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Discussion on Anti-Loosening Method of Commonly Used Fasteners in Coal Mining Machinery

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Abstract. By understanding the development level of anti-loosening technology of threaded connectors at all companies from home and abroad, we studied the problem of loosening of threaded fasteners caused by the harsh working environment and strong vibration during the use of coal mine machinery and equipment, resulting in mechanical equipment failures Even hazards such as casualties. Through analysis and research on the basic principles of fastener loosening, we tried to find out the root cause of fastener loosening, through practice accumulation and application, research and discuss several commonly used fastener loosening methods, and by comparing and analyzing the advantages and disadvantages of many different anti-loosening methods, a solution is provided for solving the loosening of threaded fasteners of coal mine machinery and equipment. This method is not only applicable to coal mine machinery and equipment, but also provides a reference for solving the loosening problem of threaded fasteners of non-coal machinery and equipment.

Keywords. Mining machinery, fasteners, anti-loosening method, research, application

1. Introduction

In today's vigorous advocating and developing industrial construction, modern machinery and equipment have developed and applied large-scale development and application in all walks of life in my country in the direction of efficient, fast, and intelligent development, especially in coal mining as a heavy industry. The coal mineral resources in China are relatively abundant, leading most of the world's coal storage countries. At the same time, as a country with a relatively high degree of mechanization of coal mine resources, it is bound to be inseparable from high-efficiency, safe and intelligent mechanical mining equipment. The higher the efficiency of coal mining, the greater the production capacity, and the main factor that hinders the efficiency of mining is mechanical failure. Among the many influencing factors that

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cause mechanical failures, the loosening of fastening parts leads to mechanical failure is one of the most common and most common influencing factors. As the most common and most widely used small parts of the installation and use of machinery and equipment, it not only plays a role in connecting and fastening, but some key parts will also use special, high-intensity, special fastening parts It also needs to bear the pretightening operation and undertaking role of key structures. When an inconspicuous fastener is loosened, a chain reaction may be caused due to the subtle defect, resulting in a major mechanical failure or safety accident in the equipment. Especially during the mining process of coal mines, due to the complexity and harsh nature of geological conditions and working conditions, strong vibrations have caused fastening to loosening. Essence In order to loosen the fundamental problem of fastening parts in the cradle, we must conduct in -depth discussions on the anti -loose method of fastening parts used in different occasions, and effectively find the fundamental method to solve the inhibitory thread loosening [1].

2. Harm and Cause Analysis of Fastener Loosening

2.1. Harm Caused by Loose Fasteners

As an important part of coal mine machinery and equipment, fasteners not only play a role in connecting parts and components, but also play a role in fixing and protecting equipment. Loosening of fasteners can cause damage to components and equipment, and even cause casualties [2].

2.2. Causes of Loose Fasteners

In the assembly of the equipment, it is unavoidable to use various types of fastening threads for connection, as shown in figure 1. In order to enhance the reliability and tightness of the connection, a certain tightening torque must be applied according to the thread fastening standard before the working load is applied, so as to obtain the pre-tightening force F0, so as to prevent the gap C, relative slippage or looseness of the connection after the working load is applied. However, due to the harsh particularity of the working environment, hard rocks and coal will give coal mine production machinery a variety of high-intensity impact, under the repeated action of this impact force, it will cause the loosening of threaded fasteners, when the loosening amount reaches a certain extent, the thread pre-tightening force will disappear, and the protection of pre-tightening force will be lost. The threads are subjected to shearing forces F from all directions of the connecting piece, the service life and the connection reliability are greatly reduced. Thereby causing various hazards such as thread loosening and even fracture [3].



Figure 1. Threaded Fastening Force. (A/B. Upper and lower workpieces; C. Workpiece clearance; F. Shear force; F0. Preload)

3. Fastener Anti-Loosening Method

Because of the harsh and complex underground working environment, the service life and reliability of coal mine machinery and equipment will be severely tested. As the most basic core parts of the equipment, the service life and reliability of fasteners directly restrict the normal work and operation of the equipment. While choosing the correct threaded fasteners, we should pay more attention to the possible loosening of fasteners in the use process, so as to truly ensure their performance. Through the equipment overhaul and the actual use of the process, constantly accumulated experience, summed up the following methods to prevent fasteners from loosening.

3.1. Welding Type Anti-Loosening Method

As a destructive anti-loosening method, the method is rarely applied to the antiloosening of fasteners of coal mine mechanical equipment, but the method can be used for the anti-loosening of threaded fasteners in a certain special use environment, for example, on the premise that subsequent disassembly is not needed or permanent antiloosening is needed. The specific method is as follows: after the thread is tightened according to the standard thread tightening torque, the thread is spot-welded by electric welding, and the thread can no longer rotate by destroying the thread buckle, so as to achieve the purpose of permanent anti-loosening, as shown in figure 2.



Figure 2. Threaded welding type anti-loosing.

3.2. Anti-loosening Method of Thread Fastening Glue

The thread fastening adhesive is an adhesive based on acrylic diacetate or special acrylic acetate. The fastening adhesive can be stored for a long time in the presence of oxygen at room temperature. When it is isolated from the air, it can be quickly cured to form a firm bonding layer [4] due to surface catalysis. Through the curing effect of the fastening adhesive, it can be adhered to the thread to achieve the purpose of anti-loosening. The specific operation method is as follows: when the bolt needs to be loosened, it is necessary to drop a few drops of thread fastening glue on the thread of the bolt, and then tighten the bolt according to the specified tightening torque. The anti-loosening method of that fasten glue has the advantages of bee convenient to use, low in shrinkage rate, good in sealing property, non-toxic, detachable and permanent in fastening and the like. However, because the adhesive is based on acrylic diacetate or special acrylic acetate, it hinders the relative movement of bolts and other ironware in the use process, and its service life and strength will certainly fail slowly with the

vibration of bolts, so this method is generally applied to occasions where the antiloosening requirements are not high or the vibration environment is not very intense.

3.3. "8" Anti-Loosening Method

As one of the most commonly used anti-loosening methods, the "8" anti-loosening method is widely applied to the anti-loosening of fasteners of various mechanical equipment. This anti-loosening method requires the use of special bolts: bolts with holes in the head GB/T 32.1-2020 [5]. The principle is to use the tension of iron wire to carry out an anti-loosening method of bolt interlocking. The specific operation method is as follows: the same iron wire passes through the iron wire holes of the fastened bolt heads in sequence by utilizing the anti-loosening iron wire holes of the bolt heads, so that two or more adjacent groups of bolts are connected into a mutually-related 8shaped ring, and meanwhile, the 8-shaped ring needs to achieve a mutually locked structure, namely, in one group of bolts connected by the 8-shaped ring. When one of the bolts is turned in the direction of loosening. The iron wire passing through the head of the bolt will pull the other bolt and rotate in the opposite direction to achieve the tightening effect. Because the bolt is locked and fixed through the tightening torque, the bolt can release a counterforce to restrict the bolt to be loosened to rotate in the loosening direction, a certain tension force of the bolt is ensured by utilizing the tension of the iron wire, and the bolts in the same group which are wound through the 8-shaped ring are mutually restricted to prevent the bolt group from rotating relatively, so that the purpose of locking is achieved.

Because that principle of the method is simple, the method is widely applied to various bolt loose-proof structures of coal mine machinery, but the method has certain restriction: firstly, a bolt with a hole on the head must be selected when the method is used, and meanwhile, the fixing method require operators to bind, and completely depends on the proficiency and binding skills of the operators, It will be difficult to achieve the desired effect of mutual restriction, in addition, due to the limitation of the size of the bolt head hole. The selected iron wire is generally not too thick, and the strength of the iron wire will be limited. Therefore, when this method is applied to places with strong vibration or high requirements for anti-loosening effect, it is necessary to guard against the breakage of the iron wire.

3.4. Anti-loosening Method for Special Bolts and Gaskets

In the method, a special matching structure of a bolt and a gasket is utilized to achieve the purposes of mutual matching and locking, and the principle of the method is mainly that a mutually-restricted acting force is injected between a nut and the gasket, Thereby achieving the anti-loosening effect of restricting the relative movement between the bolt and the gasket [6].

3.4.1. Anti-loose Method of Slotted Nut and Cotter Pin

This method is shown in figure 3 below. A special bolt is required, and a hole is drilled at the fixed position of the bolt thread. The purpose of the hole is to penetrate the cotter pin and use it together with the slotted lock nut. The anti-loosening method has remarkable effect, and once the bolt is fixed, the bolt is difficult to loosen, but the method has certain disadvantages, because the determination of the position of the bolt drilling hole depends on the height of a fixed workpiece, in order to ensure that the method can be accurately applied, after the nut is tightened by a tightening torque specified by a standard, the position of the bolt drilling hole can be just exposed and passes through a cotter pin, Therefore, this method has some limitations. This method is generally applied to the thread locking of workpieces with special processing [7].

3.4.2. Matching and Anti-loosening Method of Hexagon Nut and Stop Gasket

The method is shown in figure 4 below, and the principle used is: through the fit between the tightened nut and the special gasket, one end of the gasket is folded up, and a certain side of the hexagon nut is fixed by the folded part, so as to achieve the purpose of limiting the rotation of the nut. The method is simple to operate and has a remarkable anti-loosening effect, so that the method is widely applied to the antiloosening of coal machinery equipment and other mechanical structures; however, due to different application scenarios, the stop washer needs to be customized according to the hole spacing of the application scenarios, and a single used washer also needs to be specially made, so that the processing cost may be high.





Figure 3. Schematic Diagram of Matching between Slotted Nut and Cotter Pin.

Figure 4. Schematic Diagram of Hexagon Nut Matching with Stop Gasket.

3.4.3. NORD-LOCK Washer Anti-loosening Method

NORD-LOCK washer is a kind of lock washer invented by a Swedish company. It has a unique multifunctional design. The washer conforms to the standard of DIN25201 and has the function of wedging lock, that is, a unique method of using tension instead of friction to prevent spontaneous bolt loosening and decay of bolted connection. The concrete structure is composed of two identical tooth-shaped gaskets, which applies the new sandwich composite material technology, combines the geometric shape principle and the unique function of wedge shape, and can completely realize that the connecting elements can resist the loosening of spontaneous bolts, thus fundamentally solving the problem of nut loosening. The action principle of the lock washer is as follows: the lock washer consists of two same washers, the upper surface and the lower surface of each washer are provided with different saw teeth, one surface is provided with camshaped large teeth, the slope angle alpha of the cam-shaped large teeth is greater than the bolt thread angle beta, and the other surface is provided with dense small teeth. Gaskets shall be installed in pairs with large tooth surfaces facing each other. And that small tooth surface are respectively contacted with the nut and the fasten piece. After tightening the bolt to connect the fastener, when vibration occurs, the large tooth surface will move and lift, and the bolt will be locked by the principle that the angle α is greater than the angle β , so that it can not be loosened.

At present, the X series derived from this washer, as shown in figure 5, adopts a unique multi-functional design, which combines excellent Lotiron wedge effect and special spring effect. The wedge effect can prevent the loosening of bolts caused by vibration and dynamic loads. The spring effect (Fs) counteracts the attenuation change of bolts and prevents the loss of preload of bolted joints. As a result, the gasket can provide additional safety for applications that operate under extreme conditions. The use of NORD-LOCK lock washers has many advantages, such as ensuring that the bolt connection will not loosen, compensating for the loss of preload caused by settlement and relaxation, achieving more accurate preload under the specified and constant friction force, being standardized and available in a variety of specifications (metric and imperial), being reusable, etc.



Figure 5. Anti-loosening diagram of NORD-LOCK lock washer. (α . Angle of slope β . Thread angle Fs. Spring effect).

4. Comparison of Various Anti-loosing Methods

(1) As a permanent and non-reusable bolt anti-loosening method, the welding anti-loosening method has few application scenarios and is mainly used in occasions where permanent fixation is required and disassembly is not required. After welding, the thread anti-loosening strength is very high, but due to the destruction of the thread structure, it can not be disassembled later. Therefore, the selection of this anti-loosening method needs to be careful.

(2) The invention relates to an anti-loosening method of thread fastening glue, which applies the principle that a coagulant is added in the matching of threads to achieve the purpose of fixing the looseness of the threads, and the anti-loosening method has simple operation and remarkable effect and can realize the secondary reuse of bolts, but the service life of the coagulant is gradually reduced along with the fatigue generated by the vibration frequency of the bolts, The anti-loosening method is generally applied to common occasions where the vibration environment is not strong and the anti-loosening effect requirement is not strict.

(3) The principle of the 8-shaped anti-loosening method is that an iron wire passes through a bolt with a hole on the head and is wound to form a reverse 8-shaped ring, and a plurality of bolts are mutually locked and limited by the pulling force generated by the iron wire to achieve the purpose of anti-loosening. The use of this method requires the selection of bolts with holes on the head, and the operation method also depends on the experience and skills of operators, which has a certain amount of work and low installation efficiency.

(4) As the most commonly used anti-loosening method, the special bolt and gasket anti-loosening method has been widely used in the anti-loosening of fasteners in various fields of coal mining machinery and non-coal machinery, especially in important occasions or parts with high anti-loosening requirements. The method has the advantages of simple installation, remarkable locking effect, reusability and the like, and particularly, the NORD-LOCK locking washer has been standardized in the English system and the metric system, and is very convenient to select.

The characteristics of several common anti-loosening methods are shown in table 1[8].

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Anti-loose method	Welding type anti- loosening method	Anti-loosening method of thread fasten glue	"8" anti-loosing method	Anti-loose method for special bolt and gasket
Loosening strength	Extremely strong	Weaker	Strong	Strong
Ease of installation	More difficult	Simple	Difficulty	Simple
Installation efficiency	Low	High	Very low	High
Installation cost	Low	Low	Low	Higher
Whether it can be reused	No	Yes	Yes	Yes

Table 1. Comparison of characteristics of	several common anti-loosing methods
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5. Conclusion

Due to the complexity and abominable nature of the coal mining environment, coal mining machinery in the use of fasteners often occur due to vibration and other factors leading to loosening, after analyzing the causes of loosening, according to the principle of fasteners to prevent loosening and the requirements of the use of the environment, through specific practice and application, this paper studies and compares several commonly used methods of fasteners to prevent loosening in coal mining machinery. The advantages and disadvantages of each method are discussed. It provides the solution and selection basis for the loose problem of fasteners in coal mine machinery and equipment [9]. These anti-loosening methods are not only suitable for coal mine machinery and equipment, but also provide a reference for other non-coal machinery and equipment fastener anti-loosening methods.

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