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The Effect of Thread Coating Glue Height to Screw Breaking Torque

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Abstract: *Screw loosen is one of the main factors of thread connection failure, and there are many ways to avoid it. There are many methods to avoid screw loosen, such as anti-loosening washer, double nuts, coating thread glue etc. Coating thread glue is an important way to solve the problem of screw looseness, and the amount of glue coating is an important factor affect the thread glue process quality. Too much glue coating on screw will lead to waste, insufficient glue coating on screw will lead to the decrease of bonding strength, cannot realize screw anti-loosen. So, thread coating glue quantity need to be controlled in process. As a typical coating glue process, glue dipping has a very wide range of application scenarios. In glue dipping process, the height of coating glue will affect the quantity of coating glue. In this paper, thread coating glue height is studied. The optimal gluing height is obtained through theoretical calculation, and the relationship between coating gluing height and breaking torque of screws is obtained through experimental testing.*

Keywords: *Thread Glue, Breaking Torque, Screws Loosen, Glue Coating Quantity*

1. Introduction

Threaded connection occupies an important position in the production manufacture process because of its advantages of convenient disassembly, simple structure and low cost. In practical work, threaded connection often to face with vibration, shock and tension conditions, which may lead to thread loosening. Screws loosen not only affect normal production quality, but also may cause safety risk. Therefore, it is very important to reduce the frequency of thread loosening.

There are many methods to decrease thread loosened [1],Such as permanent locking, mechanical locking and friction locking, etc. The ways of friction locking include double nut locking, self-locking nut locking, adding spring washer locking and thread glue locking. Thread glue locking not only have low cost, but also could improve product quality, it is widely used in practical production.

2. Thread Glue

The main component of the thread glue is Di methacrylate, and suitable stabilizers, accelerators and initiators are added, and certain materials such as pigments, fluorescent agents, fillers or plasticizers are added according to the actual production needs. Under the condition of full contact with oxygen, the thread glue can exist in a liquid state for a long time. Under the condition of oxygen isolation, it can be quickly glued to form insoluble solid particles and connected with threaded parts to achieve bonding [2]. After the thread is glued by thread glue, the friction between the thread pairs increases, and the probability of relative movement between the thread pairs decreases. In addition, some thread glue can also play a sealing role to prevent liquid or gas leaking through the thread gap [3]. Thread glue is widely used in machinery, automobile and aviation industries because it can be quickly solidified in the absence of oxygen to realize bonding [4].

There are many factors that affect the bonding strength of thread glue[5]:Different thread materials will produce different bond strength, so it is necessary to choose the thread glue that matches the thread material; Temperature also has a great influence on the bonding strength, when the working temperature is beyond the tolerance range of thread glue, the bonding strength of thread glue will drop sharply, so the working temperature of the product should be considered when selecting thread glue; The curing time also affects the bonding strength, and the strength of the thread glue that is not completely cured will be greatly reduced. In actual production, the curing time of the thread glue

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should be considered.

Glue coating amount is also an important factor affect the bonding strength. When glue coating amount is insufficient, the thread glue can't fill the thread gap, which will cause the bonding strength of thread glue to decrease. If glue coating amount is too much, it will waste thread glue, also could pollute working environment. So, coating glue quantities need to be controlled in production process.

In coating glue process, it is a critical point to control glue coating quantity. Insufficient glue coating will lead to the decline of product quality, and excessive glue coating will lead to the increase of cost. There are many ways to coat glue, such as dispensing, spraying, rolling and glue dipping. Different coating glue methods have different control plan. In this study, coating glue method is glue dipping. And we need seek a good method to control coating glue quantity in glue dipping process, controlling the amount of glue coating to improve the quality of coating glue quality. According to test screw breaking torque, we can check if coating glue quality is improved. This paper will study how to control the coating glue quantity depend on control thread coating glue height.

3. Calculate Coating Glue Height

Because of screw breaking torque could demonstrate thread coating glue process quality, so, we validate coating glue quality by screw breaking torque. Coating glue quantity is a primary factor that affect coating glue quality. In current coating glue process, it is hard to measure coating glue quantity, but it is easy to measure coating glue height. So, we need find a method to measure coating glue quantity by coating glue height. And in this study, we will find the relation between screw coating glue height and screw coating glue quantity by theoretical calculation, and then through the experimental test to find the relation between coating glue quantity and breaking torque of screw coating glue. At first, we need calculate coating glue quantity and coating glue height of screw. And the method that calculate screw coating glue height as below.

This method could break down into three steps to calculation coating glue height: 1) Calculate the space of two threads, and then infer that the total coating glue quantity on screw; 2)Calculate the quantity of coating glue attached on the thread groove of a single pitch after finish glue coating; 3)Calculate coating glue height according to the total coating glue quantity and the quantity of coating glue attached on the thread groove of a single pitch.

3.1 Calculate Coating Glue Quantity

3.1.1 Calculate Thread Interlock Length

After screw finish coating glue, operator will turn screws into screw hole. Thread glue adhere on thread will fill into space of interlock thread, and after thread glue is solidified, adhesion force will be generated. So, we need calculate space of interlock thread and base on this value to infer total quantity of thread coating glue. Before calculate space of interlock thread, we need calculate thread interlock length. After we calculate thread interlock length, we can calculate internal thread volume and external thread volume base on this length. Calculate thread interlock length as below, define thread interlock length as l,and then calculate thread interlock length base on equation(1).

$$l = l_1 - l_2 - l_3 - l_4 \tag{1}$$

l_1 is the total length of screw; l_2 is screw chamber length;l_3 is been connected part length;l_4 is washer thickness. According to the design parameters, the calculated length of thread interlock(l) is 25mm.

3.1.2 Confirm Thread Parameters

Table 1 Thread Parameter

Thread type	Major Diameter D_{max}	Major Diameter d_{min}	Pitch Diameter D_{2max}	Pitch Diameter d_{2min}	Minor Diameter D_{1max}	Minor Diameter d_{1min}	Tooth Angle
Internal Thread M18X2.5-6H	18	-	16.6	-	15.7	-	60°
External Thread M18X2.5-6g	-	17.6	-	16.2	-	14.9	60°

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In this paper, the nominal diameter of the thread that we studied is M18. The dimensional tolerance of threads studied in this paper is M18-6H/6g, when the internal and external threads are in the minimum solid state, the space of interlock thread is largest. According to Mechanical Design Manual [6], we can find the relevant parameters of thread as Table 1.

3.1.3 Calculate Thread Interlock Space & Total Coating Glue Amount

Before calculate space of interlock thread, we need calculate internal thread volume and external thread volume. And space of interlock thread is equal to difference of internal thread volume and external thread volume. We can use integral equation to calculate internal/ external thread volume. At first establish thread section curve in rectangular coordinate system. Take the plane where the central axis of the thread is located as the cutting plane to cut the thread with a single pitch, thread section curve as Fig.1, X axis is the central axis of thread. The coordinates of relevant points on the thread can be obtained by the thread parameters, according to the coordinates of related points, the linear equation of thread section can be obtained.

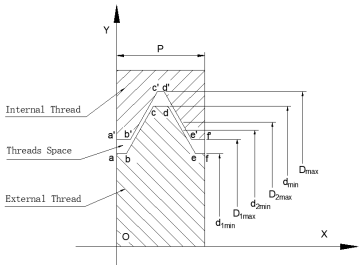

Fig.1 Thread section curve

According to the linear equation of thread section, establish the equation of the volume of external thread with single pitch (V_1), equation (2).

$$V_1 = \int_{x_a}^{x_b} \pi y_{ab}^2 * dx + \int_{x_b}^{x_c} \pi * y_{bc}^2 * dx + \int_{x_c}^{x_d} \pi * y_{cd}^2 * dx + \int_{x_d}^{x_e} \pi * y_{de}^2 * dx + \int_{x_e}^{x_f} \pi * y_{ef}^2 * dx \quad (2)$$

Input the relevant thread parameters to above equation, and result is V_1=517.58mm^3, Similarly, we can establish internal thread volume equation, and calculate the internal thread volume of a single pitch, V_2=555.20mm^3. Thus, the interlock thread space of a single pitch can be obtained, V_3=V_2-V_1=37.62mm^3. According to equation (3),calculate total space of interlock thread(V_X).

$$V_x = (l/P) * V_3 \quad (3)$$

l is thread interlock length, mm; P is thread pitch, mm. Input relevant parameters, and result is V_x=376.2mm^3. Total coating glue amount (V) approximately equal to total thread interlock space, so V=V_X=376.2mm^3.

3.2 Calculate Glue Quantity Adhere on Thread Groove

After the external thread is coated by thread glue, we need to do glue dripping. According to glue dripping, excess glue will fall into glue dipping pond. This method could avoid glue waste, also could make working environment clean and tidy. Under the action of gravity, the thread glue beyond the large diameter area of the thread will drop into glue pond, thread glue within the large diameter area of the thread will adhere on the thread as Fig.2. Thread glue adhere on the thread will filling into space of interlock thread after we rotate screw into internal thread hole. If we know the quantity of thread glue adhere on the thread groove, it will be easy to know if these thread glue could be full with space of interlock thread.

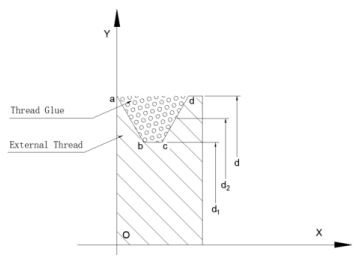

Fig.2 Thread glue adhere on thread groove

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Follow the method of 2.1.3, establish one single pitch thread glue amount equation (4), according to this equation, we could calculate the amount of thread glue(V') adhere in the thread groove of a single pitch, V'=92.23mm^3. It will be easy to calculate total quantity of thread glue adhere on external thread by this value.

$$\mathbf{V' = \int_{x_a}^{x_b} \pi y_{ab}^2 * dx + \int_{x_b}^{x_c} \pi * y_{bc}^2 * dx + \int_{x_c}^{x_d} \pi * y_{cd}^2 * dx} \quad (4)$$

3.3 Calculate Coating Glue Height

According to 2.1., we could calculate total thread glue quantity which is need to full of space of interlock thread. And according to 2.2., we calculate thread glue quantity that adhere in one single pitch thread groove. We could calculate the number of coating glue teeth of screws by these two values. According to the number of coating glue teeth, we can calculate the height of coating glue on screw. The number of coating glue teeth(n) calculate method as equation (5)

$$n = V/V' \quad (5)$$

V is total coating glue amount, mm^3; V' is single pitch coating glue amount, mm^3. According to related data that calculated in precious chapter, we can calculate the coating glue thread teeth quantity is n=4. Because of there is chamfer on the bottom circle of thread teeth, the thread glue adhered in this area is hard to be filled into the space of the threads. Therefore, the quantity of thread glue adhered in the bottom thread teeth is not considered in theoretical calculation. So, the quantity of coating glue thread teeth should increase 1, and become to 5. And then we can calculate the height of coating thread glue base on coating glue thread teeth and thread pitch. The result is equal to 5*P (thread pitch) =12.5mm.

4. Calculate Screw Breaking Torque

4.1 Calculate Bonding Torque

If interlock thread space is full of thread glue, after thread glue is solidify there will produce bonding torque. The bonding torque will enhance thread locking. And different diameters screws have different bonding torque. The type of thread glue been selected in this study is Loctite 277, according to the study on bonding strength of thread glue [7], after all thread space are full of thread glue, the equation (6) can be used to calculate the bonding torque of thread glue.

$$T_{18} = (A_{18}/A_{10})T_{10} \quad (6)$$

T_{10} is tested data from supplier, means the bonding torque of screw (M10X1.5), T_{10}=32N.m; A_{10} & A_{18} is thread specification factor, calculate by equation (7).

$$A_i = \frac{\pi l}{2p\cos\lambda}\left[\frac{(d^2+d_1^2)p}{8} + \frac{(d-d_1)d_2^2}{\cos\alpha}\right] \quad (7)$$

l is thread interlock length, mm; P is thread pitch, mm; λ is lead angel; α is thread tooth half angel; μ is friction factor; d is major diameter of thread, mm; d_1 is minimum diameter of thread,mm; d_2 is pitch diameter of thread, mm. Input relevant parameter to equation (7), and result is A_{10}=1549mm^3, A_{18}=9550mm^3. According to equation (6), could calculate the bonding torque of screw (M18) is T_{18}=200N.m.

4.2 Calculate Breaking Torque of Screw Without Glue

After screw is applied torque, along with stress release, the torque of the screw will be reduced. Breaking torque of screw is not equal to initial torque of screw. And the breaking torque of screw coating with glue is equal to the breaking torque of screw without glue and bonding torque of screw coating with glue.

Before calculate breaking torque of coating glue screw, we need calculate breaking torque of screw without glue. After both this value and bonding torque of coating glue screw been calculated, it will be easy to calculate breaking torque of coating glue screw. According to study on screw breaking torque [8], if screw is not coated glue, screw initial torque(T_1) is calculated by equation (8) and screw breaking torque(T_2) is calculated by equation (9).

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$$T_1 = (d_2/2) \cdot F_1 \cdot (2\mu + \tan\lambda) \quad (8)$$

$$T_2 = (d_2/2) \cdot F_1 \cdot (2\mu - \tan\lambda) \quad (9)$$

d_2 is pitch diameter of thread, mm; F_1 is screw tension, mm; μ is friction factor; λ is lead angel. According to above equations, for M18 screw, we can estimate the relation between screw initial torque(T_1) and screw breaking torque(T_2) is T_2=0.8T_1.

4.3 Calculate Breaking Torque of Coating Glue Screw

When calculating the break torque of gluing screws, it is necessary to consider the initial applied torque of screws, the break torque of glue-free screws and the bonding torque of gluing screws. In 3.1. we have calculated bonding torque of coating glue screw, and in 3.2. we find the relationship between initial torque of screw and breaking torque of screw without glue. According to above parameter, we could calculate breaking torque of coating glue screw(T') by equation (10).

$$T' = T_2 + T_{18} = 0.8 * T_1 + T_{18} \quad (10)$$

According to the design requirements of products, initial torque of screw(T_1) is 300N.m, according to result of 3.1, we know that bonding torque of screw(T_{18}) is 200N.m, so, we can calculate breaking torque of coating glue screw(T') as table 2. And T'=440N.m.

Table 2 Different Torque of Screw

Thread Type	Torque Name	Value (N.m)
M18X2.5	Initial Torque(T_1)	300
M18X2.5	Breaking Torque of Screw without Glue(T_2)	240
M18X2.5	Bonding Torque(T_{18})	200
M18X2.5	Breaking Torque of Coating Glue Screw(T')	440

5. Test of Breaking Torque of Coating Glue Screw

5.1 Purpose of This Test

According to the theoretical calculation of above chapters, we get the quantity of coating glue on screw and the height of coating glue on screw, we also calculate the bonding torque of coating glue screw. We need do a breaking torque of the coating glue screw test to validate our calculate result.

We need validate two points by test the breaking torque of the coating glue screw, 1) validate the effect of different coating glue heights to breaking torque of screw coat with glue; 2) validate whether the theoretically calculated coating glue height matches with the actual requirement.

5.2 Related Hardware of This Test

We need prepare related hardware before this test. All equipment & tools need have a good maintain, could be used normally. All gauges need to be calibrated and not overdue. Hardware list as below.

Equipment and Tools: Torque Equipment/ Torque Wrench/ Coating Glue Fixture.

Gauges: Torque Detection Wrench/ Vernier Calipers.

Material: Screws/ Washer/ Counterpart of Screws/ Thread Glue.

In this test, torque wrench and torque equipment are used for applying initial torque to screws. Coating glue fixture is used for coat glue on screws, thread glue dripping task also be finished on this fixture. And vernier calipers is used to measure the height of thread coating glue on screws. After screws are fasten in counterpart of screws, and thread glue is solidify, we will use torque detection wrench to measure breaking torque of coating glue screws.

5.3 Test Method

The environment of this test is the normal product manufacture workshop, the temperature of the environment is 25°C, and the humidity is 50%. This test based on below five steps: 1) Prepare 20

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screws, check all screws, the dimensions of all screws need meet design specifications. Five screws are in one group, divide screws into 4 groups. 2) Coating glue on all screws that used to do breaking torque test. The coating glue height of the first group of screws is 7.5mm (coating glue 3 teeth); The coating glue height of the second group of screws is 10mm (coating glue 4 teeth); The coating glue height of the third group of screws is 12.5mm (coating glue 5 teeth); The coating glue height of the fourth group of screws is 15mm (coating glue 6 teeth). 3) Install screws onto the counterparts, then apply torque on all screws by torque equipment, all screws' initial torque are 300N.m. 4) Store all screws and counterparts for 24 hours, don't move screws and counterparts until thread glue be solidify. Use torque detection wrench to detect all screws' breaking torque. 5) Record all torque value and analysis this result.

5.4 Test Results and Analysis

After finished all test of breaking torque of screws and record, we do torque result analysis base on above data. The result of breaking torque of coating glue screws as Fig.3.

According to analysis test result, we find that the breaking torque of screw is related to the height of coating glue on screw. Base on test result, if screws coating glue height is less than 12.5mm, the breaking torque of screws will increase significantly with the increase of coating glue height. If screws coating glue height more than 12.5mm, the breaking torque will not increase significantly with the increase of coating glue height.

This test result also could show another point, for the screws studied in this example, if the height of coating glue on screw is 12.5mm, thread glue that adhere on the thread groove could be full of the space of interlock threads. According to this test, we could find that the relation between the height of coating glue on screw and the quantity of coating glue on screw are consistent with the theoretical calculation.

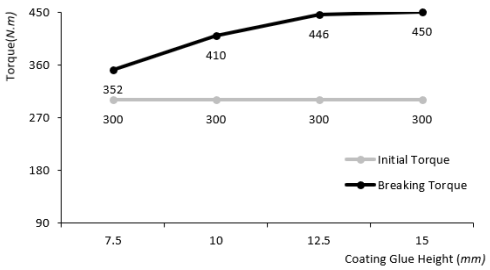

Fig.3 Test result of breaking torque

6. Conclusions

In this paper, the relation between screws coating glue height and screws coating glue quantity is studied by theoretical calculation. According to theoretical calculation, we also could know the quantity of coating glue on screw when we want thread glue to be full of the space of interlock thread.

According to our study we find that different height of coating glue on screw have different effort on breaking torque of coating glue screw. Different gluing heights are equivalent to different gluing amounts. So, we can have a conclusion as below, if the quantity of thread glue can't fill up with the space of interlock threads, the breaking torque of thread will increase with the increase of gluing height. But if the quantity of thread glue could fill up with space of interlock threads, even if screws coating glue heights increase, the breaking torque of the thread will not be obviously increased. For the screw studied in this paper, we know the proper height of coating glue is 12.5mm (coating glue 6 teeth).

In the production process, for different screws, the height of gluing should be calculated and tested to ensure that the screws are coated with the appropriate amount of gluing. In addition, we must continue to optimize the coating glue process, ensure the coating glue height of screws keeps steady.

References

[1] Liu Li, Yuan Yingqiang. Summary of research on threaded connection anti-loosening technology [J]. Modern Urban Transit,2022(1):114-120.

ISSN 2706-655X Vol. 7, Issue 2: 118-124, DOI: 10.25236/IJFET.2025.070215

[2] Li Huilu, Li Xiaojia etc. Study on influence factors of anaerobic adhesives properties for thread-locking [J]. China Adhesives,2011,20(4):31-35.
[3] Meng Ke, Xue Jian. Application of thread coating glue in mechanical assembly process [J]. Ji Xie Gongchengshi,2013(8):221-222.
[4] Jiang Y, Zhang M, Park T W, et al. An Experimental Study of Self-Loosening of Bolted Joints[J]. Journal of Mechanical Design,2004,126(5):925-931.
[5] Yang Xiaona. Study on the factors influencing the torque strength of anaerobic thread locker adhesives[C]. Bei Jing Adhesion Society the 17th Annual Conference and Forum on Adhesive and Sealant Application Technology. 2008:211-219.
[6] Wu Zongze, Mechanical Design Manual[M]. China Machine Press,2002.1:435-450.
[7] Shao Ruiqing, Chen Jixiang. Estimation of Breakdown Torque of the Thread Fastener locking by Anaerobic Adhesive[J]. Adhesion,1986(06):33-35.
[8] Xu Zhiyuan, Rong Yuanqing. Chemical locking and sealing technology of screw [J]. Automobile Technology,1992(6):34-43.