

In addition to elastic and visco-elastic deformation behavior, materials can undergo plastic deformation. The main characteristic of plastic deformation is that it is *irreversible*. Plastic deformation can be virtually instantaneous or time-dependent depending on the conditions under which deformation takes place. The main controlling variables are temperature and deformation rate.

We will be mostly concerned with *instantaneous or time-independent, permanent deformation or plastic deformation for short*. Figure 1.2 is a schematic load-extension diagram when a specimen is plastically deformed in a tensile test. *Initial yield* occurs at *a* with departure from linearity. Range *Oa* is called the *elastic region*. Only for some very high-strength metals is it possible to have nonlinear elastic behavior prior to internal yield. If the specimen is deformed beyond *a* to *b* and then the load is reduced to zero, the permanent deformation *Oc* remains. The slope of *cb* is to a very good approximation the same as that of *Oa*, i.e., proportional to Young's modulus *E*. The point of maximum load is *d*. At or near this point localized necking begins and the specimen no longer deforms uniformly. At some point past *d* the specimen fractures. Necking is a material-geometric instability in which strain hardening of the material is insufficient to compensate for a local reduction in cross-sectional area. If one could obtain tensile data past the necking point, one would find that the true stress, $\sigma = P/A$, increases monotonically until failure starts. Typically, the initial yield strain is between 0.1 and 1% while the strain at necking is 10 to 40 times larger. There is virtually no permanent change in volume after the specimen has been deformed. Furthermore, the force-elongation curve is essentially unchanged when the specimen has hydrostatic pressure superimposed on it. Hydrostatic pressure alone induces almost no permanent deformation.

Plastic deformation of typical structural materials can be considered rate-independent at room temperature and at normal strain-rates. For strain rates in the range of 10^{-6} /sec. to 10/sec., the behavior is relatively insensitive to the strain-rate at which the test is conducted. If the temperature is a significant fraction of the melting temperature (in Kelvin), however, the strain-rate sensitivity becomes marked. Tin or lead are examples where even at room temperature rate effects play a role. Figure 1.12 shows the result of tests conducted at constant strain-rate. The strain-rate dependence increases with increasing temperature. Rate effects are also more important in BCC than FCC materials. In what follows, we will assume that the temperature is low enough that *strain rate effects can be neglected*, and we will consider *time-independent plasticity*. Typically, this means the temperature is below about 0.4 times the melting temperature on an absolute temperature scale. Above 0.4 times the melting temperature, creep becomes important (see Figure 1.10).

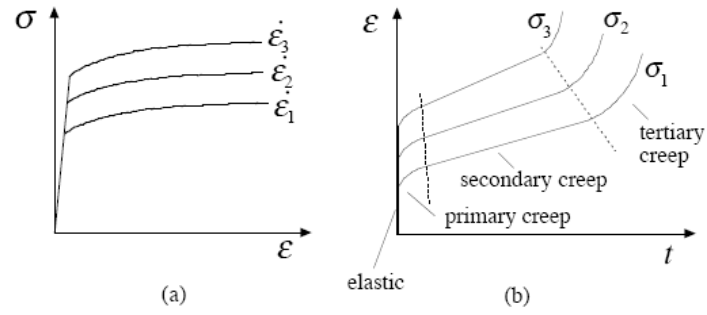


Fig. 1.12 (a) Tests conducted at different constant strain rates ($\dot{\epsilon}_1 < \dot{\epsilon}_2 < \dot{\epsilon}_3$); (b) Tests

conducted at different constant stress $\sigma_1 > \sigma_2 > \sigma_3$ (creep tests).

(注：以上阅读材料摘编自力学网站 <http://imechanica.org/>。)