EAN 2019
57th conference on experimental stress analysis

Experimental evaluation of thread locking methods for secure connections

KANAVAL Jan[1,a]

[1]Department of Designing and Machine Elements; Faculty of Mechanical Engineering; Czech Technical University in Prague; Technická 4, 166 07 Prague 6 - Dejvice, Czech Republic

[a]jan.kanaval@fs.cvut.cz

Keywords: Threaded fasteners; Prestressed bolted connection; Thread locking; Tightening torque; Untightening torque

Abstract. The term "Thread Locking" is used for methods of ensuring the threads stay in place without loosening. In some cases, the frictional forces from bolt axial preload are enough to hold the fastener together. In other cases, we need to use thread lockers. Thread locking can be separated into the following categories. Usage of mechanical parts to prevent loosening, further by increasing the coefficient of friction in the thread to prevent loosening, and finally by using adhesives in the thread to prevent loosening. This contribution describes analytical and experimental evaluation of untightening torque of bolted joints using Loctite thread lockers depending on surface degreasing quality.

Introduction

Threaded connections, such as prestressed bolted connections, are used in a wide variety of industrial applications. The term "Thread Locking" is typically used for methods of ensuring the threads stay in place without loosening. Bolts and nuts, this is probably the most common and low cost type of threaded connection. Screws and tapped holes, with this type of connection, we are installing a screw into a hole that has been drilled and tapped into a housing or mechanical component. The most commonly recognized difference between a screw and a bolt is that screws typically go into threaded holes while bolts go through 2 unthreaded components and fasten with a nut [1].

In some cases, the frictional forces from bolt axial preload are enough to hold the fastener together. But in other cases, we need to use thread lockers. Some of these cases are high vibration, expected stress relaxation (creep in plastics), and cyclic stresses [1]. Thread locking can be separated into the following three categories. Usage of mechanical parts to prevent loosening, further by increasing the coefficient of friction in the thread to prevent loosening, and finally by using adhesives in the thread to prevent loosening. This contribution describes analytical and experimental evaluation of selected thread locking methods to prevent loosening.

Standard Thread Locking Methods

1) By using of mechanical parts to prevent loosening of the bolt connection (see Fig. 1).
2) By increasing the coefficient of friction in the thread to prevent loosening of the bolt connection (see Fig. 1).
3) By using adhesives in the thread to prevent loosening of the bolt connection (see Fig. 1).

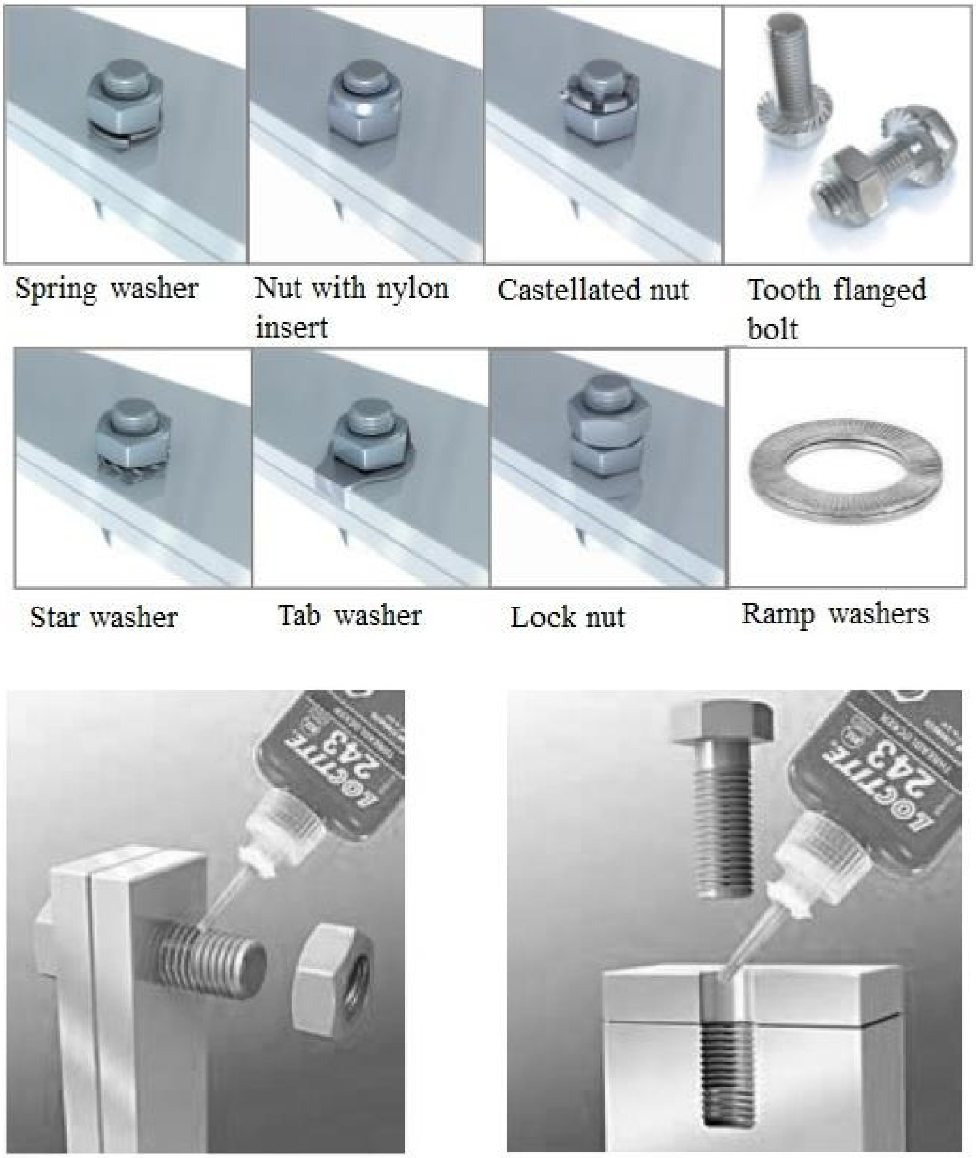

Fig. 1: Traditional threadlocking devices

Thread Locking Theory and Thread Locking Experimental Evaluation

To calculate the untightening torque moment of threaded connection Eq. (1) can be used:

$$M_{KK} = M_K + M_{TM} + M_{SL} + M_{LL} = Q_o \cdot \frac{d_2}{2} \cdot tg(\varphi' - \gamma) + Q_o \cdot \rho_{TM} \cdot f_{TM} + M_{SL} + M_{LL} \quad (1)$$

γ - thread pitch angle [°]; φ' - friction angle in thread (corresponding to the coefficient of adhesion) [°]; d_2 - flank diameter of the bolt thread [mm]; ρ_{TM} - friction radius under the nut [mm]; f' - coefficient of friction in thread (adhesion coefficient) [1]; f_{TM} - coefficient of friction under the nut [1]; M_{KK} - untightening torque [Nmm]; M_K - torque [Nmm]; M_{TM} - friction torque under the nut [Nmm]; Q_o - mounting - pretension force [N]; M_{SL} - self-locking torque of the nut [Nmm]; M_{LL} - Loctite locking torque of the nut [Nmm].

To verify the thread locking capability of selected thread locking methods to prevent loosening *Junkers Vibration Test* according to standard DIN 651151 can be used (see Fig. 2).

Another method to verify the thread locking capability may be measuring of the static untightening torque using a torque wrench. Measurements were performed on M8 screw connections (screw M8x50 - strength class 8.8; nut - strength class 8, galvanized - Zn; without the use of oil/grease; tightening torque 27.3 Nm) 24 hours after tightening. BMS PADDY, model TAW 200, (maximum capacity 200 Nm), torque wrench was used.

A simple testing fixture for measuring of the static untightening torque using a torque wrench is shown in Fig. 3.

The experimentally measured static untightening torque values for selected thread locking methods are shown in Table 1 and also graphically in Fig. 4.

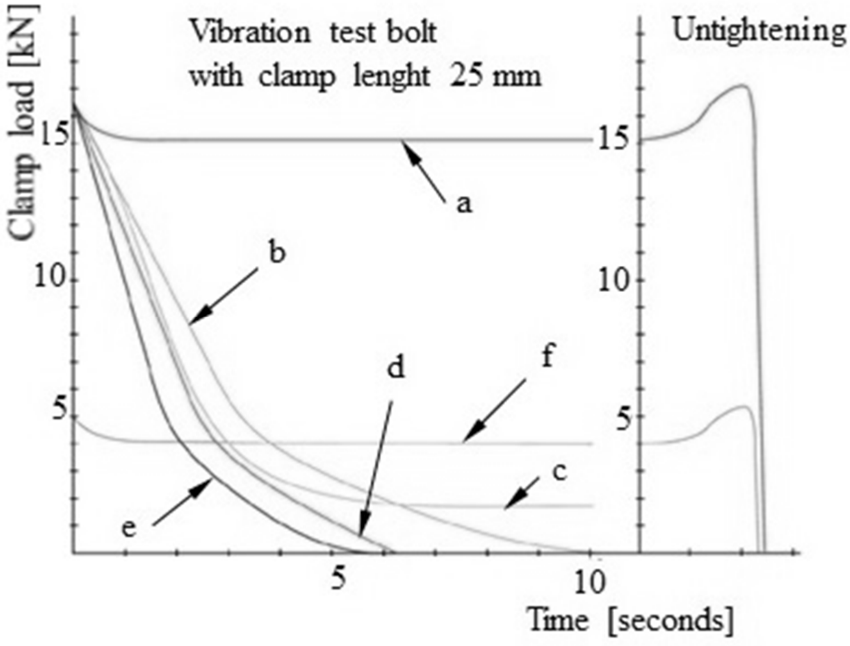

Fig. 2: Vibration test bolt size M8 with clamp length 25 mm (a - nut M8 on bolt with Nord-Lock at 70 % of yield point; b - nut M8 on bolt, clamp lenght 50 mm; c - nut M8 with nylon insert on bolt; d - nut M8 on bolt with split ring (spring washer); e - nut M8 on bolt; f - nut M8 on bolt with Nord-Lock at 25 % of yield point

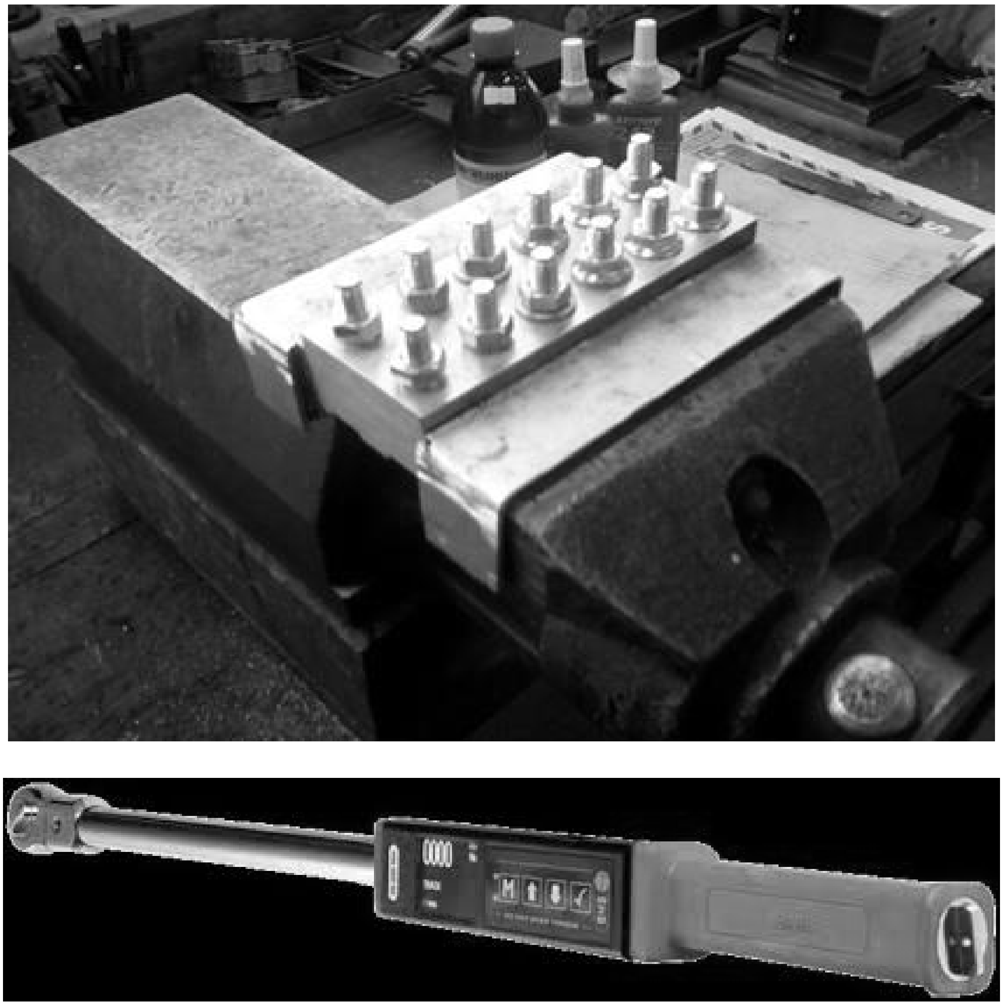

Fig. 3: A simple testing fixture for measuring of the static untightening torque using a torque wrench BMS PADDY, model TAW 200, (maximum capacity 200 Nm)

Table 1: Untightening torque measurement results (using a torque wrench)

Thread locking method	Untightening static torque [Nm] (average of the measured values)
A) Screw + nut (without any washer)	23.6
B) Screw + nut with spring washer	20.2
C) Screw + nut with nylon insert	26.2
D) Screw + nut with Schnorr (VS) washer	25.2
E) Screw + RIPP LOCK nut	24.8
F) Screw + nut (DIN 6923)	28.5
G) Screw + nut with Heico-lock washers [2]	24.8
H) Screw + nut, Loctite 243 was applied [3]	25.8
I) Screw + nut, Loctite 270 was applied [4]	28.1

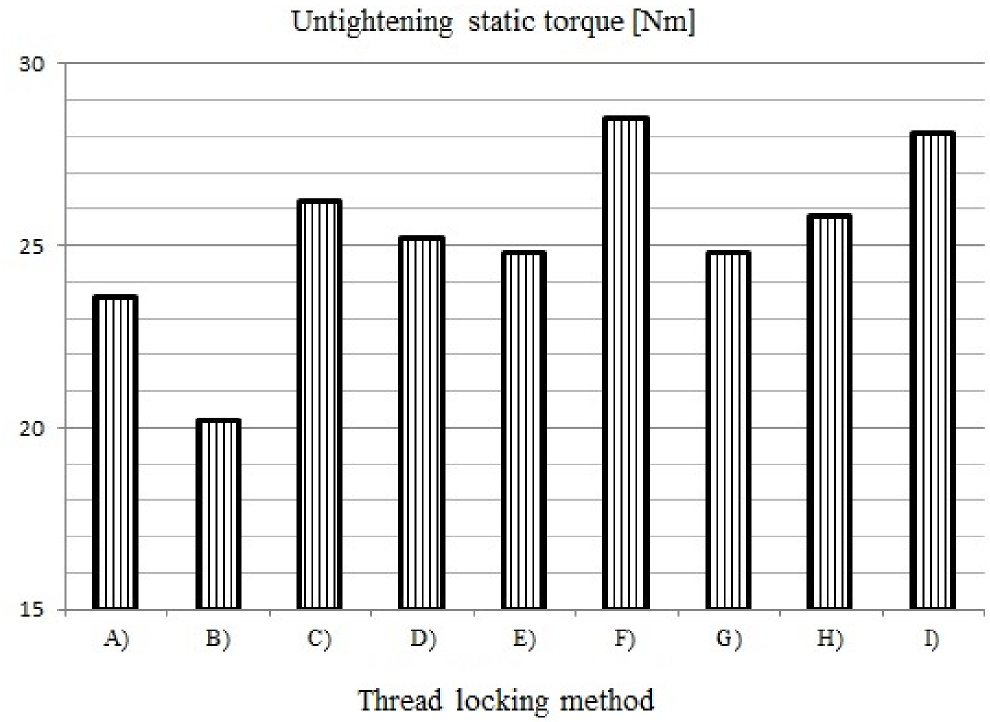

Fig. 4: Experimentally measured static untightening torque values for selected thread locking methods (A - Screw + nut (without any washer), B - Screw + nut with spring washer, C - Screw + nut with nylon insert, D - Screw + nut with Schnorr (VS) washer, E - Screw + RIPP LOCK nut, F - Screw + nut (DIN 6923), G - Screw + nut with Heico-lock washers, H - Screw + nut, Loctite 243 was applied, I - Screw + nut, Loctite 270 was applied)

Conclusions

Measurements of selected thread locking method's static untightening torques were realized. The measured static untightening torque values correspond in some cases to the results of the *Junkers Vibration Test* (see Fig. 2 - c, d, Fig. 4 and Table 1). The results of further experiments will be presented at the EAN 2019 conference.

Acknowledgment

Threaded fasteners and washers for experimental testing were provided by the company HEICO Czech s.r.o.

References

[1] Sean, T., Threaded Locking Methods for Secure Connections, Inf. on https://www.blog.fictiv.com/authors/sean-thomas, last accessed 2019-03-20.

[2] URL: https://www.heico-group.com/cs/heico-lock/, last accessed 2019-04-16.

[3] Prumex s.r.o., Technical sheet, Inf. on https://proprumysl.cz/soubory/20/243.pdf, Hrušovany nad Jevišovkou, last accessed 2019-03-20.

[4] Prumex s.r.o., Technical sheet, Inf. on https://proprumysl.cz/soubory/33/270.pdf, Hrušovany nad Jevišovkou, last accessed 2019-03-20.