For 2020 (IES, GATE & PSUs)

Strength of Materials

Contents

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Note

"Asked Objective Questions" is the total collection of questions from:-

28 yrs IES (2019-1992) [Engineering Service Examination]

28 yrs. GATE (2019-1992) [Mechanical Engineering]

16 yrs. GATE (2018-2003) [Civil Engineering]

and 14 yrs. IAS (Prelim.) [Civil Service Preliminary]

Every effort has been made to see that there are no errors (typographical or otherwise) in the material presented. However, it is still possible that there are a few errors (serious or otherwise). I would be thankful to the readers if they are brought to my attention at the following e-mail address: swapan_mondal_01@yahoo.co.in

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1. Stress and Strain

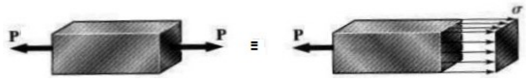
Theory at a Glance (for IES, GATE, PSU)

1.1 Stress (σ)

When a material is subjected to an external force, a resisting force is set up within the component. The internal resistanceforce per unit area acting on a material or intensity of the forces distributed over a given section is called the stress at a point.

- It uses original cross section area of the specimen and also known as engineering stress or conventional stress.

  Therefore, $\sigma = \frac{P}{A}$



- *P is* expressed in *Newton*(N) and *A,* original area,in square meters (m^2), the stress σ will be expresses in N/ m^2. This unit is called *Pascal (Pa).*
- As *Pascal* is a small quantity, in practice, multiples of this unit is used.

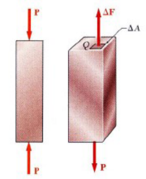
  1 kPa = 10^3 Pa = 10^3 N/ m^2 (kPa = Kilo Pascal)

  1 MPa = 10^6 Pa = 10^6 N/ m^2 = 1 N/mm^2 (MPa = Mega Pascal)

  1 GPa = 10^9 Pa = 10^9 N/ m^2 (GPa = Giga Pascal)

Let us take an example: A rod 10 mm $\times$10 mm cross-section is carrying an axial tensile load 10 kN. In this rod the tensile stress developed is given by

$$(\sigma_t) = \frac{P}{A} = \frac{10\,kN}{(10\,mm \times 10\,mm)} = \frac{10 \times 10^3\,N}{100\,mm^2} = 100\,\text{N/mm}^2 = 100\,\text{MPa}$$

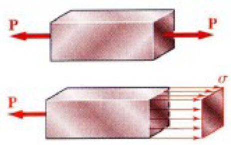


- The resultant of the internal forces for an axially loaded member is normal to a section cut perpendicular to the member axis.
- The force intensity on the shown section is defined as the normal stress.

  $\sigma = \lim_{\Delta A \to 0} \frac{\Delta F}{\Delta A}$ and $\sigma_{avg} = \frac{P}{A}$

- Stresses are not vectors because they do not follow vector laws of addition. They are **Tensors.**Stress**,** Strain and Moment of Inertia are second order tensors.

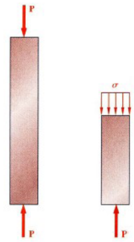
- **Tensile stress (σ_t)**



If σ > 0 the stress is tensile. i.e. The fibres of the component tend to elongate due to the external force. A member subjected to an external force tensile P and tensile stress distribution due to the force is shown in the given figure.

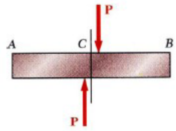
- **Compressive stress (σ_c)**

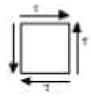
  If $\sigma < 0$ the stress is compressive. i.e. The fibres of the component tend to shorten due to the external force. A member subjected to an external compressive force P and compressive stress distribution due to the force is shown in the given figure.



- **Shear stress (τ)**

  When forces are transmitted from one part of a body to other, the stresses developed in a plane parallel to the applied force are the shear stress. **Shear stress acts parallel to plane of interest. Forces *P* is applied transversely to the member *AB as shown. The* corresponding internal forces act in the plane of section *C* and are called *shearing* forces. The corresponding average shear stress** $(\tau) = \dfrac{P}{Area}$





1.2 Strain (ε)

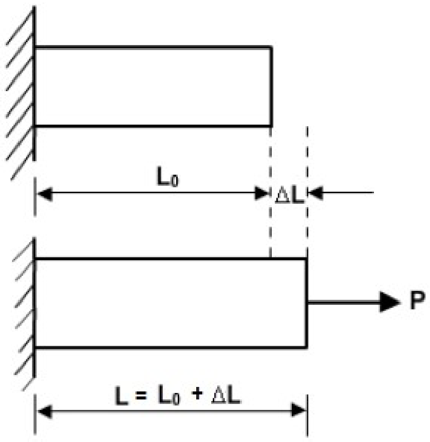
Thedisplacement per unit length ***(dimensionless)*** is known as strain.

- ε_t**)**

  The elongation per unit length as shown in the figure is known as tensile strain.

  $\varepsilon_t = \Delta L / L_o$

  It is engineering strain or conventional strain. Here we divide the elongation to original length not actual length ($L_o + \Delta L$)



Sometimes strain is expressed in microstrain. (1 μstrain = 10^{-6}) eg. a strain of 0.001 = 1000 μstrain)

Let us take an example: A rod 100 mm in original length. When we apply an axial tensile load 10 kN the final length of the rod after application of the load is 100.1 mm. So in this rod tensile strain is developed and is given by

$$(\varepsilon_t) = \frac{\Delta L}{L_o} = \frac{L - L_o}{L_o} = \frac{100.1mm - 100\,mm}{100\,mm} = \frac{0.1mm}{100\,mm} = 0.001 \text{ (Dimensionless) Tensile}$$

- **Compressive strain (ε_c)**

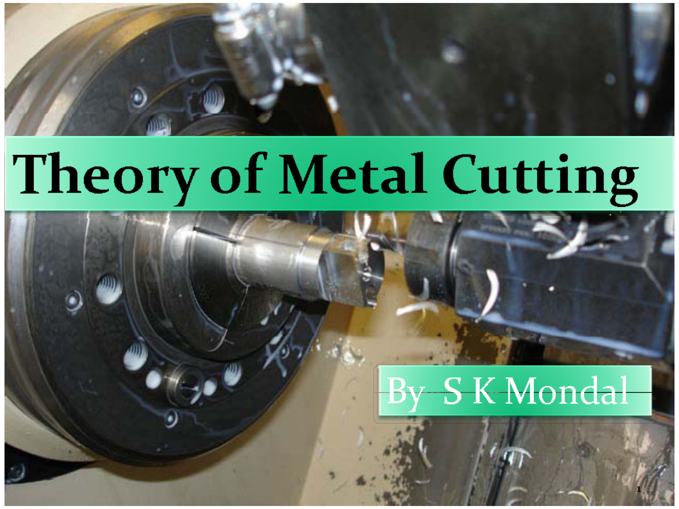
  If the applied force is compressive then the reduction of length per unit length is known as compressive strain. It is negative. Then $\varepsilon_c = (-\Delta L)/ L_o$

Metal Cutting, Metal Forming & Metrology

Questions & Answers-For 2020 (All Questions are in Sequence)

IES-1992-2019 (28 Yrs.), GATE-1992-2019 (28 Yrs.), GATE (PI)-2000-2019 (20 Yrs.), IAS-1994-2011 (18 Yrs.), some PSUs questions and conventional questions IES,

For-2020 (IES, GATE & PSUs)



Manufacturing Vs Production

- Manufacturing is a process of converting raw material in to finished product by using various processes, machines
- Production is a process of converting inputs in to outputs it is a broader term.

  Eg. 'crude oil production' not 'crude oil manufacturing', 'movie production' not 'movie manufacturing'
- Manufacturing and production are often used

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URL

Short URL

http://bit.do/skmondalies

Original URL

https://drive.google.com/folder view?id=0BxfQqBdt-h66akdi

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Classification of Manufacturing Process

- Shaping or formi
- Joining
- Removal
- Regenerative

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Regenerative Manufacturing

- Production of solid products in layer by layer from raw materials in different forms.
  - ✓
  - ✓
  - ✓
  - ✓ wire – e.g., FDM. (Fused Deposition Modeling)
- Very rapid, accurate and used for Rapid prototyping and tooling

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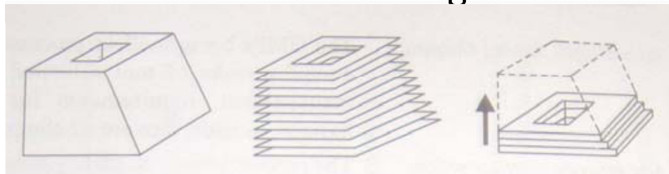
Basic Principle of Regenerative Manufacturing



Advantages:
- Process is Independent of Part Feature
- No Blanks are Requires
- Toolless process
- Easily Automation Possibl

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Machining

- Machining is an essential process of finishing by which jobs are produced to the desired dimensions and surface finish by gradually removing the excess material from the preformed blank in the form of chips with the help of cutting tools moved past the work surface.
- Machining is a removal process.

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Machining aim to

- Fulfill its functional
- Improve its
- Prolong its

Drawback in Machining

- Loss of material in the form of
- Slow process (Low

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Machine tool

A machine tool is a non-portable power operated and reasonably valued device or system of device in which energy is expended to produce jobs of desired size, shape and surface finish by removing excess material from the preformed blanks in the form of chips with the help of cutting tools moved past the work surf

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Why even a battery operated pencil sharpener cannot be accepted as a machine tool?

Ans. In spite of having all other major features of

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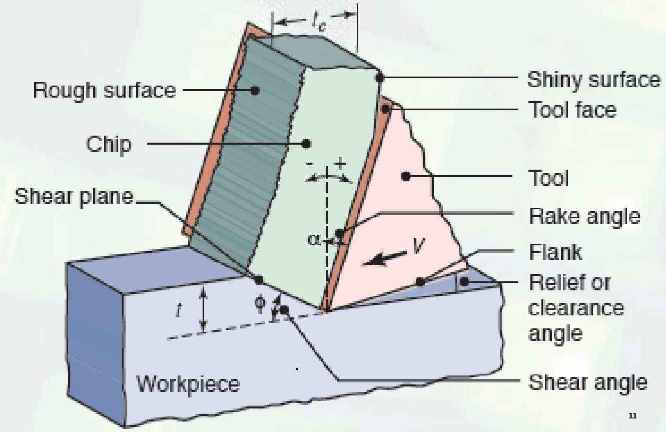
Orthogonal Machining



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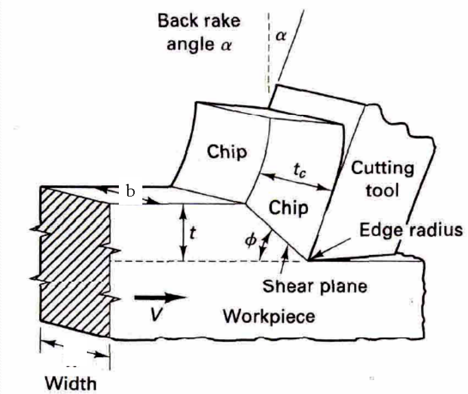
Orthogonal Machining



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Rake Surface and Flank

- The surface along which the chip moves upward is called 'Rake surface' of tool.

Flank or Relief

- The other surface which is relieved to avoid rubbing with the machined surface, is called 'Flank' or Flank Surf

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Rake angle and Clearance Angle

- **Rake angle (** α **):** Angle of inclination of rake surface from reference plane i.e. normal to horizontal machined surface
- It allows chip flow direction.
- It provides keenness (sharpness) to the cutting edge.
- It reduces the cutting force required to shear the metal
-

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IES 2011

Which one of the following statement is NOT correct with reference to the purposes and effects of rake angle of a cutting tool?

(a) To guide the chip flow direction

(b) To reduce the friction between the tool flanks and the machined surface

(c) To add keenness or sharpness to the cutting edges.

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GATE-1995; 2008

Cutting power consumption in turning can be significantly reduced by

(a) Increasing rake angle of the tool

(b) Increasing the cutting angles of the tool

(c) Widening the nose radius of the tool

(d) Increasing the clearance angle

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IES-2006

Consider the following statements:

1. **A large rake angle means lower strength of the cutting edge.**
2. **Cutting torque decreases with rake angle.**

Which of the statements given above is/are correct?

(a) Only 1 (b) Only 2

(c) Both 1 and 2 (d) Neither 1 nor

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Rake angle and Clearance Angle

- **Clearance angle or Relief angle** (γ) : Angle of inclination of clearance or flank surface from the finished surf
- It reduces friction and tool wear
- It improve tool lıfe
- Excessive clearance angle weakens the tool
- Must be positive ($3^o – 15^o$)

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IES-2004

Consider the following statements with respect to the relief angle of cutting tool:

1. This affects the direction of chip flow

2. This reduces excessive friction between the tool and work piece

3. This affects tool life

4. This allows better access of coolant to the tool work piece interface

Which of the statements given above are correct?

(a) 1 and 2 (b) 2 and 3

(c) 2 and 4 (d) 3 and

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IAS-2003

In orthogonal cutting, shear angle is the angle between

(a) Shear plane and the cutting velocity

(b) Shear plane and the rake plane

(c) Shear plane and the vertical direction

(d) Shear plane and the direction of elongation of crystals in the

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Turning

- Turning is not orthogonal cutting it is an oblique

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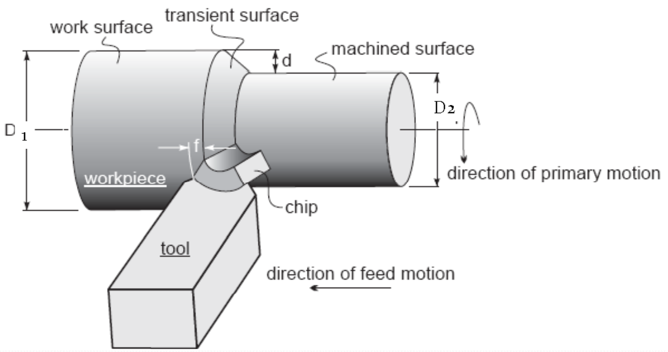
Speed, feed, and depth of cut



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Speed, feed, and depth of cut

$$\text{Speed}(V) = \frac{\pi DN}{60}, m/s$$

$$= \pi DN, m/\min$$

$$= \frac{\pi DN}{1000}, m/\min$$

$$\text{Feed}(f): f \text{ in mm/rev}$$

$$= fN \text{ mm/min}$$

$$\text{Depth of cut}(d) \quad \frac{D_1 - D_2}{2}$$

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IES-2013

Carbide tool is used to machine a 30 mm diameter steel shaft at a spindle speed of 1000 revolutions per minute. The cutting speed of the above turning operation is:

(*a*) 1000 rpm

(*b*) 1570 m/min

(*c*) 94.2 m/min

(*d*

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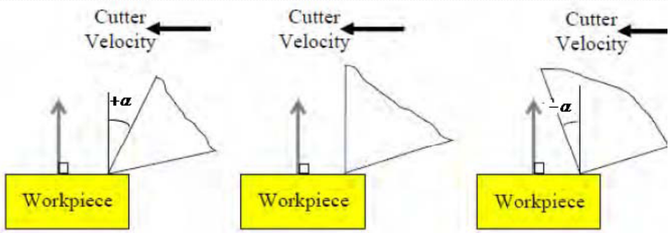
Discussion on Rake angle

Rake angle can be positive, negative or zero.



Positive Rake Zero Rake Negative

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Positive rake (5 – 30 deg)

- Reduce cutting
- Reduce cutting

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Positive rake angles are recommended

- Machining low strength
- Low power
- Long shaft of small
- Set – up lacks strength and
- Low cutting
- Cutting tool Material:

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