SNS COLLEGE OF TECHNOLOGY

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Coimbatore – 35

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DEPARTMENT OF AEROSPACE ENGINEERING

19ASO301 BASICS OF AERONAUTICAL ENGINEERING

UNIT 3 – AIRPLANE STRUCTURES AND MATERIALS

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- ***Components & Functions***
- ***Aircraft Materials***
- ***Mechanical Properties***
- ***Definition – Mechanical Properties***

TEXT BOOK

- ***Anderson. J D, "Introduction to Flight", McGraw-Hill, 1995***

- ***Richard S. Shevel, "fundamentals of Flight", Prentice Hall, 2010***

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 of a metal may be tensile, compressive, shear, bending, torsion.*

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 =*** $\dfrac{\boldsymbol{Ultimate\ Stress}}{\boldsymbol{Working\ Stress}}$

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*

$$\textbf{Tensile Stress} = \frac{\boldsymbol{Maximum\ tensile\ load}}{\boldsymbol{Original\ cross-sectional\ area}}$$

- *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 of compressive stress applied to break it off by crushing.*

Shear Strength

- *The shear strength of a material is the maximum value of tangential stress applied to shear it off across the resisting section.*
- $\textbf{Shear Stress} = \frac{\textbf{maximum tangential load}}{\textbf{Original cross sectional area}}$
- *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.*
- $$\textbf{Bending Stress} = \frac{\textbf{Maximum bending load}}{\textbf{Original cross -Sectional area}}$$
- *Torsional strength of a material is the maximum value of stress applied to break it off by twisting across the resisting section.*
- $$\textbf{Torsional Stress} = \frac{\textbf{Maximum twisting load}}{\textbf{Original cross -Sectional area}}$$
- *The twisting stress is torsion.*

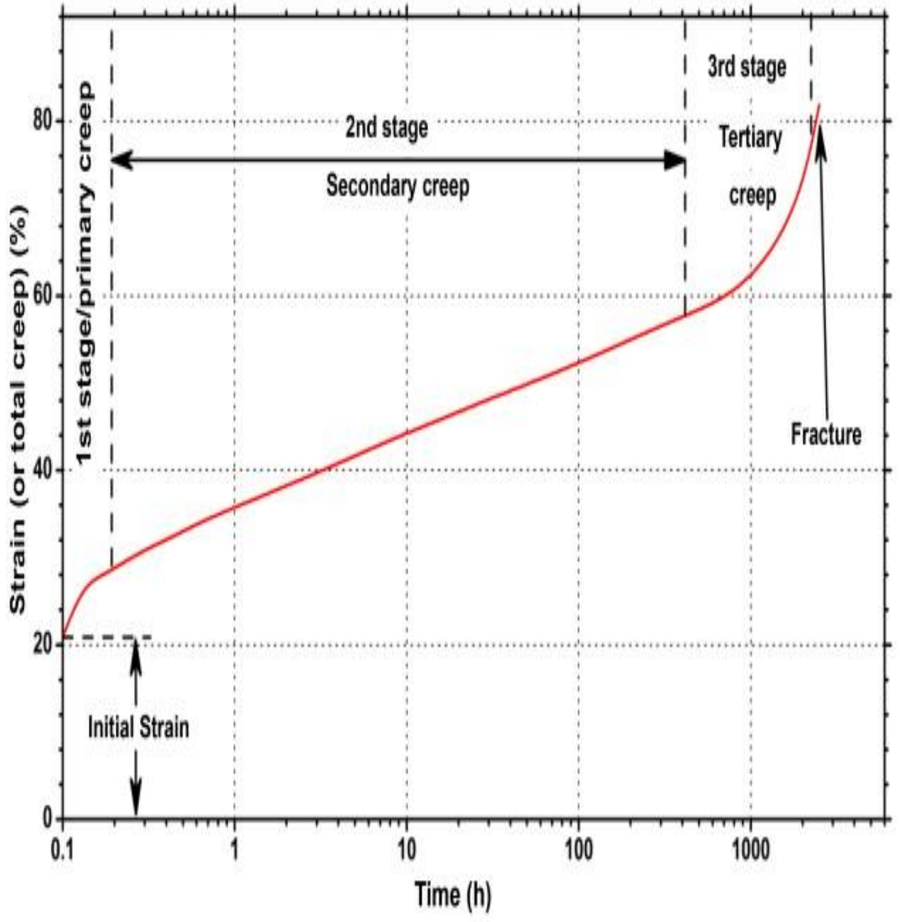
Creep

- *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.*

Creep

- *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.*

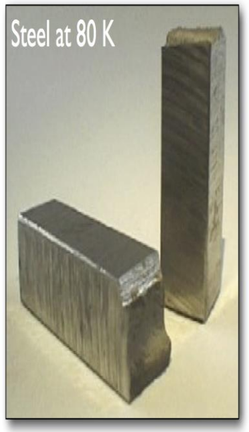
Stages of Creep



- *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 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.*

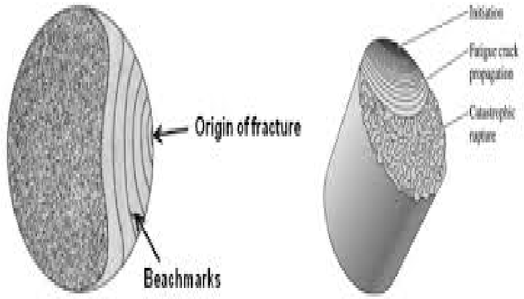
Types of Fractures

Brittle Fracture



Ductile Fracture

Fatigue Fracture



(a) Fatigue fracture with benchmark

(b) Fatigue crack initiation and propagation

Creep Fracture