MESH CONSIDERATIONS

THE RELATIVE MOTION BETWEEN TWO GEARS IN MESH IS:

- PURE ROLLING WHEN THE CONTACT POINT IS THE PITCH POINT
- A COMBINATION OF ROLLING AND SLIDING WHEN THE CONTACT POINT IS NOT THE PITCH POINT.

THE CONTACT RATIO (m_c) IS THE AVERAGE NUMBER OF PAIRS OF TEETH IN CONTACT.

- CONTINUOUS MOTION TRANSFER REQUIRES TWO PAIRS OF TEETH IN CONTACT AS THE MESH MOVES FROM ONE PAIR OF TEETH TO THE NEXT.
- GEARS SHOULD NOT TYPICALLY BE DESIGNED WITH $m_c < 1.2$
- THE CONTACT RATIO IS CALCULATED FROM THE LENGTH OF THE LINE OF ACTION BETWEEN THE ADDENDA CIRCLES OF THE PINION AND GEAR (L_{ab}):

$$m_c = \frac{L_{ab}}{p\cos\phi}$$

BACKLASH IS THE DIFFERENCE BETWEEN THE TOOTH THICKNESS AND THE WIDTH OF SPACE.

- A SMALL AMOUNT OF BACKLASH IS REQUIRED TO PREVENT GEARS BINDING.
- TOO MUCH BACKLASH CAN BE PROBLEMATIC, PARTICULARLY IF THE PINION ROTATION REVERSES.

INTERFERENCE OCCURS WHEN THE TOOTH PROFILES OF MESHING GEARS ARE NOT CONJUGATES.

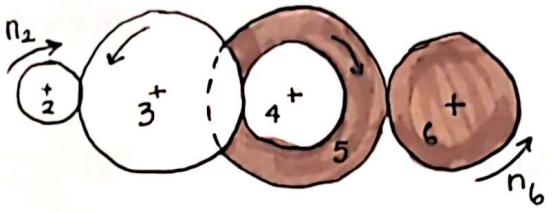
- CONTACT OCCURS IN THE NONINVOLUTE PORTION OF THE GEAR TOOTH.

INTERFERENCE CAN BE CORRECTED BY UNDERCUTTING THE GEAR TEETH.

- A CUTTING TOOL CAN REMOVE INTERFERING PORTIONS OF THE TEETH.
- THIS WEAKENS THE TEETH.

GEAR TRAINS

IN THE DRAWN GEAR TRAIN, PINION 2 IS DRIVING GEAR 3.



THE SPEED OF GEAR 3 IS:

$$n_3 = \left| \frac{N_2}{N_3} n_2 \right| = \left| \frac{d_2}{d_3} n_2 \right|$$

WHERE n = SPEED IN RPM
N = NUMBER OF TEETH
d = PITCH DIAMETER

NOTE: A GEAR RATIO OF UP TO ABOUT 10:1 CAN BE ACHIEVED WITH A SINGLE PAIR OF GEARS. LARGER GEAR RATIOS CAN BE ACHIEVED BY COMBINING MORE GEARS IN A GEAR TRAIN.

THE SPEED OF GEAR 6 (THE OUTPUT OF THE GEAR TRAIN) IS:

$$n_6 = - \frac{N_2}{N_3} \cdot \frac{N_3}{N_4} \cdot \frac{N_5}{N_6} n_2$$

NOTICE THAT GEAR 3 IS AN IDLER (ITS TOOTH NUMBERS CANCEL IN THE EQUATION).

THE **TRAIN VALUE** OF A GEAR TRAIN IS:

$$e = \pm \frac{\text{PRODUCT OF DRIVING TOOTH NUMBERS}}{\text{PRODUCT OF DRIVEN TOOTH NUMBERS}}$$

e IS POSITIVE IF THE FIRST AND LAST GEARS ROTATE IN THE SAME DIRECTION AND NEGATIVE IF THEY ROTATE IN OPPOSITE DIRECTIONS.

- TIP: COUNT THE NUMBER OF MESHES. e IS NEGATIVE FOR AN ODD NUMBER OF MESHES AND POSITIVE FOR AN EVEN NUMBER.

NOW WE CAN WRITE:

$$n_L = e\, n_F$$

WHERE n_L IS THE SPEED OF THE LAST GEAR AND n_F IS THE SPEED OF THE FIRST GEAR.

A COMPOUND GEAR TRAIN HAS TWO OR MORE GEARS ATTACHED TO THE SAME SHAFT.

- LARGER GEAR RATIOS CAN BE ACHIEVED WHILE MINIMIZING FOOTPRINT.

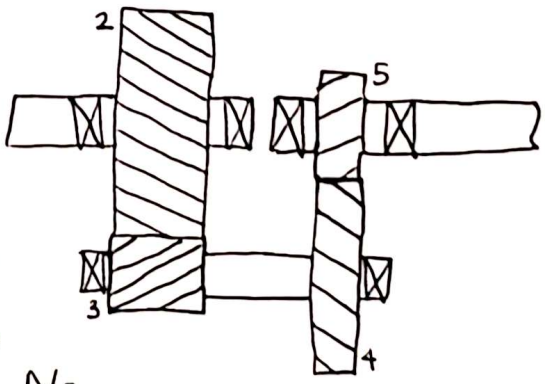
THE GENERAL PROCEDURE FOR DESIGNING A COMPOUND GEAR TRAIN IS AS FOLLOWS:

1. DETERMINE/CHOOSE THE NUMBER OF STAGES TO ATTAIN THE DESIRED GEAR RATIO/TRAIN VALUE.
2. DIVIDE THE OVERALL RATIO INTO PORTIONS FOR EACH STAGE.
   - KEEP PORTIONS AS EVENLY DIVIDED BETWEEN STAGES AS POSSIBLE.
3. PICK THE NUMBER OF PINION TEETH
   - AVOID INTERFERENCE
   - SELECT STANDARD PRESSURE ANGLE ($\phi = 20°$) AND MODULE/DIAMETRAL PITCH, IF POSSIBLE.
4. PICK THE NUMBER OF TEETH FOR THE MATING GEAR.
5. CHECK THE RESULTING GEAR RATIO/TRAIN VALUE.
6. IF NECESSARY, REPEAT.

A COMPOUND REVERTED GEAR TRAIN IS A COMPOUND GEAR TRAIN WHERE THE INPUT & OUTPUT GEARS ARE ALIGNED.

- THIS REQUIRES THE DISTANCES BETWEEN THE SHAFTS TO BE THE SAME FOR BOTH STAGES OF THE GEAR TRAIN.

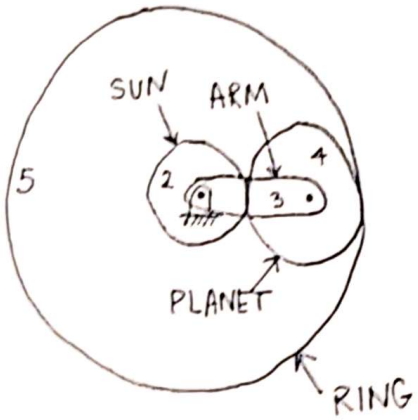
$$\frac{d_2}{2} + \frac{d_3}{2} = \frac{d_4}{2} + \frac{d_5}{2}$$



- TO MESH, $P_2 = P_3$ AND $P_4 = P_5$
- IF WE ASSUME A CONSTANT DIAMETRAL PITCH P IN BOTH STAGES (AND RECALL THAT $P = N/d$), THEN WE CAN WRITE: $\frac{N_2}{2P} + \frac{N_3}{2P} = \frac{N_4}{2P} + \frac{N_5}{2P}$

$$\Rightarrow N_2 + N_3 = N_4 + N_5$$

EPICYCLIC GEAR SETS (ALSO KNOWN AS PLANETARY GEAR SETS) ARE CHARACTERIZED BY ONE OR MORE GEARS THAT DO NOT HAVE FIXED AXES OF ROTATION.



THE TRAIN VALUE OF AN EPICYCLIC GEAR SET IS:

$$e = \pm \frac{N_{sun\,(first)}}{N_{ring\,(last)}} = \frac{n_L - n_A}{n_F - n_A}$$

WHERE n_F = SPEED IN RPM OF FIRST GEAR IN TRAIN
n_L = SPEED IN RPM OF LAST GEAR IN TRAIN
n_A = SPEED IN RPM OF ARM

THE SIGN OF e FOR EPICYCLIC GEAR SETS DEPENDS ON THE DIRECTION OF THE FIRST AND LAST GEARS.

- IF THE FIRST (SUN) AND LAST (RING) GEARS ROTATE IN OPPOSITE DIRECTIONS WHEN THE ARM IS HELD STATIONARY, e IS NEGATIVE.

* TIP: e IS ALWAYS NEGATIVE FOR INTERNAL RING GEARS.