Simulation and Analysis of Screw Thread based on Workbench

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Abstract. The fastener has an unavoidable common character, easy to lose and easy to fall off, especially in violent vibration. This paper wants to examine the stress state of different kinds of screw thread based on Workbench in order to analyze the reason of screw-thread looseness and provides the measure and method of looseness-proof.

1. Introduction

Due to the common character, looseness, regular screw thread has defects. Owning to the problem of the fastener falling off, it will lead to a device damage, disintegration, and lead to a serious accident.

The purpose of this paper is to analyze the state of screw thread in stress condition. Different thread types result in different stress states.

2. Force analysis (theoretical)

2.1. Partial Analysis

Threaded fasteners are used in assembly connections of various machines and components.

The structure and shape of thread is the key to looseness. As shown in figure 1, this is a stress diagram of regular screw thread.

![Figure 1. Example of normal force diagram of regular screw thread contact surface.](image)

When the wedge thread fits with the thread fastener, the cusp of the external thread is precisely on the wedge slope of the wedge internal thread, and the force direction of the contact point is changed by the change of the wedge thread profile.
Figure 2. Example of normal force diagram of wedge thread contact surface.

Apply the same size of force in the axial direction, then

$$F_n = \frac{F}{\cos 60^\circ} \Rightarrow \frac{F}{\cos 30^\circ}$$

The results obtained from the formula show that the friction force is determined by the magnitude of the directional force, and the directional force of the wedge thread is obviously larger than that of the regular screw thread. So the friction force is much larger, thus achieving the effect of anti-loosening.

2.2. Global Analysis

The force between the teeth is not uniform in the regular thread engagement, and the rear teeth are almost suspended, even not carrying capacity. The first and the second tooth carry the most of the bolt tension. In these circumstances, a violent vibration can make the first tooth be plastic deformation and the whole structure be loosen. The first few teeth of our regular thread engagement are easy to wear and slip.

Because of the variable structure of the wedge inclined plane, the bearing capacity of the wedge thread is relatively average in each tooth. So it is not easy to wear the first few teeth of the common thread, the stress is dispersed, and the structure is more stable.

3. Modeling

WORKBENCH 18.0 ANSYS has released two versions, ANSYS Classic Mechanical APDL) and ANSYS Workbench Version. Workbench is a collaborative simulation environment proposed by ANSYS to solve the heterogeneous problem of CAE software in the process of enterprise product development. And we choose Workbench 18.0 to analyze the state of screw thread in stress condition.

3.1. Regular Screw Thread Model

Figure 3. Example of regular screw thread model
3.2. Wedge Thread Model

Figure 4. Example of wedge thread model

4. Software analysis

After modeling, we do a separate analysis of each tooth. Both of the models are analyzed in turn.

4.1. Regular screw thread model

We use WORKBENCH 18.0 to analyze each tooth individually. We keep the nut fixed, and give the displacement of the bolt in the axial direction (Y-axis) is 0.01mm. The stress of each tooth can be analyzed by WORKBENCH 18.0, as we can see in figure 5.

Figure 5. Example of first tooth of the regular screw thread
And now we can summarize the MAX equivalent stress on each tooth, the results are listed in the conclusion, as we can see in Table 1.

**Table 1.** Table of the equivalent stress on each tooth of the regular thread

| Order (unit: pa) | 1st tooth | 2nd tooth | 3rd tooth | 4th tooth |
|------------------|-----------|-----------|-----------|-----------|
| data             | 2.7331e8  | 2.3132e8  | 2.0072e8  | 1.6394e8  |

4.2. **Wedge Thread Model**

In the same way, the stress of wedge thread’s each tooth can be analyzed by WORKBENCH 18.0, as we can see in figure 6.

**Figure 6.** Example of first tooth of the wedge thread

We also summarize the MAX equivalent stress on each tooth, the results are listed in the conclusion, as we can see in Table 2.

**Table 2.** Table of the equivalent stress on each tooth of the wedge thread

| Order (unit: pa) | 1st tooth | 2nd tooth | 3rd tooth | 4th tooth |
|------------------|-----------|-----------|-----------|-----------|
| data             | 1.5233e9  | 1.6927e9  | 1.6451e9  | 1.8868e9  |

5. **Calculation and analysis**

After obtaining the data, following conclusion can be summarized.
When an object is deformed by an external cause (force, humidity, temperature field, etc.), it produces an internal force of interaction between the various parts of the body to resist this external cause. Trying to restore the object from the position after deformation to the position before deformation, that is equivalent stress.

Refers to Table 1 and Table 2, the equivalent stress has been calculated by WORKBENCH 18.0. In the regular screw thread model, equivalent stress decreasing in each tooth. So the first few teeth carry most of the stress. In the wedge thread model, equivalent stress is scattered in every tooth. Due to this characteristic, the effect of anti-loosening has been achieved.

6. References
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