SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF AGRICULTURE ENGINEERING

R2019-MACHINE DESIGN

III YEAR V SEM

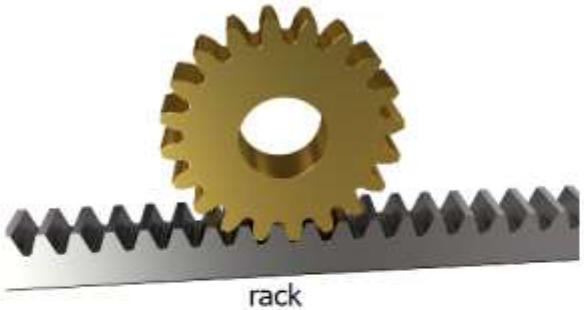
UNIT 5 –DESIGN OF MACHINE ELEMENTS

TOPIC 5–Gears

WHAT ARE GEARS???

- **A friction wheel with teeth cut on it, i.e. ; a synchronous arrangement of projections and recesses on a wheel.**

spur gears
(external toothing)



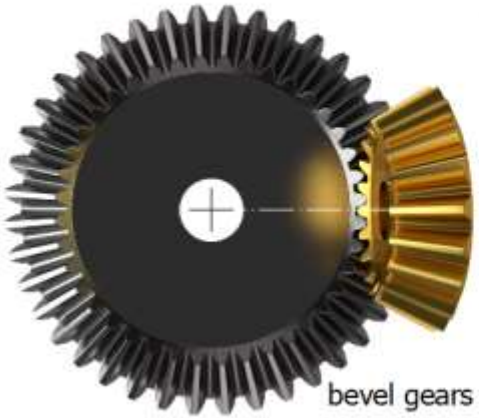
rack

internal toothing

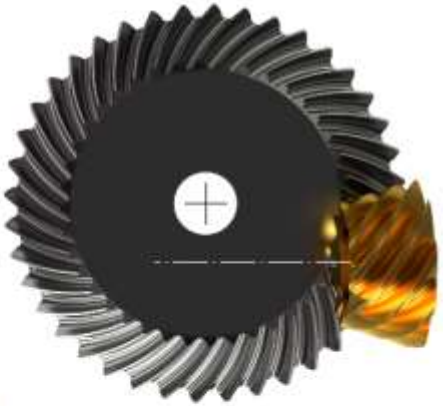
screw gears
(hyperboloid gears)

worm gear

worm



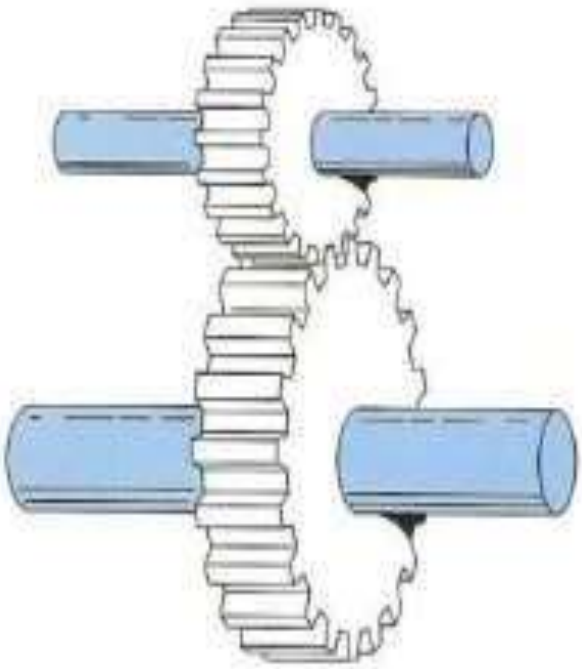
bevel gears



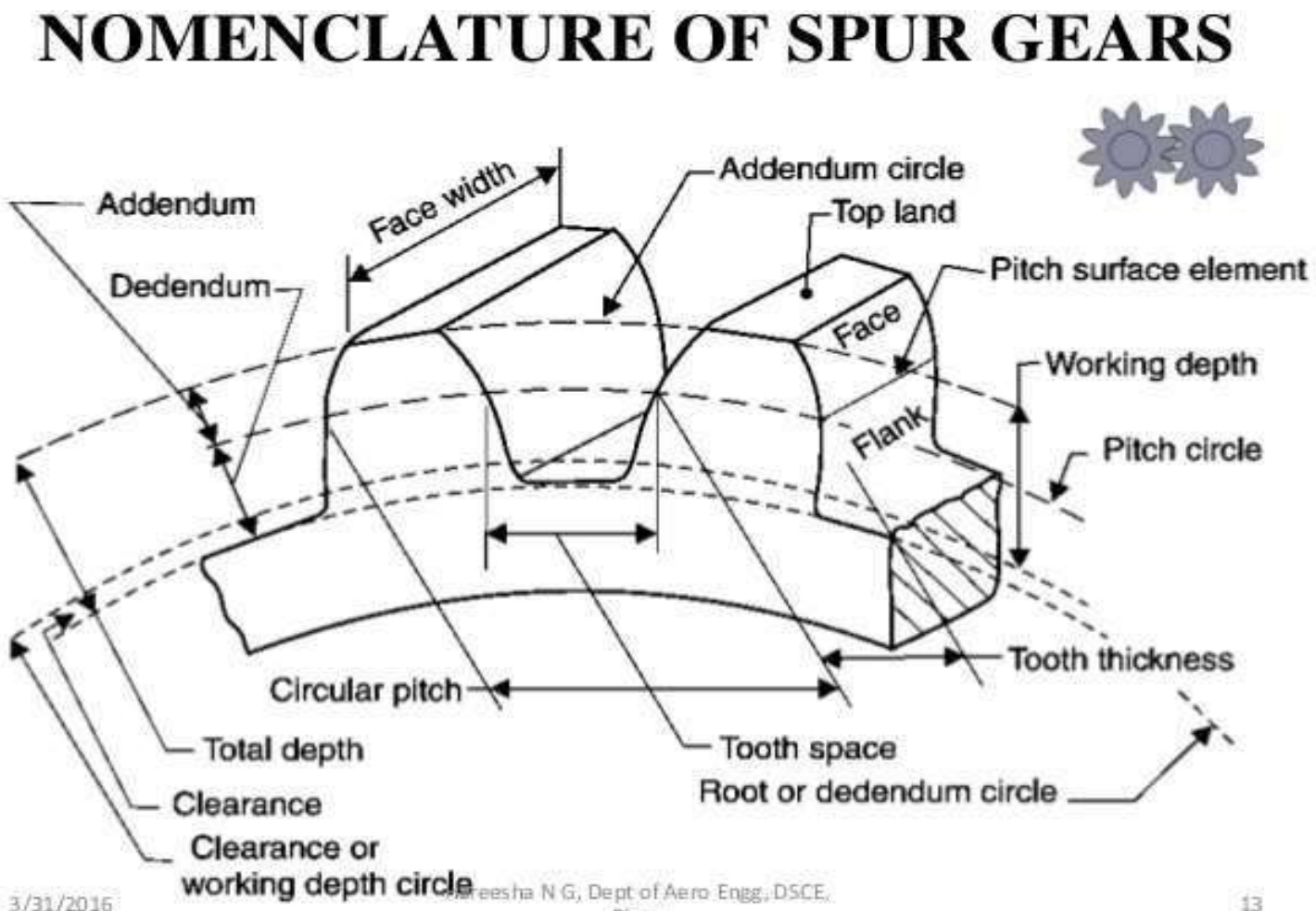
screw bevel gears
(hypoid gears)

INTRODUCTION

- Gears are broadly classified into four groups, spur, helical, bevel and worm gears. In case of spur gears the teeth are cut parallel to the axis of the shaft. As the teeth are parallel to the axis of shaft, spur gears are used only when the shafts are parallel. The profile of the gear tooth is in shape of involute curve and it remains identical along the entire width of the gear wheel. Spur gears impose radial loads on the shafts.



Gear Terminology



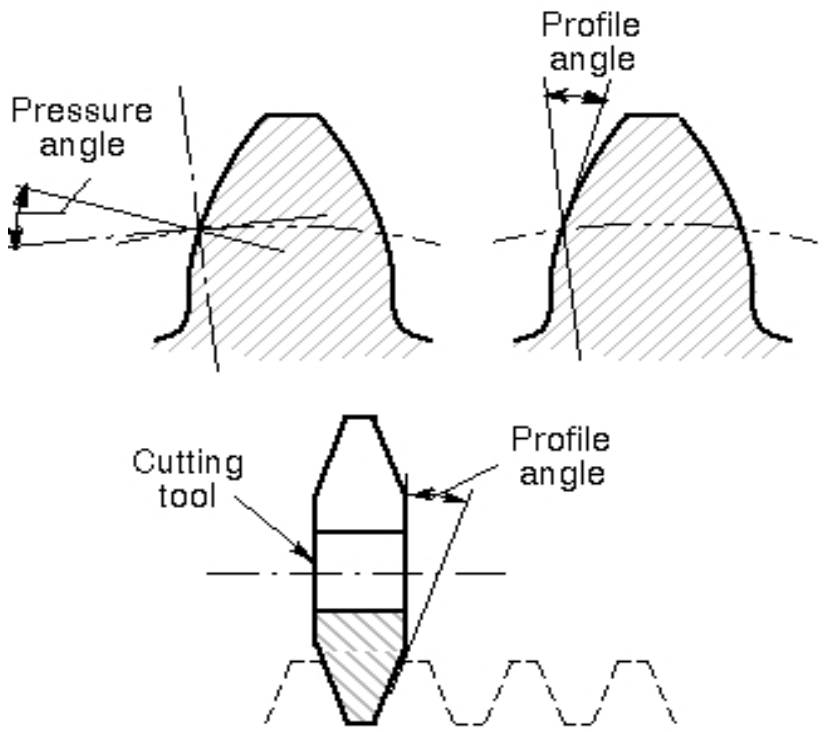
- **Pitch surface :** The surface of the imaginary rolling cylinder (cone, etc.) that the toothed gear may be considered to replace.
- **Pitch circle**: A right section of the pitch surface**.**
- **Root (or dedendum) circle:** The circle bounding the spaces between the teeth, in a right section of the gear.
- **Addendum:** The radial distance between the pitch circle and the addendum circle.
- **Dedendum:** The radial distance between the pitch circle and the root circle.
- **Clearance:** The difference between the dedendum of one gear and the addendum of the mating gear.

- **Face of a tooth:** That part of the tooth surface lying outside the pitch surface.
- **Flank of a tooth:** The part of the tooth surface lying inside the pitch surface.
- **Circular thickness (tooth thickness) :** The thickness of the tooth measured on the pitch circle. It is the length of an arc.
- **Tooth space**: The distance between adjacent teeth measured on the pitch circle.
- **Backlash:** The difference between the circle thickness of one gear and the tooth space of the mating gear.

- **Module (m):** Pitch diameter divided by number of teeth. The pitch diameter is usually specified in inches or millimeters; in the former case the module is the inverse of diametral pitch.
- **Fillet :** The small radius that connects the profile of a tooth to the root circle.
- **Pinion:** The smaller of any pair of mating gears. The larger of the pair is called simply the gear.
- **Velocity ratio:** The ratio of the number of revolutions of the driving (or input) gear to the number of revolutions of the driven (or output) gear, in a unit of time.

- **Pressure angle:**

  Pressure angle in relation to gear teeth, also known as the angle of obliquity**,** is the angle between the tooth face and the gear wheel tangent. It is more precisely the angle at a pitch point between the line of pressure (which is normal to the tooth surface) and the plane tangent to the pitch surface.



Force Analysis

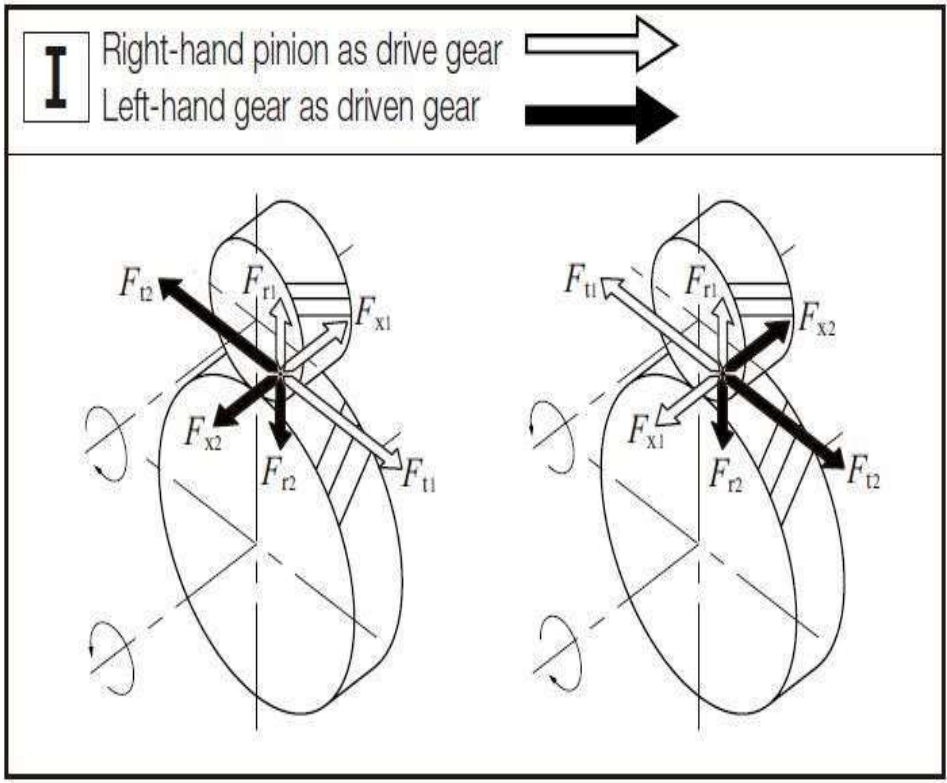
- Tangential component or Tangential Force (F_t):-

  This component is useful for transmitting power. It is tangent to the pitch circle at the pitch point.

$$F_t = \frac{P}{V} = \frac{T_p}{d_p/2} = \frac{T_g}{d_g/2}$$

- Radial Component or Radial Force (Fr):-

$$F_r = F_t \tan\emptyset$$



Design Procedure of Spur Gear

- **Step 1**:- Note down peripheral speed (V)

$$V = \frac{\pi DN}{60}$$

  - Peripheral speed will be same for gear & pinion
  - If peripheral speed is not given or unable able to find we can decide any value in between 3 to 15
- **Step 2**:- Note down the material
  - For low velocity decide cast iron & low grade steel for high velocity
  - Note down σ_b & BHN from given material

- **Step 3:-** Design transmission load

$$F_t = \frac{1000 \times P \times C_0}{V}$$

- **Step 4:-** Lewi's Equation $F_t = \frac{\sigma_b \times f \times m \times Y}{K_f}$
  - We need to calculate module from above equation
  - First from gear & pinion whichever is having small value of σ_b for that only we will apply Lewi's equation $m = \frac{D}{t}$ $Y = \pi y(lewi's\ form\ factor)$

$$y = 0.124 - \frac{0.684}{Z}\left(14/\frac{1}{2}°\right) \quad y = 0.175 - \frac{0.841}{Z}(20°\ stup\ depth)$$

$$y = 0.154 - \frac{0.912}{Z}(20°)$$

- In case where Number of tooth are not given
- Y = 0.29(20 degree) Y = 0.35(20degree stup) Y = 0.25(14.5 degree)
- f = Face width $f = 3 \times P_c \; to \; 4 \times P_c \; (approax)$

$$f = 9.5 \times m \; to \; 12.5 \times m (final)$$

$K_f = 1.5(20°)$ $K_f = 1.6(14.5°)$

$\sigma_b = permissible \; bending \; stress$

- Lewi's Equation for Dynamic condition

$$F_t = \frac{\sigma_b \times f \times m \times Y}{K_f} \times C_v$$

$$C_v = \frac{6}{6+v} \; (v > 12.5) \qquad C_v = \frac{4.5}{4.5+v} \; (v \; 7.5 \; to \; 12.5)$$

$$C_v = \frac{3}{3+v} \; (v < 7.5)$$

- **Step 5:-** Calculate gear tooth properties if asked
- **Step 6:-** Calculate dynamic load using buckingham equation

$$F_d = F_t + F_i$$

$$F_i = \frac{21V\,(c \cdot f + F_t)}{21V + \sqrt{c \cdot f + F_t}}$$

$$C = \frac{k \times e}{1/E_p + 1/E_g}$$

$$k = 0.107(14.5°)$$

$$k = 0.115(20°\ stup)$$

$$k = 0.111(20°)$$

- **Step 7:-** Find out weaker element from gear and pinion $\sigma_b \times Y$

- **Step 8:-** Calculate the beam strength for weaker element $F_b = F_{ef} \times f \times m \times y$

$$f_{ef} = flexural\ endurance\ strength$$
$$= 1.75 \times BHN\ (BHN < 400)$$
$$= 700\ MPa\ (BHN \geq 400)$$

- **Step 9:-** Calculate wear strength (Fw)

$$F_w = D_p \times f \times K_w \times Q$$

$$K_w = \frac{{F_{es}}^2 \times sin\emptyset}{1.4}\left[\frac{1}{E_p} + \frac{1}{E_G}\right]$$

$$Q = ratio\ factor = \frac{2Z_g}{Z_g + Z_p}$$

$$F_{es} = 2.8 \times BHN - 70\ (average\ of\ BHN)$$

$$Check\ The\ Safe\ Condition\ F_w \geq F_d$$

- NOTE:- If condition is not safe then change value of BHN by applying hardening process and increase the value up to 400 if it is not sufficient then increase it further.

- **Reference:-**
  - (Machine Design By V.B. bhandari)
  - (Machine Design By Sharma and Agarwal)

THANK YOU