Gears

Scope

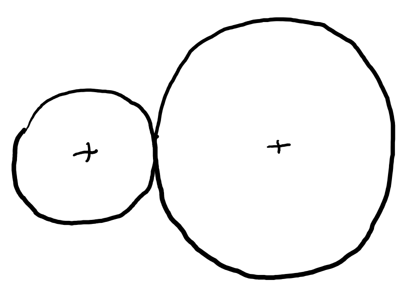
- Spur gears
- Gear geometry
- Gear Kinematics
- Gear Forces
- Gear Stresses
  - Tooth bulk stresses
  - Tooth Surface stresses

(AGMA method)

American Gear Manufacturing Association

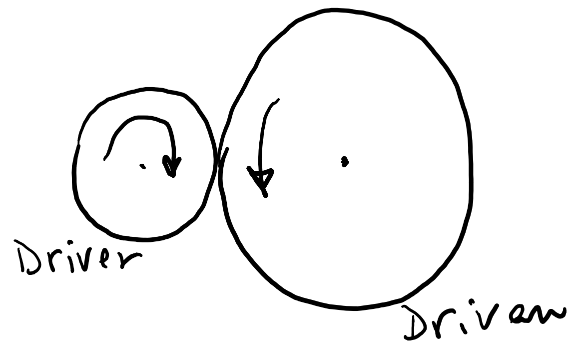
Terminology + Basics

- Smaller gear : Pinion
- larger gear : Gear



- one is driver
- one is driven

- For gear reduction, the pinion is the driver



Gear ratio $\equiv m$

$n \equiv$ rpm

N = Number of teeth

$$m = \frac{n_{driver}}{n_{driven}} = \frac{N_{driven}}{N_{driver}}$$

Example

if $n_p = 100$ and $n_G = 25$

(& Pinion is the driver)

$$m = \frac{100}{25} = 4 \quad (\text{or } 4:1)$$

$\Rightarrow$ Number of teeth $N_G = 4 N_p$

How do we order a gear?

- Two numbers determine the shape of the gear in plane (minus hub geometry)

- Number of Teeth N
- Diametral Pitch (Pitch) : P

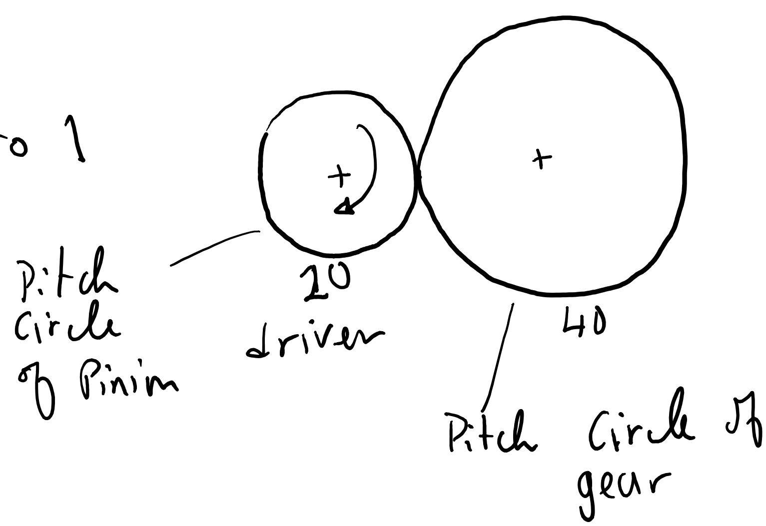
for example, if $P = 10 \Rightarrow h = \frac{2.25}{10}$

$$h = 0.225$$

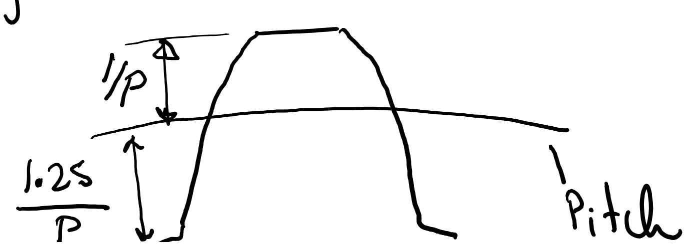
By definition $P = \frac{N}{d}$

what is d (Pitch diameter)

$m = 2$ to 1



For standard gear



- The larger the P, the smaller the teeth

  Common 16 32 64 ...

- Example gear measured in class

  $N = 18 \Longrightarrow P = 10$

  $d \cong 1.8$

- we also have

$$m = \frac{n_{driver}}{n_{driven}} = \frac{N_{driven}}{N_{driver}} = \frac{d_{driven}}{d_{driver}}$$

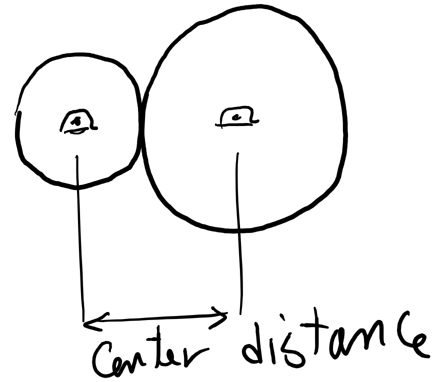
if pinion is the driver

$$m = \frac{d_G}{d_P}$$

Center distance calculation

Example: $P = 10$ $\quad$ $P = 10$

$N_p = 15$ $\quad$ $N_G = 60$



[Two gears in mesh must have same size teeth]

Calculate Center distance

$$d_P = \frac{N_P}{P} = \frac{15}{10} = 1.5$$

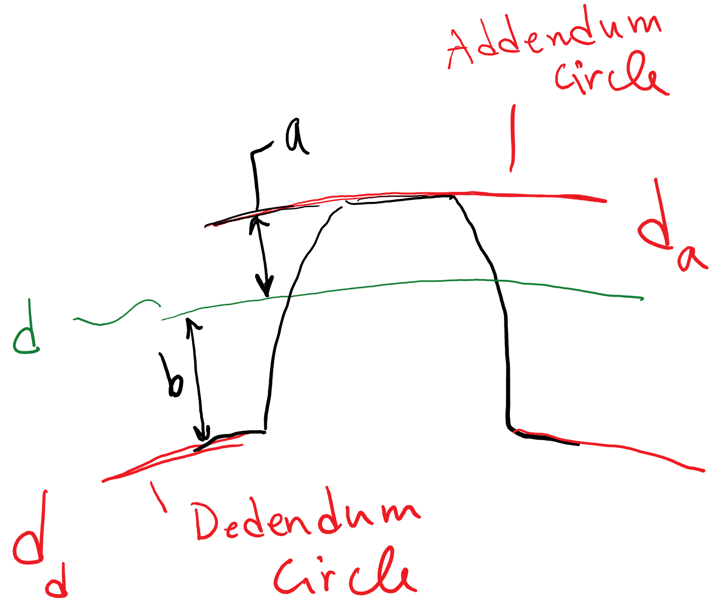
$$d_G = \frac{N_G}{P} = \frac{60}{10} = 6.0$$

$$C = \frac{1}{2}(d_P + d_g) = \frac{1}{2}(1.5 + 6)$$

$$C = 3.75''$$

Addendum $= a = \frac{1}{P}$

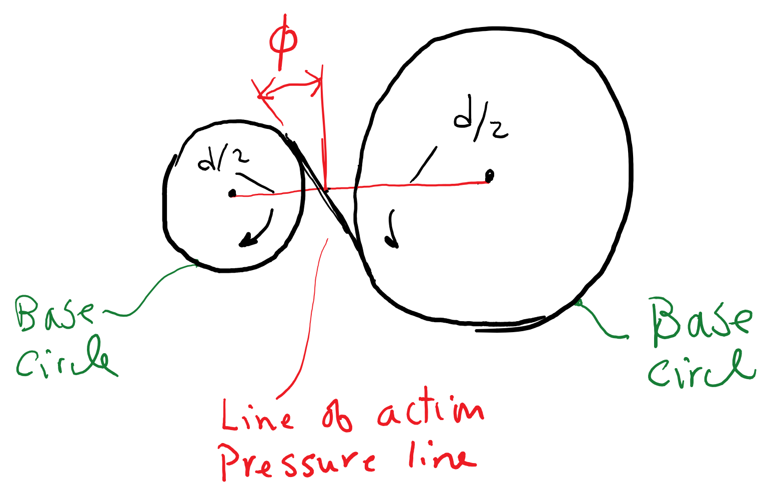
Dedendum $= b = \frac{1.25}{P}$



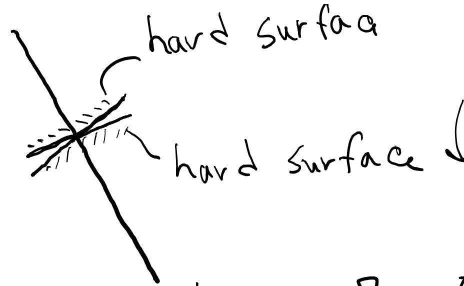
More terminology

ϕ = Pressure angle

$\phi = 20°$



Force is transmitted along pressure line



As gears rotate, the curvature of the hard surfaces change to maintain a normal contact along pressure line

$\Longrightarrow$ Force direction does not change

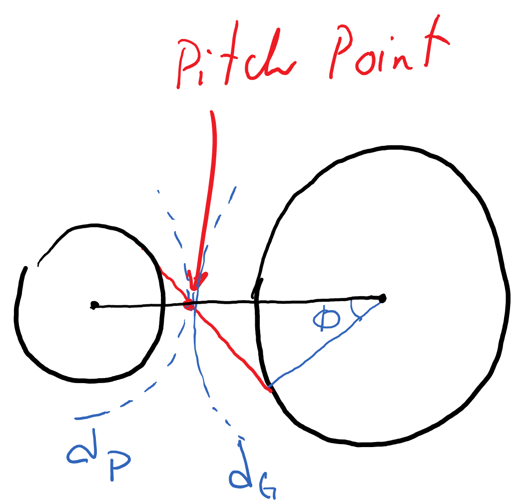
That magical curve is called (involute)

Radii of base circles

$$\underbrace{r_b}_{\text{base}} = \underbrace{r}_{\text{pitch}} \cos\phi$$

$$d_{b,P} = d_P \cos\phi$$

$$r_{b,P} = r_P \cos\phi$$



Ordering gears

- P, N
- Material
- Hub design

- Thicknen (Face width)
- Pressure angle (14.5°, $\underline{20^\circ}$, 22°)

vast majority

- Surface finish
- Surface hardnen

Couple of AGMA indeces

- material quality index
- Geometry quality index

>> Summary

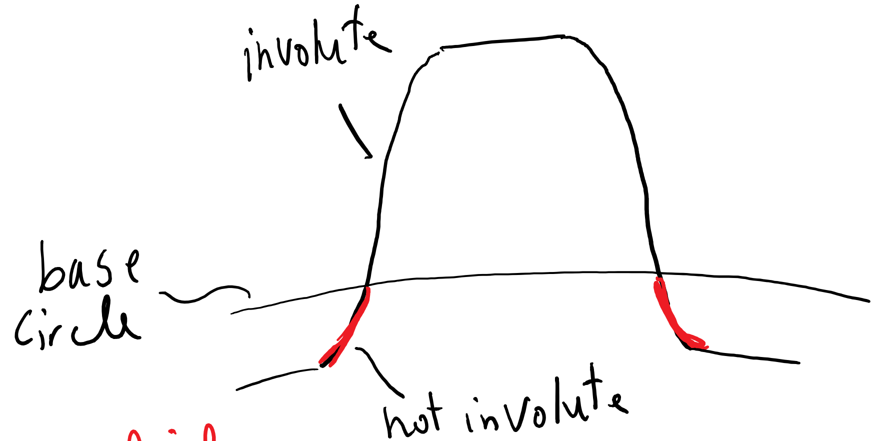
- start with desired gear ratio
- guess the tooth size that would take the loads $\Rightarrow P$
- guess the number of teeth for Pinion (favor smaller # of gears)

Smaller # of teeth may not work for 2 reasons:

- Interference (under Cutting)

\- Contact ratio

Interference



Interference

The condition in which contact occurs below the base circle on non-involute portion resulting in vibration, noise, excessive contact forces

Checking for Interference

Using EQ 13-11

example $K = 1$ (regular gears)

$K = 0.8$ (stub teeth)

m = gear ratio $= 2$

$\phi = 20$

Work @ home N_{min}

Contact Ratio

Average # of teeth in contact

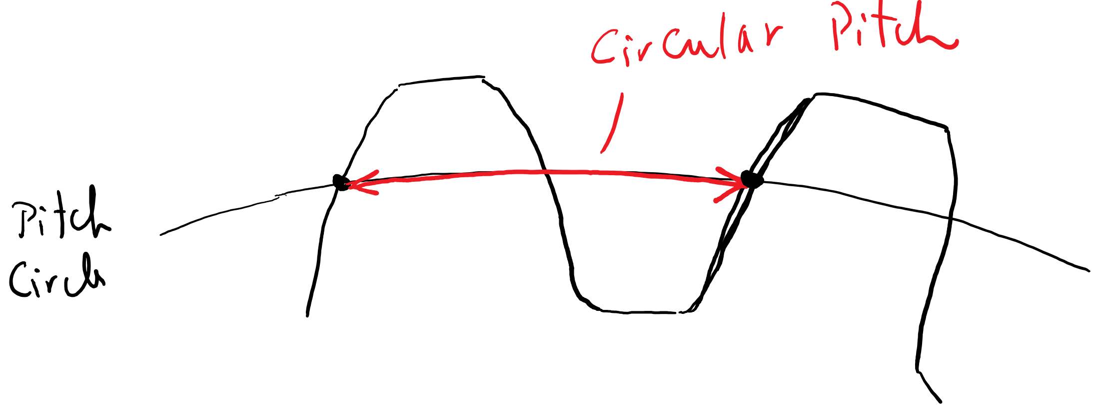
Recommendation $CR > 1.2$

$$CR = \frac{\sqrt{r_{ap}^2 - r_{bp}^2} - \sqrt{r_{ag}^2 - r_{bg}^2} - C \sin\phi}{p \cos\phi}$$

where

p = circular pitch

$$pP = \pi \Rightarrow p = \frac{\pi}{P}$$



$$p \cdot N = \pi d \qquad P = \frac{N}{d} \Rightarrow d = \frac{N}{P}$$

$$p \cdot \cancel{N} = \pi \left(\frac{\cancel{N}}{P}\right)$$

$$\boxed{pP = \pi}$$

$r_{ap}, r_{ag} \equiv$ Pinion & gear addendum radii

$r_{bp}, r_{bg} \equiv$ Pinion & gear dedendum radii

$$r_{a,p} = r + a$$

$$r_{a,p} = \left(\frac{d_p}{2}\right) + \frac{1}{P}$$

Use Excel Work sheet to find contact Ratio