

The Stress at the Base of a Screw Thread*

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The stress at the base of a screw thread was examined by means of electroplating. The results show that the peak stress at the base of screw attains maximum at the close vicinity of the ends of the screw thread and that the maximum stress is perceptively larger as compared to the stress for multiple-grooves.

With a view of eliminating the considerable difficulty arising in mathematical analysis, the stress occurring at the base of a screw thread is usually approximated by the one for circumferential multiple-grooves. The stress at the close vicinity of the ends of a screw thread, however, is apparently different from that for multiple-grooves.

Though the problem is very complicated and out of the scope of theoretical investigation, it is presumed from the common knowledge of elasticity that the stress concentration near the ends of a screw thread is more intense than in multiple-grooves but is more minor than in a single groove. As is shown later, in some instances, however, the discrepancy of the stress concentration being perceptible in a single groove and in multiple-grooves, reliable data useful for the design of machines and structures cannot be secured from this presumption. But so far as the author is aware, little information is available in connection with the subject.

To investigate the subject experimentally, we begin with a torsion test for specimens of 12 mm in outer diameter with a screw thread of Japan Industry Standard. The pitch, the depth and the base radius of the screw thread are 1.75 mm, 1.07 mm and 0.25 mm, respectively. The total number of turns of the screw thread cut in a specimen is 11, as is shown in Fig. 1. To eliminate the disarrangement in result, precautions are taken for the cutting of screw thread. The shape of the screw thread was carefully examined with a magnifying projector ($\times 50$), especially for the base radius.

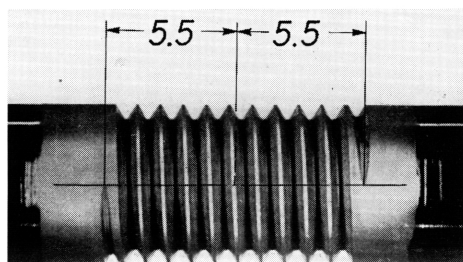


Fig. 1 Test-piece, partially electroplated.

Using the specimens plated with copper, the peak stress at the base of screw thread was measured precisely along the thread by the electroplating method of stress analysis which has been applied successfully to similar problems.¹⁾ The stress was measured by observing the grain growth in the deposit copper, caused by cyclic stressing, in stead of the flecking on the surface of the plated copper, since the examination of grain growth is more favourable for the accurate measurement of highly localized

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stress. The strain amplitude generating grown-grains in deposit copper for an assigned number of cyclic stressing being found by a calibration test, the stress at the base of the screw thread is readily estimated by observing the number of cycles of stressing for which grain growth begins to occur in deposit copper.

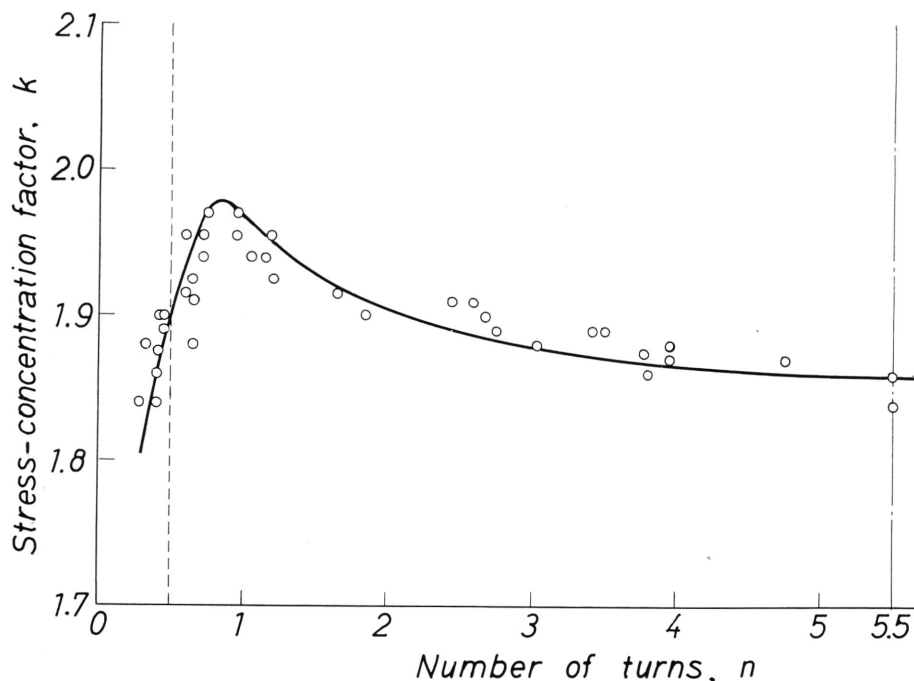


Fig. 2 Stress concentration factor along the screw thread, torsion.

The result thus obtained from the torsion test for three specimens is shown in Fig. 2. In the figure, the abscissa, n , represents the number of turns from both ends of the screw thread, Fig. 1, showing the location of the base examined, and the stress concentration factor, k , is based on the minimum diameter of specimens. The screw thread was so cut for every specimen as it attains the subscribed depth, 1.07 mm, at $n=0.5$, so the cross sectional area of the specimen becomes uniform when $n>1$. Consequently, the examination of the peak stress

at the locations near $n=0.5$ and $n=1$, is most essential in this test.

The experimental result shows that the peak stress at the base of screw thread attains maximum at the location $n=0.9$ close neighbourhood of $n=1$, as is shown in the figure. The maximum stress is about 7.5 percent larger as compared to the peak stress at the location sufficiently distant from the ends of the screw thread, namely at $n=5.5$. For comparison, the appearance of grown-grains at those locations submitted to the same cyclic

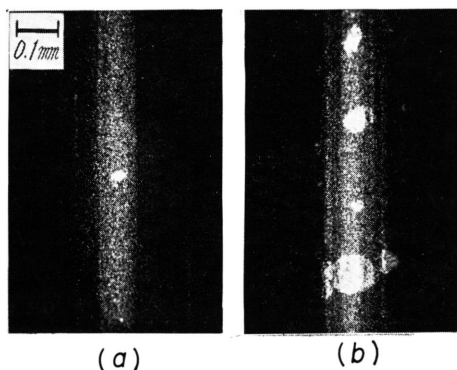


Fig. 3 Grown-grains appeared in deposit copper. (a) $n=5.5$, (b) $n=0.9$

stressing of 3.5×10^6 , is shown in Fig. 3.

For circumferential multiple-grooves, a formula of the stress concentration factor has been introduced by a simple procedure²⁾, which allows to specify the depth, the base radius and the pitch of grooves. The stress concentration factor evaluated from the formula is 1.89, for the multiple-grooves having identical depth, base radius and pitch. The shape of grooves, however, is slightly different in detail from that of the screw thread herein treated, as is shown by a dashed line in Fig. 4.

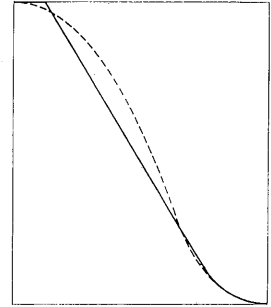


Fig. 4 Shapes of Grooves.

The experimental value of k at $n=5.5$ is 1.85, which is fairly in good agreement with the theoretical one. This apparently shows that the torsional stress in a screw thread at the location sufficiently distant from the ends is the same with that of multiple-grooves identical in shape and that the value of k , measured by means of electroplating is satisfactorily accurate.

In the same manner, the stress concentration factor is obtained for a circumferential single-groove, identical in shape. Comparison is made to the theoretical value evaluated from the author's formula for U -grooves³⁾, having the same depth and base radius. For the single-groove, the experimental value of k is 2.50 while the calculated value is 2.51 and they are in excellent agreement. Another theoretical evidence showing the accuracy of the result is that the ratio of the stress concentration factor of the screw thread to that for the single groove, almost agrees with the theoretical value for infinitely small grooves. The experimental value of the ratio herein obtained is $1.85/2.50=0.74$, while the theoretical value for the grooves with sharply rounded bases is about 0.76.⁴⁾

In the same manner, a further test was made for bending. The maximum stress occurs at the same location as in torsion, namely at $n=0.9$. In bending, however, the magnitude of the maximum stress is considerably larger as compared to the stress at the location sufficiently distant from the ends, as is shown in Fig. 5. The maximum stress is about 20 percent larger as compared to the stress at $n=5.5$. Such a large discrepancy in the value of peak stress cannot be ignored practically and it is concluded that the maximum stress occurring at the ends of a screw thread cannot be approximated by the stress at the bases of circumferential multiple-grooves, especially in bending.

When a screw thread, however, is so cut at the ends as the depth attains its normal depth very slowly, the maximum stress will be reduced perceptively. For instance, when the depth of screw thread attains the subscribed depth at $n=1.5$, in place of $n=0.5$, the k for the maximum stress reduces to 3.10 from 3.37. Consequently, it is suggested to cut a screw thread having the minimum slope of depth at the ends so far as the other requirements in the design of machines permit.

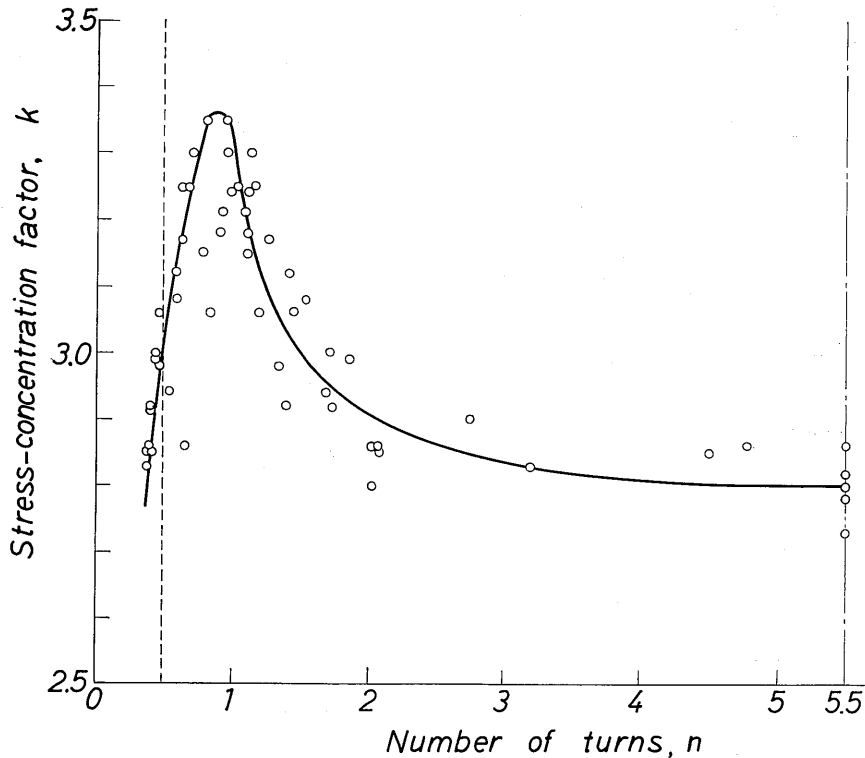


Fig. 5 Stress concentration factor along the screw thread, bending.

References

- 1) H. Ōkubo, Electroplating Method of Stress Analysis, *Memoirs of Fac. Eng., Nagoya University*, **20**, May (1968), 1, etc.
- 2) S. Momma, Deduction of the Maximum Torsional Stress in a Shaft with Notches, *J. Appl. Phys.*, **24**, 7 (1953), 959.
- 3) H. Ōkubo, Approximate Approach for Torsion Problem of a Shaft with a Circumferential Notch, *J. Appl. Mech.*, **19**, 1 (1952), 16.
- 4) H. Ōkubo, Die Formzahlen tordierter Well mit mehreren Nuten, *Ingenier-Archiv*, **23**, 2 (1955), 130.