

The present article deals with the phenomenon of uneven loading of nuts after tightening of threaded connections. Although this is a serious problem, it does not seem to bother designers. In the professional literature it is only sporadically mentioned. In particular, solutions are lacking.

# Stress Distribution of Threaded Connections & Optimization Options

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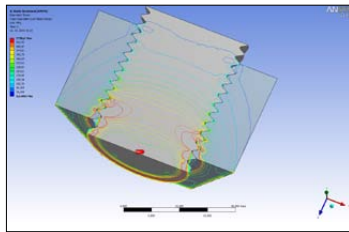


Fig. 1. FEM visual display

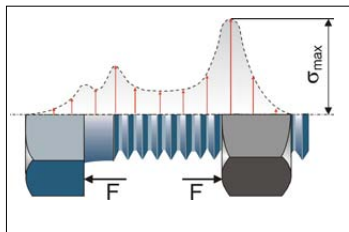


Fig. 2. Source



Fig. 3. Fatigue fracture

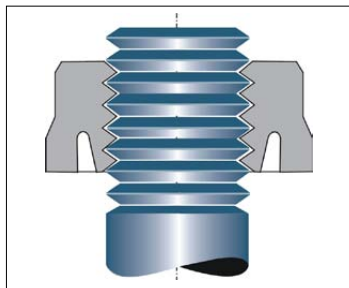


Fig. 4. Proposal 1

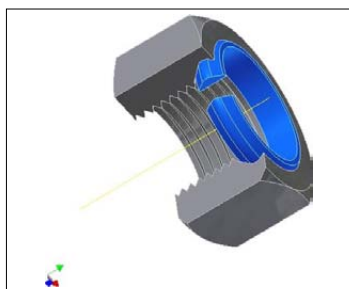


Fig. 5. Proposal 2

## Introduction

It is well known and generally accepted that the threads of nuts after tightening screws are not evenly loaded (see course of isobars by FEM visual display in Fig. 1). Fig. 2 shows the source; the largest stress peak  $\sigma_{max}$  is located in the region of the nut input threads.

In most cases this is a critical area of the screw joint. Especially under dynamic stress, fatigue fracture occurs there (Fig. 3). It is not uncommon for the nut thread to break out.

This is not the only critical phenomenon of nuts. We must not forget that the technology of internal thread rolling has not yet been satisfactorily mastered. Therefore, internal threads are produced by turning only, which reduces their strength because this breaks off the steel fibers. It has been accepted that the nut should be stronger than the screw with which it is paired. Appropriate design recommendations have been drawn up in this respect (Table 1).

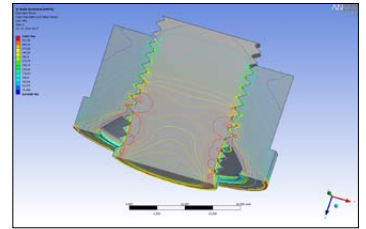


Fig. 6. FEM analysis 1

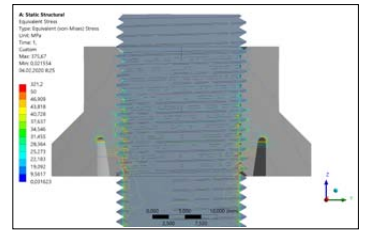


Fig. 7. FEM analysis 2

Table 1. Design Recommendations

Bolt		The Mating Nut	
Strength Class	Thread Diameter	Strength Class	Thread Diameter
3.6, 4.6, 4.8	≤ M16	4	≤ M16
5.6, 5.8	≤ M39	5	≤ M39
6.8	≤ M39	6	≤ M39
8.8	≤ M39	9	≤ M39
10.9	≤ M39	10	≤ M39
12.9	≤ M39	12	≤ M39

## Solution Options

It has already been mentioned that the uneven loading of the threads of the screw connections does not greatly bother designers. They simply accept it as a fact. This is partly understandable because the relevant theoretical research & development do not offer adequate rational solutions. Sporadic proposals only confirm this (Fig. 4 and 5).

Both designs in Fig. 4 and 5 are based on the same principle - production of a groove on the face of the nuts. FEM analysis (Fig. 6 and 7) showed a positive effect on stress distribution in both cases (compared with Fig. 1). Although a completely uniform distribution of stresses over the height of the nuts has not been achieved, it can be stated that the stress peaks have been distributed over a larger number of threads than in the case of conventional nuts.

It is not known that the solution according to Fig. 7 has been applied in practice, but the variant according to Fig. 6 is used in practice for dynamically stressed structures as a barrier against loosening of bolted connections. For this purpose, the existing groove is suitably used for application of IstLock locking ring (Fig. 5). Similarly, the groove according to Fig. 7 can also be used. The idea of applying a wedge ring is rising here for example.

## Conclusion

Uneven loading of nuts after assembly is one of the unresolved problems of today's threaded fasteners. It's a challenge for investigative designers to seriously address this problem. According to some authors, the main drawback of the current threaded connection technique is their unnecessary oversizing. This is of course a complex of problems, but uneven thread load is certainly one of them. □

