The Problems with Finishes
后制表面处理所存在的问题

by Thomas Doppke

Once upon a time a fastener had only to hold things together. But with the rise in customer expectations today it has been assigned other duties as well. In years past rust and corrosion was a common thing on cars and other large components exposed to the weather. Paint covered much of the areas that were of concern but when the hood was opened rusty red was a predominant color there. Now a variety of new coatings and finishes keep the inside and outside of metal shiny like the day it was bought for years. So then when a hood was opened the only rust seen and commented upon is on the fasteners. This led to a radical change in finishes. The automotive industry instituted a standard for fasteners- "no corrosion on the parts for five years for outside areas and two years for under the hood applications". Other industries upgraded as well. This has caused a change in the fastener finishing industry. However, with this increase in corrosion protection a whole raft of other problems has occurred.

Dimensional Fits

First and foremost was the impact on dimensional fits. Before we can understand the problem fully, we need a short review of fastener thread dimensioning. While designers are familiar with bolts and nuts and the fact that they fit together, many do not understand the complexities of their interaction. **The philosophy of fastener dimensioning is that an dimensional allowance would apply to the threads to accommodate variation in the manufacturing process, tooling variation, coating thickness addition, and so on.** Threads that exceed the maximum dimensional limits will not easily fit into mating threaded holes. And in the worst case scenarios, will not fit at all. To avoid complex and duplicate calculations, only the external threads were given this allowance. To have variations on both threaded members would be a nightmare. This allowance was carefully calculated to insure it didn't get too tight when male and female were matched. Nor would it get too loose and reduce the strength of the joint. What small amount of enlargement that occurred due to coating buildup would be deducted from the allowance on the external threads. This is well and good if the fasteners are made with the smallest dimensioned limits. Whatever increase in diameter would be absorbed by the coating allowance and things were thought to be satisfactory. Since the finishes used in former times were mainly phosphate and oil and zinc or cadmium based electroplates, there was

从前，紧固件只要将不同元件锁在一起就已达成任务。如今，使用者对紧固件的要求和期待却不止于此。过去汽车以及其他大型器具中的元件，往往会因为气候的作用，而发生锈蚀的现象。虽然元件往往会用涂料覆盖，但也免不了在打开汽车引擎盖时，仍然会看到红锈一片。现在，业界存在着许多表面涂层与后制处理技术，可以确保金属的内部及外部都保持刚购买时闪闪发亮的光彩。所以现在打开引擎盖后所看到的红锈，都是在紧固件上面。这个问题造成后制处理上的重大变革。汽车产业也因此而制订了一个标准规格－「外部元件五年内不可发生锈蚀现象；引擎盖底下之内部元件两年内不可发生锈蚀现象。」其它的产业也同样做了类似的品质升级动作。此现象造成了紧固件后制处理业中的变化。然而，随着锈蚀防护技术而来的却是许多延伸出来的问题。

尺寸相符

第一个发生的问题，是尺寸相符的问题。为了要全面理解这个问题，我们必须先回顾扣件螺纹尺寸的相关设计与制作方式。紧固件设计人员都知道螺栓和螺帽必须合在一起，但很多设计人员却不了解其中的复杂性。**紧固件尺寸的设计原则，是要预留应用于螺纹上的尺寸误差空间，以确保生产制程、生产模具以及表面涂层上的差异不会造成紧固件无法使用。**超过最大尺寸限度的螺栓螺纹，会造成其转入螺帽时相对应的螺纹尺寸不合，不容易转入，甚至可能

little concern. Yellow dichromate treatment increased corrosion protection slightly without a thickness increase as the dichromate coating was a conversion coating (it replaced part of the zinc/cadmium). The standard phosphate and oil finishes did not add any thickness either as they are also conversion coatings. Zinc was usually applied (in pre-increased corrosion days) in a **thin** electrodeposited layer, and so on.

As we all know, today cadmium is out and chrome 6+ coatings are also. The first thoughts on increased corrosion protection were to increase the present coating thicknesses. However, to increase the thickness enough to cause a significant increase in corrosion resistance would increase the thread dimensions to beyond allowable limits. The mating pitch diameters would be too great to allow any installation fit. **Remember, while the thickness increases on both the internal and external side, only the external side has any space to accommodate it.** **Fig. 1** shows the fit of two mating threads. Note that the pitch diameter is defined as the point on the thread cylinder where the distance across the thread is the same as the distance between the threads. (A = B). Remember this comment about pitch diameters as it will come up in the discussion below.

Space between Crests and Roots of Threads

Another fact that does not come into consideration much is that there is some space between the crests and roots of the threads. Also that the thread contacts the mating flank only on the side is being driven (this space is called the backlash) (See **Fig. 1**).

It is these areas of extra space which have allowed many of the coatings used in the past to function at all. The new processes of finishing technology used to coat parts with today's heavier, highly corrosion resistant coatings are hard to control and to produce a consistent thickness coating. Most of the new thick, corrosion resistant coatings are applied by a process called "dip-spin". In the process, parts are placed in a porous (wire mesh) basket and immersed in the plating solution. Most of the plating solutions are paint-like, base coat mixtures of finely ground zinc and a variety of proprietary chemicals. Sometimes a paint-like organic chemical is used either by itself (for a lower corrosion resistant value) or as a second, topcoat over the zinc base. That is also applied by the "dip-spin" method. The basket is then spun at a high rate of revolution to spin off the excess chemical. The thing found wrong with this process is that there is little control on thickness. If the basket is overfilled (too many parts) the zinc "paint" does not spin off effectively, causing retention of the zinc paint on threads, recesses, and causing some smaller parts to stick together. Also the thickness appears to be uneven from point to point, hexagon face to thread and so on. The coated parts are then baked which hardens and sets the coating. To prevent corrosion **test** failures (salt spray test, etc.), the coater will over plate to forestall the possibility of a test reject. This adds another, uncalculated increase in the thickness.

Why not make the threads smaller and give more space for the finish thickness? The idea of undersizing has been tossed around for years. Some engineers do specify an unplated dimension (undersized) and an "as plated" set of dimensions on prints; most do not. It is rarely

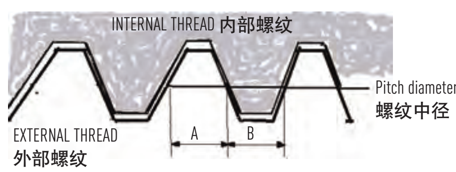

Fig. 1 Thread Pitch Diameter
图一 螺纹中径

完全无法转入。为了避免重复性的复杂计算，我们只在外部的螺纹上要求预留该尺寸误差空间。如果在内外部的螺纹上都要求尺寸误差空间的预留，会造成许多问题。我们小心翼翼地计算此公差，以确保公母螺纹相合时，不会造成太紧或太松（使得连接点的强度不够）的问题。表面涂层处理时所造成的膨胀变化，会从外部螺纹公差中扣除。当紧固件系依照最小尺寸限度制作时，这个方法非常有效。不管直径如何增加，都会被涂层的预留空间所吸收，因此一切都不会有问题。过去所使用的表面涂料，主要是由磷酸盐和油类以及锌或镉的电镀层所构成，因此不会有任何问题。黄色重铬酸的表面处理可以稍微增加侵蚀保护性，却不增加厚度，因为重铬酸涂层为一转化性涂层（其取代了原本锌／隔的一部分）。标准的磷酸盐和油类表面处理材料也是属于转化性涂层，因此也不会增加厚度。锌通常（在过去侵蚀现象尚未如此严重的时候）是以电沉积**薄层**涂上。

大家都知道，如今我们已不再使用隔和铬6+涂层。起初，人们为了要增加侵蚀的保护，尝试增加涂层的厚度。但是，若要能够起实质的作用，必须将螺纹尺寸增加到超过可允许的范围之外。对应的螺纹中径会大到无法正确安装锁合。**请切记，虽然内部与外部的厚度都会增加，只有外部有多余的空间允许厚度的增加。图一**所示为两对应螺纹锁合的状况。请注意，螺纹中径的定义为螺纹圆柱体上螺纹两端距离等于螺纹间距离的点（A=B）。这个定义在后面还会用到，因此请记住。

followed anyway. The reasons are economical, technical, and just laziness. It is cheaper and easier to run parts with the same (standard) dimensions than to have special set-ups with different dimensions (undersized threads). Mix-ups between standard and special dimensioned parts will occur all down the line- manufacturing, heat treatment, plating, even handling in the assembly plants.

The maximum thickness that can be plated/coated on a standard thread without interference with mating part is:

Thread Pitch/Per Inch	Maximum Thickness(inch)
32 or less	0.00015
30-13	0.00020
10-5	0.00030
Greater than 5	0.00050

Or to state it in other words, even many of today's coatings cause interference and tight assembly. The facts that they work at all are due to that extra clearance space mentioned above, that the tools used in assembly easily overpower most cases of resistance due to the plating interference, and that many of the finishes used were paint like in origin and are soft and easily pushed aside in the installation.

The new metallic base coatings deposit about 0.0010inch or greater on the part. It also deposits about the same on the internal threads and those threads have no space allowance.

As the plating is deposited, its dimensions are not consistent across different areas. Thread tips are coated thicker, roots less, heads more on the top and corners, underhead surfaces little. Internal parts of recesses get little coating and soon become visible rust areas. Imagine the plating on a cylinder. The cylinder will grow in thickness on the north, south, east, and west sides, or a total amount of 4 times the thickness on any one side! Since some process allowance is required to insure that the finish is above the minimum everywhere on the part, a factor is added to the specification. Experience has shown that 50 percent of the minimum listed value is a good number. As explained in **Fig. 2**, the increase becomes unmanageable. It figures that the maximum amount of plating that can be added to the threads for a correct fit is only 1/6 of the specified thread allowance in the dimensional standards. And now what about the NUT? It doesn't have any allowance. So a corrosion resistant bolt and nut combination can only be allowed 1/12 of the specified allowance in the standards if it is fit together without incidence (and that is only if the coating has some sort of thickness consistency).

Looking to **Fig. 2** again, as the thickness increases the pitch diameter also grows. The

螺纹牙顶与牙底间之距离

另一个常被人们忽略的事实，是螺纹牙顶与螺纹牙底间仍然是有一些距离的。另外，螺纹只会与对应螺纹被驱动的一面接触（此空隙称为齿隙）。请见**图一**。

往往是这些具有多余空间的地方让过去的涂层得以产生作用。新式后制表面处理技术使用现今较重且防侵蚀能力更强的涂层来处理元件，而此新技术较难控制且较不容易产生厚度均匀的涂层。多数较厚实的防侵蚀涂层材料以称为「浸转」的方式涂上。该过程中，元件被放在多孔的（丝网）篮中，并浸入电镀溶液中。大多电镀溶液为含有研磨到很细小的锌以及各种其它化学物质组成的独有配方涂层基底物质（很像油漆）。有时会单独使用像是油漆的有机化学物质（如此会得到较低的防侵蚀系数），或者在锌的涂层上面再加上这一层有机化学物质。其也是使用「浸转」的方式涂上。然后，篮子以高转速转动，以甩掉多余的化学物质。这个制程的问题在于其对于厚度无法掌控。若篮子太满（放入太多元件），「锌漆」就不会有效地被甩掉，造成锌漆残留在螺纹、头部凹槽处，并使得一些较小的元件黏在一起。另外，点与点之间或六角面与螺纹之间的厚度也显得不均匀。上涂层后的元件再经过烘烤，以使涂层硬化固定。为预防产品无法通过侵蚀测试（盐水喷雾测试等），涂层器具会让涂层厚度更厚一些。这个因素更进一步增加了厚度的不确定性。

为何不让螺纹更小，以提供更多的表面涂层空间？小型化的想法已经提出多年。有些工程师确实在制图上列出了未电镀尺寸（较小）以及电镀后尺寸，但多数工程师不会。反正人们也鲜少按照所提供的数据进行后续设计规划。此现象的原因，主要为经济考量、技术考量以及人们懒惰的特性所致。使用相同（标准的）的尺寸制造元件比使用特殊的不同尺寸设计（较小的螺纹）要来得容易且更符合经济效益。标准尺寸元件与特殊尺寸元件间的混淆，将整条生产线上一 制造、热处理、镀层、甚至在组装厂阶段发生。

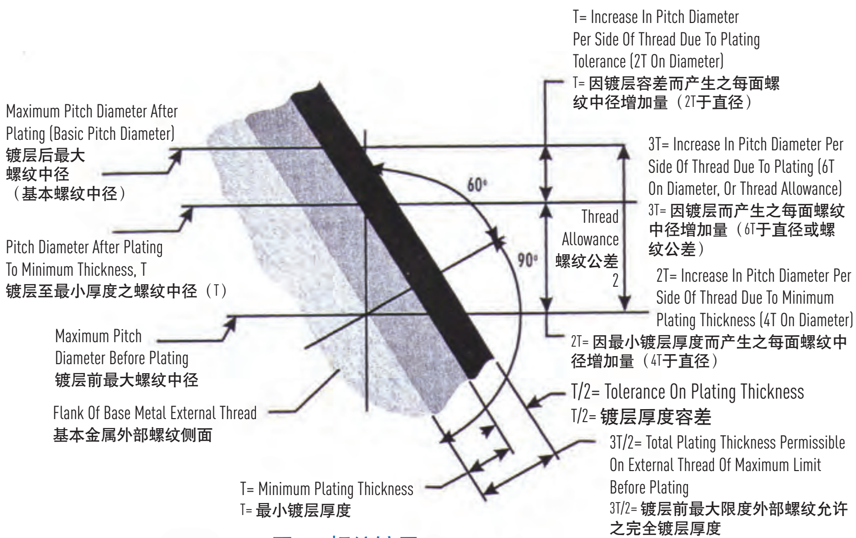

Fig. 2 Plating on Thread　图二 螺纹镀层

coating causes the pitch diameter to extend outwards (flank dilateral displacement). Too much and parts will jam. Or the most probable case is that the parts will go together thanks to the installation tool muscle. However, the torque that is needed for a secure joint has been expended on overcoming the friction of the plating thickness. As the torque is lost, the joint becomes potentially looser. Soon the wheels will fall off (worst case scenario, of course).

The Coater

Since the coating of a part is about the last step in a part's manufacture, the coater often bears the brunt of any problems. Routine testing of incoming products often include a salt spray corrosion test, a test that will fail undercoated parts. To forestall any failed shipments, the coater often overcoats the part; if 0.0005" is good then 0.0010" is better. This, obviously, adds to the problem enormously.

Thick Coating & Dip/ Spin Process

The threads are affected another way as well. The organic paints and zinc metal based coatings are thick as mentioned above. When the parts are spun in the plating machine and dumped out on a conveyer belt to be oven dried, the coating is still slowly flowing. To save expense, the coater often overfills the barrels; the more parts per barrel, the fewer operations he runs and less cost to him. Overfilled barrels cannot spin off the excess effectively. When the paint is cured, the material that did not flow off the part "plugs" the valleys between the threads. The cured state of the finish is quite hard especially with some of the metallic based paints (the plug being almost solid metal). This can prevent the threaded part from mating with its component part. From hard driving to no fit, all have been reported.

The example photograph **Fig. 3** shows what the condition of the threads

在不影响对应锁合元件的前提之下，标准螺纹上所能电镀／上涂层的最大厚度为：

螺距／每英吋	最大厚度（英吋）
32 以下	0.00015
30-13	0.00020
10-5	0.00030
大于5	0.00050

换句话说，就连现今的涂层材料都会造成干扰及产生过于紧密的组装。这些涂层仍然可以使用的原因，是因为前述的预留空间：组装时工具的力量往往大于电镀干扰的力量，以及因为多数表面处理材料较软（类似于油漆的质地）且容易在组装时被推开。

新式的金属基底涂层会使得元件厚度增加约0.0010英吋或者更多。其也会造成内部螺纹增加相同厚度，而内部螺纹却不具有任何预留空间。

镀层在不同的区域厚度会不同。螺纹顶端镀层较厚；螺纹牙底镀层较薄；头部的上方和角落较多，而头部下的面则较少。头部凹槽处的内部所上的镀层很少，因此很快就会出现锈蚀。试想像圆柱体的镀层。圆柱体的上面、下面、右边、左边的厚度都会增加，或者可以这样说，所增加的厚度为任一边所增加厚度的4倍之多！为了确保后制处理所造成的厚度，在元件各处均超过最低限度，规格中会加入一个数值。过去的经验告诉我们，最低值的50%是一个好的数值。如**图二**所示，所增加的厚度会变得无法想像。因此，为了正确锁合，所能加到螺纹上的镀层厚度只有尺寸规格中螺纹预留空间的1/6而已。那么，螺帽那边又如何呢？其不具有任何预留空间。因此防侵蚀的螺栓与螺帽组合，若要确保能够正确锁合，只能允许其有规格中所注明预留空间的1/12（且这还是在涂层具有基本的厚度均匀性情况下）。

再次观察图二，其实不难发现，厚度增加的时候，螺纹中径也会增加。涂层会造成螺纹中径向外扩张（侧面双向位移）。此现象若过于明显，会造成元件卡在一起。亦或，可能性更高的是，元件将因工具的大力驱动力量而锁合在一起。然而，确保

of a zinc base dip/spin coating could look like in its worse condition. However, the illustrated screws are galvanized coated instead of the zinc base finish. Since few sources of the examples that I have would allow themselves to be mentioned as the manufacturers of poor quality platings, the actual examples could not be shown. The illustrated parts were chosen just to show an **exaggerated** view of what the poor coating could look like. While the screw is typical of galvanized parts and could be driven into wood, the bolt did not turn into a nut, rendering even this coating a failure. **Galvanizing is the process where a part is dipped into molten zinc to protect it from long term exposure, usually on fasteners used in road construction structures (guard rails, signs, bridges, etc.)**

The new coatings cause a fit problem when applied on screw and washer assemblies. Dip/spin applied paints cause the washers to stick to the bolts or nuts, making free turning an impossibility. The washer is designed to be a "free spinning" part. The bolt/nut, when tightened against the washer, has a constant bearing surface of known hardness and friction, making correct torque specification possible. The finish "glues" the washer to the fastener (and is hardened in place by baking) and causes: changes in the clamping load (potential failures of the joint), can spin the entire fastener/washer assembly and cut the surface beneath it with attendant paint and surface damage, and/or cause misassambly since the washer is often frozen at an angle, allowing the screw or nut to be driven askew and cross threaded.

Recess Fill

A final finish problem is that of recess fill. The zinc paint-like finishes are very thick and are high in viscosity. Since the method of application is to dip a barrel of parts in the paint and spin off the excess, sometimes much of the coating is retained in the head recesses, especially if the parts are aligned in the barrel as to minimize the removal in the spin direction. The converse also happens; the alignment of the screws in a tightly packed barrel will prevent some coating from entering the recess and a low

Fig. 3 Screw Threads with Zinc Clogs
图三 锌堵塞现象之螺丝螺纹

thickness, rust susceptible part is produced. Overfilled and tightly crowded barrels do not let the parts move freely enough coat correctly. Filled and partially filled recesses cause fit problems in assembly as the driver bit will not fully, if at all, enter the drive recess. Poor driver bit connection causes bit spinout in the plant, usually with paint scratches and possible operator injury.

How about Torque?

Why make such a fuss about the finish's thickness? The problem lies with the torque to tighten the joint. As it has mentioned previously in several past articles, the force applied to a joint is dissipated by many factors. First of all, the torque applied generates a force that holds the joint together. If the installation force

连接点为稳固的扭矩，却在克服镀层厚度所造成的摩擦阻力时耗尽。当扭矩因被消耗而消失，连接点的强度将减弱。过不久，轮子将掉落（当然，这是最坏的状况）。

上涂层者

由于涂层的步骤是元件制造过程的最后步骤之一，问题发生时针对上涂层者的追究往往首当其冲。元件的例行性测试中，常包含盐水喷雾测试，涂层不足的元件将无法通过此测试。为了避免无法出货的状况发生，上涂层者通常会将元件的涂层制作得更厚一些：其哲学为，如果0.0005的厚度是好的，那么0.0010的厚度会更好。当然，这将大幅增加了问题的严重性。

厚重涂层&浸转处理方式

还有另一种现象也会影响螺纹。如前所述，有机涂料与锌金属基底涂层的厚度较厚。元件在镀层机器中旋转后，会被倒出到输送带上晾干（此时涂层材料仍然在流动）。为了减低成本，上涂层者经常会将桶子塞得过满，因为每桶所装的元件数越多，所需的运转次数就越少，其成本也会因此降低。过满的桶子将无法有效地将多余物质甩开。涂料经处理而固化以后，没有确实甩开的物质，将造成元件螺纹间的堵塞。固化后的涂层物质，质地其实很

(clamp load) is too low, the joint will separate due to the forces of vibrations, gravity, impacts and so on. The engineer calculates what the correct force for a joint to survive is depending on bolt strength, what is actually needed, and a bunch of other factors. Anything that affects the joint torque is critical. Often he relies upon other past situations, tables of similar parts and values, etc. The finish on the fastener greatly affects the amount of force (torque) that goes into pulling the parts tightly together. Roughly figuring, of 100% of the applied torque to a joint, approximately 40% is lost in thread friction, the rubbing together of the threads as they mate. About 50% of the torque is lost to friction of the underhead surfaces as it turns and is tightened down. ONLY 10% of the calculated torque goes into pulling the parts up to the specified and anticipated clamping load. As **Fig. 4** shows, if the toque is increased by only 8.8% (i.e., 90 to 98 units of torque) caused by the frictional increase of the thicker coating, the actual amount of force that goes into tightening the joint is reduced to only 20% of its original value. To repeat, **the clamp load has lost 80% of its tightening force.** The wheels that were tightened to 20 ft.lbs, are now only at 4. How long before something happens?

Yes, the engineer can increase the torque but will the new torque exceed the strength of the fastener? Is he even aware that there is a problem? With every improvement there are always problems which were not considered. The use of highly resistant coatings is one of them. Tests with actual parts, instrumented to give actual readings should be a part of every program that involves critical joints. What often happens is that a present design is "upgraded" by the addition of new parts with corrosion resistant coatings without any re-test or evaluation of the present specifications. An unscientific survey a few years back made a list of the factors that affected a joint, for fun; the list included almost 100 items. Truly, some often overlooked or little considered items do make a great deal of difference in the performance of a fastened joint.

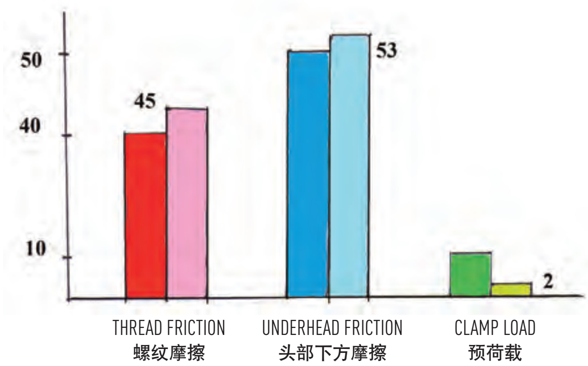

Fig. 4 Thread Friction
图四 螺纹摩擦力图

硬，尤其是金属性的涂料（固化后几乎等于是金属的硬度）。这可能会造成该元件无法和其对应的元件进行锁合。而锁合困难以及完全无法锁合等问题过去皆有业者曾提报过。

图三的例子所显示的是锌质浸入/旋转涂层制程中，螺纹所可能出现的最坏状况。然而，图中的螺丝是使用热镀锌后制处理法而不是锌基底的表面处理。由于鲜少有厂商愿意公开承认自己所生产的电镀层为劣质品，因此笔者手边的实际案例无法在此当做实例使用。选中此图中的元件只是以一个较夸大的方式，显示劣质涂层可能的样子。虽然螺丝是典型的热镀锌元件，且可以转入木头中，螺栓却无法转入螺帽中，显示此类的涂层为失败的。**热镀锌处理是将元件浸入熔化之锌以保护其长期暴露不会受到侵蚀，此方法常应用于道路建设用途的紧固件（护栏、标志牌、桥梁等）。**

新式的涂层，使用于螺丝或垫圈组装时，会产生锁合上的问题。浸入／旋转制程中的涂料会使得垫圈黏住螺栓或螺帽，并进一步造成元件无法自由转动。垫圈在设计上应为「可自由转动」之元件。当螺栓／螺帽与垫圈锁紧时，其支撑面之硬度与摩擦力为固定之已知量，因此可以制定正确的扭矩规格。表面处理层会将垫圈「黏着」于紧固件上（且烘烤后会硬化），并会造成：预荷载（连接处的可能失效点）的变化，可能会使整个紧固件／垫圈组转动，并因所上的涂料对下方表面的切割而造成表面伤害。另外，也可能因为垫圈卡在某个角度而造成不正确的组装，让螺丝或螺栓得以歪斜且螺纹无法正确对齐。

头部凹槽堵塞

最后一个后制表面处理问题为头部凹槽处的堵塞问题。锌表面涂料很厚重且黏度很高。由于制程所使用的方法是将一整桶的元件，浸入涂料中，然后再以旋转的方式将多余的涂料甩去。这种方法，有时会造成涂料残留于头部的凹槽处当中，尤其是当元件在桶中的方向恰好会阻碍涂料甩去的时候。另外一种相反的状况也有可能会发生，也就是因为桶中塞满过多元件，使得桶中元件的位置和方向可能会让涂料无法进入元件之头部凹槽处，这会造成涂层过薄且容易生锈的元件的产生。过满或元件数过多的桶子因为无法让元件于其中自由移动，所以无法让元件浸入适量的涂料。完全堵塞和部分堵塞的头部凹槽会造成组装时的问题，因为起子头将无法完全正确转入元件头部凹槽中。劣质的起子头锁合状态会造成起子头冲出，并往往会造成漆面的刮伤甚至是人员受伤。

那么扭矩呢？

我们为何要花这么多时间和精力研究后制表面处理的厚度？问题在于将连接处转紧所需的扭矩。如过去几篇文章中所述，施于连接点之力道会因数种因素而减弱。首先，所施予之扭矩将产生将连接点紧紧固定的力量。若安装的力道（预荷载）太小，该连接点将因震动、重力、撞击等力道而分开。工程师须依据螺栓强度、实际需求以及许多其他因素而计算让连接点能够屹立不摇的力量为何。任何影响连接点扭矩的因素都是很关键的。工程师往往会仰赖过去的经验、相似元件的资讯表格和参数值等。紧固件上的表面处理或涂层材料，对将元件锁紧所需要的力量（扭矩）有非常大的影响。粗略地估计，对一个连接点所施予的100%扭矩中，大约有40%被螺纹摩擦力所消耗，亦即螺纹间锁合时之摩擦。约50%的扭矩是消耗在头部下方表面于锁紧时之摩擦力。只有10%的扭矩是用于将元件转至指定的预荷载量。如**图四**所示，若扭矩因为较厚涂层之摩擦增加而只增加8.8%（也就是90到98个扭矩单位），锁紧连接点所使用之实际力道将减少至只有原先值的20%。这里再次强调，**预荷载量会失去80%的锁紧力道**。原先被锁紧至20 ft.lbs的轮子，现在只有4。试想，意外何时会发生？

没错，工程师是可以增加扭矩，但是该新扭矩会不会超过紧固件的强度？甚至他知不知道有问题存在？每一个改良的背后，总是会有被忽略的问题。高抗度涂层材料的使用就是其中之一。每一个关键性连接点，都应经过元件之实际测试，并测得真实数据。往往一个系统，会以具有新式涂层材料的新元件进行「升级」，但却没有确实做好所有规格的重新测试与评估的工作。前几年，曾有人做过一个非科学调查，并制做了一个列举所有可能影响连接点之因素的名单。虽然只是为了好玩罢了，但该名单包含了近100个项目。事实上，许多常被人们忽略的项目，却对紧固件连接点的效能产生了很大的影响。