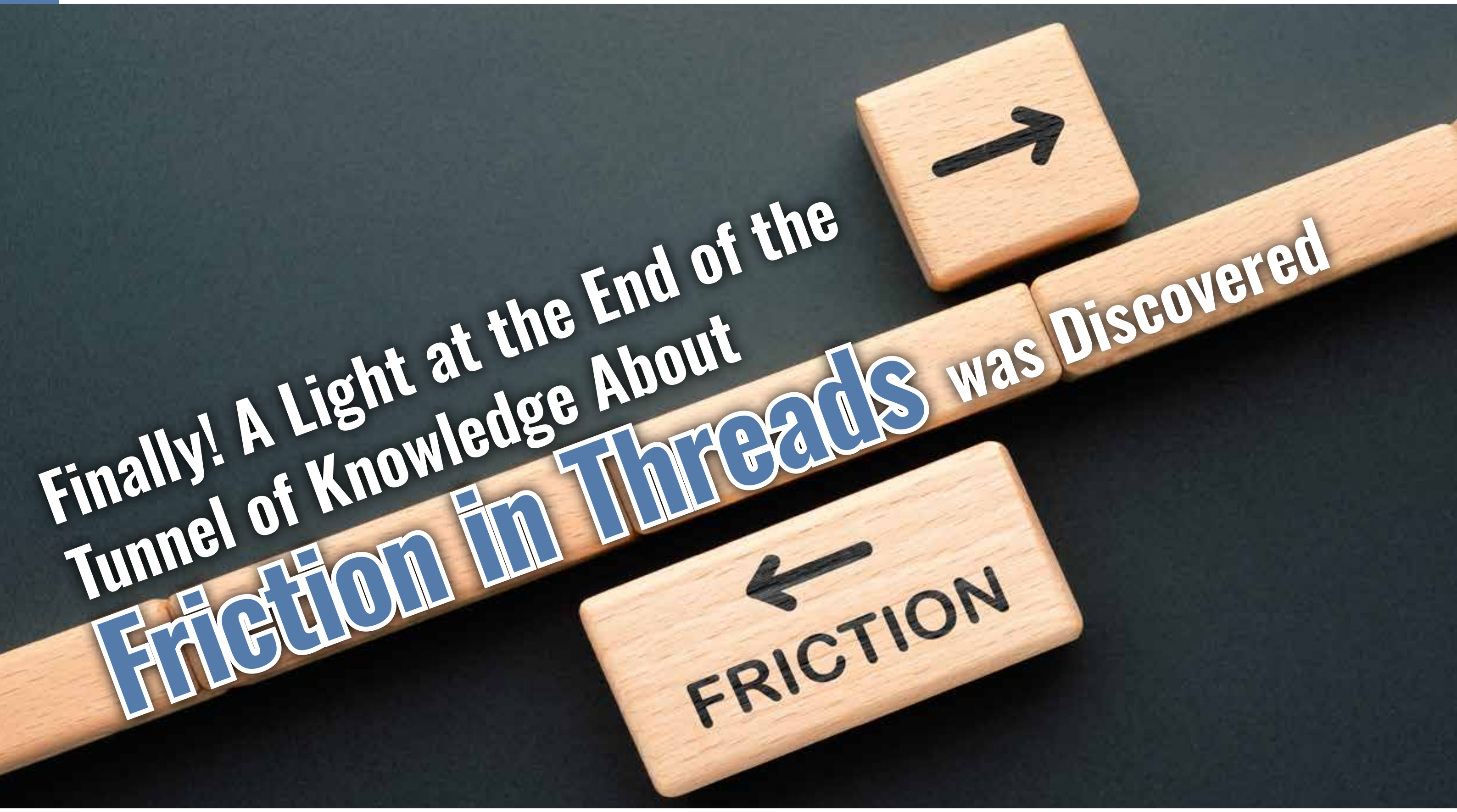


Finally! A Light at the End of the Tunnel of Knowledge About Friction in Threads was Discovered

> ***Rudyard Kipling: "There's nothing so contagious as screws going."***
> *(in "The Ship That Found Herself")*

When the known expert on tribology Prof. Peter Jost wrote his magnificent "Jost Report", published in 1966, he had no idea what contradictory meaning the friction has on the screw connections. He was only interested in global impact of friction and wear on energy consumption, economic, expenditure, and carbon dioxide emissions. The friction of the screw connections is, however, very specific and requires separate attention. Without friction, no preloaded screw connection would be possible. ***The basic condition for reliable operation of bolted joints is exact tightening which requires precise torque wrenches and information about friction ratios on contact surfaces, i.e. under the screw head and nut, but especially between the threads.***

Behavior of Bolted Joints During Assembly and Under Operating Conditions

To understand the importance of friction in threaded joints, it is important to analyze their behavior during assembly and under operating conditions. ***Fig. 1*** shows that the assembly takes place in two stages. First, there is loose screwing until the nut touches the contact surface, and only then does the actual tightening follow. From a thermodynamic point of view, the system enters a non-equilibrium state (see the right side of ***Fig. 1***) with a natural tendency to return to the equilibrium state. To prevent this from happening, friction is important.

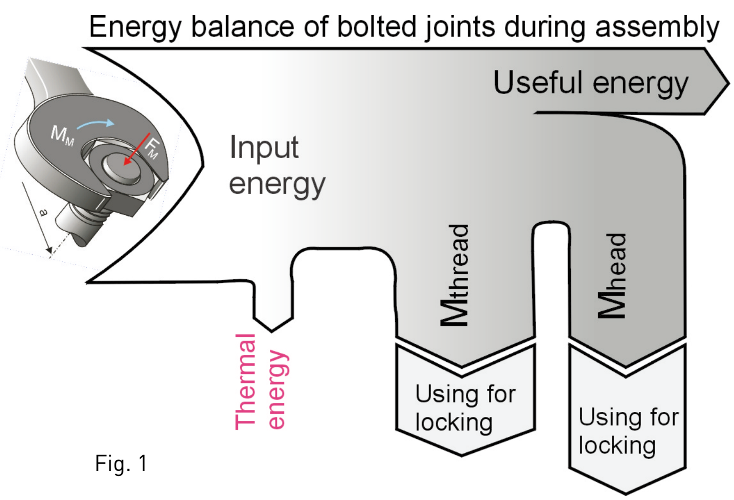


Fig. 1

Specifics About Friction in Bolted Joints

Leonardo da Vinci already proved in his experiments that friction depends on the roughness of the contact surface and the magnitude of the acting force and does not depend on the size of the contact area.

FF = μ. FN (1)

FF - friction force in [N], FN - normal force in [N] and μ - friction coefficient (dimensionless number)

Fig. 2

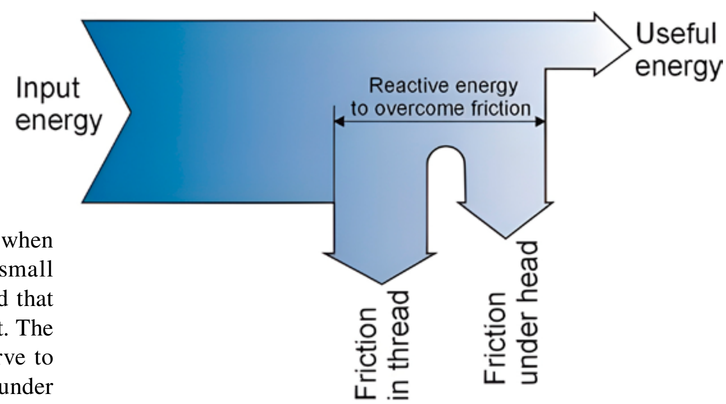
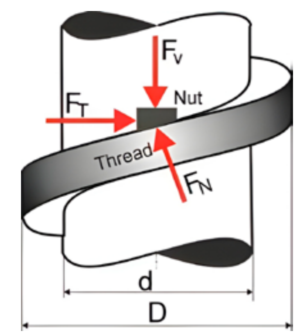
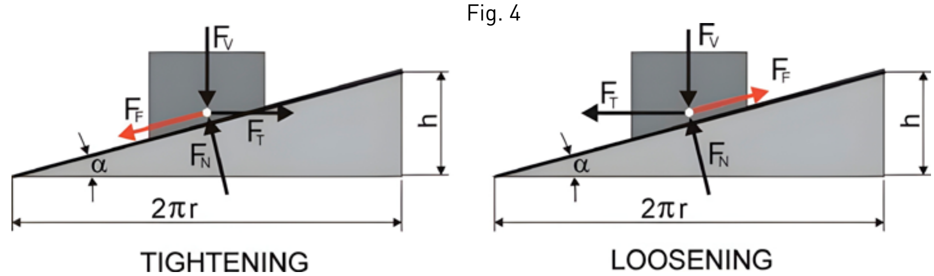


Fig. 3



As can be seen from *Fig. 2*, when tightening bolted joints, only a small part of input energy is useful, and that is the one used to preload the joint. The rest, (Mthread) and (Mhead), serve to overcome friction in thread and under heads. The next specific feature of screw connections is so-called friction paradox. When tightening, friction is undesirable, but after assembly it is necessary not to loosen (see the direction of friction force FF when tightening and in operating conditions where dangerous self-loosening of screws occurs on *Fig. 4*).

Fig. 4



From the above it follows that a bolted joint is a machine with a very low efficiency coefficient η ~ 0,2 (ca 20%). Nevertheless, it is the dominant structural element in the mechanical joining of components (compared with welding, gluing, riveting, etc.). In connection with friction, one more interesting fact is worth commenting on. Despite the fact that the main consumer of input energy is friction in the thread, the vast majority of competent institutions only have a methodology for measuring friction on flat surfaces. Most of the development capacities of the relevant institutions are devoted to increasing the friction under the head of a bolt or nut. In this, friction in the thread (*Fig. 3*) is unaccountably neglected. This is also documented in *Fig. 5*, which represents the most commonly used methods of securing bolted joints in practice. Two of them are based on the principle of increasing friction in the contact surfaces (I and II) and only one of them (III) uses friction in the thread, which is the only one that does not depend on the assembly force FM. This is not the result of a misunderstanding of the meaning of friction in threads, but the absence of relevant data on friction there.

This is crucial for the total breakdown of bolted joints after they are loosened (s. preamble oven). It is always first an initial sharp decrease and then a gradual loss of the original mounting force. ***It is enough to notice the course of the loss of assembly force in any Junker test. There is always an initial sharp drop, for which the force ratios under the screw head and nut and plastic deformation of unevenness of contact surfaces are responsible, and then a gradual loss of the original assembly force (Fig. 6).***

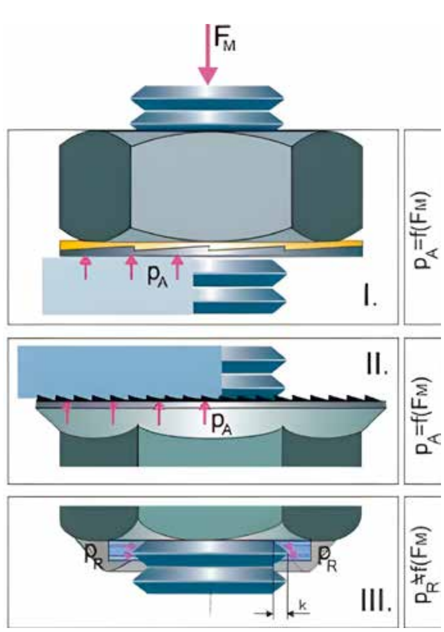


Fig. 5

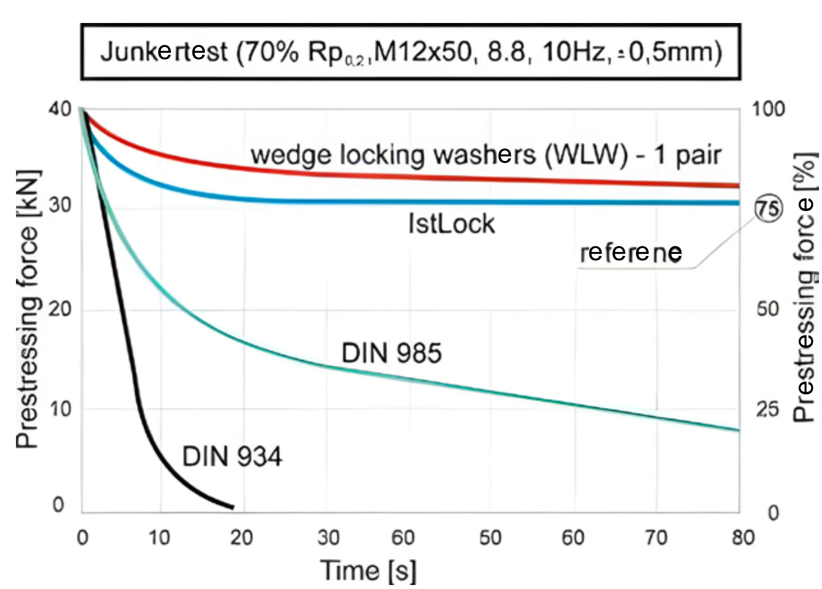


Fig. 6

However, the sporadically used methodologies for testing friction in the thread are burdened with a systematic error, as they do not respect the permitted manufacturing tolerances of screws and nuts according to the standard ISO 2768. The result is a high scattering of the measured values (*Fig. 7*).

From the basic formula (1) it can be deduced that in the case of bolted joints the torque depends on the coefficient of friction μ and the applied force F, so M = f (μ.F). This is an important statement in terms of the accuracy of measuring friction in threads, because it requires the same constant force F for all measurements. Only under such an assumption can the measurement results be reliable. The designer needs exact friction values in order to prescribe the correct assembly conditions,

This basic condition for measuring friction in threads is met by the presented system for stabilizing force conditions between threads. More than once, accidents have occurred not because the assembly conditions were not observed, but because the assembly instructions were incorrectly compiled. Torque Stabilization System (TSS) s. model in *Fig. 8* can do it. The solution is obvious - to ensure constant force ratios between the internal and external threads when measuring thread friction.

Fig. 7

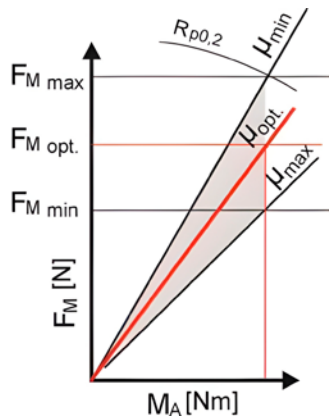


Fig. 8

Conclusion

As it was shown, threaded joints represent difficult tribological system when the friction plays contradictory role which is necessary during operation but undesirable during assembly. In contrast to other structural elements such as toothed washers, bearings and similar tribological pairs, in this case the friction is not so important from the service wear and energy consumption point of view but from the aspect of the exact assembly and safety of construction. Despite these, professor H. P. Jost is right. It is important to pay increased attention to tribology of threaded joints. Investment to that will return in the way of reliability of products and credibility of producers.