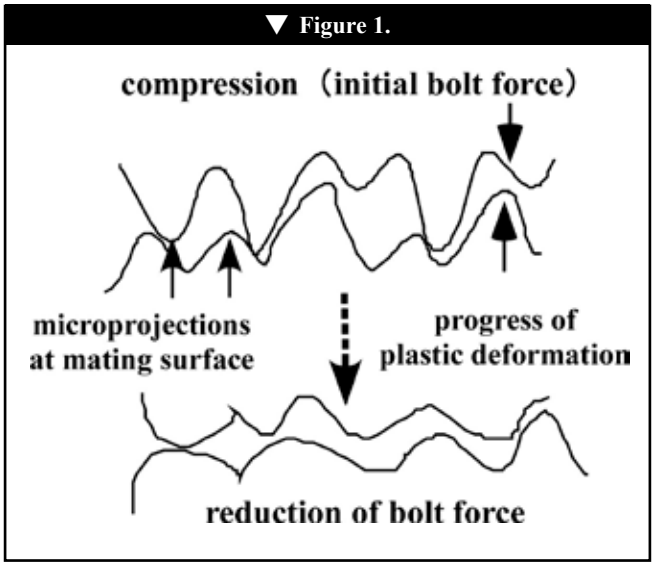
Dr. Fastener

Thread Loosening and Prevention Measures

Q A Although the nut has not undergone return rotation, the axial bolt force has decreased. What is the cause?

The phenomenon of thread loosening due to return rotation is well known, but loosening can also occur without any rotation. The former is called "rotation loosening," and the latter is called "non-rotation loosening." A decrease in axial force caused by thermal loads is an example of non-rotation loosening. Rotation loosening has been significantly mitigated by using threaded fasteners with anti-loosening features. However, non-rotation loosening inevitably occurs regardless of its degree. For non-rotation loosening, even marking the initial tightening position cannot enable the detection of loosening. It is important to pay attention to whether the amount of axial force decrease affects the safety of the bolted joint. Additionally, rotation loosening often immediately leads to major problems, and non-rotation loosening is also very dangerous because it can cause fatigue failure. The loosening in the question here is considered to be non-rotation loosening. The main cause is a phenomenon called "embedment," where the plastic deformations of surface asperities progress at each contact interface of the bolted joint. **Figure 1** explains the embedment mechanism with an enlarged view of the contact surfaces.

▼ **Figure 1.**



In what type of joint is thread loosening most likely to occur?

Loosening is most likely to occur in bolted joints subjected to repeated loads. Particular attention must be paid when vibration loads are present. Regarding the shape of the bolted joint, loosening is more prone to occur when the grip length is short. The reason is as follows: when tightening bolts of the same nominal diameter with the same axial force, a shorter grip length results in a smaller rotation angle of the nut despite the same tightening torque being required. This means that even a slight return rotation can cause a significant drop in axial force. Also, assuming the amount of embedment explained in **Figure 1** is constant, the shorter the grip length, the greater the ratio of the deformation due to embedment to the axial deformation of the whole fastened plates, thereby causing a large decrease in axial force.

How do we predict the amount of axial force reduction in bolts when no return rotation occurs?

Loosening induced by thermal load was explained in the last article by the author. In order to predict the axial force reduction due to embedment, the magnitude of the embedment is necessary. Unfortunately, there is no accurate equation to precisely predict the amount of embedment, but the VDI (Association of German Engineers) has published useful reference materials. By multiplying the amount of embedment by the spring constant representing the overall stiffness of the bolted joint, one can calculate the amount of axial force reduction. Please refer to **Reference 1** for details.

Is there a simple way to prevent thread loosening?

Rotation loosening progresses when the bearing surface of the nut slips. Therefore, setting the axial bolt force high is effective in preventing loosening. **Reference 1** provides a detailed explanation using the results of computer analysis conducted by the author. Regarding loosening due to embedment, assuming that the amount of axial force reduction is irrelevant to the initial axial force, increasing the initial axial force can reduce the rate of axial force reduction. As for the shape of bolted joint, designing to increase the grip length is also effective.

Is there such a thread fastener that absolutely never loosens?

Non-rotation loosening inevitably occurs regardless of its degree. Therefore, if loosening is considered to be the reduction in axial force, there is no thread fastener that absolutely never loosens. For rotation loosening, the probability of loosening depends on the loads acting on the bolted joint. The widely used NAS-type test machine applies the impact load to bolted joints, so its loosening mechanism differs from the one produced by the Junker-type test machine, which applies repeated shear loads. As explained in **Question 2**, vibration loads tend to cause loosening, but the probability of loosening varies with the amplitude, frequency, direction of external forces, and other factors. Thus, it is more appropriate to say "loosening is unlikely to occur under these load conditions" rather than "absolutely will not loosen." ■

Reference

1. Toshimichi Fukuoka, "The Mechanics of Threaded Fasteners and Bolted Joints for Engineering and Design", pp.256-268, ELSEVIER. (2022)