
By Kameichi Yuasa.

Institute of Mechanical Engineering, Tokyo Imperial University.


The process of the failure of metals under stress depends not only upon the property of metals, but also greatly to the temperatures and the loading speeds to which they are subjected.

So far as the author is aware, Mr. A.V. de Forest is only one investigator on this line. He experimented principally with brass wires and concluded that brass wire stretches very differently from copper, aluminium, nickel, soft iron and German silver, and further that these latter stretch in a fairly uniform manner and the stress-strain diagram shows an apparently smooth curve, while that for brass is an irregular one.

According to his method the tensile load was applied with a constant speed by an ingenious device. Thus, as the load was not self-adjusting, abrupt changes in the resistance of material due to slipping were indicated merely as a step-shaped figure in the diagram. Moreover the effect of inertia of the weight used as the load might have masked more or less the real feature of the phenomenon.

In order to avoid such an inconvenience the author devised an apparatus which is free from inertia effect and in which the applied load is self-adjusting. By this apparatus, he experimented with test pieces of steel which is alleged to have no irregularity during its plastic elongation.

Fig. 1 indicates the author's apparatus diagramatically. The tensile load applied on the test-piece T is measured by the amount of the elastic elongation of the weigh bar S calibrated by means of the author's mirror extensometer E. This weigh bar has a sufficient size in order to keep it within the limit of elasticity when the test piece is subjected to the breaking load.

The image of the vertical slit A which is illuminated by a point light L through a condensing lens R, is accurately focussed on a sensitive paper rolled on a recording drum D by means of a concave mirror M and a plane one N.

This image moves on the surface of the sensitive paper in horizontal direction along a horizontal slit H which is cut on the side of a camera containing the recording drum, close to the surface of the paper, and records thereon the amount of the horizontal displacement which is proportional to the elastic extension of the weigh bar S; thus the amount of the applied tensile load is recorded optically.

As the drum D rotates uniformly the trace of the image recorded on the drum optically is the load-time curve of the test piece.

On the other hand, since the pull is applied with a uniform velocity with a constant speed motor the test piece extends with a uniform rate, the load-time curve is no other than the tensile load-elongation diagram.

The heating of test pieces was done with an electric resistance furnace F and the temperatures of the test piece were measured thermo-electrically.

Fig. 2 shows the dimensions of the test piece and Figs. 3 to 7 are the diagrams showing the results of the experiments with test pieces of the same material under varying temperatures.

The chemical constituents of the test pieces were C = 0.65%, Mn = 0.35%, S = 0.32%, P = 0.015%, S = 0.015%, W = 1.98%, and they were annealed at 800 degrees C.

It will be seen from these diagrams that at certain temperatures there are irregular jumps on these curves after the yield-point (point marked Y in the diagrams) is passed. It will also be seen that at each discontinuity the resistance of material decreases suddenly and then it increases uniformly until another discontinuity is reached.

The number of occurrence and the intensity of these irregularities increase with the rise of temperature and reach a maximum at about 250°C, as shown in Fig. 5; this temperature nearly corresponds to that of "blue shortness." With the further rise of temperature this irregularity decreases and finally at about 350°C, we can no more observe it as shown in Fig. 7. Under such a temperature the nature of deformation of the test piece would be that due to viscous flow.

In the course of such an irregular deformation we hear craking sound from time to time; such a sound seems to occur whenever the stress makes sudden change.

Lastly it may also be noted that this character is retained even with comparatively high speed of loading.
No. 9.] On the Process of the Failure of Metals under Tensile Stress.

Fig. 1.

Fig. 2.

Fig. 3. 139°C.
Fig. 4. 171°C.

Fig. 5. 198°C.

Fig. 6. 295°C.

Fig. 7. 358°C.