# UNIT-3

# MECHANICAL PROPERTIES

Mechanical properties of materials play a vital role in the development of structures , machines and other products. Normally these constructions are subjected to natural and manmade loads under widely varying environments and temperatures.

## STRENGTH OF ENGINEERING MATERIALS

## 3.1 TENSILE TEST

**Tensile testing** is one of the simplest and most widely used mechanical **tests**. By measuring the force required to elongate a specimen to breaking point, material properties can be determined that will allow designers and quality managers to predict how materials and products will behave in their intended applications.

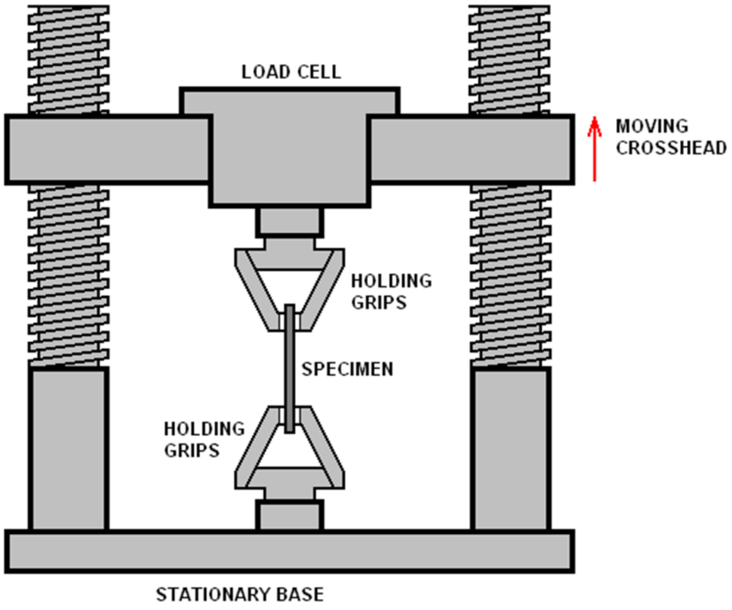

**Fig.3.1.1 Tensile test machine**

The permanent deformation of materials on the application of a load can be either plastic deformation or creep. In crystalline materials, at temperatures lower than $0.4T_m$, where $T_m$ is the melting point in Kelvin, the permanent deformation is called ***plastic deformation***. In this temperature range, the amount of deformation that occurs after the application of load is small enough to be ignored. The rate at which the material is deformed may, however, play a role in determining the deformation characteristics. At temperatures about $0.4T_m$ permanent deformation continues as a function of time, following the application of the load. This behaviour is termed as ***creep***.

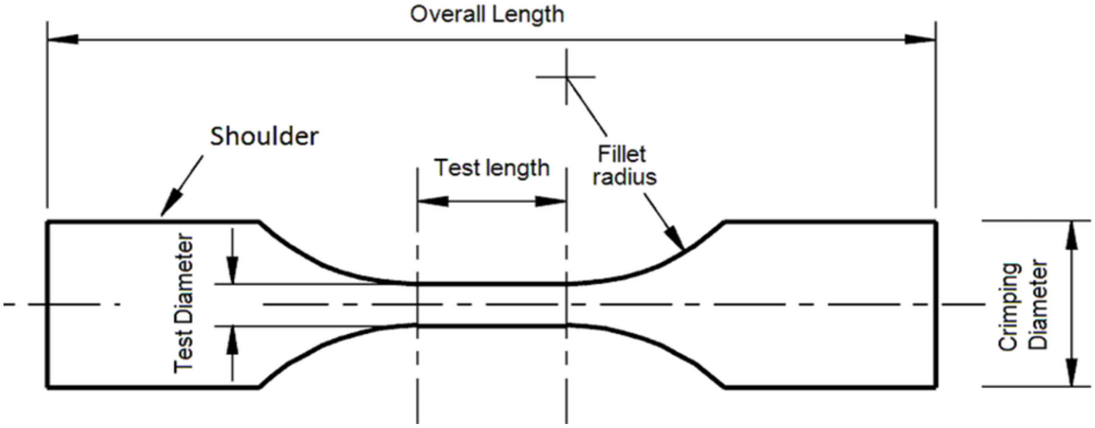

**Fig 3.1.2 Tensile test specimen**

## Tensile Strength

Plastic deformation can occur under tensile, compressive or torsional loads. A typical tensile stress-strain curve is shown below. The applied load is plotted against the elongation or extension of the test specimen. The applied load P divided by the initial cross-sectional area $A_o$ of the specimen gives the engineering stress:

Engineering stress = $P / A_o$

Engineering strain is given by the fractional increase in the gauge length $l_o$;

Engineering strain = $\Delta l / l_o$

Where, $\Delta l$ is the increase in gauge length.

The deformation of the specimen is elastic up to the yield point, beyond which it becomes plastic. The load at the yield point divided by the initial cross-sectional area of the test specimen is called ***yield stress*** or ***yield strength*** of a material. Mild steel exhibits a clearly defined yield point, but a number of other materials do not have a clear demarcation between the elastic and the plastic regions.

Beyond the yield point, the linear elastic region is followed by a non-linear plastic region. In this region, the load required to cause further deformation increase with increasing strain. This phenomenon is called ***work hardening***. The slope of the load-elongation curve decreases, as the elongation increase. It becomes zero at some maximum load. The engineering stress corresponding to the maximum load is called the ***ultimate tensile strength*** (UTS) of the material. Beyond this maximum a neck forms in the middle of the specimen, where the cross-sectional area locally decreases. The applied load decreases up to the point of fracture, where the specimen breaks into two pieces across the reduced cross-section of the neck.

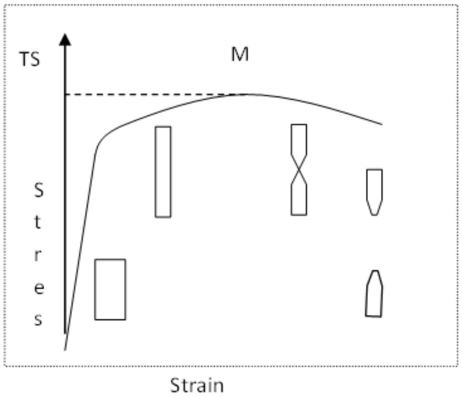

*Fig3.1.3 The tensile load-elongation curve*

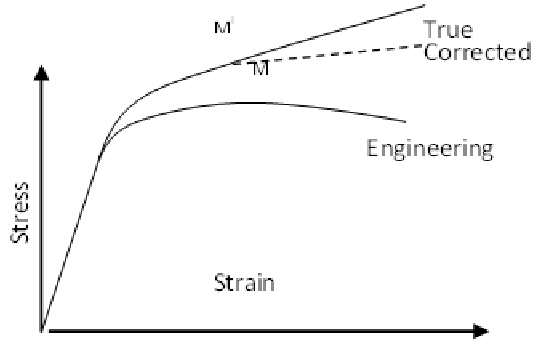

***Fig.3.1.4Stress-Strain curve***

It is observed from the above figure, that after the necking point, the strength of the deformed portion becomes weaker. The strength is calculated by load divided by original cross-section area. In the real sense, it is the reverse, after necking that portion becomes stronger. Since the cross-section area decreases rapidly after necking, the True stress is calculated as the applied load divided by the instantaneous cross-sectional area. i.e.,

$$\text{True stress } \sigma_T = \frac{P}{A_i} \text{ and True strain } \varepsilon_T = \ln \frac{l_i}{l_o}$$

When the deformation of the specimen becomes non uniform after necking starts the true strain becomes a function of the length over which it is measured. In order to avoid ambiguity, it is specified as the integral of – dA /A, where, A is the cross-sectional area at the neck. The true stress-true strain curve is plotted and unlike the load-elongation curve, there is no maximum. The slope in the plastic region decreases with increasing strain, but does not become zero before fracture. This indicates that there is not work hardens continuously till fracture, although at a decreasing rate.