ME102: Subunit 2.2.2: Testing of Mechanical Properties and Performance of Materials

Solid materials generally respond to stress as illustrated in figure 1. At low stresses, they respond elastically (they deform temporarily and then rebound); at larger stresses, they deform permanently; and at still larger stresses, they fracture. Many of the mechanical tests and properties used to characterize the performance of materials can be understood in terms of the behavior presented schematically in figure 1; you may wish to review subunit 2.2 at this time, and study figure 1 in depth. Several mathematical approximations to the shape of such curves are available and generally involve two distinct regimes: the linear, or elastic, regime and the plastic regime.

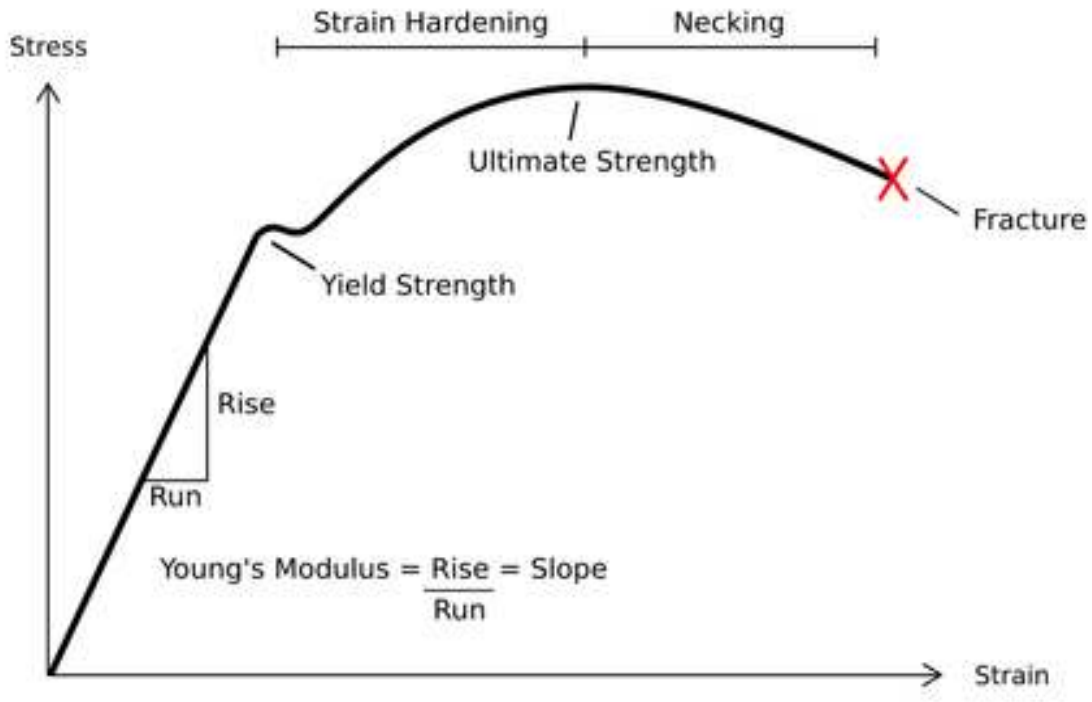

Figure 1 Typical Stress-Strain Diagram for a Ductile Material. Figure contributed by user Brakeydown under a Creative Commons Attribution-Share Alike 3.0 Unported license. The original version can be found at this link.

In this brief reading we will consider some of the most common mechanical tests.

Tensile and Torsion Tests

These tests are used to measure deflection or strain of test specimens under various load or stress conditions. An example of a universal test machine for measuring compressive strain is shown in the figure blow.

Figure 2 Photograph of a universal test device. Contributor: Rainer Knäpper. License: artlibre. Downloaded from Wikimedia Commons.

Similar devices may be used in slightly different geometries to measure, for example, tensile deformation, bending, torsion, and compression of test specimens. A convenient guide to such load conditions may be found here. Such measurements may yield several material properties including elasticity, yield strength, and ultimate strength. Extensive tables of such data are available.

Hardness Tests

In general, hardness represents a measure of the resistance of a material to plastic deformation. There are at least three common measures of hardness: scratch, indentation, and rebound. They are all slightly different indicators of material properties.

1. Scratch Test. This test, and the resulting Mohs' scale, is one of the oldest measures of hardness used. In it, we just measure the ability of one material to scratch another. For example, quartz has a Mohs' hardness of 7; if quartz can scratch the material under question, then that material has a Mohs' hardness

less than 7. The test can be repeated with different materials until the desired accuracy is achieved. On the Mohs' scale, diamond has a hardness of 10 and talc has a hardness of 1.

2. Indentation Test. The idea here is that one uses a very hard indenter (diamond, for example) of standard geometry to push into a material surface with a known force. One measures the force and the depth of indentation. Mathematical combinations of the force (or load), indenter geometry, and depth of indentation then give an index of material hardness. There are many such scales: Rockwell, Brinell, Janka, Shoop, Meyer, Shore, Barcol, and Vickers. You may peruse the details of such tests and their specific realms of applicability at this link.
3. Rebound Test. The idea here is to measure the rebound height of a very hard-tipped hammer-like device (a scleroscope) from a surface. This height then provides an index of the elasticity of the material. See, for example, this discussion of the Leeb rebound test.

Plastic Deformation, Ductility, and Fracture

Several impact-type tests that involve extensive deformation and fracture of material specimens are also used. One of the most common of these are the Charpy and Izod impact tests in which a large, pendulum hammer is applied to a standard specimen shape from a range of starting heights. Specimens are typically grooved or notched in a known way before applying impact so that deformation and fracture are more reproducible. Parameters indicating the strength of the specimen can then be deduced from the reduction in hammer energy and the degree of the specimen deformation or fracture.