Aircraft Materials -2

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Resilience

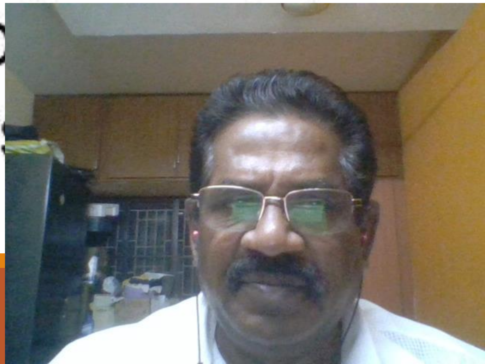
- Resilience is the property of materials by virtue of which it stores energy and resists shocks and impacts.
- The resilience of the material is measured by the amount of energy that can be stored per unit volume after it is stressed upto the elastic limit.

Endurance

- The endurance is the property of a material by virtue of which it can withstand varying stresses or repeated application of stress.
- It is important property in the design and production of parts in a reciprocating machine or components subjected to vibrations
- The endurance limit or fatigue strength is the maximum stress that can be applied for indefinitely large number of times without causing failure.
- The failure of a material under repeated loads is called fati
failure.

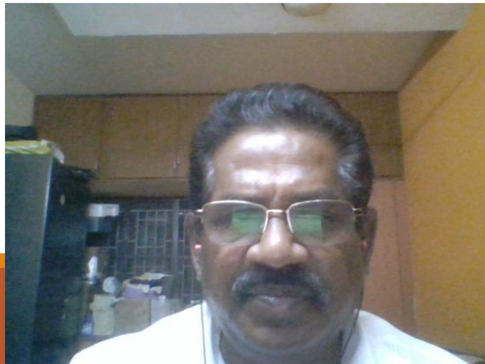
Strength

- It is the property of a material by virtue of which it resists or withstands the application of an external force or load without rupture.
- A metal has different types of strengths.
- Depending upon the value of stress, the strengths of a metal may be elastic or plastic.
- Depending upon the nature of stress, the strengths o may be tensile, compressive, shear, bending and tor



The Elastic Strength

- It is the value of stress or strength which corresponds to the transition from elastic range to plastic range.
- Thus, elastic limit is used to define the elastic strength of a material.



The Plastic Strength

- It is the value of stress or strength corresponding to plastic range and rupture, it is also called ultimate strength.
- Working stress is the greatest value of stress to which a material is subjected to as a machine part or a part of structure during operation or working.
- Normally working stress is kept below the elastic limit of a material.
- Safety factor = $\dfrac{\text{Ultimate Stress}}{\text{Working Stress}}$

Tensile Strength and Compressive Strength

- Tensile strength the maximum value of tensile stress, under a steady load, that a material can withstand before fracture or breaking.

$$\text{Tensile stress} = \frac{\text{Maximum Tensile Load}}{\text{Original cross-sectional area}}$$

- It is also called as ultimate tensile strength.
- Usually tensile strength of metals and alloys increases on cooling and decreases on heating.
- Compressive Strength of a material is the maximum value o compressive stress applied to break it off by crushing.
- Compressive stress = Maximum compressive

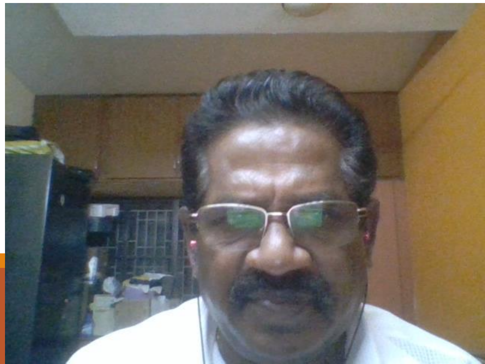
Shear Strength

- The shear strength of a material is the maximum value of tangential stress applied to shear it off across the resisting section.
- Shear stress = $$\frac{\text{Maximum tangential load}}{\text{Original cross sectional area}}$$
- When the application of an external force on a body tends to cause relative movement of the layers, shear stress results.

Bearing Strength and Torsional Strength

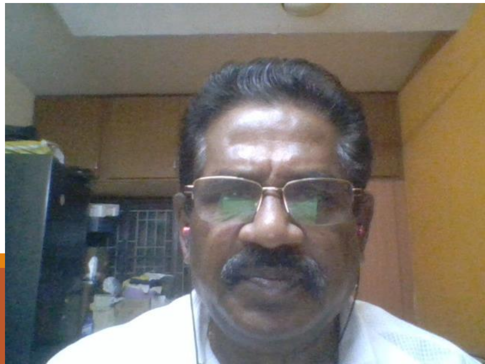
- Bending strength of a material is the maximum value of the bending stress applied to break it off by bending across the resisting section
- Bending stress = $\dfrac{\text{Maximum bending load}}{\text{Original cross-sectional area}}$
- Torsional strength of a material is the maximum value of stress applied to break it off by twisting across the resisting section.
- Torsional stress = $\dfrac{\text{Maximum twisting load}}{\text{Original cross-sectional area}}$

The twisting stress is torsion.



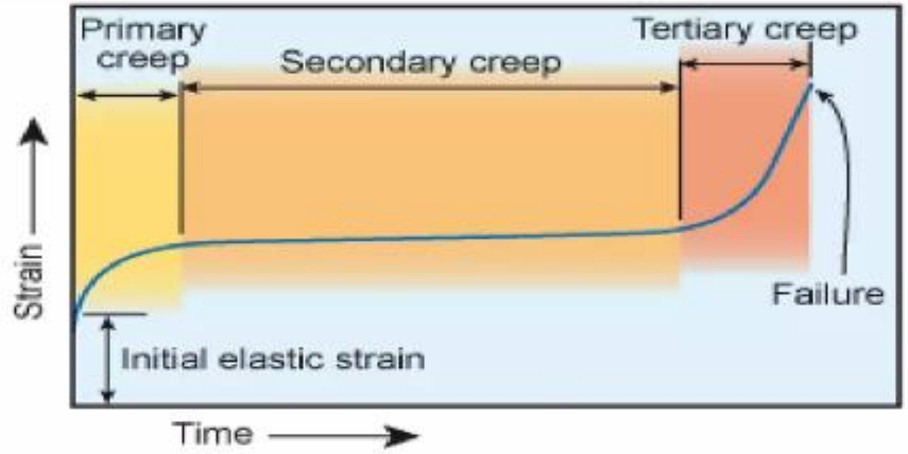
Creep

- It is defined as the tendency of a material to slowly deform permanently under the influence of stress
- This yielding (increase of strain without increase in load) may continue to the point of fracture.
- Rate of deformation depends on exposure time and temperature.
- Usually creep occurs at high temperatures.
- This property is exhibited by iron, nickel, copper and their alloys at elevated temperatures.
- But zinc, tin, lead and their alloys show creep at room temperature.



- In metals creep is a plastic deformation caused by slip occurring along crystallographic planes in the individual crystals together with some deformation of the grain boundary material.
- After complete release of load, a small fraction of this plastic deformation is recovered with time.
- Thus, most of the deformation is non-recoverable
- Creep limit is defined as the maximum static stress that will result in creep at a rate lower than some assigned rate at a given temperature

Stages of creep

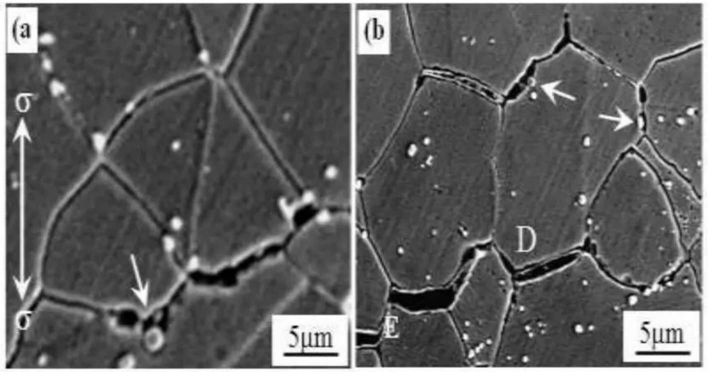


- In the initial stage, or primary creep, the strain rate is relatively high, but slows with increasing time. This is due to work hardening.
- The strain rate eventually reaches a minimum and becomes near constant. This is due to the balance between work hardening and annealing (thermal softening). This stage is known as secondary or steady-
- This stage is the most understood. The characterized "creep strain rate" typically refers to the rate in this secondary stage.
- Stress dependence of this rate depends on the creep mechanism.
- In tertiary creep, the strain rate exponentially increases with stress because of necking phenomena.
- Fracture always occur at the tertiary stage.
- Creep is a very important aspect of material science.

Types of fractures

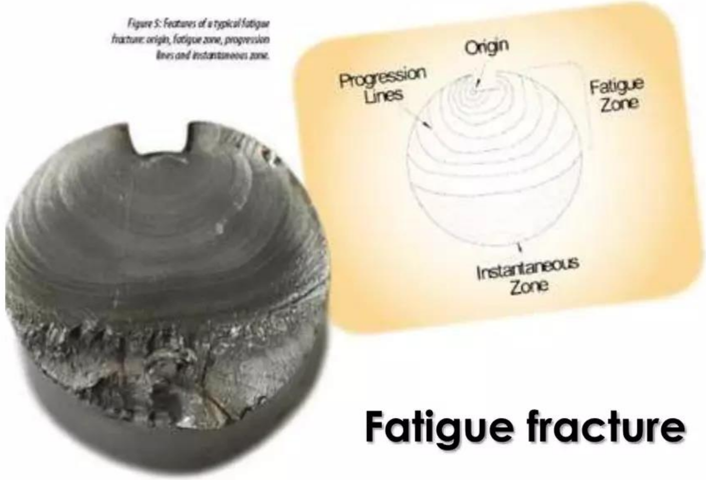
Brittle Fracture

Ductile Fracture



Creep fracture

Figure 5: Features of a typical fatigue fracture: origin, fatigue zone, progression lines and instantaneous zone.



Fatigue fracture