What should be tightened – the nut or the bolt head?

By Bill Eccles – Bolt Science

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The question is often asked as to whether the nut or the bolt head should be tightened. The answer depends upon which tightening process is being used. For torque controlled tightening whether the nut is tightened and the bolt head held, or the bolt head tightened and the nut held, can be of importance.

The general objective from a tightening process is to achieve a consistent bolt preload. Controlling the torque during tightening and completing subsequent inspection checks to ensure that the specified torque is being achieved, are common ways that this objective is implemented.

When applied torque and the resulting tension (preload) in the bolt are measured during tightening and plotted on a graph, there is a linear relationship between the torque and the tension. The bolt tension is directly dependent, and proportional to, the applied torque. This is illustrated by the graph, which is based upon experimental results, that is shown in figure 1. From such test results it is possible to establish the appropriate torque for a required bolt preload that may be required.

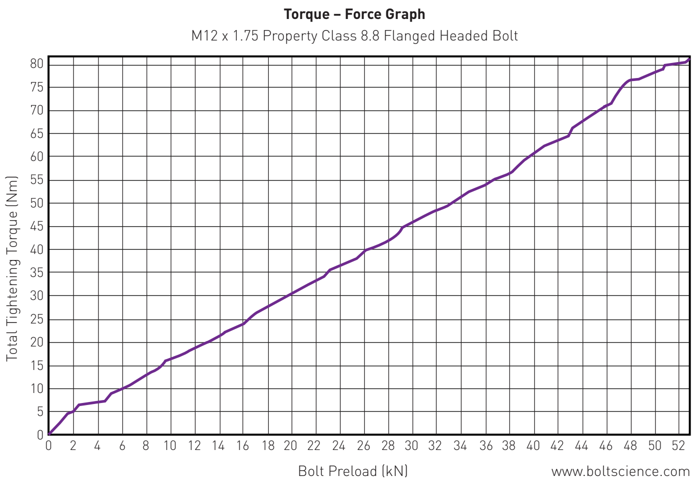

Figure 1: Torque – Tension Relationship

One of the disadvantages of using torque control is that there can be a significant variation in the bolt preload achieved for a given torque value. There are several reasons for this e.g. inaccuracy in applying the torque, dimensional variations of the thread and hole size variation amoungst others. However, the dominant factor is usually due to the frictional variation that is present between the contact surfaces that are being rotated.

From tests, it is known that approximately 50% of the tightening torque is dissipated in overcoming friction under the bolt head or the nut face (whichever is the face that is rotated). Typically only 10% to 15% of the overall torque is actually used to tighten the bolt, the rest is used to overcome friction in the threads and on the contact face that is being rotated (nut face or bolt head). This is illustrated in the piechart shown in figure 2. Relatively small changes in the nut face friction can have a significant effect on the bolt preload. As more torque is perhaps needed to overcome friction, less remains for the bolt extension and hence as the effect of adversely reducing the preload. If the friction under the nut face is reduced, then, for a given torque, the bolt preload will be increased.

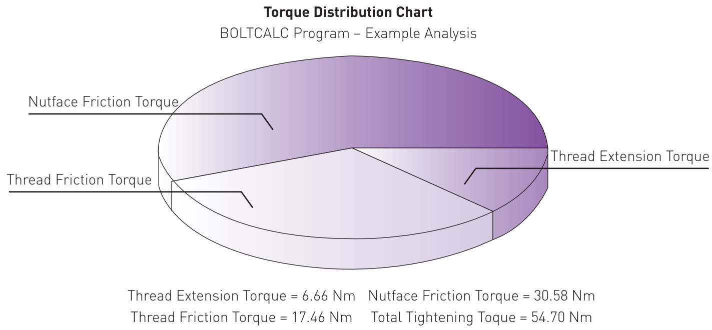

Figure 2: Typical Torque Distribution

Figure 3 is perhaps the most common situation where the top and bottom plates of the joint are made from the same material, have the same finish and the hole size is the same

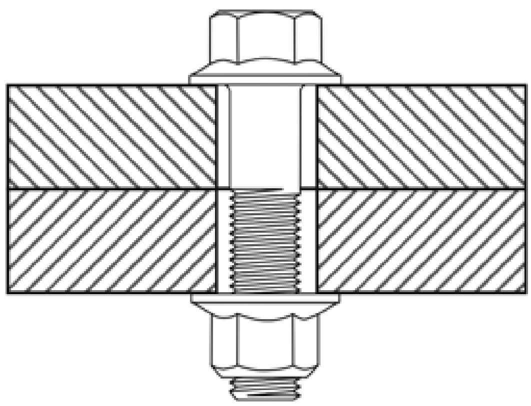

Figure 3: Top and Bottom Plates of the Same Material

through both of the plates. For such a joint, when the nut face and bolt head sizes have the same diameter and finish, it will not matter whether the bolt head or the nut is tightened. Some people believe that by tightening the bolt head rather than the nut it will affect the torsion in bolt shank. The torsion in the shank of the bolt depends upon the thread friction torque. For a given finish condition, the thread friction has some scatter associated with it, but will not depend on whether the nut or the bolt head is tightened. If the thread friction torque remains the same, the torsion in the shank will be the same irrespective of whether the bolt head or the nut is tightened.

Figure 4 shows the situation when the plates comprising the joint are different materials (such as one being steel and the other aluminium) or have different finishes (such as one plate being galvanised and the other painted). In such situations, it will, in general, be important as to whether the bolt head or nut is . The reason is that each face will have a different friction coefficient. If the tightened torque was determined either by testing or by looking up the friction characteristics of the surface, say based upon the nut face, then it is probable that the head face would have a different friction coefficient. If it had a lower friction value then the preload would be increased if the bolt head was tightened. In the extreme case, if the frictional differences were large, bolt breakage could occur.

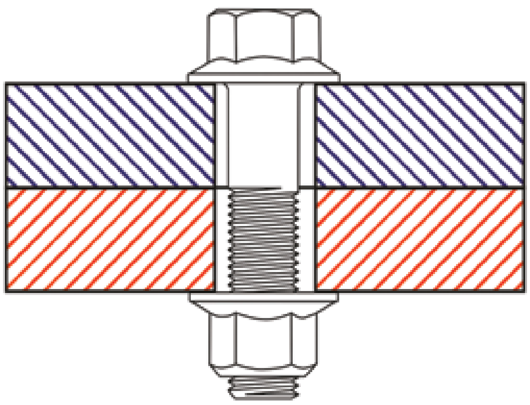

Figure 4: Top and Bottom Plates are Different Materials

Figure 5 illustrates the case when the clearance hole in the top plate differs from that used in the bottom plate. Such situations are relatively common. There is an effective friction radius on the part that is rotated (nut or bolt head) that is usually taken as the mean of the clearance hole and outer bearing face radii. Because this radii would be greater for the bolt head than the nut in the situation shown, less bolt preload would result by tightening the bolt head rather than the nut, other factors such as friction being the same. Hence another example of a situation as to whether the nut or bolt head is tightened.

Figure 6 illustrates the case when there are style and dimensional differences between the bolt head and the nut.

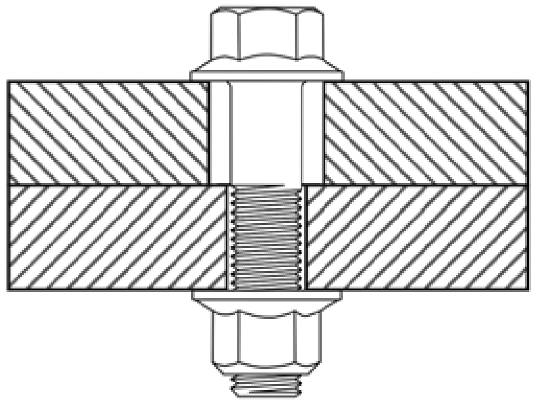

Figure 5: Top and Bottom Plates having Different Clearance Hole Diameters

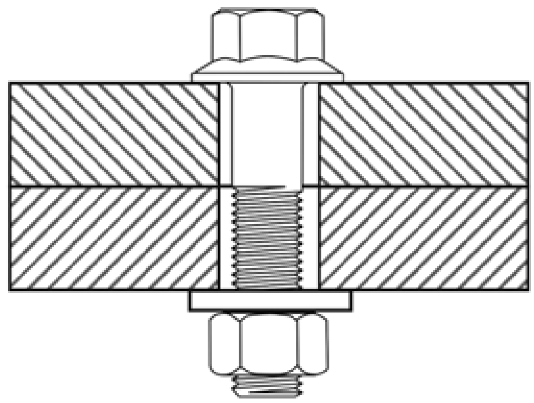

Figure 6: Head Style Differences Between the Bolt Head and Nut

The effect is similar to that which happens in the figure 5 case. Differences in the friction radii between the bolt head and the nut-washer interface result in the preload being affected by which item is tightened. In the case shown here, there would probably also be differences between the friction coefficient that is present when the nut is tightened on the washer and the bolt head onto the joint. This would increase the variability still further.

Washers are occasionally used as a means of minimising frictional scatter besides the common reason of reducing the bearing stress on the joint face. The friction condition between the washer and nut face can be reasonably well defined and controlled, more so than the joint surfaces usually can. By controlling the friction, the preload can be more reliably achieved. To do this consistently, a close fit is needed on the inside diameter of the washer. One way in which this can be achieved is by the use of a SEMS unit (in which a washer is held captive on the bolt shank). The same can be achieved by using a KEPS unit (a washer being held captive on a nut).

So in general, when using torque control, tightening the bolt by rotating the bolt head or the nut can matter. It is good practice to specify which part should be tightened so that the bolt preload variation is minimised.