Lecture No. Ten: Test (Cont.'d

Time: 2 Hours

Impact test

Impact tests may be performed for two purposes:

1. to determine the ability of the material to resist impact under service conditions.
2. to determine weather a metal has resistance to failure due to brittleness under service conditions in a machine or structure.

Impact tests may be classified into two groups:

1. Utility impact tests:

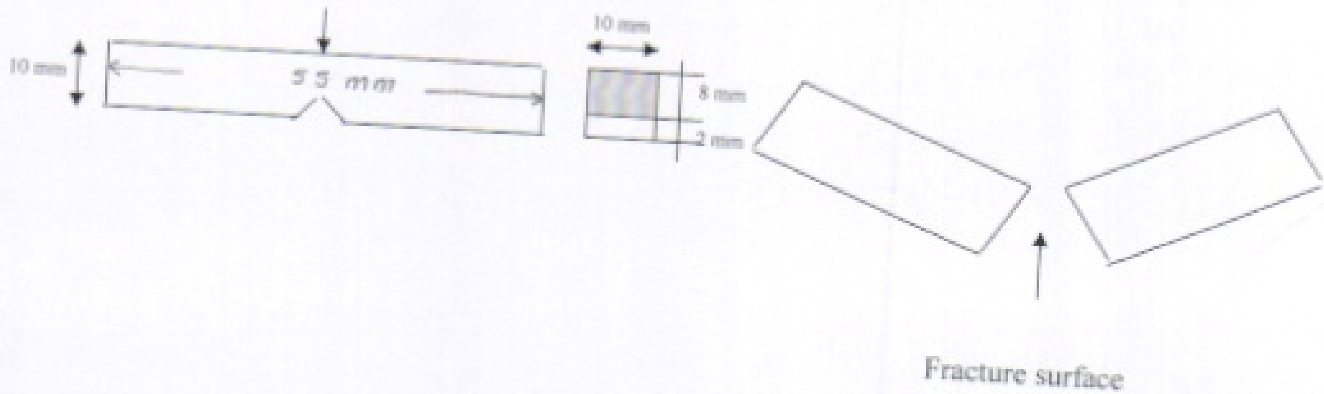
Utility impact tests for detecting the presence of brittleness or determining the comparative toughness of material are applied to steel rails, pipes, as well as to non-metal materials such as concrete, stone, wood …etc.

2. Standard impact tests:

The charpy and Izod impact testing machines are the two most common machines for conducting standard impact tests on metals. These machines determine the amount of work necessary to fracture a small test specimen by impact. They consist essentially of a weighted pendulum, suitable holders or supports for the specimen, and a device for recording the angular swing of the pendulum.

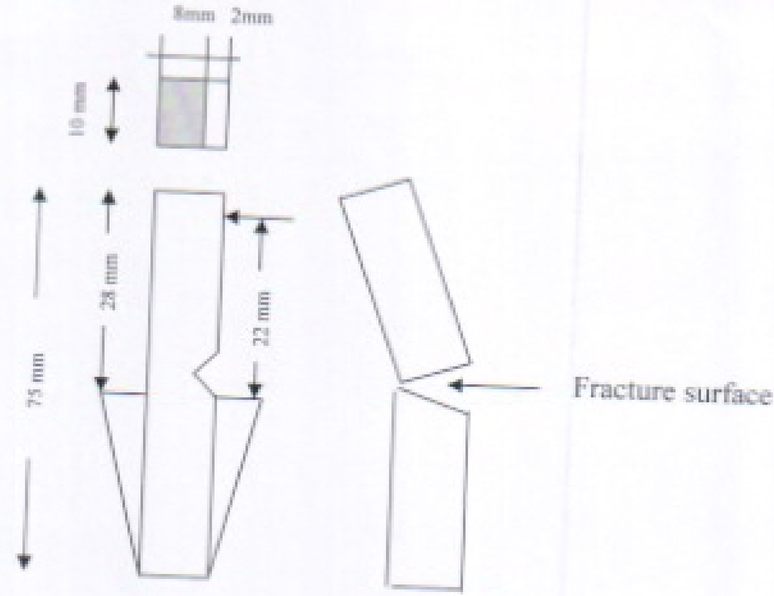
Charpy method

This method is well adapted for examining metals that break with a relatively low absorption of energy. The presence of notch eliminates the influence of surface effects.



Izod method

For tough metals the notched Izod type of specimen tested as a cantilever is used. For extremely brittle metal that test specimen requires no notched, because the first suddenly applied stress causes a brittle failure.



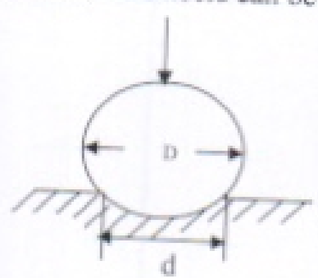
Hardness

Hardness is resistance to plastic deformation. Thus a hard material may have a high elastic limit. Other meanings are given to term, however, such as resistance (1) to abrasion, (2) to scratching, or (3) to indentation of a cone or ball.

Hardness of metals is determined by measuring the resistance to penetration of a ball, cone, or pyramid.

The brinell method is based upon determining the resistance offered to indentation by a hardened sphere that is subjected to a given pressure. The pressure used in testing steel is 3000 kg and a diameter of the ball is 10mm. When softer materials a pressure of 500 kg is used. Brinell numbers can be computed by the formula:

$$BHN = 2P/\pi D(D-\sqrt{(D^2 - d^2}\ )$$



Where P- pressure in kg
D- Diameter of the ball
d- Diameter of the impression, mm

The harder the steel, the smaller the indentation under the load and the greater the BHN.

Lecture No. Eleven: Creep and Fatigue

Time: 2 Hours

Creep

We have discussed the mechanical properties of materials on room temperature. Many structures, particularly these associated with energy conversion, like turbines, reactors, steam and chemical plant operate at much higher temperature.

As the temperature is raised, materials under loads continuous deformation with time, i.e. start to creep, the strain instead of depending only on the stress, now depends on temperature and time also.

$$\epsilon = f(S, t, T)$$

The temperature at which materials start to creep depends on their melting point. As a general rule, it is found that creep starts when:

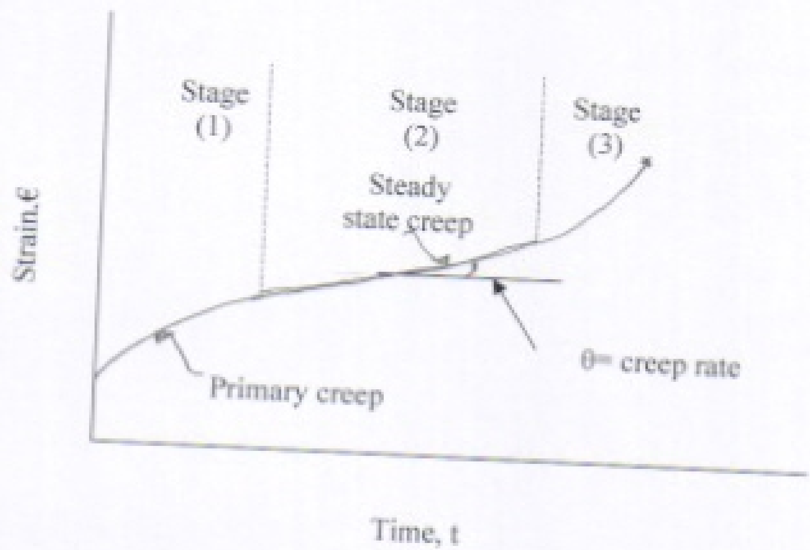
T > 0.3-0.4 Tm for metals

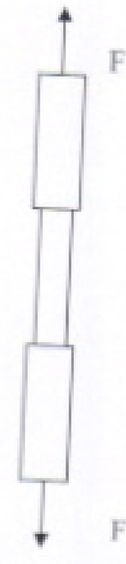
T > 0.4-0.5 Tm for ceramic

Where Tm – the melting temperature in degree Kelvin

Creep testing and creep curves:

Creep tests require careful temperature control. Typically, a specimen is loaded in tension or compression usually at constant load, inside a furnace which is maintained at a constant temperature, T- The tension is measured as a function of time. Fig. below shows a typical set of results from such a test. Metals polymers, and ceramic, all show creep curves of this general shape.





Creep occurs in three stages:

Stage 1 – Primary creep stage

Consist of a short part during which strain increases rapidly

Stage 2 – Secondary creep stage

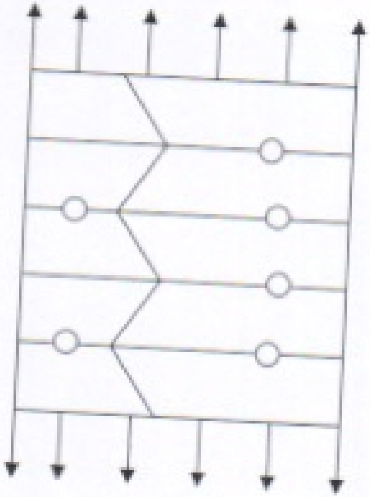
Consist of a long period where the rate is much slower and constant

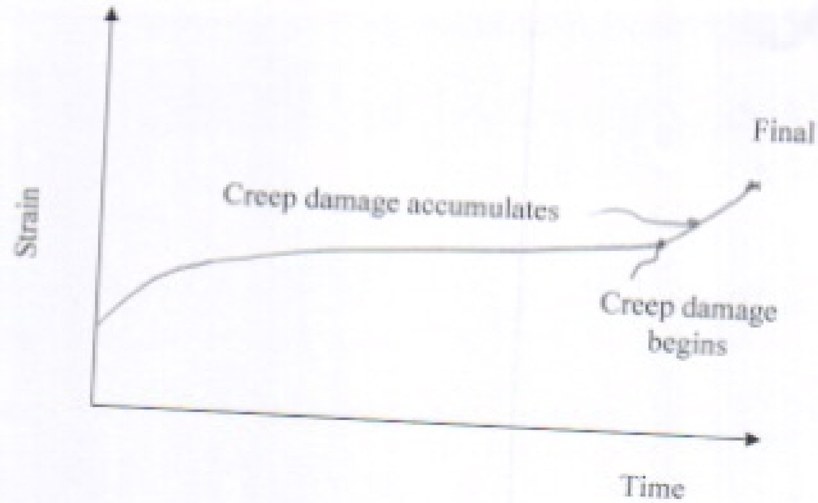
Stage 3 – Tertiary creep stage

At this stage the creep rate increases and the material fractures

Creep damage and creep fracture:

During creep, damage, in the form of internal cavities, accumulates. The damage first appears at the start of the tertiary stage of the creep curve reflects this as the holes grows. The section of the sample decreases and (at constant load) the strains goes up and the creep rate goes up even faster than the stress does.





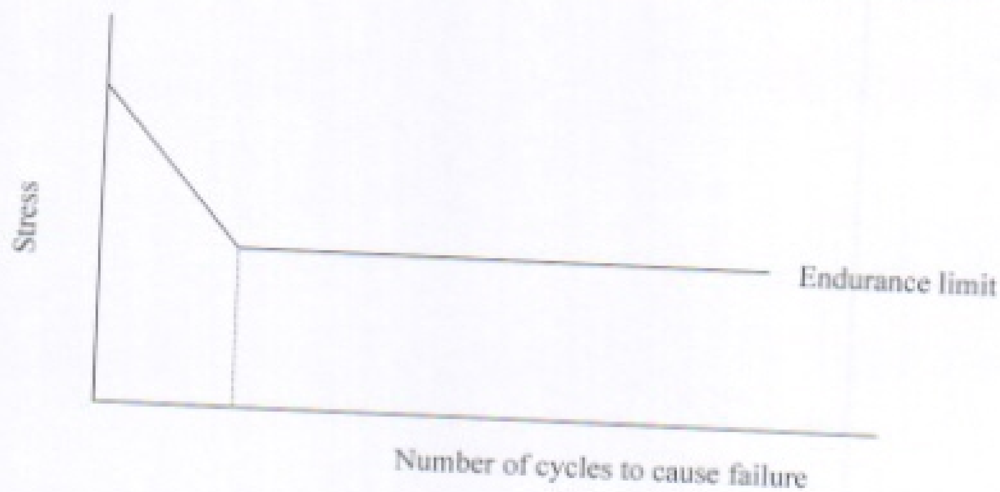
In high temperature design it is important to make sure:

a. That the creep strain during the design life is acceptable.
b. That the creep strain at failure is adequate to cope with the acceptable creep strain.
c. That the time to failure, at the design loads and temperatures is longer (by a suitable factor) than the design life.

Fatigue strength

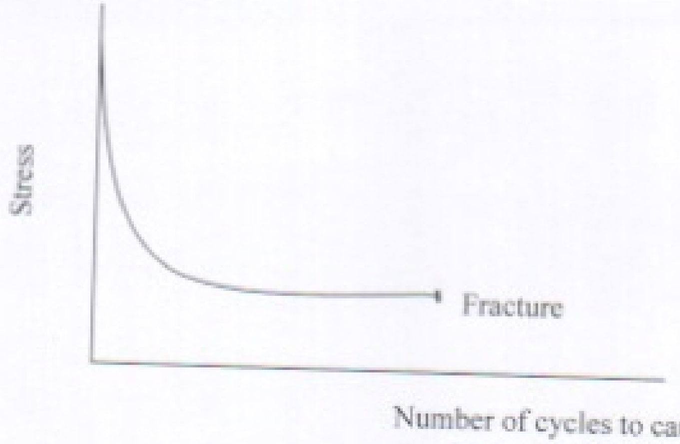
We have considered so far only the strength of material under static loading. In many structures, repeated loading is applied, and when a material fails under a number of repeated loads, each smaller than the ultimate strength, failure in fatigue is said to take place.

The results of fatigue test are represented by a relationship between stress and number of cycles to failure.

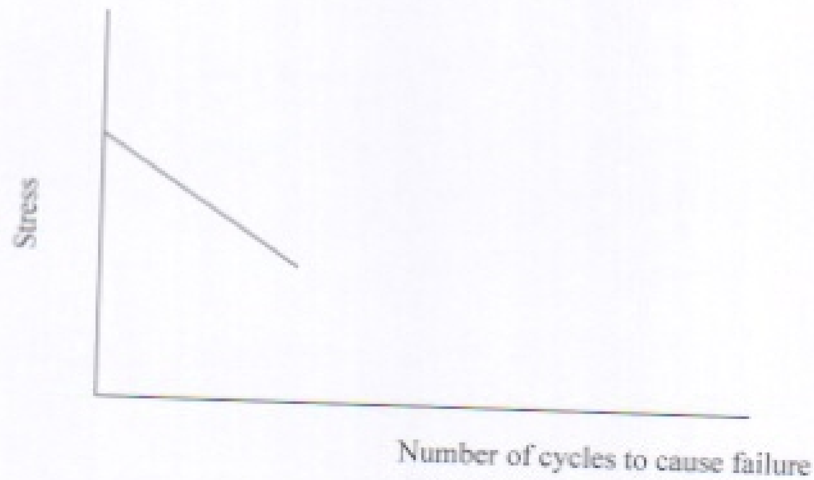


S-N diagram for ferrous metals

At the beginning the stress decreases as the number of cycles increases. After several million cycles the curve becomes horizontal line whose stress value is known as the endurance limit. While almost all ferrous materials exhibit an endurance limit, most nonferrous alloys do not.



S-N diagram for nonferrous metals



S-N diagram for concrete materials

Endurance limit:

The stress below which a material can withstand an indefinitely large number of repetition of stress without failure.

Fatigue strength:

The stress which exceed the endurance limit and at which failure may occur after indefinite number of repeated cycles.

Fatigue failure:

Fatigue failure appears to begin with a crack at a point of weakness in the material, with the crack. Progressing long crystal boundaries. During the stress cycle, these small cracks open and close. The cracks cause highest stress at the base of the crack as compared to the stress if there is no crack. Under this repeated concentration of stress, the cracks will gradually extend a cross the section of the member, finally causing complete failure of the member.