Cylinder Head Stretch Bolts

Cylinder head bolts may not seem particularly interesting engine components, but with modern designs more is happening than might be realised. At one time cylinder head bolts were only replaced when the threads became worn or damaged. Now engine rebuild instructions will often demand new bolts at each assembly and cause seemingly perfect bolts to be thrown away. These notes explain the reason why.

The conventional method of tightening a cylinder head bolt is to use a torque wrench. However, this tool only measures a bolt's resistance to rotation and whilst this is related to clamping load (the prime factor of importance), the relationship can be highly variable (fig. 1).

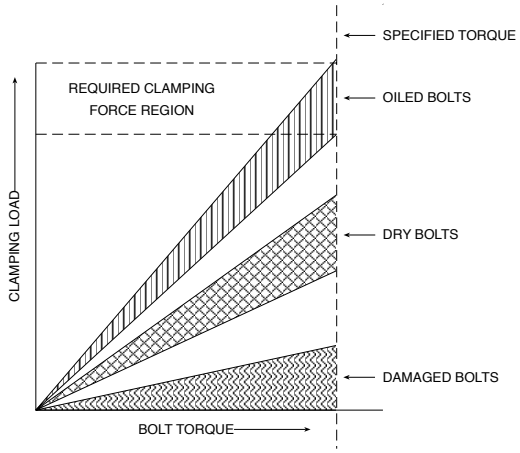

FIG 1: VARIATION OF CLAMPING FORCE WITH BOLT CONDITION FOR SPECIFIED TORQUE VALUE

Such variation in clamping load would be unacceptable for many modern engine designs, particularly those with aluminium cylinder heads and complex gasket designs. As the action of tightening a bolt causes it to stretch, and as the degree of stretch has a fixed relationship to clamping load, the solution has been to control the belt stretch by specifying an angle of rotation. This is quite independent of the force or torque required to turn the bolt.

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Whilst a bolt is within its elastic phase, a small amount of stretch gives a large change in clamping load (line OA in fig. 2) and the bolt's angle of rotation would have to be very accurately controlled. Accordingly the bolt is stretched beyond its elastic limit and into the plastic phase where the clamping load increases slowly for a large amount of stretch (line AB) and the accuracy of rotation is much less critical.

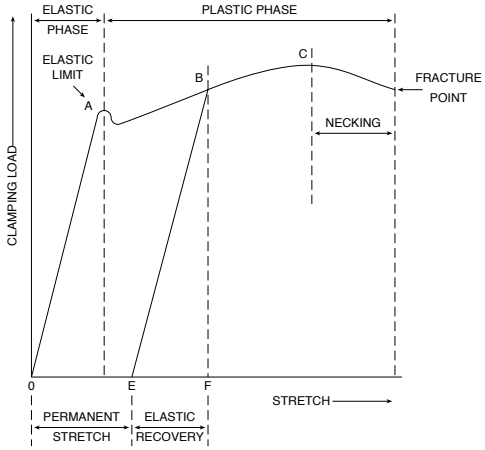

FIG 2: CLAMPING LOAD VARAIATION WITH BOLT STRETCH

Unfortunately, once a bolt has passed it's elastic limit it is subjected to two conflicting internal conditions, it's elasticity, which tends to return the bolt to it's original length, and it's plasticity which tends to make it retain it's new length. A bolt tightened to point B in fig. 2, if loosened, would return to zero clamping load along the line BE (parallel to AO). The partial return to its original length (line FE) is the elastic recovery and the deformation of the bolt (line OE) is the permanent set or permanent stretch.

If the bolt was now re-used, because of the permanent stretch, it would start from Point E, move along the load vs. stretch curve to Point B and then move towards Point C as it was turned through the specific angle of rotation. The bolt would then be in a most critical condition. Beyond Point C the bolt would start to neck and fail during assembly, which is perhaps the best situation as at least the mechanic would know that a replacement bolt was necessary. At worst, the bolt would stop just short of Point C only to fail later during operation as an expanding cylinder head stretched the bolt beyond the limit.

Some OE manufacturers (particularly in commercial applications) do specify the number of times a stretch bolt can be re-used, which is essentially the number of times the permanent stretch of the bolt can be increased. However, unless the history of the bolt is known, re-use is not advisable.

Be safe - always replace stretch bolts.

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