The Screw Connection is Not a Soulless Monster...

... but a living organism with its own life. And that this "life" real exists and is very varied, should demonstrate the presented article.

緊固力大小對螺絲產生的變化

by Jozef Dominik

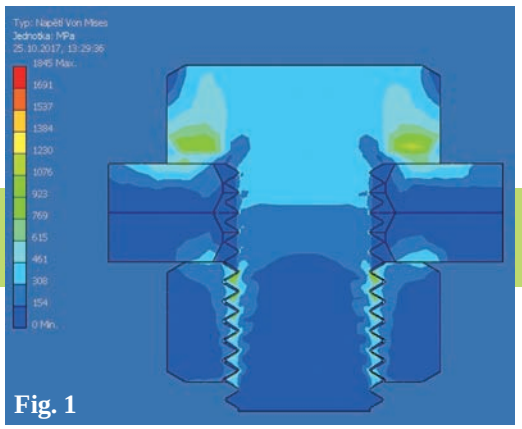


Fig. 1

Activity of Screw Connections

The activity of screw connections can be divided into two stages:

1. Tightening
2. Operating

What Happens During the Tightening

Properly tightened screw connection is a basic condition of its function. The result is a clamping force to hold components together. However, this is a drastic interference into the "lives" of not only the screw connection itself but into the whole construction node as well (s. FEM analysis in **Fig. 1**).

As shown in **Figures 2** and **3**, the seemingly simple operation causes significant changes in the screw connection. After tightening with the appropriate assembly force F_M the jointed parts are shortened by f_{PM} and the bolt extended by f_{SM}. The resulting pre-stressing force must not exceed the level of the F_{Mmax}. limited by strength of steel. Otherwise, the connection may be damaged as soon as it is assembled (**Fig. 4 - 7**). The situation complicates the fall of the pre-stressing force FZ due to the material seating on the contact surfaces under the head of the screw and below the nut and between the threads and between the jointed parts. The residual pre-stressing force after tightening must have a sufficient reserve to compensate for the negative effect of the various operating forces of the screw connection. We can speak about the so called Pre-stressing Force Rubicon (PFR) limited on one side by steel yield strength $Rp_{0,2}$ and on the other hand by the necessary pre-stressing force minimum F_{Mmin} (**Fig. 1**). PFR also indicates that the system of screw connection-joined parts is in an imbalance state with a natural effort to return to the original state. The return to the original condition prevents friction. This is its positive role. But the excessivley high friction between the threads can even cause the screw to be damaged during the tightening or disassembling (**Fig. 6**). This is often the case when the surfaces of the screw and the nut are mismatched. The friction limits the relationship between torque and tension. Tightening threaded fasteners is basically an energy transfer process.

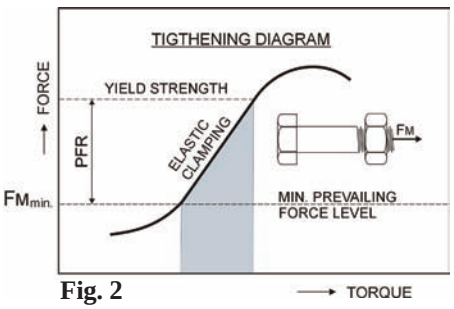


Fig. 2

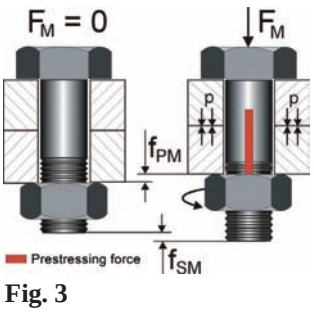


Fig. 3

The rising of friction coefficient decreases the elastic clamping energy that is responsible for the holding power to clamp the parts together.

Latent Consequences:


Fig. 4


Fig. 5

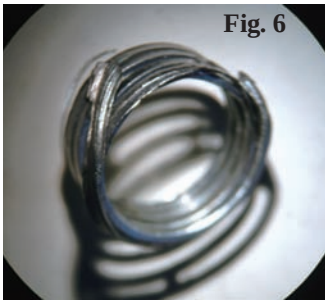


Fig. 6

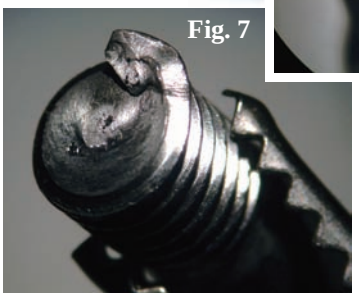


Fig. 7

What Happens During the Operating

During operation the screw connections may be stressed by a number of forces:

1. Static Load

Situation in the axial static load of the screw connection is shown in **Fig. 8**. The effect of the F_A's operating force causes extension of the bolt by f_{SA} and the deallocation of joined parts by f_{PA}. The result is a decrease of pre-stressing force of the bolts and the reducing pressure between jointed parts.

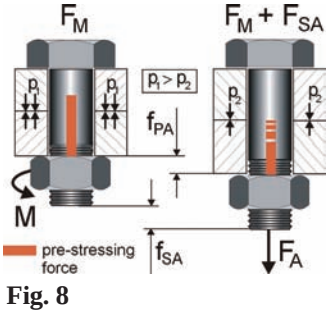


Fig. 8

2. Dynamic Stressing

A more complicated situation occurs with the dynamic operational forces. They can act either in the axial or radial direction (**Fig. 9**). In both cases there is a risk in the extreme case of disintegration either by separating the nut from the screw (**Fig. 10**) or the fatigue fracture (**Fig. 11**).

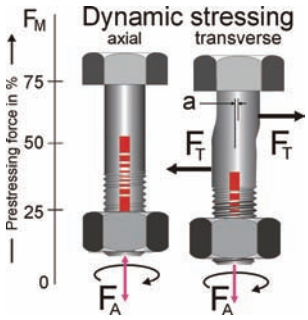


Fig. 9

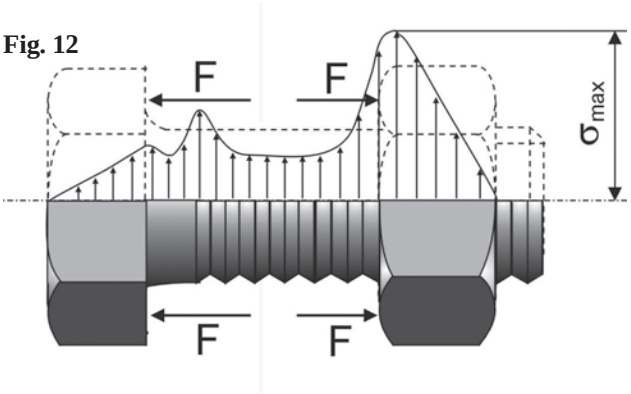
Fig. 10

Fig. 11

Latent Consequences:

What's particularly dangerous is the material fatigue that comes suddenly without a prior warning. The fatigue fracture occurs preferably in the area of stressing peaks, such as the transition from the screw shaft to the thread (**Fig. 11**). Into the category of failures without a cautionary warning also falls the hydrogen brittleness. It occurs as a result of hydrogen diffusion into the crystal grid of the steel. Like fatigue it is very dangerous.

Fig. 12



Summary

As shown the tightening is drastic intervention in “life” on the screw connection and connected parts. It is an energy transfer process by which the absorbed energy in the form of torque moment is consumed to overcome friction and to create required clamping force that holds the parts together. Logically, on the changing of energy ratios must the screw connection seemly respond. The result is a change in the tension state of the screws and parts exhibiting length. For secure screw connection it is important that all lengthwise changes take place within the framework of elastic deformations and not under the minimal prevailing force level.