1. Finite element analysis, shown in Figure 2, confirms that there are no particular problems with the loosening performance when flat washers are used, unless the fasteners are subjected to severe vibrations or impact loads.

Fig 1

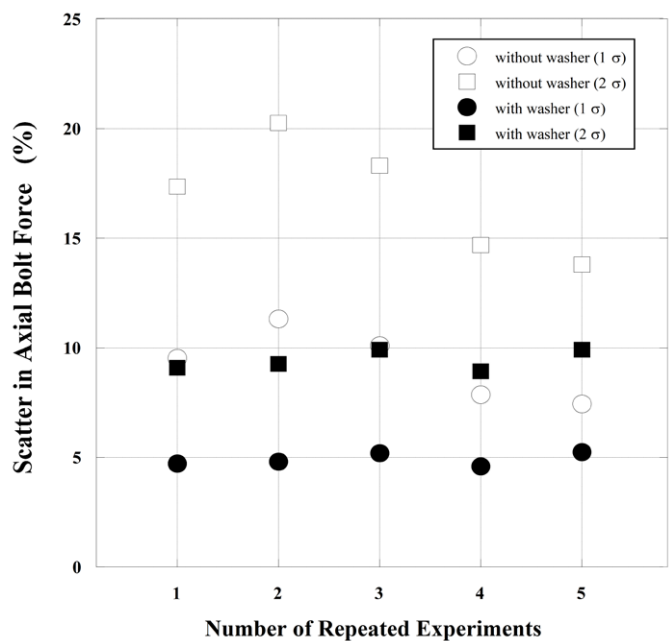
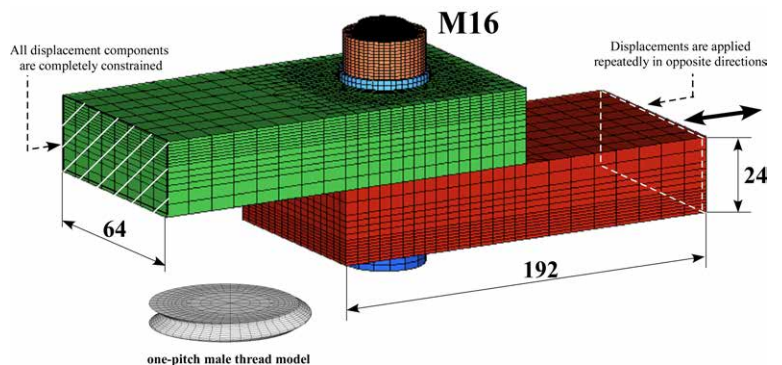


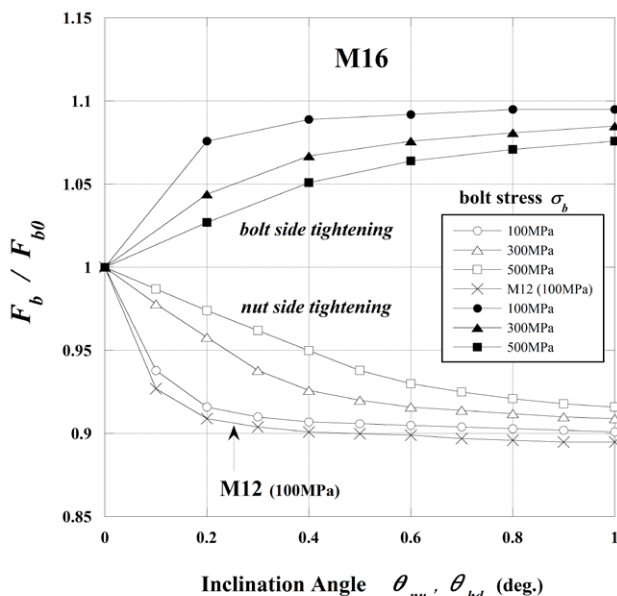
Fig 2



## Q2. Is the friction coefficient the only factor that affects the accuracy of Torque Control Method?

Basically, the nut bearing surface and the bolt head bearing surface are "perfectly flat," so that they are closely in contact with the fastened plate surface. However, the nut bearing surface is sometimes slightly tapered inward and the bolt head bearing surface is tapered outward within the tolerance of the JIS standard. When the taper angle is large, the axial force may be reduced up to 10% in case of the torque being applied to the nut side, even if the friction coefficient is the same. In contrast, the axial force may be increased up to 10% when tightening from the bolt head side, as shown in Figure 3. The reason for this is that the equivalent friction diameter changes due to the inclination of the bearing surface, and then the frictional work being consumed at the bearing surface changes. In addition, when a powered torque wrench is used and the tightening operation is performed from the bolt head side, the axial force may be low. This is because part of the torque is consumed by frictional work when the bolt body and bolt hole come into contact due to the effect of counter-torque.

Fig 3



## Reference

1. Toshimichi Fukuoka, "The Mechanics of Threaded Fasteners and Bolted Joints for Engineering and Design", pp.81-86, pp.93-96, pp.256-261, ELSEVIER. (2022)

## Q3. Please explain why high tightening accuracy cannot be attained even with a hydraulic tensioner.

Including thin plates, when applying a hydraulic tensioner to bolted joints with short grip lengths, the tightening accuracy reduces. In the tightening operation with a hydraulic tensioner, the axial bolt force to be generated is lower than the tension initially applied, because the nut bearing surface deforms so that it sinks into the fastened part when the work is completed. If the grip length is short, the ratio of the deformation of the nut bearing surface to the bolt's elongation increases, resulting in a large reduction in axial force. At the same time, the variation of axial force also increases. Although it is difficult to give an exact figure, hydraulic tensioners should be used for bolted joints whose grip length is several times or more larger than the nominal diameter of the bolt.

## Q4. What precautions should be taken when tightening by use of bolt heaters?

In order to ensure that the bolt, which has been elongated by heating, generates the target axial force by contraction during cooling, the snug torque of the nut bearing surface should be large enough so that the average surface contact pressure on the bearing surface is 10 MPa or higher. Another important point is that the bolt heater should be kept inserted in the hole until the snug operation is completed. If it is removed before that, the temperature of the bolt drops rapidly and the bolt will not have enough elongation, resulting in a decrease in the value of the final axial force.

## Q5. What are the important points when tightening is performed using the nut rotation angle as an indicator?

Since Elastic Range Rotation Angle Method is used together with Torque Control Method, it should be applied to the bolted joints whose target axial bolt stress is above a certain level (e.g. 300 MPa). The amount of axial stress generated by the torque should be at least 50 MPa to 100 MPa. In addition, as with Tension Method and Thermal Expansion Method, it is not desirable to apply this method to bolted joints with short grip lengths. ■

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