Visualisation of Screw Connections Work Using FEM

by Jozef Dominik

As known, the threaded joint is not a soulless monster, but a living organism with its own lively life. This is also confirmed by the virtual analysis of its behavior during assembly and in operation conditions by the finite element method (FEM).

Introduction

As already outlined in the preamble of this post, the screw connection is a "living organism" that responds very responsibly to external mechanical changes. This concerns assembly as well as operations when subjected to multiple forces. What happens to him in such cases? To answer this question, the virtual analysis will be attempted in the following text.

Assembly

According to SKF's knowledge, assembly is the most common cause of screw connection failure (Fig. 1). Inaccurate tightening, failure to observe the friction coefficient or failure to observe the mounting instructions are notorious errors that may have fatal consequences.

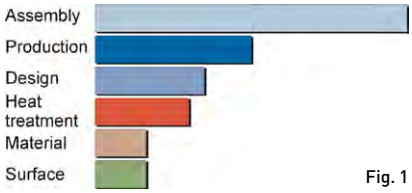

Fig. 1

The visualization using the FEM tightening process in comparison with the steel tensile diagram (Fig. 2) demonstrates the change in the pre-stressing state of the fasteners and the joined parts. From the zero state the pre-stressing gradually increases to the final level, corresponding to the elasticity of the material, where the distribution is uneven. Particularly noteworthy is the high stress concentration in the region of contact of the nut with the joined parts. This shows in detail the pre-stressing distribution of von Mises stress in the ANSYS program in Fig 3. The location of the stressing peaks in the

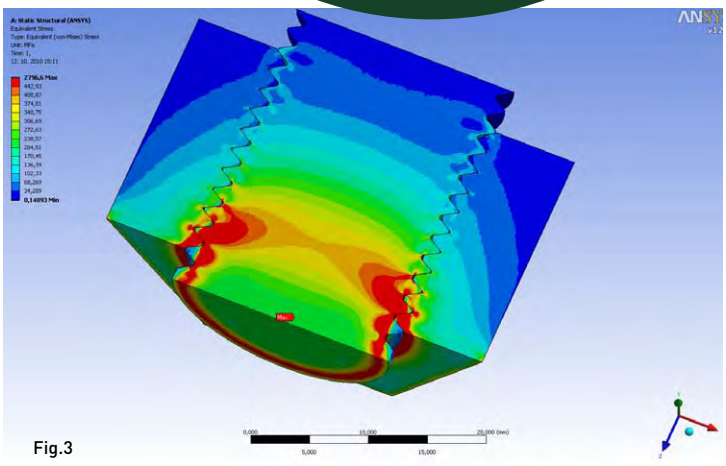

Fig.3

region of the nut contact with the joints is the most common cause of the fatigue fracture of the screws (Fig. 4) right here.

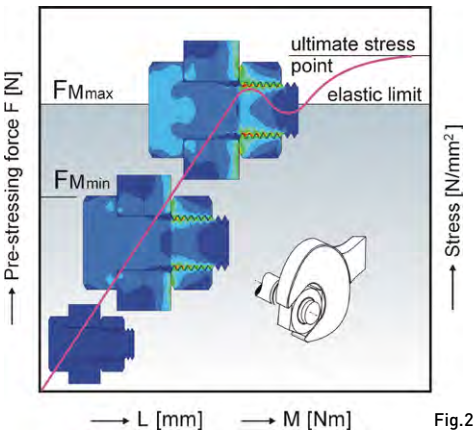

Fig.2

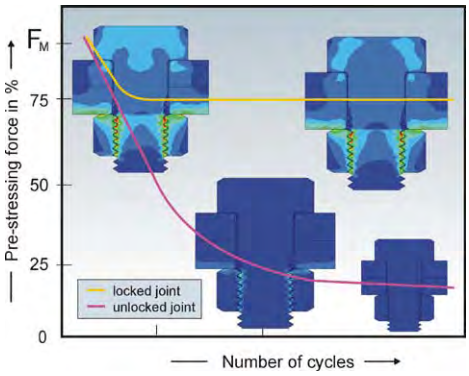

Fig.5

Fig.4

Fig. 2 highlights the limit values for the montage forces FMmax and FMmin which define the allowable range for tightening, called Montage Force Rubikon (MFR). Above the MFR there is a risk of overhead load destruction of screw connections and below this level threatens its degradation during operation due to vibration and repeated dynamic stress.

Operation

During operation the screw connections are subjected to varying statically or dynamically acting external forces, accompanied by a drop in the original FM montage force to zero level (Fig. 5). The process is the opposite of the assembly (see Fig. 2) - the imbalance state changes to the equilibrium state, it means without the tension.

In the case of correctly tightened joint the FM mounting force should not drop by more than 20% of the original value (upper curve in Fig. 5). However, if the transverse force FP corresponds to the relationship:

$$FP > FM \cdot \mu,$$

where μ is the coefficient of friction, the nut and/or the screw will spontaneously unscrew. This is a frequent and very dangerous phenomenon, especially with the fastening screws of the automobile wheels (Fig. 6) after their amateur assembly, when changing. This can be avoided by visiting an authorized service center in advance or by applying one of the available methods of external locking.

Summary

Virtual analysis using FEM helps to understand what's happening with screw connections during assembly and operation. From the point of view of the safety of machinery and especially of transport this is very important, because it allows timely prevention from of latent accidents.