MARCH 29/18
MACHINE DESIGN.

Example 4: A ball bearing is to operate on the following work cycle

Radial load of 1400 lb at 200 rpm for 25 % of the time
" " 2000 lb at 500 rpm for 20 % " "
" " 800 lb at 400 rpm for 55 % " "

The inner ring rotates; loads are steady. Find the minimum value of the basic rating load C, for a suitable bearing for this application if the required life in 7 years at 4 hrs per day.

Solution:

On the basis of a work cycle of 1 min., we have:

Load lb.	Assumed interval 1 min	rpm	In assumed interval, rev.
P_1 = 1400	0.25	200	50
P_2 = 2000	0.20	500	100
P_3 = 800	0.55	400	220
TOTAL:	1		370

Then $\alpha_1 = \dfrac{50}{370}$; $\alpha_2 = \dfrac{100}{370}$; $\alpha_3 = \dfrac{220}{370}$

Assuming 250 working days in a year

$$N_c = 7 \times 250 \times 4 \times 60 \times 370 = 155,400,000$$

$$\frac{10^6 C^3}{N_c} = \frac{50}{370} \times 1400^3 + \frac{100}{370} \times 2000^3 + \frac{220}{370} \times 800^3$$

$$= 2,837,400,000$$

or $C^3 = 2,837.4\, N_c = 440,930,000,000,000$

$C = 7,610$ lb

TABLE 9.1:

∴ bearing No. 308 should be satisfactory with 90 % prob. of surviving 7 years.

5 - Design For Different Confidence Levels

When a degree of reliability greater than 90% is required, the expected life will be reduced as follows: $\boxed{L_R = a_1 L_{10}}$

Where a_1 is found from Table 9-4 (Spotts)

↳ see Assignment 10

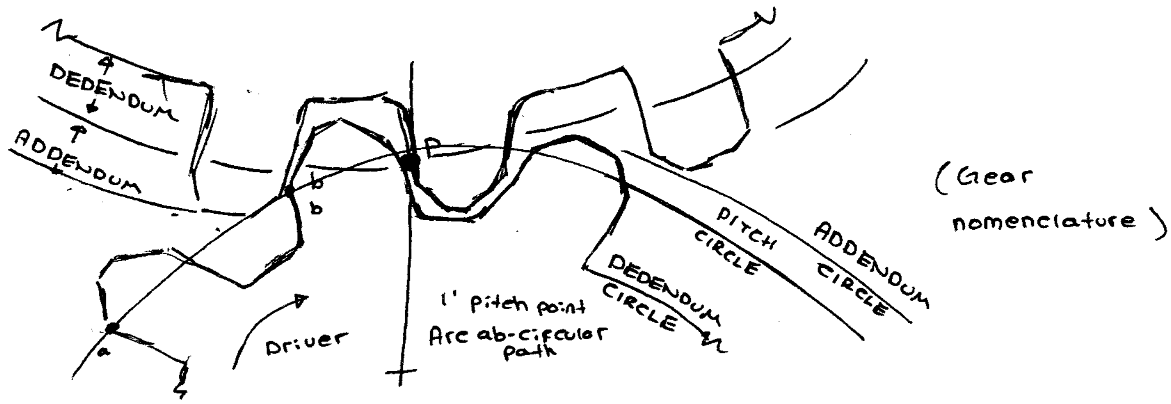
Spur Gears

1 - Characteristics:

- the drive is positive, and with circular gears, the angular velocity ratio is constant
- the center distances may be relatively short, thus making a compact drive
- Provision may be made for shifting gears, and in some cases for interchanging them to change the speed of the driven members
- the efficiency is high, since the loss of power may be 1 percent or less of the power transmitted
- the maintenance of the drive is inexpensive and the life is long.

2 - Spur gear terminology

- Pitch surfaces: The pitch surface is the surface of the rolling cylinder that the gear may be considered to replace



Pitch circle : the pitch circle is a right section of the pitch surface

Addendum circle : the addendum circle is the circle bounding the ends of the track

Dedendum circle : the dedendum circle is the circle bounding the bottom of the spaces between the teeth

Addendum : the addendum is the radial distance between the addendum circle and the pitch circle.

Dedendum : the dedendum is the radial distance between the pitch circle and the dedendum circle

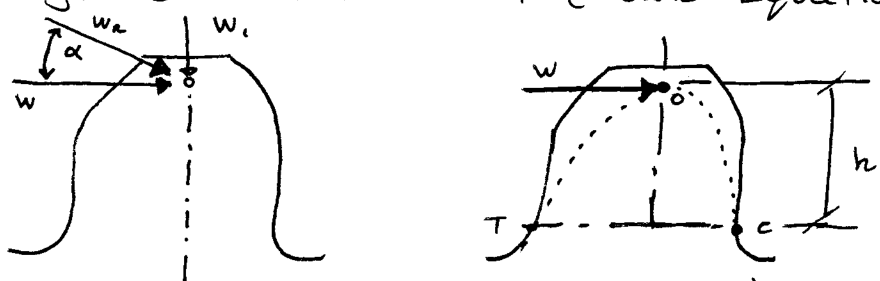
Clearance : the difference between the dedendum of one gear and the addendum of the mating gear

Backlash : the difference between the tooth space of one gear and the tooth thickness of the mating gear measured on the pitch circle

Circular pitch : circular pitch is the distance from a point on one tooth to the corresponding point on the adjacent tooth measured on the pitch circle. Its symbol, p; the units are inches.

Diametral pitch: diametral pitch is the number of teeth on a gear per inch of its pitch diameter. it's symbol is P.

3 - Strength of Gear Teeth (Lewis Equation)



(Forces on Gear Teeth)

Lewis assumed the tooth to be a cantilever beam of parabolic profile, and therefore, it has uniform strength at all cross-sections. Since the tooth is stronger than the assumed beam except at TC, this is considered the critical section where he found:

$$Wh = \frac{SFt^2}{6} \quad \text{or} \quad W = \frac{SFt^2}{6h}$$

Introducing the circular pitch p

$$W = \frac{SFt^2}{6h} \times \frac{p}{p} = SFpy$$

where $y = \frac{t^2}{6hp}$ = Form Factor (Table 18-1, H.O.)

To approximate the effect of dynamic loading the allowable stress is given by:

$$S_{all} = S_o C_v$$

where, S_{all} = allowable stress, psi

S_o = basic stress, psi (From table 18-2, H.O.)

C_v = $600/(600 + v)$ = velocity factor (Table 18-4 H.O.) for spurgears

v = pitch-line velocity (fpm)

(For all values in 18-1 H.O.)

The induced stress is :

$$W = SFPy$$

$$\text{or} \quad S_{ind} = \frac{W}{FPy}$$

Let T = transmitted torque, lb-in
D = pitch diameter, in
n = number of teeth
P = diametral pitch = n/D
K = F/p = 3 to 4 (normal service)

Then ; $S_{ind} = \dfrac{W}{Fpy} = \dfrac{WP^2}{\frac{F}{p}\,p^2 P^2 y} = \dfrac{W P^2}{K\pi^2 y}$ $\left\{ \begin{array}{l} pP = \frac{p n}{D} \\ = \pi \end{array} \right.$

but $W = 2T/D = 2TP/n$

and $S_{ind} = \dfrac{2TP^3}{K\pi^2 n y}$

Based on experience it is found that for good proportions the following relation must hold ·

$\hookrightarrow$ must hold ; $3p \leq F \leq 4p$
or broadly ; $2p \leq F \leq 5p$

Example 1 → It is required to determine the proportions of a spur-gear drive to transmit 10 hp from a shaft rotating at 1170 rpm to a low-speed shaft with a speed reduction of 3 : 1. Assume that the teeth are a 20° full-depth system, with 24 teeth on the pinion. The pinion is to be SAE - 1045 and the gear SAE-1030 steel. Assume that the torque at starting is 130 % of torque at rating.

Solution :