

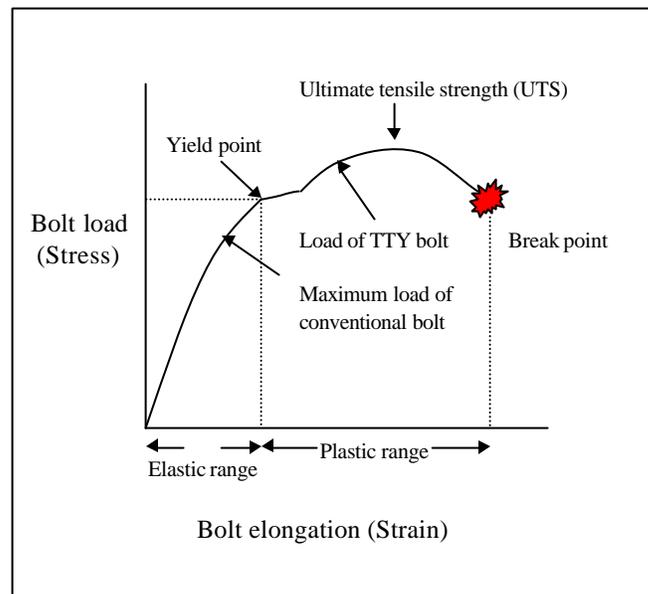
ACL TECH TALK

TORQUE TO YIELD HEAD BOLTS

There is a lot of controversy about torque to yield head bolts, also known as angle torque, torque to turn, wasted or stretch bolts. How are they different? Can they be reused or do they need to be replaced? I would like to clarify some issues regarding these types of bolts now commonly in use in the automotive industry.

FIRST SOME HISTORY

While modern engines have become more fuel efficient, fuel consumption is mainly a function of vehicle mass. The need for heavier structures due to stringent safety regulations and added safety features that are now mandatory has caused increases in vehicle mass. In an effort to contain these increases the designers are forced to strive for reduction in mass in other components. In the case of cylinder head bolts the mass of ten 12mm x 125mm long bolts are 1.1kg; for the same number of 10mm bolts in the same length is 600 grams. If the smaller bolt bosses in the cylinder head and block are added, the total saving could be easily one kilogram. This is a significant amount for just one engine component! TTY head bolts offer a number of other advantages for the engine manufacturer, which include flexibility in cylinder head design as this type of clamping style can require less head-bolts, and there is also a reduction in material costs. Another major advantage for the manufacturer is a more controlled cylinder head clamping torque.



HOW DO CONVENTIONAL HEAD BOLTS WORK?

When a conventional bolt is tightened it stretches slightly. When the tension on this bolt is released it will recover back to its original length. This phenomenon is called elasticity. A conventional bolt therefore can be reused, over and over, as long as it is not over-tightened. Typical maximum loading of a conventional head bolt is 20% short from its yield point.

WHY TORQUE TO YIELD HEAD BOLTS THEN?

To generate the necessary clamping load the smaller diameter torque to yield head bolts must be tightened to near their maximum permitted stress levels. To achieve this the TTY head bolts are tightened past their yield point into the plastic phase. The yield point or yield strength is the maximum load that can be applied to a bolt without causing plastic deformation. In other words if the bolt is tightened past its yield point it will not return to its original dimension or state when the loading is released. This is due to plastic deformation! If the bolt loading is increased even further the bolt will quickly reach its ultimate tensile strength point and the bolt material wastes and breaks. This is the reason that the TTY head bolts should not to be under or over-tightened and why an accurate system of tensioning is required.

When conventional bolts are tightened they generally have a final torque figure in imperial foot pounds (Lb.-ft) or metric Newton meters (N.M.). This is a relatively inaccurate method of fastening as 80-90% of the clamping load is lost to friction. The torque-to-turn method reduces inaccuracies significantly because the initial torque figure is often low, so any friction variations have a much smaller effect on the end result.

CAN TTY HEAD BOLTS BE REUSED?

Due to the nature of their design these bolts do wear out and often cannot be reused. Unlike a conventional bolt the TTY bolts are tightened well beyond their yield point into the plastic phase. Furthermore the head bolts will stretch even further during service when fitted to an Aluminium cylinder head. Aluminium alloy has roughly twice the expansion rate of steel and the head bolts need to compensate for this. If these types of bolts are to be used a second time or any subsequent times thereafter, the already permanently stretched bolts will stretch even further and rapidly lose clamping load. The loss of clamping load could ultimately lead to head gasket failure. The end user will ultimately have to pay for the extra cost of new bolts when replacing a head gasket, but this is a relatively inexpensive form of insurance against future head gasket failure.

HOW ARE TTY HEAD BOLTS FITTED?

We have now learned that TTY head bolts require a different torque procedure than a conventional head bolt. These bolts usually require a numerical initial torque setting, sometimes called a pre-load, followed by one or more angle settings. Care must be taken that the correct procedure is adhered to and an accurate angle gauge is used to ensure correct and even bolt loading. The equipment used to tighten the TTY head bolts in the factory assembly plant is automated. The angle torque (or torque-to-turn) system was chosen for the repair industry as this most closely resembles the applied torque of the factory specifications.

Note: As with conventional head bolts a good thread and under bolt head lubricant is still important. Lubricants reduce the amount of friction between the fastener and the surface it contacts while being tightened. A quality thread lubricant will convert more of the torque to more usable clamping force instead of having it lost to friction.