RESEARCH ARTICLE OPEN ACCESS

Cross-Threaded Effects

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ABSTRACT
Pre-invention bolts and nuts used to be cut by hands before industrialization when a semi-automatic screw-cutting lathe was invented (Bickford, 1982). Before the Besson invention, there were no standards outside any manufacturer, forcing the industry to standardize. Cross-threading is when a fastener is pragmatic at a given angle in a position and then enforced to a bolt. To engage with the axis of its plugged bolts, the threads are designed in a way that allows the valleys and peaks of the threads to slide across one another or match the thread at right angles. When the bolt gets screwed into the female screw obliquely, the thread part with minimal diameter gets contact with the female screw at a certain point, although, the ball gets to make rotation around the point. Hence, the phenomenon of cross-threading is avoided. Cross-threading can happen in the following ways:

1. Debris and damage, that is, debris such as dirt and little damage from abrasion, can lead to damaged threads which cause them to cut new threads in the opposite piece.
2. If not threaded to its mate, the wrong insertion angle results in new threads being cut along the angle, damaging one or both pieces.
3. Mismatched thread pieces which are not interchangeable will cut new threads into each other.

Meticulous accommodation and compliance techniques have been considered the most important supplement of threaded fasteners. Most of the translational adjustments in position errors are easily rectified, and thus errors that exist in the tilt between the threaded parts are most difficult to change and hinder the divergence region.
As discussed in this research paper, I have discussed the dangers and causes of cross-threading and their remedies.

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I. CAUSES OF CROSS THREADING

As aforementioned, cross-threading is a result of the fastener, which is then applied at a given angle to the required position and being joined to the bolt. The bolts threads or nut are so designed to engage with each aligned thread's axis, thus enabling the threads' highs and lows to slide across each other during the fastening of the nut to the bolt. The applied bolt is at an angle, and this makes the engagement of the threads to the nut or the hole that is threaded in such a way as to cut through the thread existing, creating a poorly sliced section. The turning bolt proceeds into the hole but does not typically straighten out and hence will stop functioning.

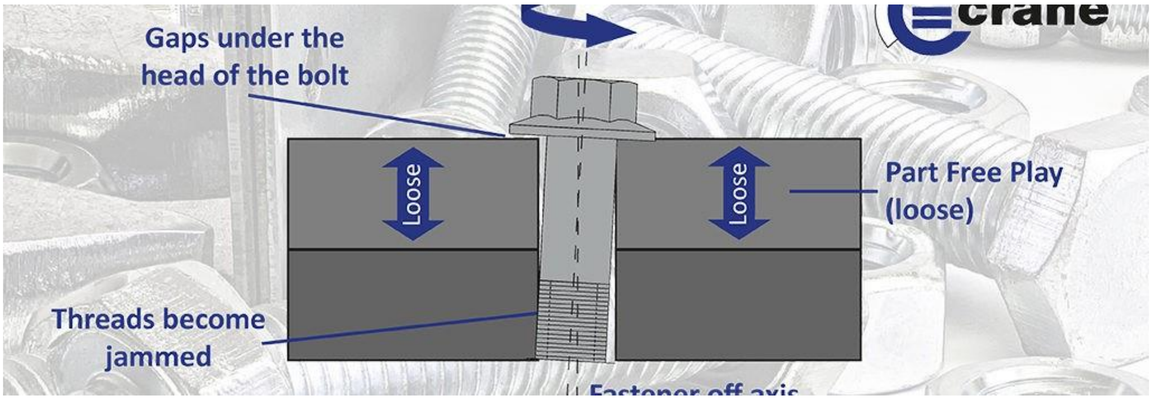

Figure 1. Cross-threading nut and bolt.

Apart from that, cross-threading is also caused by using the wrong match between nut and bolt. If a quarter-twenty bolt (1/4-20) is forced into a quarter-twenty-eight-hole, one can achieve optimality in the nut's axis alignment and the bolt but incorrect threads. Even though it would be possible to drive the bolt into the nut to the fullest extent, the threads on both would likely be mangled, damaged, making it not provide rated strength. Furthermore, in some cases, the damage is large enough to prevent extraction. Either way, the damage can remove the fastener from service. One can be able to cross-thread a fastener and tighten it well enough to strip the threads. In the eventuality that it happens deeply enough in the assembly, it may not be possible to extract, as the threads would have achieved full damage and hence no longer functioned as intended.

One of the main causes of cross-threading is caused by fastening of nuts in wrong angle thus forcing it into studs which will eventually cause difficulty when trying to remove the nuts.

The use of wrong nuts will also cause cross-threading wince each bolt has specific specifications which require given dimensions like diameter and thus lead to threads not matching in the mounted brackets and thus continued forcing of the bolt leads to damaged threads. Since the nuts and bolts are made of different materials precautions have to be taken when bolting to avoid cross threading. Nuts that have not been changed for a very long time will also cause cross-threading since this causes them to rust and corrode which causes them to stick together thus making them difficult to remove.

II. DANGERS OF CROSS-THREADING

Cross-threading being problematic leads to the following dangers;

1. Wheel-nuts that have not been cross-threaded would not hold the torque properly, leading to nuts loosening, hence extra noise and vibration. When torque is not held properly, it leads to no force created in the joint (Blair, 1962). When the tightening of a fastener is not started perpendicular to the hole, the fastener's threads do not match the threads of the hole during the tightening process. This causes the fastener to attempt to cut new threads as it is torqued.
2. Due to the loosening of nuts by cross-threated wheels, which does not hold the nuts properly, it can eventually lead to wheel stud or falling off the wheels, which is dangerous.

Solving the fastening issues hinders future or anticipated problems that are unwanted.

To avoid cross-threaded fastener issues, the following tips have to be followed:

1. Cleaning threads inside and outside using a solvent spray and brush and drying them will help in removal of rust and dirty which will help in easing of the nuts when using them thus reducing the effect of cross-threading. For easy installation after cleaning, engine oil application can be useful.

Figure 2: Cross-threaded spark plug hole in the engine block.

2. By using a tap and die set, the threads can be repaired, not necessarily to replace them, using the lubricant to lubricate the tap, die, bolt and hole. Avoiding lubricant use is a better way to destroy the tap and quickly destroy the threads in the piece you are repairing.
3. Replacement of parts can be done, which is simple and easy, that is, nuts.
4. By use of a drift punch, alignment of pieces before starting bolts can be done to prevent cross-threading issues.
5. Starting nuts by hands is recommended before using tools; this will help notice any difficulties that indicate anticipated problems.
6. Threading of all bolts by hand until they flush in pieces like torque converters and wheel hubs leads to avoidance of misalignment caused by the tightening of one bolt.
7. By using fingers to turn the fasteners counterclockwise till a click is heard indicates that the first contact has been made.

Repairing of cross-threaded bolts involves cutting new threads on the affected bolts and those of the damaged counterpart which will repair the damage. The process includes:

1.matching a socket to the head of the bolt which has been cross-threaded and then attach that socket to the handle and finally turn the bolt counterclockwise to detach it.
2.Threading of the bolt to the threading gauge.
3.Selecting of the matching tap diameter and the count of the bolt into a handle then pour the cutting fluid into the threads of the damaged paths.
4.Turning of the tap counterclockwise threading it into the damaged threads.

5.Locking of the head of the bolt into the vise jaws by setting the head of the bolt into a vise with the threads bolt facing up.
6.Turning of the die socket clockwise to cut the new threads on the bolt. And then thread the bolt into the threaded bolt.
Steps to follow to avoid cross-threading bolts and screws.
1. Insert the screw and line holes up when needed.
2. Use a screwdriver and turn the screw as if you are losing it, preferably anticlockwise.
3. Turn the screw in the wrong direction until you feel a bump and hear a click or sound. Hence this is the screw that is falling into position.
4. Once the click is hard, tighten it.
5. You are done, and if you followed the steps, it would be hard to cross-thread a screw.

III. CALCULATION OF THREAD LENGTH AND SHEAR STRENGTH

The factors below have effects on the striping strength of a given thread. Variations such as major, pitch, and minor pitch have internal and external threads stripping strength. The bending effects of threads are mostly caused by actions on the fastener's tensile force, which results in wedging action that leads to a decrease of the shear area of threads.

Bolts being longer than six, and they contain a diameter thread length twice the bolt diameter plus half. The thread length is calculated as half times six hex bolts having 3/4 of thread and half times 5/2 hex bolt will have half thread.

The tensile stress area, or stressed area, is the cross-sectional area of the threaded part in direct contact with the mating threads. Threads are typically the weakest part of a bolt and most likely to be the cause of failure/fracture when in pure tension. Calculating and understanding the area of the bolt providing strength in tension will help in understanding how the thread engagement length can increase and decrease the strength of a joint.
T is the tensile stress which the sample can hold before breaking symbolized by s.
The formula is: $\sigma = F/A$.
Where σ - tensile stress.
F - acting force.
The thread strength is calculated using the shear strength, which Fs=T Ath defines.
Where, T is shear strength and Ath thread shear area.
Pitch is the distance from a point on the screw thread to the next thread.
P=1/n
Substituting P = 1 / n
gives $A_t = 0.78 * [d - (0.9382 / n)]^2$,
d is denoted by millimeter, n is denoted by threads/mm.
$A = (\pi / 4) (d_n - 0.9743/ n)^2$
A = stressed area (in^2)
d_n = nominal bolt diameter
n = 1 / p = number of threads per inch
p = pitch, length per thread

Charts are showing the yield point of the thread and the nut.

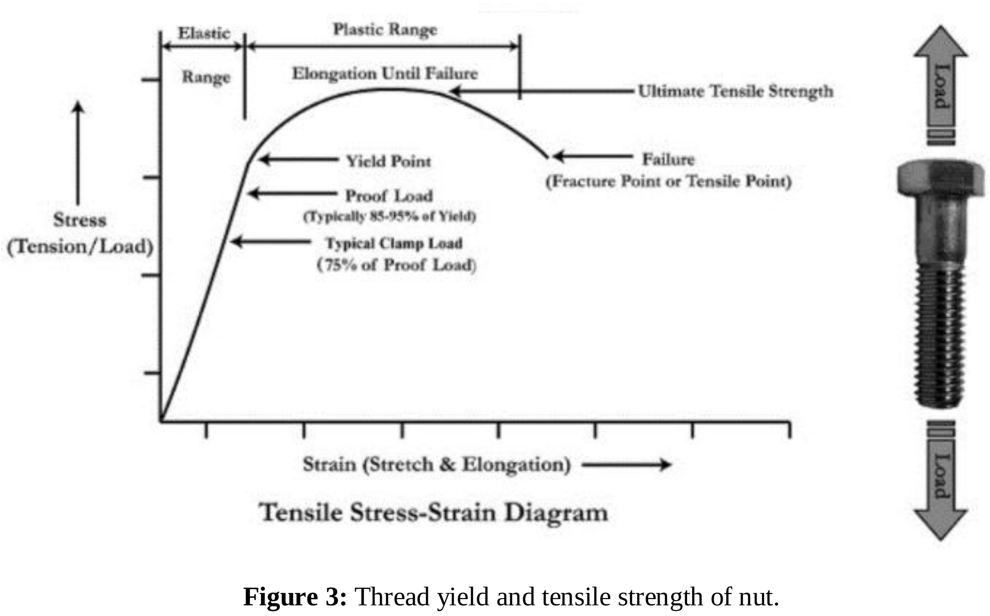

Figure 3: Thread yield and tensile strength of nut.

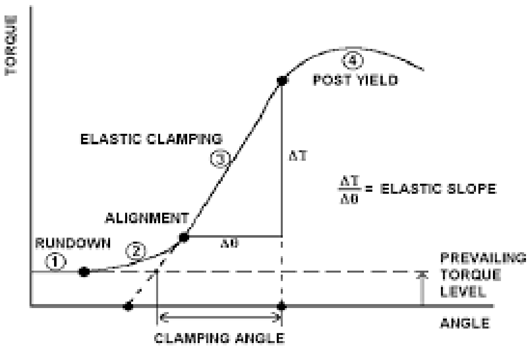

Figure 4: Analysis of yield point and thread and nut.

The zones in the above diagrams are:
Zone 1 -prevailing torque caused by deformed threads.
Zone 2 -alignment zone; thus, non-uniform zone is a complex function process of drawing mating parts together.
Zone 3 -elastic clamping zone. The clamping region, which is elastic, is vital to each bolted joint. The slope can be used to locate the elastic region. The turn angle from the elastic region is multiplied, but the coefficient angle of tension in the calculation of the tension created by the process of tightening.
Zone four begins with an inflection point immediately after the elastic point. This zone is due to yield of thread and the yielding of the joint.

The complex function zone which is the non-linear zone of the drawing together process in mating of the threads and bending of the faster and mating parts which is a result of non-joining in the bearing surface of the fastener and thus these factors are macro-effects. The micro effects include; contract stress defections and thread deformations. The fastener absorbs three types of shocks including underheard friction, thread friction and applied friction.

Bolt is tightened, its shaft obtains a stress which is due to the strain of elongation and a stress known as torsion stress caused by the force of torque which acts on the threads of the bolt. Majority of the bolts tend to avoid the stress and that they assume that the direct stress in the threads will yield the stress in the bolts. A wedging action which is produced by the force of tension consisted in the fastener during threads tightening results in radial replacement and this displacement nut distention and it usually occurs in conventional nuts. The upper part of nut undergoes expansion and contraction in the centrifugal direction and its insolence surface expands and thus the total effect of this dilation is to significantly decrease the area of shear of the internal and external thread. The tension force in the fastener during the tightening process results into threading degree which bends between the internal and external threads and thus this bending thread leads to the reduction of the shear area of the internal and external threads. A dominant factor that predominantly dominates the controlling factor of the thread degree in the strength amongst the external and internal threads. A force which is causes nut thread to strip and it is divided by the force which will cause the bolt to thread to strip is known as strength ratio.

IV. CONCLUSION

General objectives needed are providing a threaded member, which promotes alignment between fastener member and threaded bore across the adjacent to provide resistance cross-threading upon engagement which is mostly applied in blind holes or very thin threaded holes. Another provision is the fastener member, which has a large window of engagement into a tapped bore to reduce the insertion time and resistivity (Whitney, 1982). Meticulous accommodation and compliance techniques have been considered the most important supplement of threaded fasteners. Most of the translational adjustment positioning errors are easy to be rectified. Therefore, errors that exist in the tilt between threaded parts, are most difficult to rectify and avoid in the area of convergence. In conclusion, cross-threading of bolts can be dangerous and cause losses; hence as discussed above, cross-threading can be prevented in many ways. To avoid adverse effects like wheeling off nuts which can cause accidents, the above prevention methods have to be accorded to and followed to the latter. Recommendations of replacement of threads rather than rethreading are recommended.

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