Stress Synergism of Screw Connections

by Jozef Dominik

Introduction

Each functional screw connection goes through three stages during its lifetime. These are the following:

1.Fabrication
2.Assembly
3.Operation

Each of these stages leaves some traces behind which are reflected in the resulting stress state of the screw joint. While the effects of assembly and operation conditions are relatively well managed in theory, the first phase, that is, fabrication unjustifiably remains without researchers' interest. As will be apparent from the following text, the nuts already exhibit a certain stress state after manufacture, which, through a synergistic effect, contributes to the final stress state of the screw connection.

Theory

The classical method of producing nuts involves pressing or, for larger diameters, hot forging. This is followed by thread cutting and heat treatment. Each of these operations leaves its share of the overall level of the internal stresses of the nut. In Fig. 1 such a stressing state is shown by FEM.

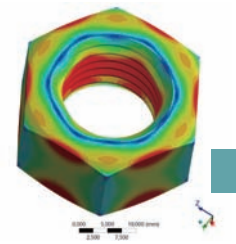

Fig. 1

The image had to be modeled because ANSYS program does not yet show the internal stress distribution of the material. In the future, it cannot be expected that any program can handle it, so, as we will see below, another method had to be applied to quantify internal stress of nuts.

Fig. 1 can be hypothetically considered to be the starting point for the subsequent assembly and operation of screw connections.

Note, therefore, that the manufacturing process induces accumulated internal stresses in the nuts. Tightening and operation work much more drastically (Fig. 2 - detail of rolling mill of tubes). This is illustrated in detail in Fig. 3.

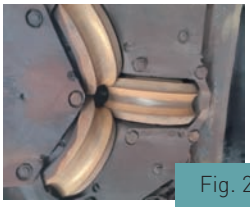

Fig. 2

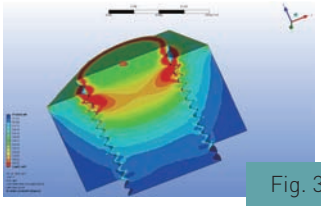

Fig. 3

Typical is the concentration of stress peaks in the region of the input threads of the nut and at the transition between the cylindrical and threaded portion of the screw (Fig. 3 and 4).

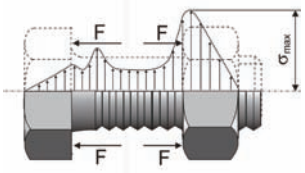

Fig. 4

The effect of operating forces can vary the stress distribution. The decisive factor here is the nature of the operating forces and the method of locking against the decrease in assembly force. Fig. 5 illustrates a case where operating forces in the axial or transverse direction are applied to the screw connection.

If the screw connection is not effectively locked, the primary assembly force has already dropped sharply after several operating cycles. This also logically changes the stress state accordingly.

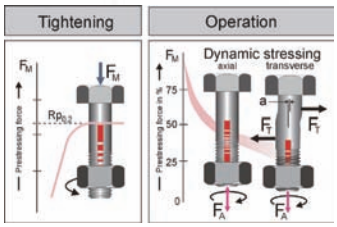

Fig. 5

Possibilities of Quantification of Internal Stresses of Nuts

As mentioned above, the current level of computation of stress distribution by the FEM method does not allow to characterize the so-called internal tension of nuts after their manufacture. Fortunately, there is a simple method that can do this. The principle is shown in Fig. 6.

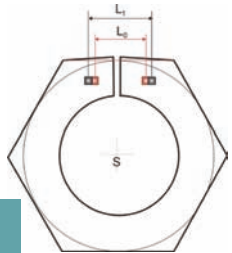

Fig.6
(L0 – distance before cutting
L1 – distance after cutting)

Two marks are made on the front of the nut using a micro hardness tester and their distance is accurately measured. Next, the nut is cut according to Fig. 6 and the mark distance is measured again. From the difference in distance L1 – L0 can deduce not only the magnitude of the internal stresses, but also their meaning, i.e., whether they are compressive stresses or tensile stresses. This depends on whether this difference is positive or negative. The principle is to relax the stresses after cutting the nut (Fig. 7).

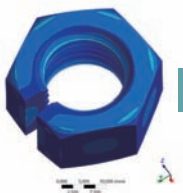

Fig. 7

As can be seen from Figure 7, the subject nut has no more accumulated stresses, but it obtained an equilibrium stress-free state.

Conclusion

Although the article does not explicitly have the level of scientific work, it provides important information on the possible impact of nuts production technology on the resulting stress state of screw connections. Known FEM stress distribution methods cannot express the relationship between the initial state of the nuts and the stress state after tightening the screws. The problem lies in the absence of input data. This is the chance of the described method of mechanical control of internal stresses (MCIS) of nuts. It is up to scientists from universities and research institutes to pay due attention. The generally accepted knowledge of the stress distribution after screw assembly may not be fully correct. ◘