Just Looking at the Bolts in Stock or Catalogues Doesn't Give you a Grasp of How It Works

by Jozef Dominik

Preface

As the Ferodom's theorem goes: The screw threaded connection is not a soulless monster, but a living organism with its own life. Only those who know and respect this life can count on a reward in the form of reliability and safety. Otherwise, it can cruelly avenge!

Of course, this requires a thorough knowledge of the properties and work of screw connections in operating. The most common cause of accidents of machines, steel structures and vehicles are namely not unpredictable external influences, but rather unforeseen standard behavior of screw joints. And wherefore? From my own many years of experience, I know that designers are not always sufficiently theoretically prepared. But superficial information about screws is not enough. They can even be the cause for major disasters. Examples from practice are available.

What is Important to Know

There's not so little and most importantly it cannot be read from the catalog and not at all from the warehouse tours. A screw connection is such a complicated structural element that it requires special study and practical experiences. Let the reader consider himself. These are the basic criteria for safe construction:

1. Conditions under which the future structural unit will operate
2. Mechanical properties of steel
3. Behavior of screw connections during assembly and operation
4. Modern methods of locking screw connections offered by the current market
5. Tightening tool properties
6. The amount of friction on the contact surfaces

Of course, the available media space does not allow for a detailed elaboration of this extensive issue. Therefore, only the most frequently neglected factors are listed here:

(1) Operating conditions

It means mainly influence of environmental aggressiveness. **Fig. 1** shows a case of incorrect choice of Cr - Ni stainless steel in a chlorine vapor environment. Due to such a fatal mistake, the ceiling of the covered swimming pool collapsed.

It is not uncommon for a designer to mistakenly believe that a priori stainless steel is a panacea for corrosion. Corrosion itself is a complex system that can only be controlled by knowing its laws. Panacea does not exist.

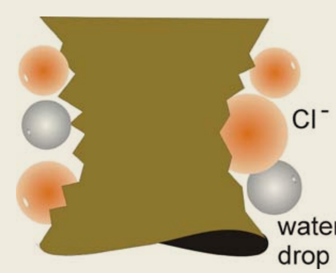

Fig. 1

(2) Mechanical properties of steel

The most commonly used steels for the production of bolts and nuts are shown in **Table 1**. Here, it is important that the same bolt strengths are used, especially for flange joints, and the nut should be at least the same strength as the bolt. If the nut has a lower strength than the screw with which it is paired with, there is a risk of the nut thread being torn off **(Fig. 2)**.

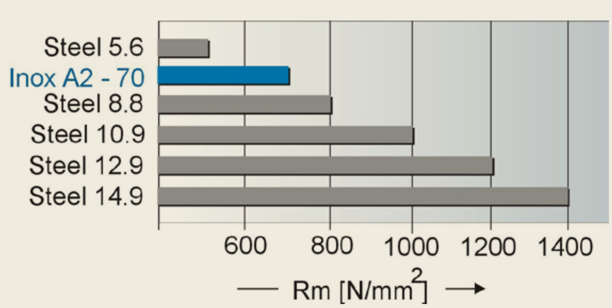

Table 1. Commonly used steels for the production of bolts and nuts

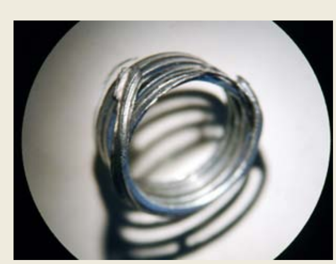

Fig. 2. Thread being torn off

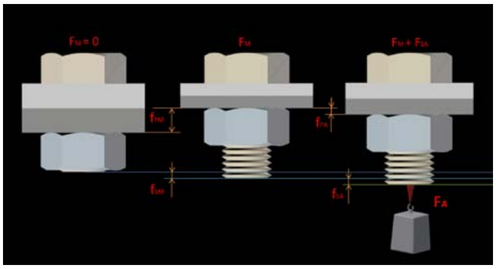

Fig. 3. FM montage pre-stressing force and axial operating force FA

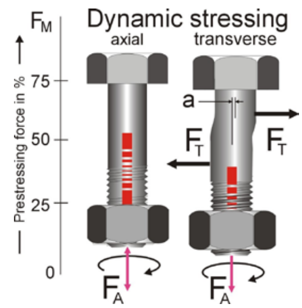

Fig. 4. Loosening of nuts

Fig. 5. Material fatigue

(3) Behavior of screw connections during assembly and operation

Another important factor - behavior of screw connections during assembly and operation - is shown in **Fig. 3**. This figure clearly shows what happens after the application of the FM montage pre-stressing force and the additional axial operating force FA.

A more complex situation occurs with dynamic stress, when there is latent danger of structural collapse due to loosening of nuts **(Fig. 4)** or due to material fatigue **(Fig. 5)**. In this case, the screw must be properly secured externally.

(4) Methods of locking screw connections

The current market offers a wide range of screw connection protection systems. It is important to choose the right type. The author has published several articles on this topic in various journals, including Fastener World. It is important to remember here that just as there is no corrosion panacea, there is no universal method of locking screw connections. This also applies to the still used obsolete and ineffective combination in **Fig. 6**.

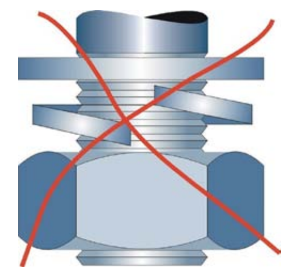

Fig. 6. Obsolete and ineffective combination

(5) Tightening tool properties

Tightening screw connections is one of the most important technological operations. The tightening accuracy is characterized by the so-called alpha factor αF:

$$\alpha F = Fmax/Fmin$$

The closer the value of αF is to 1, the more accurate the tightening **(Fig. 7)**. One of the most accurate methods is hydraulic tightening with value αF ≈ 1 **(Fig. 8)**. Manual tightening is the least accurate **(αF ≈ 4)**.

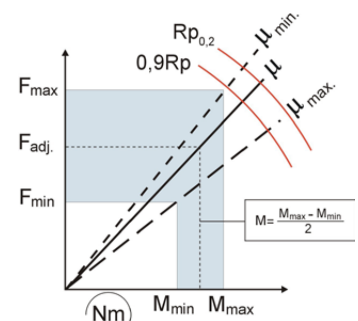

Fig. 7. The closer the value of αF is to 1, the more accurate the tightening

(6) The amount of friction on the contact surfaces

Like tightening accuracy, friction on contact surfaces is important too **(Fig. 7)**.

Only about 20% of the assembly energy is used to produce the pre-stressing force. The rest is used to overcome of friction on the contact surfaces **(Fig. 9)**. At an applied torque of 650 Nm, the new bolts and nuts are tightened more to double the pre-stressing force of rusty ones.

Fig. 8. Hydraulic tightening

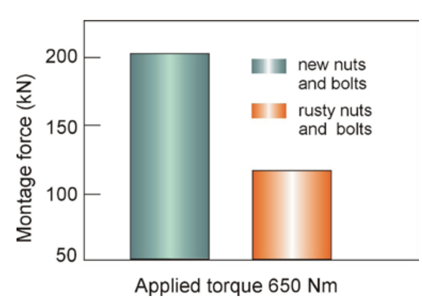

Fig. 9. Montage force and applied torque

Conclusion

This is only a minimal example of the extensive issue of mechanical screw connection. The role of this article is to arouse students' and young engineers' interest in studying this science with interdisciplinary character. A cursory glance will convince us that such scientific disciplines as the science of metals, classical construction and the finite element method, tribology, fracture mechanics, etc. will be applied here. Because the production of fasteners has a series of character, modern methods of production planning and control are applied here. We must not forget about logistics either. Numerous logistics centers are currently being built, located as close as possible to customers.

The consumption of fasteners in the world is enormous. It is all the more necessary that as many experts as possible address this topic. Unfortunately, experience shows that the number of young relevant educated engineers is declining. Why? Maybe we'll talk about the causes at the next opportunity.