Discussion on Causes and Solutions of the Biting Mechanism of Stainless Steel Bolts

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Abstract. Due to the influence of the peculiar material characteristics, austenitic stainless steel bolts are always easy to be locked during disassembly. This is not only seriously affected the service performance of austenitic stainless steel bolts, but also affects the reuse of bolts. In this paper, the main causes and mechanism of the locking of austenitic stainless steel blots in the process of fastening is summarized, and the effective measures containing correct material selection, carefully clean before assembly, spraying loosening agent, thermal expansion method, raw material belt tape winding and development of anti-locking austenitic stainless steel fastening bolt to prevent locking through theoretical analysis and experimental verification are also provided, which is hoped that certain guiding significance can be provided to prevent the phenomenon of bolt locking from the source as far as possible.

Keywords: Austenitic stainless steel; bolt; locked; mechanism; measurement

1. Introduction

Bolt is indispensable standard parts in daily life and industrial production, which is always used from mechanical products to electronic products, from ships, vehicles, hydraulic engineering to chemical experiments, from engineering, construction, showing that the bolts are widely used and convenient. Austenitic stainless steel is a common bolt material with stable mechanical properties, beautiful appearance and corrosion resistance[1-4]. However, due to its peculiar material characteristics, austenitic stainless steel bolts (Fig.1) are usually prone to lock the thread connection during installation[5-6]. Locking is a phenomenon of bolts in the process of assembly, which shows that the bolts stick together after several assemblies and are difficult to disassemble and tighten. Bolt locking will directly affect the maintenance and repair of the equipment, and may even lead to the damage and scrapping of the equipment. When the austenitic stainless steel bolt is locked, the pressure and heat generated between the teeth will destroy the chromium oxide layer between them, making the metal teeth block or shear, and then adhesion. As the continue of this phenomenon, the austenitic stainless steel bolt will be completely locked and can no longer be removed or locked[7].

Fig.1 Physical drawing of austenitic stainless steel bolt

2. Locking cause and mechanism of austenitic stainless steel bolt

The locking of austenitic stainless steel bolts is similar to a cold melting process. The main reason is that the instantaneous high temperature caused by friction during bolt tightening leads to metal fusion and bonding[8], as shown in Fig.2. After being damaged, the surface of austenitic stainless steel material will produce a thin oxide layer to prevent further corrosion. When the austenitic stainless steel bolt is locked, the pressure and heat generated between the teeth will destroy this oxide layer, resulting in blockage or shear between the metal threads, and then adhesion. The stress increases with the bolt locked, and finally the austenitic stainless steel fastener is completely bitten and cannot be removed. Usually, the locking process of the austenitic stainless steel bolt includes blocking, shearing, sticking, and locking takes place in just a few seconds. At the same time, the scraps produced during the stickiness of the austenitic stainless

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steel are easily to stick to the nut profile, thus increasing the friction. With the gradual increase of the tightening force to overcome the friction, the locking degree will be further aggravated, especially between the similar austenitic stainless steel fasteners. In addition, if the tightening force is too large in the process of material assembly, it will also produce greater pressure on the tooth pattern, and then lock up will occur. Besides, when the tightening direction is not perpendicular to the axial direction of the bolt resulting in a wrong angle, the bolt will also be locked.

Fig.2 Picture showing the thread locking of austenitic stainless steel bolt

3. Introduction of improvement measures

3.1 Correct material selection

Products of different materials can be assembled under the condition of design permission, such as 304 austenitic stainless steel bolts with relatively low price and 316 austenitic stainless steel nuts with relatively high price. In addition, the length of austenitic stainless steel bolts shall be selected appropriately, subject to one or two tooth pitches exposed after tightening. Practice shows that this method is feasible in product assembly [9].

3.2 Carefully clean before assembly

Due to the good ductility of austenitic stainless steel, rough tooth lines or foreign matters sticking, it is easy to increase the friction force, which often leads to the locking of austenitic stainless steel bolts. Therefore, clean the austenitic stainless steel bolts before assembly, improving the working environment of austenitic stainless steel bolts and the locking condition.

3.3 Spraying loosening agent

Using surface coating can greatly reduce the friction coefficient and effectively reduce the probability of austenitic stainless steel thread biting. Experience shows that reducing the mutual matching friction of austenitic stainless steel thread pairs can better avoid the locking problem. Based on this, the design principle of anti locking material formula is put forward, which is reducing the friction and lubrication effect is good, preventing the direct friction of matching thread pairs, and improving the matching surface between threads. In addition, the coating material design should also consider adapting to various working conditions of the connector as much as possible, such as high temperature, cleanliness and other factors. Coating materials commonly used in industry include butter, molybdenum disulfide, etc.

3.4 Thermal expansion method

For rusted fasteners or other fasteners that are ineffective in spraying thread loosening agent,the thermal expansion method is advised to be adopted, which is mainly heat the nut to make it easy to take out after thermal expansion. Heat is an important factor of thread biting. Friction in the assembly process leads to heat accumulation, and the heat increases with the acceleration of speed. Reducing the assembly speed can also reduce the risk of biting. Before using this method, first consider whether there is hot work space between bolts and nuts and the heat resistance of fasteners. This disassembly method can be adopted only if there is hot work space between the bolt and nut and the fastener has good heat resistance. Jiang et al. found in the theoretical study of locking failure at elevated temperature that the high temperature of the connecting part will lead to locking, this is because the metal is fusion welded under the influence of local high temperature. Therefore, reducing the contact temperature of the metal surface can improve the sliding friction and anti locking ability of the bolt. However, the above two methods are all required a certain amount of loosening agent to penetrate into the gap and hot work space at the connection between bolt and nut.

3.5 Raw material belt tape winding

Winding the raw material belt on the austenitic stainless steel bolt thread with appropriate thickness along the locking direction, so as to avoid direct contact between thread and nut when the austenitic stainless steel bolt is locked, thus preventing the thread surface being damaged. At the same time, due to the self-lubricating and non stick surface of raw material belt, the process of blockage→ shear→adhesion→locking in the fastening of austenitic stainless steel bolts can be effectively avoided. Besides, the raw materials also have cold fluidity, using which can generate the pressure between threads during the initial tightening and make the raw material belt fill the gap between the thread surfaces of austenitic stainless steel bolts, achieving the effect similar to film coating and improve the smoothness of thread surface. Even if the wrapped raw material belt is fell off during disassembly, it can still play a certain role in lubrication, so that the austenitic stainless steel bolts can be reused. In addition, the corrosion resistance of the raw material belt also meets the anti-corrosion application requirements of austenitic stainless steel bolts. And its non water absorption characteristics can also protect the bolt threads from the influence of humid environment with no environment pollution.

3.6 Development of anti-locking austenitic stainless steel fastening bolt

Biting or locking is also a common phenomenon in austenitic stainless steel fasteners. The root cause is the lack of sufficient hardness difference between bolts and screw holes, which makes metal threads blocked or sheared, resulting in adhesion and biting. In order to prevent the thread of bolt and screw hole from locking, they usually use different materials, so there must be differences in physical properties. However, if the physical properties between the bolt and the screw hole do not match, it is easy to loosen due to heating and other reasons, resulting in fatigue failure and fracture of the bolt. However, if the materials are exactly the same, there will be no hardness difference on the surface of bolts and screw holes, and it is easy to lock. If different hardness can be obtained through different preparation processes in the same material, the problem of fastener biting can be solved and the problem of bolt loosening can be avoided [10]. Therefore, to sum up, starting from the overall material selection idea, this project uses the nitriding technology to form a dense nitriding layer on the screw thread surface to improve its wear resistance and hardness [11], so as to form a hardness difference between the screw and the nut, and then solve the technical problem that the austenitic stainless steel fastening bolt is easy to lock.

4. Conclusion

This paper analyzes and discusses the causes, treatment methods and preventive measures of austenitic stainless steel bolt locking. The locking of austenitic stainless steel bolts is mainly resulted from the serious adhesive wear occurred on the surface of steel screw teeth due to the high temperature between screw teeth caused by rapid preloading and disassembly. Taking the measures such as correct material selection, carefully clean before assembly, spraying loosening agent, thermal expansion method, raw material belt tape winding and development of anti-locking austenitic stainless steel fastening bolt is considered to be effectively improve the locking problem of austenitic stainless steel bolts. It is hoped that through the discussion of this paper, certain help and guidance can be provided to prevent the phenomenon of bolt biting from the source as far as possible, and improve the on-site work efficiency.

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