TENSILE TEST

Object:
To determine the mechanical properties of metals under tensile load.

Theory:
Tension test is a very common and useful means of determining important mechanical properties of engineering materials. It's very useful and important for design and forming of metals.
In tensile test a uniaxial tensile load is applied slowly to standard specimen until a failure occurs this can be down by gripping the end of specimen in a tensile test machine where the specimen elongate in the same direction as the applied load. The test conducted at the room temperature.
The specimen used in a tensile test is flat specimen with effective original length L_o, width w and thickness t as shown in figure (1)

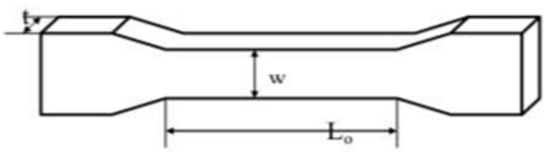

Fig. (1)

From the load and elongation results obtained the engineering stress and engineering strains from:

$$\sigma = \frac{F}{A_o}$$

F: load (N).
A_o: original cross section area (A_o=w.t).
While the engineering strain e is :

$$e = \frac{\Delta L}{L_o}$$

$\Delta L = L_c - L_o$
ΔL :deflection of specimen.
L_c:current length.

The stress strain relation is as shown in figure (2):
Curve (a) represents the ferrous alloys; curve (b) represents the non-ferrous alloys while curves (c) and (d) represent the brittle metals.
Curve (a) is the general case through the zone OB is found that OA has a linear stress strain relation till point A. after that the relation would be nonlinear. The limit A is called ***proportional limit*** and by increasing the load the strain rate will increases grater than the

increasing in the stress rate till point B which is called ***upper yield point*** or ***the elastic limit***. The stress in point B is called ***yield stress*** and the metal return to its original shape when carried by stress before point B.

Zone BC:
The strain rate increased with decreasing the stress rate and the yielding continuous in this zone, which is called the critical zone or initial plastic deformation zone.

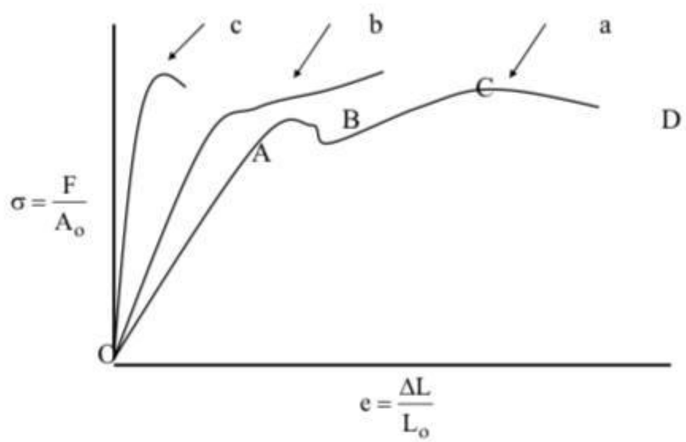

Fig. (2)

Zone CD:
After point C the metal will be strain hardened and resist the increasing in load duo to increasing the energy in the grain boundary and slip planes, which increased with load increasing. Point C called ***lower yield point***. The increasing in strain rate is grater than that in stress rate till point D, which is called ultimate tensile stress. After point D the strain rate will be increased with decreasing in stress rate. The reason of that is that the ***cracks*** will be take place, which cannot be seen by eyes. After point D the ***necking*** will takes place.

Zone DE:
With cracks and necking occurs the specimen starts to fail and broken takes place at point E.

The true stress and true strain can be calculated as:
True stress σ_t $\sigma_t = F/A_c$
A_c :current area
True strain ε $\varepsilon = \ln (L_c/L_o)$
To calculate L_c and A_c follow that
From volume constancy $V_c = V_o$
Where V_c and V_o are the original and current volumes respectively
$A_o L_o = A_c L_c$
$L_c = L_o + \Delta L$
$A_c = A_o L_o / L_c$

Apparatus used:

Tensile testing machine figure (4)

1 clamp
2 specimen
3 elongation gauge
4 load gauge
5 sensor (elongation)
6 release(load)
7 power

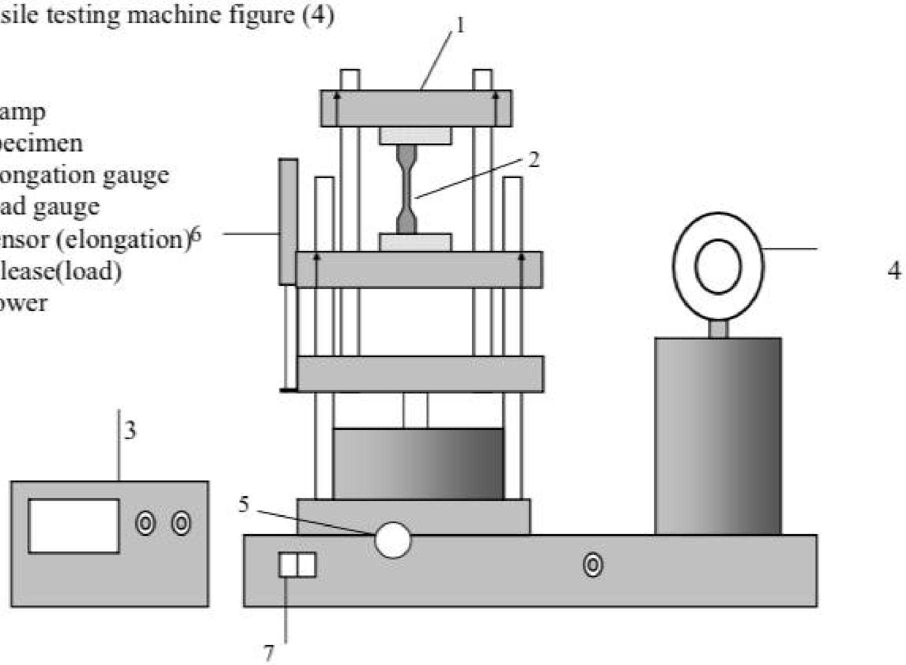

Fig. (4)

Test procedure:

1. Fixing the specimen between the clamps.
2. Switch on the machine for period without rate.
3. Reset the elongation and load gauge.
4. Give slow and constant strain rate.
5. Record the elongation and its effective load.
6. Shut down the machine after broken.

Calculations and Results:

Tabulate the calculations as in table 1

Load F(N)	Elongation ΔL(mm)	Engineering Stress N/mm^2 $\sigma = F/A_o$	Engineering Strain(mm) $e = \Delta L/L_o$	Current Length (mm) $L_c = L_o + \Delta L$	Current area mm^2 $A_c = A_o L_o / L_c$	True Stress N/mm^2 $\sigma_t = F/A_c$	True Strain $\varepsilon = \ln(L_c/L_o)$

And from the plotting the engineering stress strain curve can be conclude, Young modulus (modulus of elasticity) E (N/mm^2); slope of stress strain curve in its linear zone

$E = \Delta\sigma/\Delta e$

Yielding stress $\sigma_y = F_y/A_o$

Ultimate tensile stress $\sigma_{ult} = F_{max}/A_o$

Fracture stress $\sigma_F = F_F/A_o$

Ductility which is determine by two parameters

1. Percentage elongation $eL\% = (L_F - L_o)/L_o \quad *100\%$
2. Percentage reduction in area $eA\% = (A_o - A_F)/A_o \quad *100\%$

Where L_F and A_F are final length and area respectively.

Discussion:

1. Discuss the results and compare between the engineering stress strain and true stress strain.
2. Give the reasons for necking and strain hardening.
3. Discuss any source of error in the experiment.