- (vi) Percentage Elongation After the fracture, the two halves of the broken test specimen are fi tted together as shown in Fig. 2.5(b) and the extended gauge length l is measured. The percentage elongation is defi ned as the ratio of the increase in the length of the gauge section of the specimen to original gauge length, expressed in per cent. Therefore,

$$\text{percentage elongation} = \left(\frac{l - l_0}{l_0} \right) \times 100$$

- Ductility is measured by percentage elongation

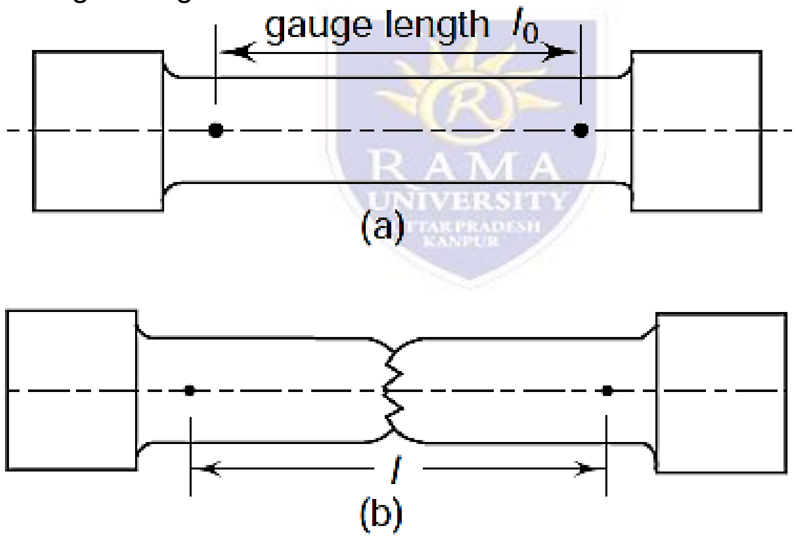

Fig. 2.5 *Determination of Percentage Elongation: (a) Original Test Piece (b) Broken Test Piece*

- (vii) Percentage Reduction in Area Percentage reduction in area is defi ned as the ratio of decrease in cross-sectional area of the specimen after fracture to the original cross-sectional area, expressed in per cent. Therefore,

$$\text{percentage reduction in area} = \left(\frac{A_0 - A}{A_0} \right) \times 100$$

- where,
- A0 = original cross-sectional area of the test specimen
- A = fi nal cross-sectional area after fracture
- Percentage reduction in area, like percentage elongation, is a measure of the ductility of the material. If porosity or inclusions are present in the material or if damage due to overheating of the material has occurred, the percentage elongation as well as percentage reduction in area are drastically decreased. Therefore, percentage elongation or percentage reduction in area is Considered as an index of quality for the material.

Lecture Machine Design

- MECHANICAL PROPERTIES OF ENGINEERING MATERIALS
- Strength is defi ned as the ability of the material to resist, without rupture, external forces causing various types of stresses. Strength is measured by different quantities. Depending upon the type of stresses induced by external loads, strength is expressed as tensile strength, compressive strength or shear strength. Tensile strength is the ability of the material to resist external load causing tensile stress, without fracture. Compressive strength is the ability to resist external load that causes compressive stress, without failure. The terms yield strength and ultimate tensile strength are explained in the previous article.
- Elasticity is defi ned as the ability of the material to regain its original shape and size after the deformation, when the external forces are removed. All engineering metals are elastic but the degree of elasticity varies. Steel is perfectly elastic within a certain elastic limit. The amount of elastic deformation which a metal can undergo is very small. During the elastic deformation, the atoms of the metal are displaced from their original positions but not to the extent that they take up new positions. Therefore, when the external force is removed, the atoms of the metal return to their original positions and the metal takes back its original shape.
- Plasticity is defi ned as the ability of the material to retain the deformation produced under the load on a permanent basis. In this case, the external forces deform the metal to such an extent that it cannot fully recover its original dimensions. During plastic deformation, atoms of the metal are permanently displacplastic range without fracture is one of the useful engineering properties of materials. For example, the extensive plastic deformability of low carbon steels enables automobile parts such as the body, hood and doors to be stamped out without fracture.ed from their original positions and take up new positions. The ability

- The difference between elasticity and plasticity is as follows:
- (i) Elasticity is the ability of a metal to regain its original shape after temporary deformation under an external force. Plasticity is the ability to retain the deformation permanently even after the load is removed.
- (ii) The amount of elastic deformation is very small while plastic deformation is relatively more.
- (iii) During elastic deformation, atoms of metal are temporarily displaced from their original positions but return back when the load is removed. During plastic deformation, atoms of metal are permanently displaced from their original positions and take up new positions.
- (iv) For majority of materials, the stress–strain relationship is linear in the elastic range and non-linear in the plastic range.
- (v) Elasticity is an important consideration in machine-tool components while plasticity is desirable for components made by press working operations.

- Stiffness or rigidity is defi ned as the ability of the material to resist deformation under the action of an external load. All materials deform when stressed, to a more or less extent. For a given stress within elastic limit, the material that deforms least is the stiffest. Modulus of elasticity is the measure of stiffness. The values of the modulus of elasticity for aluminium alloy and carbon steel are 71 000 and 207 000 N/mm2 respectively. Therefore, carbon steel is stiffer than aluminium alloy. Stiffness is an important consideration in the design of transmission shafting.

- Resilience is defi ned as the ability of the material to absorb energy when deformed elastically and to release this energy when unloaded. A resilient material absorbs energy within elastic range without any permanent deformation. This property is essential for spring materials. Resilience is measured by a quantity, called modulus of resilience, which is the strain energy per unit volume that is required to stress the specimen in a tension test to the elastic limit point. It is represented by the area under the stress–strain curve from the origin to the elastic limit point.

- Toughness is defi ned as the ability of the material to absorb energy before fracture takes place. In other words, toughness is the energy for failure by fracture. This property is essential for machine components which are required to withstand impact loads. Tough materials have the ability to bend, twist or stretch before failure takes place. All structural steels are tough materials. Toughness is measured by a quantity called modulus of toughness. Modulus of toughness is the total area under stress–strain curve in a tension test, which also represents the work done to fracture the specimen. In practice, toughness is measured by the Izod and Charpy impact testing machines. Toughness decreases as the temperature increases.

- The difference between resilience and toughness is as follows:
- (i) Resilience is the ability of the material to absorb energy within elastic range. Toughness is the ability to absorb energy within elastic and plastic range.
- (ii) Modulus of resilience is the area below the stress–strain curve in a tension test up to the yield point. Modulus of toughness is the total area below the stress–strain curve.
- (iii) Resilience is essential in spring applications while toughness is required for components subjected to bending, twisting, stretching or to impact loads. Spring steels are resilient while structural steels are tough.