LECTURE # 2

In this lecture you will learn about:

Material Testing

Destructive Testing

- Tensile Test
- Compression Test
- Shear Loads Test
- Hardness Test
- Impact Test
- Fatigue Test
- Creep Test

Course Name:

"Material Testing, Repair & Maintenance"

Course Code: CT-245

Credit Hours: 3

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MATERIALS TESTING

- Mechanical properties are obtained by mechanical testing.

- Mechanical testing is used for developing design data, maintaining quality control, assisting in alloy development programs and providing data in failure analysis.

- Mechanical testing is usually destructive and requires test specimens of the material to be machined or cut to the specific shape required by the test method.

MECHANICAL PROPERTIES

- Describe material when a force is applied to it.
- Determined through testing, usually involving destruction of material.
- Extremely important to consider in design.

MATERIALS TESTING

Two types of materials testing:

a) **DESTRUCTIVE TEST**

Results in the part being destroyed during the quality control testing program.

b) **NON DESTRUCTIVE TEST**

Is done in such a manner that the usefulness of the product or part is not damaged or destroyed.

DESTRUCTIVE TEST

Tensile Test

Compression Test

Shear Loads Test

Hardness Test

- Brinell test
- Vickers test
- Rockwell test

Impact test

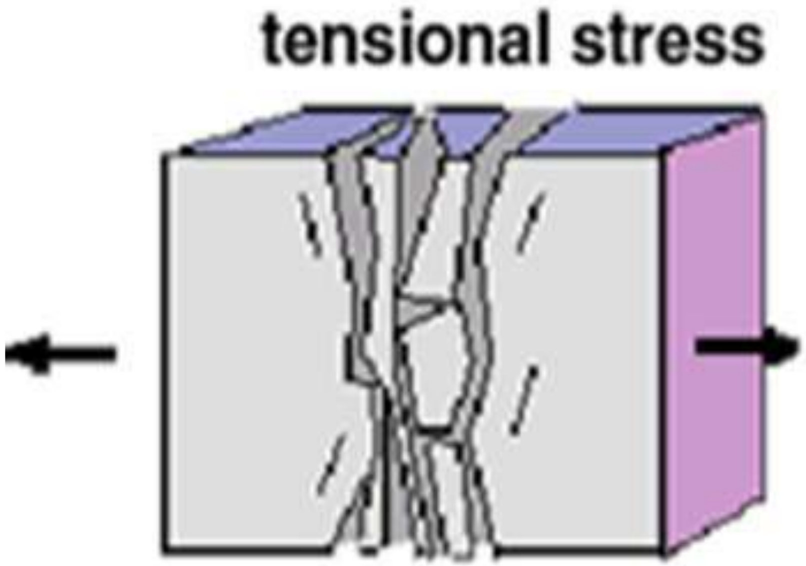
- Izod Test
- Charpy Test

Fatigue Test

Creep Test

TENSILE TEST

- The tensile test is a common test performed on metals, wood, plastics, and most other materials.
- Tensile loads are those that tend to pull the specimen apart, putting the specimen in tension. They can be performed on any specimen of known cross-sectional area and gage length to which a uniform tensile load can be applied.
- Tensile tests are used to determine the mechanical behaviour of materials under static, axial tensile, or stretch loading.



IMPORTANT MECHANICAL PROPERTIES

- Yield strength
- Tensile strength
- Modulus of Elasticity (E)
- Ductility

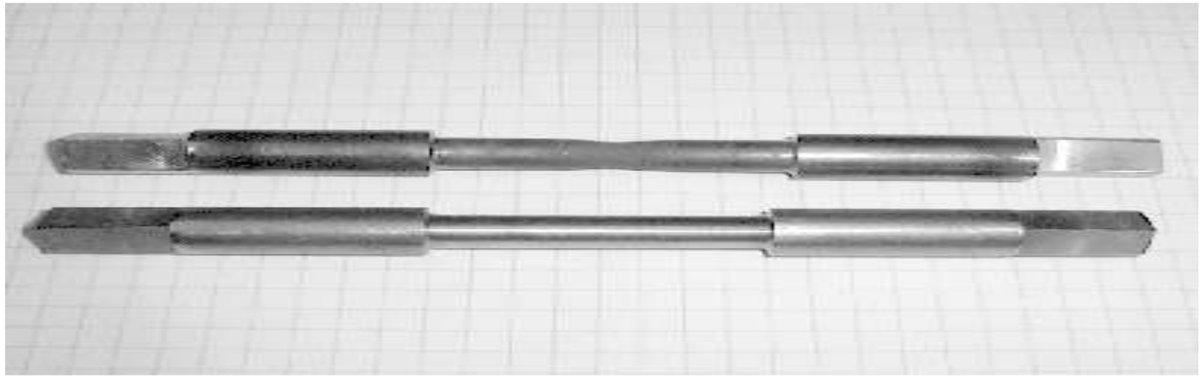
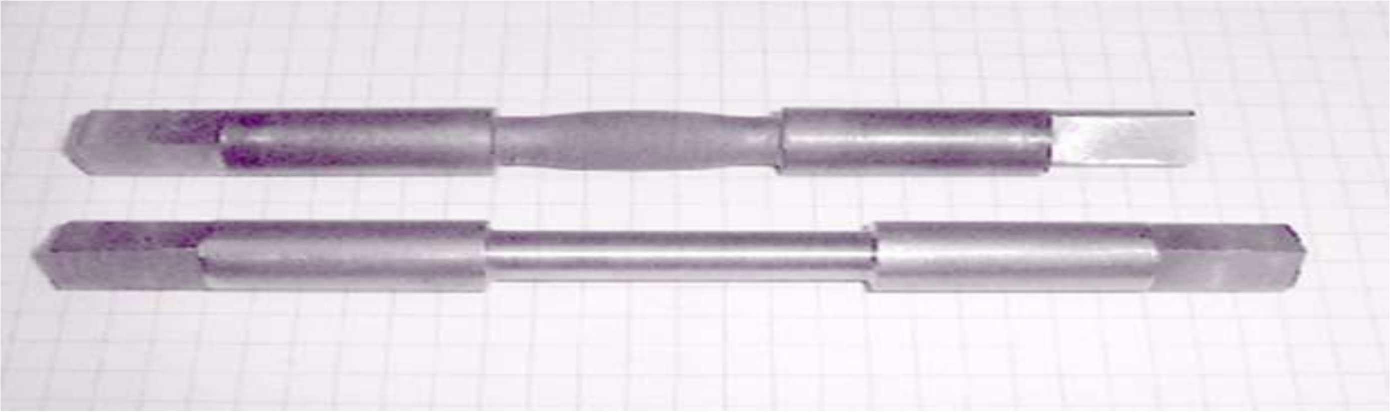
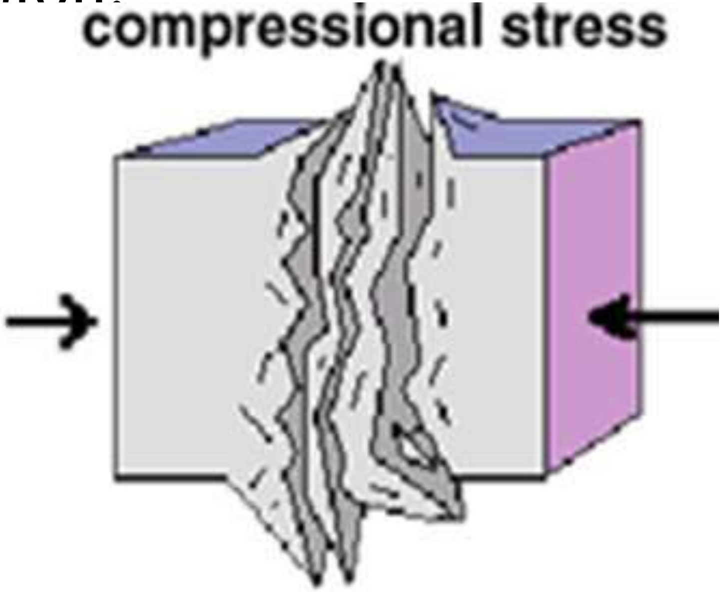


Figure 4: Necking in a tensile specimen.

COMPRESSION TESTING

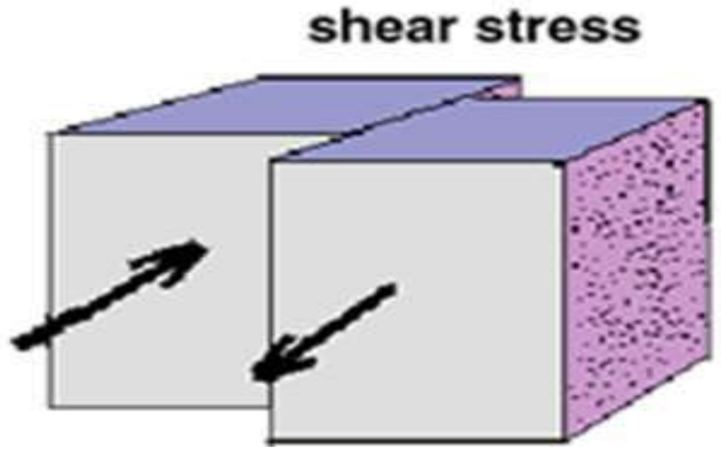
- Compression testing is the opposite of tensile testing. A compressive load tends to squeeze or compact the specimen.
- Materials, such as concrete, brick, and some ceramic products, are more often used in applications for their compressive loading properties and are, therefore, tested in compression.





SHEAR LOAD TEST

- Shear testing involves an applied force or load that acts in a direction parallel to the plane in which the load is applied.
- Shear stress is a stress state where the shape of a material tends to change without particular volume change.
- The stresses required to produce fracture in the plane of cross sectional, acted on by the shear force is called shear strength.

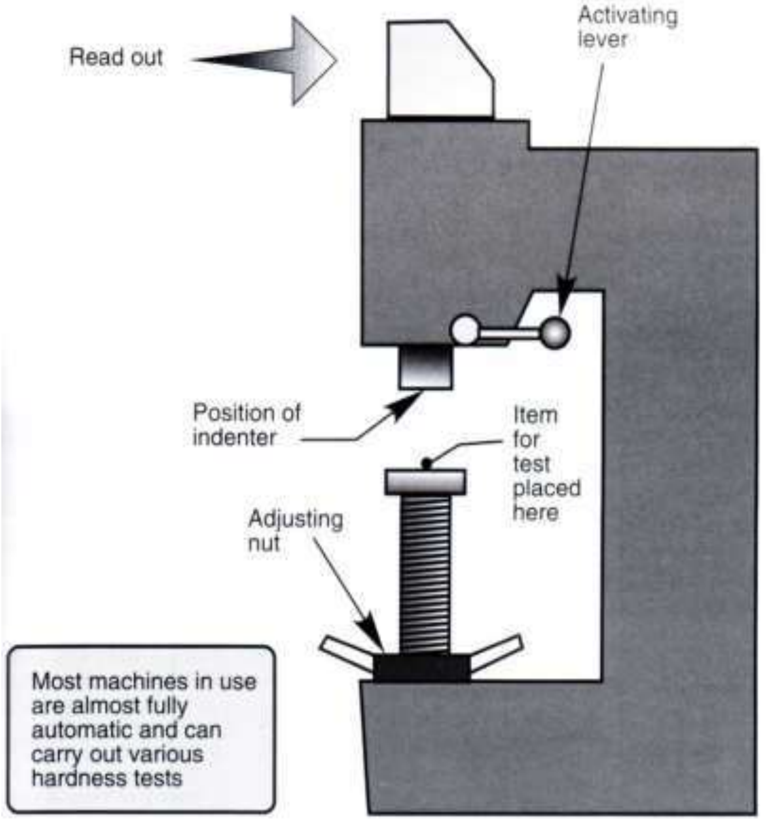


HARDNESS TESTING

Hardness is the ability to withstand indentation or scratches

These consist mainly 3-types of test:

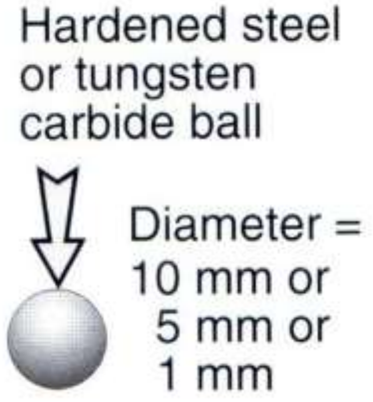
- Brinell hardness test
- Rockwell hardness test
- Vickers hardness test



BRINELL TEST

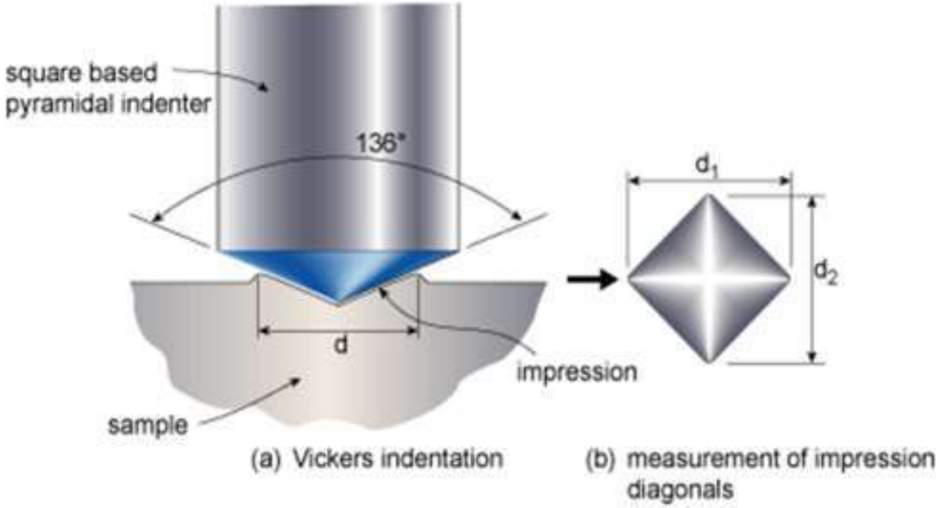
- Uses ball shaped indenter.
- Ball may deform on very hard materials
- Cannot be used for thin materials.
- Surface area of indentation is measured.
- ASTM and ISO use the HB value. It can be HBS (Hardness, Brinell, Steel) or the HBW (Hardness, Brinell, Tungsten)

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



VICKERS HARDNESS TEST

- Uses square shaped pyramid indentor.
- Accurate results.
- Measures length of diagonal on indentation.
- Usually used on very hard materials.



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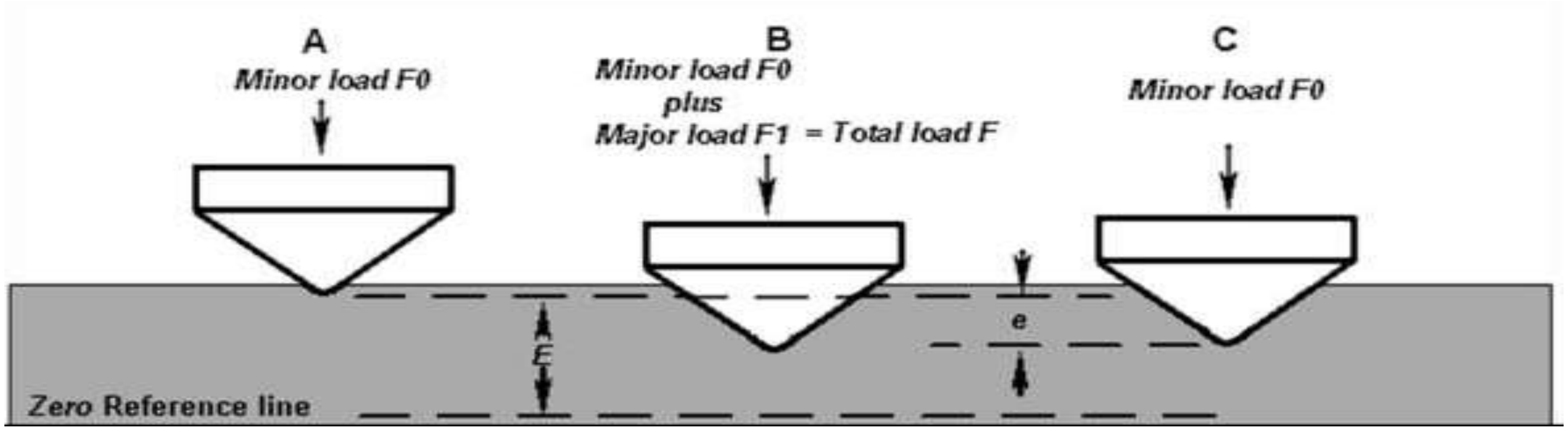
ROCKWELL HARDNESS TESTS

- The Rockwell hardness test relies on a specified load and the size of the indentation or penetration made to determine the hardness value.
- Rockwell hardness tests involve selecting the magnitude of the load to apply based on the suspected hardness of the specimen.
- Rockwell B (ball) used for soft materials.
- Rockwell C (cone) uses diamond cone for hard materials.
- Flexible, quick and easy to use.
- Give reading directly.

ROCKWELL HARDNESS TEST



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IMPACT TESTS

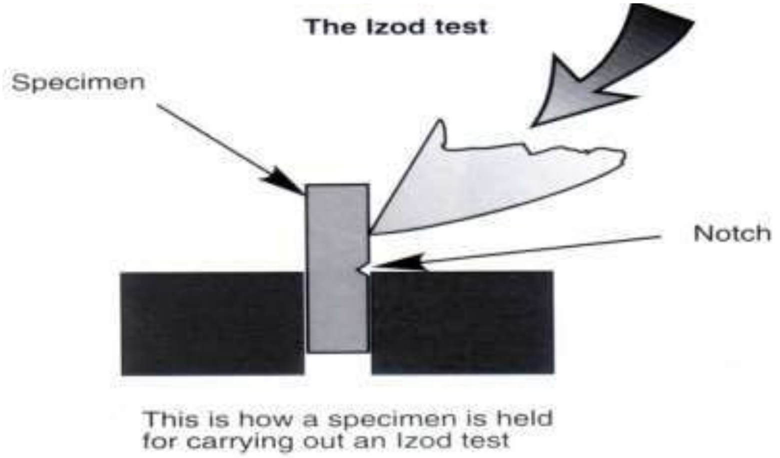
- Toughness of metals is the ability to withstand impact.
- Impact tests generally involve sudden shock loading that results in breakage of the specimen.
- The result is calculated based on the energy required to break the specimen band the resultant loss of momentum.
- This can be calculated if one knows the initial energy and final energy or the initial angle and final angle of the object used to break the specimen.

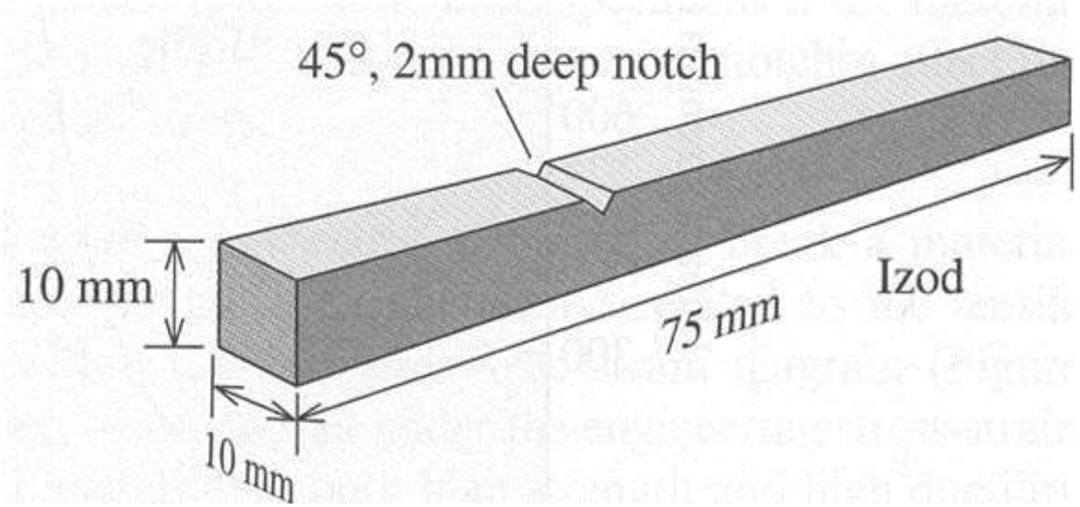
It can be measure in two way:

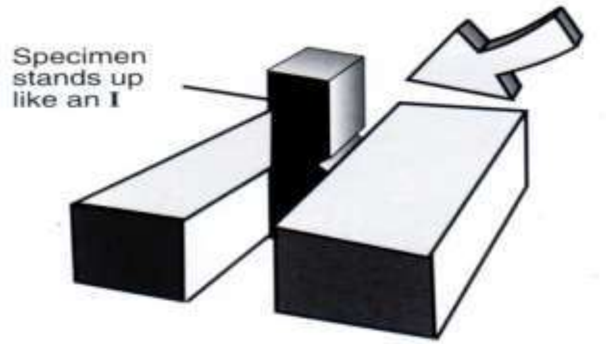
- Izod test
- Charpy test

IZOD TEST

- Izod test is different from the Charpy test in terms of the configuration of the notched test specimen
- Test specimen is held vertically.
- Notch faces striker



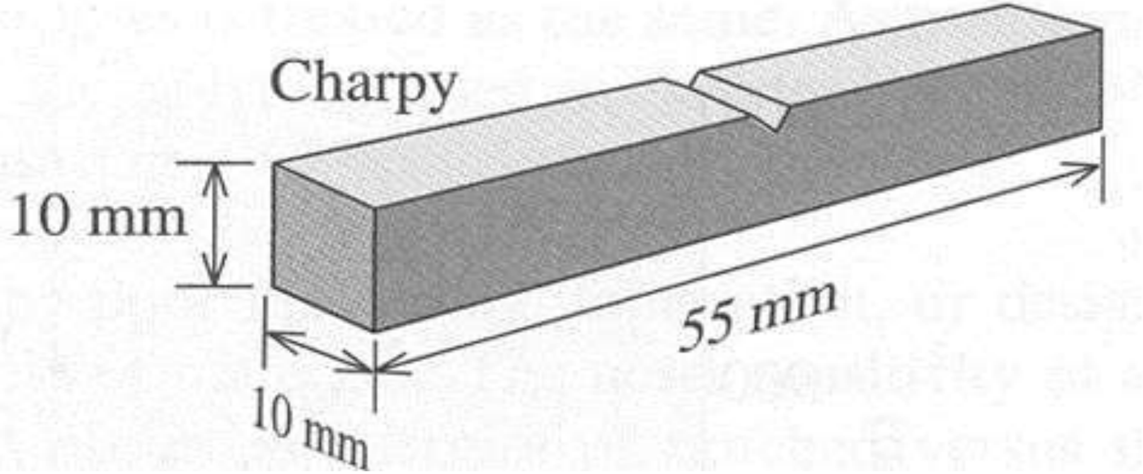


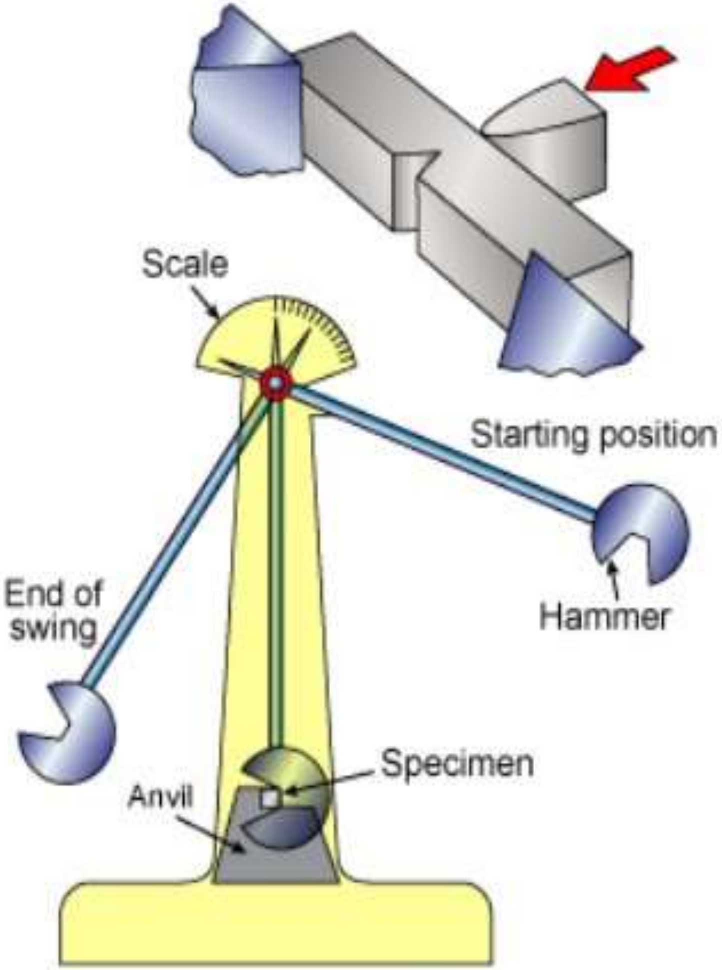


CHARPY TEST

- The energy absorbed is the difference in height between initial and final position of the hammer.
- The material fractures at the notch and the structure of the cracked surface will help indicate whether it was a brittle or ductile fracture.
- In effect, the Charpy test takes the tensile test to completion very rapidly.
- The impact energy from the Charpy test correlates with the area under the total stressstrain curve (toughness)

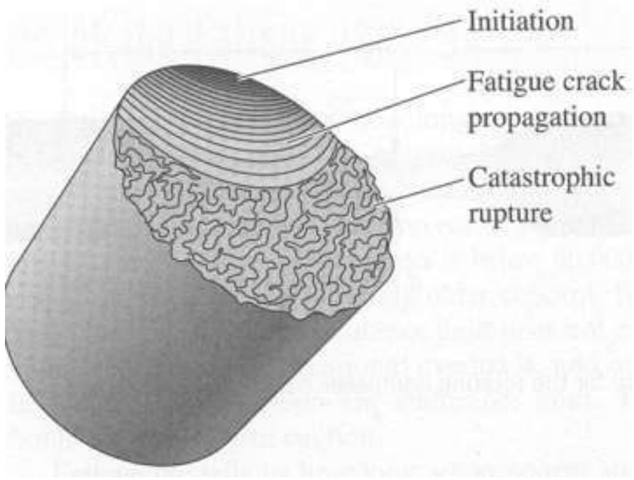
CHARPY TEST


Charpy
10 mm
55 mm
10 mm


Scale
Starting position
End of swing
Hammer
Specimen
Anvil

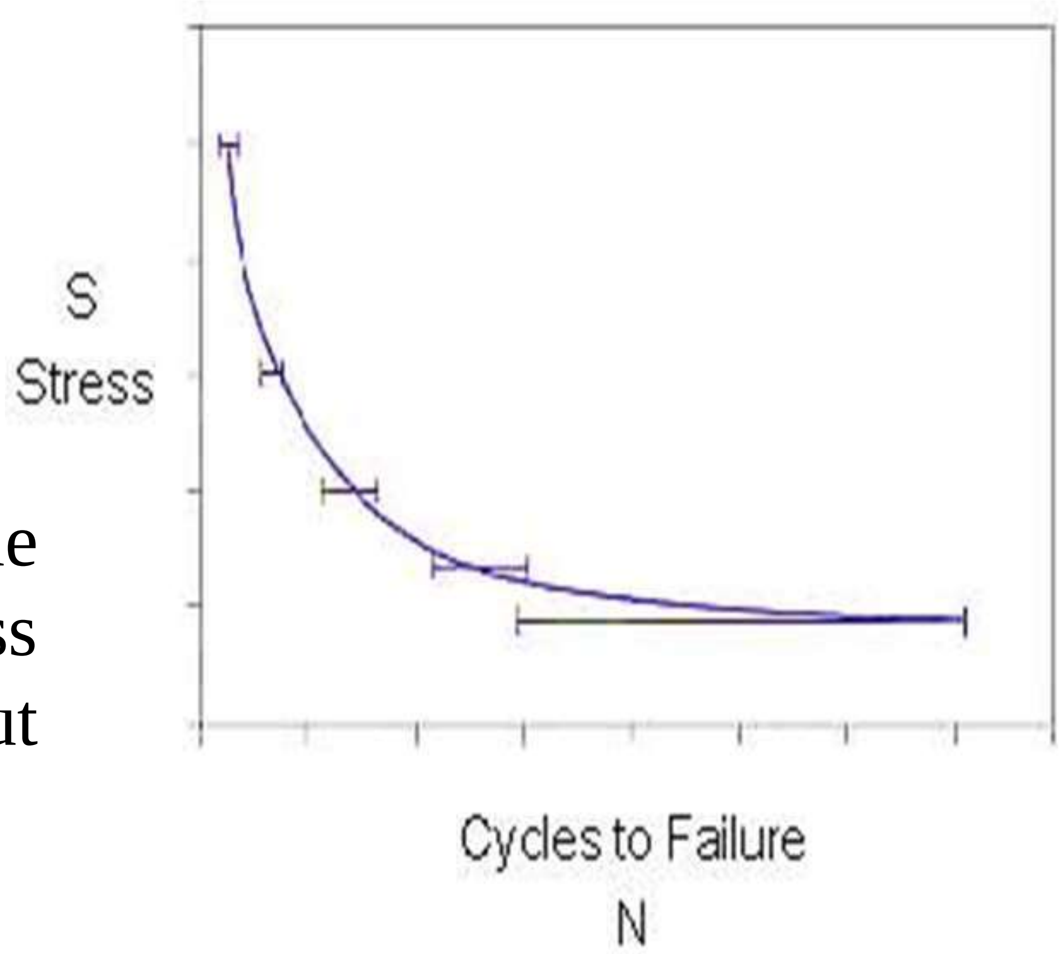
FATIGUE TEST

- Fatigue is due to the repeated loading and unloading.
- When a material is subjected to a force acting in different directions at different times it can cause cracking.
- This causes the material to fail at a load that is much less than its tensile strength, this is fatigue failure.



TYPES OF STRESSES FOR FATIGUE TESTS

- Axial (tension – compression)
- Flexural (bending)
- Torsional (twisting)



The greater the number of cycles in the loading history, the smaller the stress that the material can withstand without failure.

CREEP TEST

- All materials under constant stress and temperature will exhibit an increase of strain with time called creep.
- Creep is strain with time at constant load and temperature (time dependent strain).
- Metals usually creep at temperature above 0.3 to 0.4 Tm, where Tm is the absolute melting temperature of the metal.
- For example, carbon steel starts creep above 500 0C and Aluminum above 100 ^{O}C

CREEP TEST

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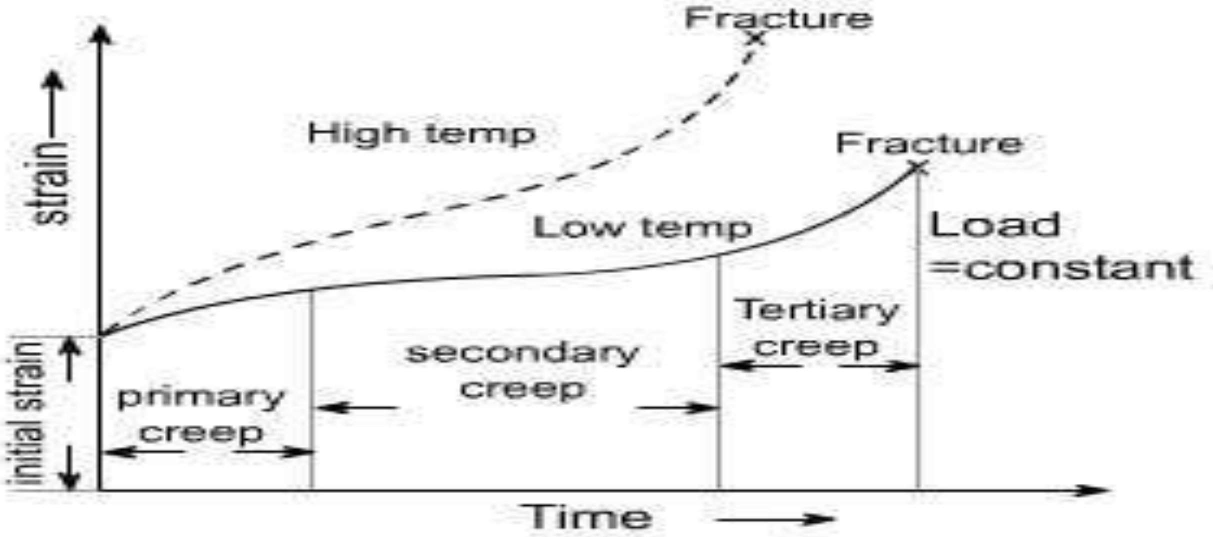
WHERE CREEP IS IMPORTANT

- When a metal is subjected to high temperature, the creep is an important design consideration.
- In many mechanical application, like turbine blades, boiler, reactors, engine, a designer must consider the creep.



[Typical creep curve]

Thank You