- The ergonomic considerations in the design of displays are as follows:
- (i) The scale on the dial indicator should be divided in suitable numerical progression like 0 –10 –20 –30 and not 0 –5 –30 –55.
- (ii) The number of subdivisions between numbered divisions should be minimum.
- (iii) The size of letters or numbers on the indicator should be as follows:
- Height of letter or number > Reading distance/200
- (iv) Vertical fi gures should be used for stationary dials, while radially oriented fi gures are suitable for rotating dials.
- (v) The pointer should have a knife-edge with a mirror in the dial to minimis e parallax error.

- The ergonomic considerations in the design of controls are as follows:
- (i) The controls should be easily accessible and logically positioned. The control operation should involve minimum motions and avoid awkward movements.
- (ii) The shape of the control component, which comes in contact with hands, should be in conformity with the anatomy of human hands.
- (iii) Proper colour produces benefi cial psychological effects. The controls should be painted in red colour in the grey background of machine tools to call for attention.

- Engineering Materials
- STRESS–STRAIN DIAGRAMS
- A very useful information concerning the behaviour of material and its usefulness for engineering applications can be obtained by making a tension test and plotting a curve showing the variation of stress with respect to strain. A tension test is one of the simplest and basic tests and determines values of number of parameters concerned with mechanical properties of materials like strength, ductility and toughness. The following information can be obtained from a tension test:
- (i) Proportional limit
- (ii) Elastic limit
- (iii) Modulus of elasticity
- (iv) Yield strength
- (v) Ultimate tension strength
- (vi) Modulus of resilience
- (vii) Modulus of toughness
- (viii) Percentage elongation
- (ix) Percentage reduction in area
- The cross-section of the specimen
- can be circular, square or rectangular. The standard
- gauge length l0 is given by

$$l_0 = 5.65\sqrt{A_0},$$

where $A_0$ is the cross-sectional area of the specimen.

For circular cross-section,

$$l_0 \approx 5d_0$$

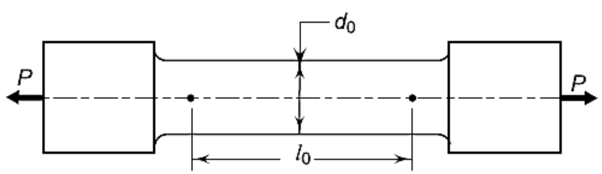
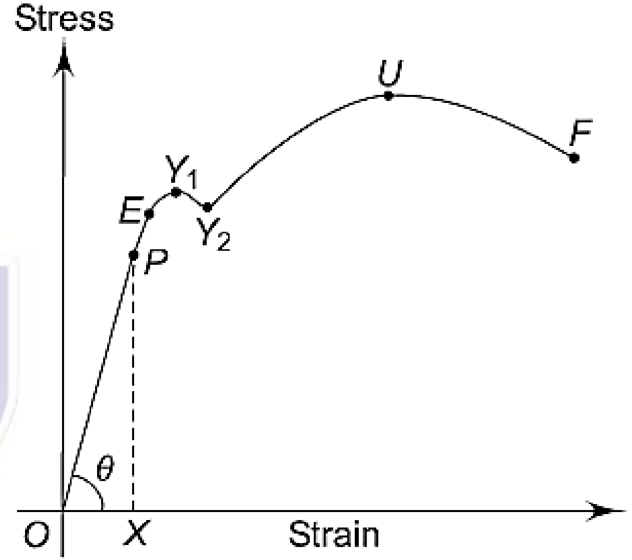



**Fig. 2.1** *Specimen of Tension-test*




*Stress–Strain Diagram of Ductile Materials*

- the results of a tension test are expressed by means of stress–strain relationship and plotted in the form of a graph. A typical stress– strain diagram for ductile materials like mild steel is shown in Fig. 2.2. The following properties of a material can be obtained from this diagram:
- diagram that stress–strain relationship is linear from the point O to P. OP is a straight line and after the point P, the curve begins to deviate from the straight line. Hooke’s law states that stress is directly proportional to strain. Therefore, it is applicable only up to the point P. The term proportional limit is defi ned as the stress at which the stress–strain curve begins to deviate from the straight line. Point P indicates the proportional limit.
- (ii) Modulus of Elasticity The modulus of elasticity or Young’s modulus (E) is the ratio of stress to strain up to the point P. It is given by the slope of the line OP. Therefore,

$$E = \tan\theta = \frac{PX}{OX} = \frac{\text{stress}}{\text{strain}}$$

- (iii) Elastic Limit Even if the specimen is stressed beyond the point P and up to the point E,
- it will regain its initial size and shape when the load is removed. This indicates that the material is in elastic stage up to the point E.
- Therefore, E is called the elastic limit.
- The elastic limit of the material is defi ned as the maximum stress without any permanent deformation.
- The proportional limit and elastic limit are very close to each other, and it is diffi cult to distinguish between points P and E on the stress–strain diagram.
- In practice, many times, these two limits are taken to be equal.

- (iv) Yield Strength When the specimen is stressed beyond the point E,
- plastic deformation occurs and the material starts yielding. During this stage, it is not possible to recover the initial size and shape of the specimen on the removal of the load. It is seen from the diagram that beyond the point E, the strain increases at a faster rate up to the point Y1. In other words, there is an appreciable increase in strain without much increase in stress.
- In case of mild steel, it is observed that there is a small reduction in load and the curve drops down to the point Y2 immediately after yielding starts. The points Y1 and Y2 are called the upper and lower yield points, respectively. For many materials, the points Y1 and Y2 are very close to each other and in such cases, the two points are considered as same and denoted by Y. The stress corresponding to the yield point Y is called the yield strength.
- **The yield strength is defi ned as the maximum stress at which a marked increase in elongation occurs without increase in the load. Many varieties of steel, especially heat-treated steels and cold-drawn steels,** do not have a welldefi ned yield point on the stress–strain diagram. As shown in Fig. 2.3, the material yields gradually after passing through the elastic limit E. If the loading is stopped at the point Y, at a stress level slightly higher than the elastic limit E, and the specimen is unloaded and readings taken, the curve would follow the dotted line and a permanent set or plastic deformation will exist.
- The strain corresponding to this permanent deformation is indicated by OA. For such materials, which do not exhibit a well-defi ned yield point,
- the yield strength is defi ned **as the stress corresponding toa permanent set of 0.2% of gauge length**. In such cases, the yield strength is determined by the offset method. A distance OA equal to 0.002 mm/mm strain (corresponding to 0.2% of gauge length) is marked on the X-axis.
- A line is constructed from the point A parallel to the straight line portion OP of the stress–strain curve. The point of intersection of this line and the stress–strain curve is called Y or the yield point and the corresponding stress is called 0.2% yield strength.The terms proof load or proof strength are frequently used in the design of fasteners.
- Proof strength is similar to yield strength. It is determined by the offset method; however the offset in this case is 0.001 mm/mm corresponding to a permanent set of 0.1% of gauge length. 0.1% Proof strength, denoted by symbol Rp0.1, is defi ned as the stress which will produce a permanent extension of 0.1% in the gauge length of the test specimen. The proof load is the force corresponding to proof stress.

(v) Ultimate Tensile Strength We will refer back to the stress–strain diagram of ductile materials illustrated in Fig. 2.2. After the yield point Y2, plastic deformation of the specimen increases. The material becomes stronger due to strain hardening, and higher and higher load is required to deform the material. Finally, the load and corresponding stress reach a maximum value, as given by the point U. The stress corresponding to the point U is called the ultimate strength. The ultimate tensile strength is the maximum stress that can be reached in the tension test.

For ductile materials, the diameter of the specimen begins to decrease rapidly beyond the maximum load point U. There is a localised reduction in the cross-sectional area, called necking. As the test progresses, the cross-sectional area at the neck decreases rapidly and fracture takes place at the narrowest cross-section of the neck. This fracture is shown by the point F on the diagram. The stress at the time of fracture is called breaking strength. It is observed from the stress–strain diagram that there is a downward trend after the maximum stress has been reached. The breaking strength is slightly lower than the ultimate tensile strength.

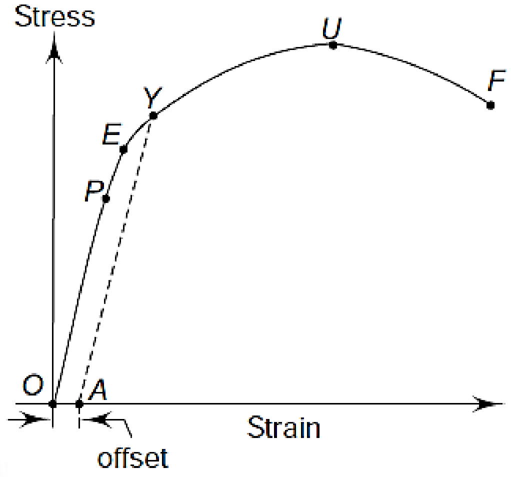
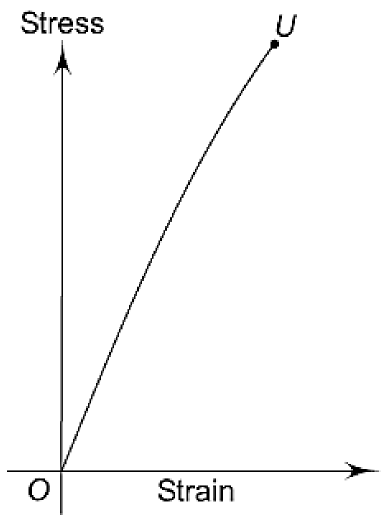



**Fig. 2.3** *Yield Stress by Offset Method*




*Stress-Strain Diagram of Brittle Materials*