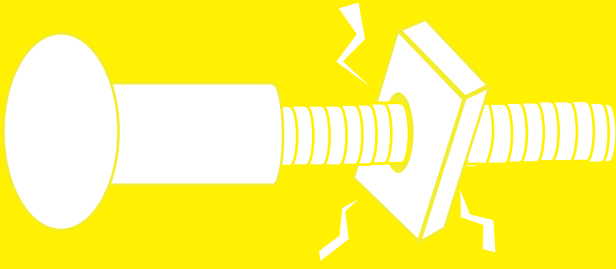


Cross Threading

by Thomas Dopke



Many of the problems encountered with fasteners in the assembly line are not really a fault of the fastener itself.

Non-attributable factors contributing to the failure rate are the inputs from tools (type, speed and so forth), line speed (how fast the parts are being assembled), the joint design (including what fastener is chosen), access to the fastening site and even the way that the parts address each other (the way that they come “together”).

“Years ago” is the common beginning that the old timer starts his story with. “Back then” there were no problems. Maybe so, but today the assembly line moves at a greater speed than ever before to produce immense numbers of products faster and at a lower price to the customer. This has brought about changes in the way that fasteners are utilized, often without anyone being aware of them. Today’s article is about cross threading, the event when a fastener does not engage into its mating partner and jams.

“Back then” parts were started into the mating component by hand and tightened with a tool. Today the usual procedure is to place the bolt into the tool socket and jam the fastener into the mating hole with the tool running. As is obvious, if the threads do not engage correctly the whole process comes to a sudden and complete halt.

While a fastener jamming does not sound like much of a problem, consider this; how long does it take to correct the situation? How long is the line down for? What is the cost of these minutes? Also, what about the cross threaded part?

A low cost piece may just be thrown away but what if this stripped thread is on an engine or very expensive circuit board. How many of these problems can be absorbed as normal manufacturing costs?

Several years ago a study was made of the reasons why cross threading occurs. The reasons varied from simple to complex geometries with commensurate solutions. One such problem found was reoccurring cross threading failures that only occurred on one side of an assembly line. The same fastener was used on both sides of the assembly line but only one side had a consistent stripping problem. Investigation also found that only one operator was having the problem.

Examination found that the operator on that location was considerably shorter than the one on the other side. He had to stretch to drive the fastener. His drive angle was not normal to the surface and in some cases the drive angle approached 30° to 45° off from normal. A stand for the operator solved the problem. Another solution would have been to utilize a taller operator but seniority issues precluded that avenue.

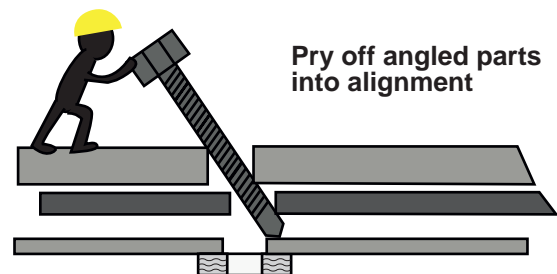
Often the designer is intent upon making the part look pleasing cosmetically. This may result in the fastener being hidden from sight as much as possible, often behind or beneath another section. Assembling the fastener then requires the operator to assume an awkward and unusual position when fastening the joint. Aside from ergonomic problems, upside down assembly and any direction other than vertical and downwards will usually cause problems.

Cross threading often occurs when the wrong type of tool is selected.

For instance the use of a side angle nut runner used where the operator has to stretch excessively to shoot the bolt. A common example of this is the inboard seat belt bolt where the operator is installing the bolt almost blindly.

Numerous cited stripping problems are found, when investigated, to be attributed to factors in the process other than the bolt and hole. Weld splatter on the internal threads effectively can strip threads, more so at higher speed installations. The presence of splatter, especially if minute in size, is almost always overlooked if the section is painted. The stripped bolt will be noticed! Dross, chips, paint, and other dragged in offal are also commonly overlooked until the fastener installation fails. Even worn sockets on tools contribute to the situation by allowing excessive wobble of the part as it comes to the mating thread.

Discounting these non-fastener factors, the study went on to look at the other major installation contributing factors. Metal misalignment, which will be discussed below in more detail, was found to be a major cause of stripped and off angled installed fasteners. Many builds, consisting of several layers of sheet metal, commonly end up with the internally threaded member being out of alignment with the several clearance holes. The bolt has to be driven in at an acute angle or not at all. Often the assembly plant uses “AC” pointed fasteners (AC points are threaded down to a cone tip) which the operator uses as a pry bar to ‘pull’ the various layers into alignment.



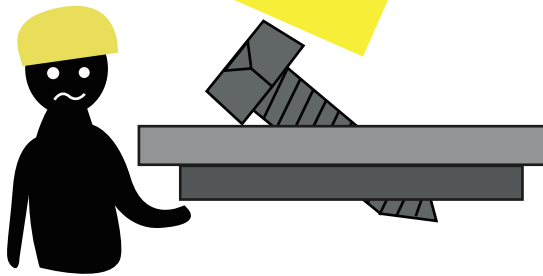
Since the part is usually partially driven before the jamming occurs, the plant will many times repair any off angled joint by using a larger gun. With enough horsepower the fasteners could probably be driven through a wall also.

The off center location of weld nuts was found to be another common reason for stripping via misalignment. Welded parts, installed off center so that the holes do not coincide, cannot be pried into alignment without breaking the welds. Neither can the panels with welded clearance holes be bent into conformance.

Historically the designer assumes that his fastener will be the solution to all of his alignment problems.

Seldom does the thought of the effect of a jammed fastener, cross threaded or otherwise not correctly seated, crossed his mind with respect to the effect upon the clamp load of the joint.

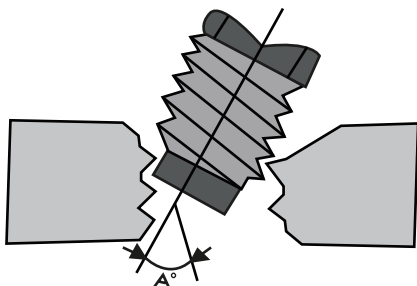
Before continuing one important point about cross threaded joints should be made. Aside from the obvious mentions above about jammed fasteners and stripped threads in costly components it should be noted that in many cases the cross threaded fastener can be driven to the required torque. With today's high speed assembly the operator does not stop and visually inspect each driven joint.



It took the 1,000kg tool but IT \nless in!!!

The bolt is installed with a "running start", run to the turn off setting of the tool (which is the specified torque) and on to the next one. Cross threaded fasteners can, as mentioned, be driven until the tool stops but the tension required to maintain the joint integrity is not present. Field failures, poor quality and irate customers will follow!

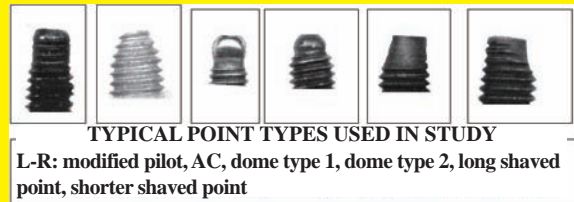
The fact that cross threading occurs with some regularity is demonstrated by the existence of dog points on current fasteners. While these are released and used to solve, apparently, cross threading problems, they generally do not work well. Their faults are explained in more detail below.



Cross threading occurs when the parts come together at an angle. As the illustration shows, as the length of the non-threaded section of the fastener (the 'pilot end' increases the angle A°) at which the threads may engage becomes less and less.

Most current parts can engage (cross thread) somewhere around 5 degrees off perpendicular (normal to the internal thread). How much of an angle was the basis of the study along with a detailed examination of the thread starting site. Axial misalignment, where the centerlines of both threaded sections are parallel but not concentric has been discussed above. The use of fasteners with some sort of protrusion, usually an AC cone threaded point, as a pry bar is used but damages the threads resulting in stripped and damaged threads. The cause and result of this condition is known.

The investigation into the phenomenon of cross threading included a study of the 'purported' anti-cross threading features already on the market. The study included 14 types of points used and/or publicized; several were proprietary but not all were in current usage anywhere. While most were of American manufactured designs, one point type was of Japanese origin and a couple were made to German patents.



Using a test stand built to run at a constant speed and with a consistent weight end load, 25 samples of each point in M6 and M8 diameters were run at 5 different angles (7, 9, 12, 15, and 25 degrees) into a fixture which allowed movement for the engaged fastener to fully drive if it could engage. During the testing two conditions occurred: Cross threading, defined as a stopping of the installation action due to the threads jamming, and 'No Start' defined as those attempts where the fastener did not institute threading at the addressed angle but spun in the hole. Although 'No Starts' were not especially considered failures as an operator on the assembly line would know that the part did not engage and would wobble it until it did, these post attempts could still result in a cross thread situation.

All of the available points were of two basic design types: an extension on the end (pilot, dog point or some modification of the same) and a shaped feature, generally of a ramp like construction. AC points and current dog point design were also included for comparative purposes.



Modified End Point



Ramp Feature. Length Varies with Maker

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It was found that, the longer the pilot point was the less problem there was with cross threading.

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However, while a 50mm long point would completely eliminate the problem the negatives are obvious. The various designs, many proprietary, all employed some modification of this concept. It was found that to work correctly the pilot end must be as large a diameter as possible and as long as practical.

The industry standard 'dog point' illustrates this idea somewhat. But since it has a narrower diameter point than some of the other designs it wobbles inside the internal threaded hole and does cross engages. The wider piloted points do not allow this movement and will not engage until the point has been seated within the internal thread, provided that the pilot is long enough (again see illustration). One popular point has reduced the thread major diameter to almost rounded and truncated nubs of the leading threads which, in effect, is increasing the overall pilot length.

The ramp design parts varied in how long the ramp was shaved off on the side. Three different ramp designs, each progressively longer, were tested. The one with the longest ramp worked best. When pushed in the hole and not in alignment the parts spun in the hole and were designated as a 'No Starts.' Generally they entered, aligned themselves adequately and installed correctly in most of the test angles.

The problem with these types of parts is that they spin at high tool speeds when they do not immediately engage and can cause thread wear on the lead threads, facilitating cross threading as an 'after' process effect. Among the observations and results of the extensive test program several other facts were discovered.

One, the orientation of the threads to each other at the start on installation (threading) was discovered to have an effect. If the starting female thread was positioned 180 degrees from the starting male thread at the start of threading there was a 32% chance that the threads would cross thread. With the 'running start' process little could be done about this.

Two, the effect of the interaction between the starting thread location and the point design (where the starting thread was located in respect to the point design) had about a 25% effect on cross threading.

And three, the point style contributed about 56% of the effect on cross threading. While in actual plant conditions cross threading does not occur regularly, when it does it is consistently a problem that cannot be resolved without the use of a special part.

A summation of the test data is as follows:

-Cross threading begins to occur when the bolt to hole address is above 5°.

-Almost all points showed few cross threaded parts and few 'No Starts'. The entire amount of failures was from 7 particular points. As the angle of installation increased the number of No Starts and cross threaded parts increased until at 25° all but 3 part point types were No Starts. Of the 3 points that passed two were shaved ramp styles.

-The 12-15 degree mark appears to be a dividing line. In general most parts are more good than bad at 12 degrees and more bad than good at 15.

The study was presented to one of the standards organizations in the late 1990's and a committee set up to write a test standard and method for comparisons of anti-cross threading features. **Nothing has been done since.** Lately the problem has been arising again. Fastener World magazine ran a short article on work on anti-cross thread features done for a major manufacturer of rivet nuts and inserts. Jammed fasteners can easily spin out inserts, especially when installed in aluminum and thin metal. They are working on correcting this through use of a special 'anti-cross thread' feature on the fastener.

Since the problem appears to still be viable, the negatives to these point styles should be addressed here.

First, many of these point styles are propriety and their use will entail license fees and raise costs. Mass increases, while small for fasteners, are still extra weight.

Extra space to accommodate the increased length (pilot points, modified or standard) or non-engaged threads (for ramp styles) presents some design challenges. The parts are more costly due to volume, the extra steps to form the point, procurement, handling, sourcing, plant mix-ups, and so on.

While cross threading does not seem a prevalent problem all the time, its occurrence usually happens with changes to the assembly process. New line process, tool changes, operator assignment will, or may, affect the problem. It will occur usually with only one assembly station and may be solved with a simple change if investigated with the above knowledge. If a point style is needed, choose wisely. If a solution cannot be easily made the plants will continue to just pry the parts into alignment whenever and wherever they can with AC points or just drive with a larger tool, torque specifications and clamp load considerations of no concern. ■