The Re-use of Threaded Fasteners

By Bill Eccles - Bolt Science

Many OEM's specify that if a part is removed, the fasteners should be replaced. On the face of it, this seems like a policy designed to increase spare part sales. However just what are the factors influencing whether or not a fastener should be re-used?

In the majority of applications, there are three major considerations:

1. Has the strength of the fastener been impaired by the first tightening in some way such that it is weaker if it is re-tightened again?

2. Has the fastener been affected by corrosion to a degree that its performance will be impaired or from an aesthetic standpoint requires replacement?

3. Has the torque-tension charateristics of the fastener changed so that its performance would be impaired if it was to be re-tightened?

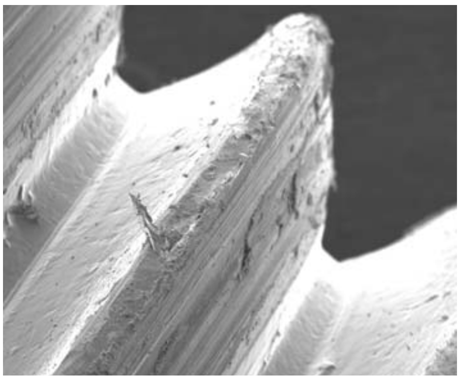
This article reports upon a study investigating the third point - is the torque-tension relationship affected by repeated tightening. This, in many applications will be the determining factor on whether a fastener should be re-used or not.

In the majority of applications, the preload or clamping force generated by the fastener is indirectly controlled by specifying a tightening torque. The big uncertainty in the torque-tension relationship is the value of the coefficient of friction under the nut face and in the fastener threads. Any changes that occur to the friction coefficient can have a significant effect on the bolt tension that results from applying a particular value of torque.

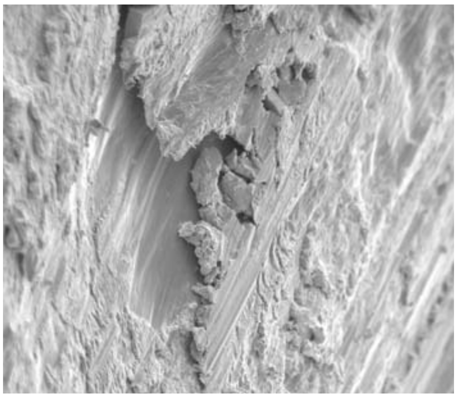
The effectiveness of the majority of bolted joints is determined by the clamping force developed by the bolts. In the majority of cases, the clamping force provided by the bolts is controlled by tightening them to a predetermined torque value. The torque value being determined from either tests or by software using experimental thread and nut face friction values. In either case, the value is usually determined for the first tightening of the fastener.

When fasteners are tightened surfaces slide over one another under high pressures. This always leads to some degree of wear on the nut face, the clamped part and on the thread surfaces.

When the fastener is re-tightened this wear increases which leads, in general terms, to an increase in the friction coefficient. Because the friction coefficient increases, the clamping force provided by the fastener decreases for a given torque.



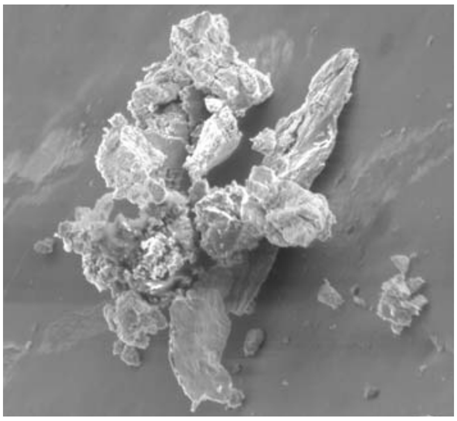
Thread surface after 10 re-tightenings



Close-up of thread surface after 5 re-tightenings

A series of tests were completed on M12 zinc electroplated bolts and nuts to assess the effect that re-tightening has on the torque-tension relationship. Tests were completed on the bolts and nuts in the as received condition and a scanning electron microscope was used to investigate what was happening to the bearing and thread surfaces upon re-tightening.

The photograph (50 times magnification) above shows the pressure flank of the bolt thread after it had 10 re-tightenings. Zinc flakes have been worn from the surface. This wear process occurs with the first tightening and progressively worsens. The close-up (500 times magnification) of the thread after 5 tightenings shows the surface ruptured as a result of the wear process. Wear particles can also be found on the surface as shown in the photo.



Wear particle on the thread surface 500x magnification

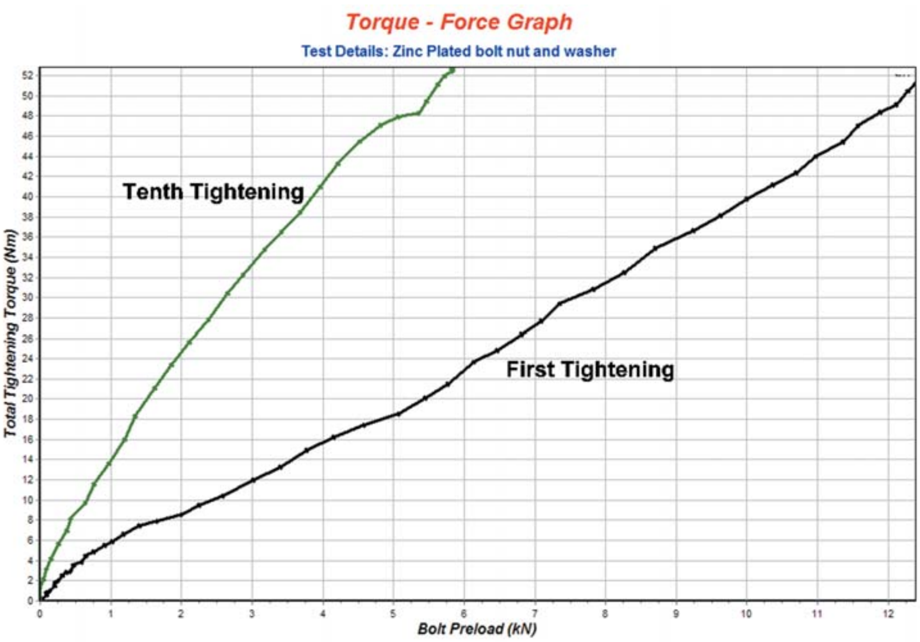
The electro zinc plated finish gives a relatively high friction coefficient (0.2 to 0.3) upon first tightening. It is known that the rate of wear is related to the friction value, the higher the friction - the higher the wear rate. As wear ocurs on the surfaces, the surface is damaged leading to an increase in the friction value. It was found that for as received electro zinc plated bolts and nuts, the coefficient of friction had doubled by the tenth re-tightening. This had a direct influence on the preload generated by the tightening torque. Maintaining the same tightening torque typically resulted in the preload on the tenth tightening being half that on the first tightening. This feature of reducing preload for the same torque is illustrated in the graph.

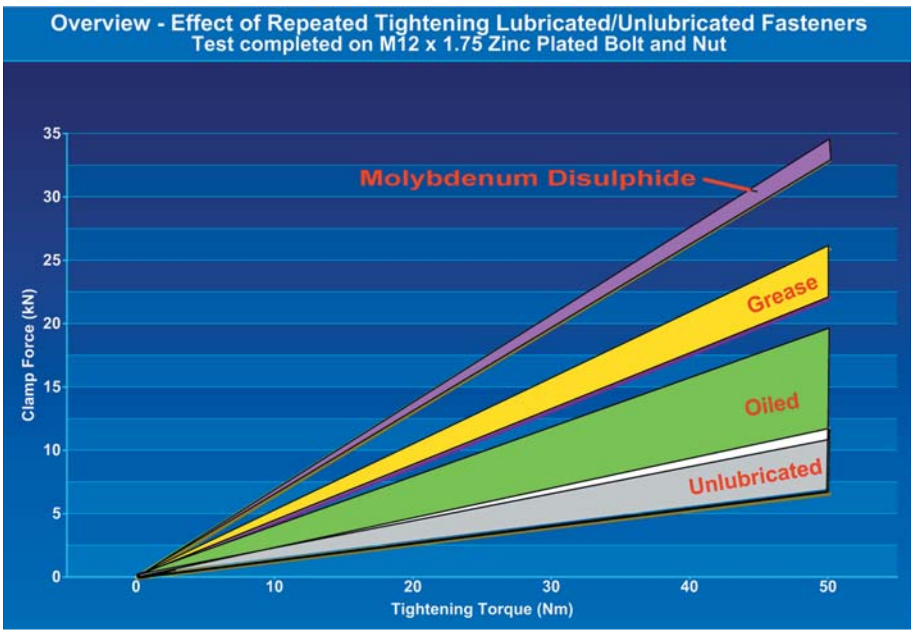
By reducing the coefficient of friction, the wear rate would also be reduced. This reduction in wear rate, it would be anticipated, will give a more repeatable torque-tension relationship when the fastener was re-tightened. Lubricants are used to reduce friction and to give a consistent torque-tension relationship. Even with the use of a lubricant, wear would still be occurring but for a low number of re-tightenings it is non-obvious unless the surfaces are examined under a microscope.

A range of lubricants were tested to investigate what their use would have on the torque-tension relationship under repeated tightenings. The graph shows the differences in the torque-tension relationship between different lubricants when fasteners had been re-tightened 10 times. All the nuts and bolts used were electro zinc plated. As can be seen from the graph, when the threads and nut bearing surfaces were coated with molybdenum disulphide paste, repeatable results were achieved between re-tightenings. Copaslip[1] paste was also tested and was found to give similar results to i.e. a consistent torque-tension relationship when the nuts were re-tightened.

It is clear from the results that re-use of fasteners can potentially have a significant effect on the tension in the bolt produced for a given torque. In critical applications this could obviously have serious consequences on the structural integrity of the product. Hence, in such applications, re-use of fasteners following dis-assembly should only be contemplated if test results indicate that the torque-tension relationship will not be adversely affected. Quality specialist lubricants such as molybdenum disulphide have been shown to significantly reduce the friction increase that occurs upon re-tightening. Tests are presently being conducted on finishes that incorporate a lubricant in their top coat which negates the use of a separately applied lubricant.

Bill Eccles is a Chartered Engineer and formed his company Bolt Science some 12 years ago to specialise in bolting technology. The company writes and markets bolted joint analysis software together with completing consultancy assignments and training courses. Further information is available from Bill via email (bill@boltscience.com) or from the website at www.boltscience.co.uk.





[1] Copaslip™ is an anti-seize assembly compound that incorporates a non-melt grease with copper, it is a registered trade mark.