CH-4

تستخدم التروس لنقل قدرات عالية بدقة وكفاءة عالية
هذه اهم ايجابيات النقل بالتروس
اما سلبياتها فهي غالية الثمن وكذلك الانقسام في التروس
واي خطأ بالتصنيع او التشغيل يسبب ضوضاء واهتزاز

* Gears

* The advantages of gear drives Compared with other drives like belts, ropes, and chains, that is used to transmit high power with high efficiency, high accuracy, exact velocity ratio, and small center distance between shafts.

There disadvantages that they requires special equipment in manufacturing, and the error in cutting of the teeth or method of applaying Cause vibration and noises.

* Classification of Gears

تصنيف التروس

The gears may be classified as follow:

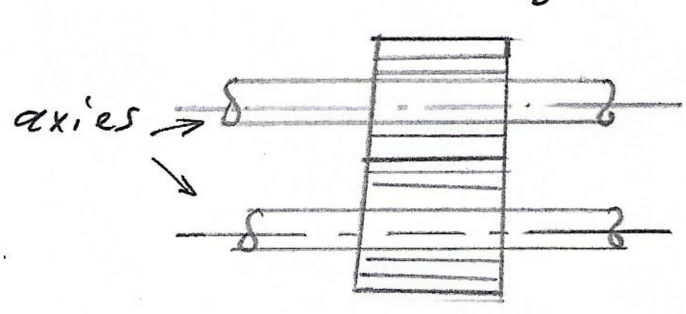
١- طبقاً لوضع المحاور

I, According to the position of axes of shafts.

1, Parallel ; like متوازية المحاور

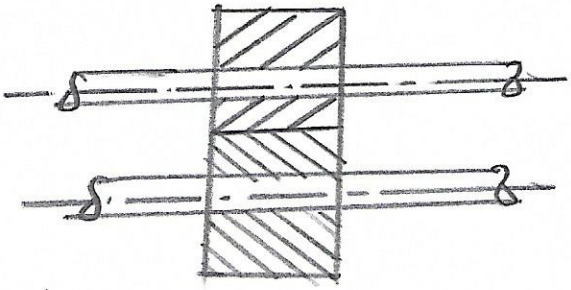
تروس عدلة

a) spur gear : with teeth parallel to the axises of the wheel, as in fig(a)



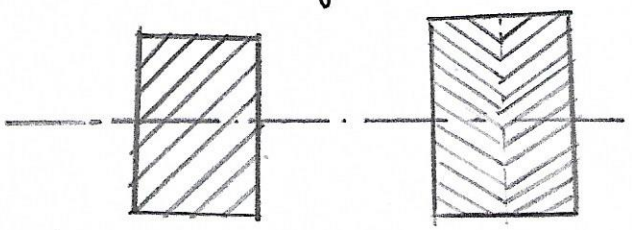
Spur gear
Fig(a)

b- Helical gear : with teeth are inclined to the axis of the parallel shaft, as shown in fig(b)



helical gear
Fig(b)

* Ther types are single and double helical gear as shown in fig(c)



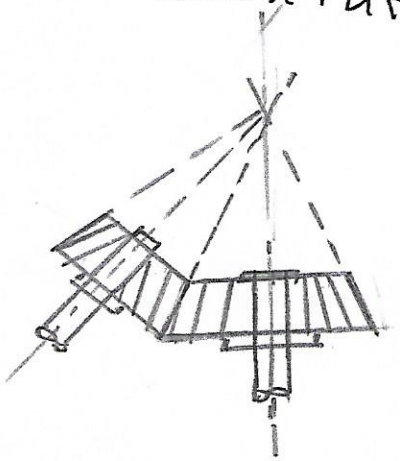
helical gear

Single helical g-r, double helical g-r

2) Intersecting : like متقاطعة

a) Bevel gear : with teeth inclined to the face of the bevel, as shown in fig(a)

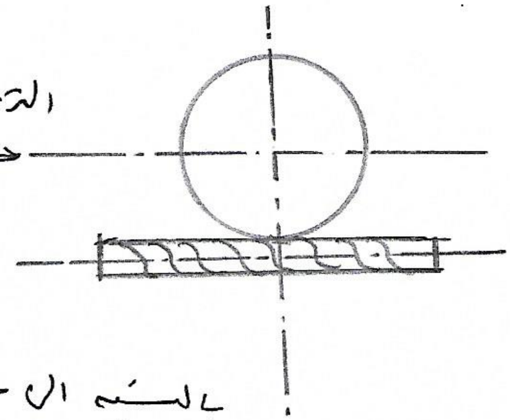
helical gear
Fig(a)



3) Non intersecting non parallel : like غير متوازية غير متقاطعة

a) Worm gear : with teeth are curved over the rim surface, and consist of pinion and rack, as shown in fig(a)

الترس الدوري والجريدة المسننة



Fig(a) rack and pinion.

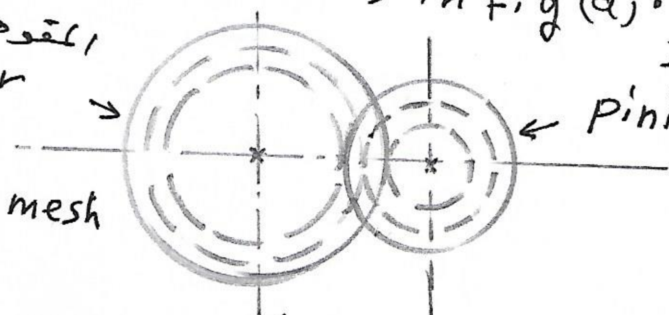
بالنسبة الى سرعة الدوران المحيطية

II) According to the peripheral velocity of the gears.

a) with low velocity → to 3 m/s
b) with Medium Velocity → from 3 m/s → 15 m/s.
c) with high velocity → more than → 15 m/s.

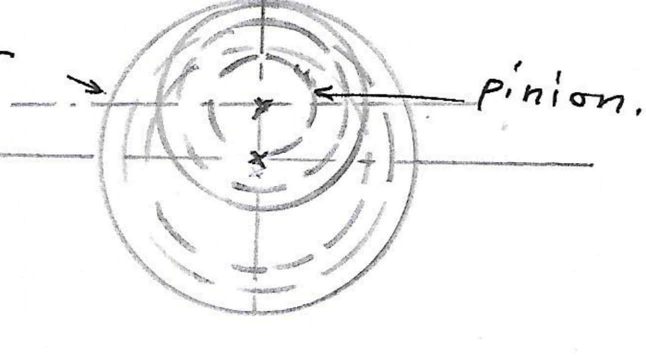
III) According to the type of gearing بالنسبة الى نوع التعشيق

a) External gearing: التعشيق الخارجي
In which the gears of the two shafts mesh externally. The largest gear is called gear, and the smallest is called pinion, as in fig(a).



Fig(a) exteral mesh

b) Interal gearing تعشيق داخلي
In which the two gears mesh internally.
In which the largest gear is called annular wheel and the smallest is called pinion, as in fig(b).



fig(b) Internal gearing

C- Rack and pinion. الكريمالستنه

IV / According to the position of teeth on the gear surface. بالنسبة لوضع الأسنان على سطح الترس

a) Straight مستقيم in Spur gear.
b) Inclined مائلة in helical gear
c) Curved منحنية in worm gear

* Terms of gears المصطلحات الفنية للتروس

Fig (a) Show all the terms of spur gear mesh الشكل التالي يوضح المصطلحات الفنية للتروس العدلة في حالة التشابك

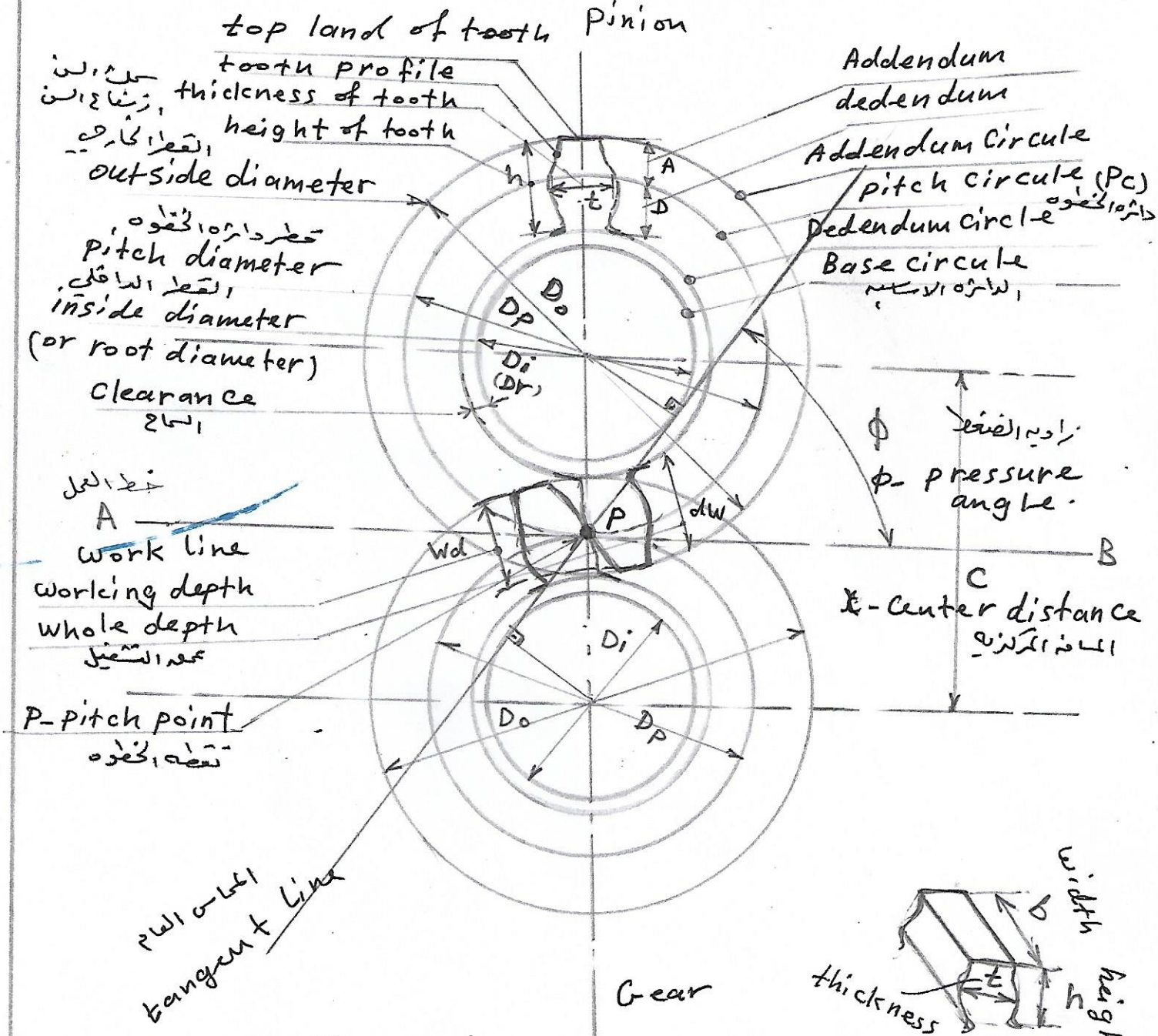


Fig (a) : Terms of spur gear Mesh. المصطلحات الفنية لتشابك التروس العدلة

Terms of spur gear mesh

1- Addendum circule - دائرة التابع
2- Pitch circule دائرة الخطوة
3- Dedendum Circule دائرة الجذع
4- Base circule الدائرة الأساسية
5) working depth circule دائرة عمق التشغيل
6) Adendum → $D_A = M$.
7 Dedendum → $D_d = (1,25 - 1,2)\,M$.
8) circular pitch → $P_c = \frac{\pi d}{T}$
where: d- pitch diameter, T- number of teeth.
In case of gear mesh, must be
$P_{c_1} = P_{c_2} \rightarrow \frac{\pi d_1}{T_1} = \frac{\pi d_2}{T_2} \Rightarrow \frac{d_1}{d_2} = \frac{T_1}{T_2}$ --- (1)
9) diametral pitch → $P_d = \frac{T}{d}$ --- (2)
where $P_c = \frac{\pi d}{T} \Rightarrow d = \frac{P_c \cdot T}{\pi} \Rightarrow P_d = \frac{T}{\frac{P_c \cdot T}{\pi}} = \frac{\pi}{P_c}$ (3)
10) Modul → $m = \frac{dp}{T}$ --- (3)
11) Whole depth العمق الكلي للسن
$d_w = D + A$ (الكلي / الجذع) $= (2,25 - 2,2)\,M$
12) Clearance → $C = M(2,5-2)$ الخلوص (السطح بين السنان)
13) Pressure angle - angle between the tangent of the two base circule in gear mesh and the work line.
where $\phi = 20° - 14,5°$
14) t - thickness of tooth.
15) h - height of tooth
16) b - width of tooth.
17 - Center distance المسافة المركزية (x)
$x = \frac{d_1 + d_2}{2}$ --- (4)

* Gear trains نقل الحركة بواسطة التروس

* Introduction :

When two or more gears are in mesh with each other to transmit power from one shaft to another, this Combination is Called gear train, and it depends upon the Velocity ratio, and the relative position of the axis of the shafts.

* Types of Gear trains :

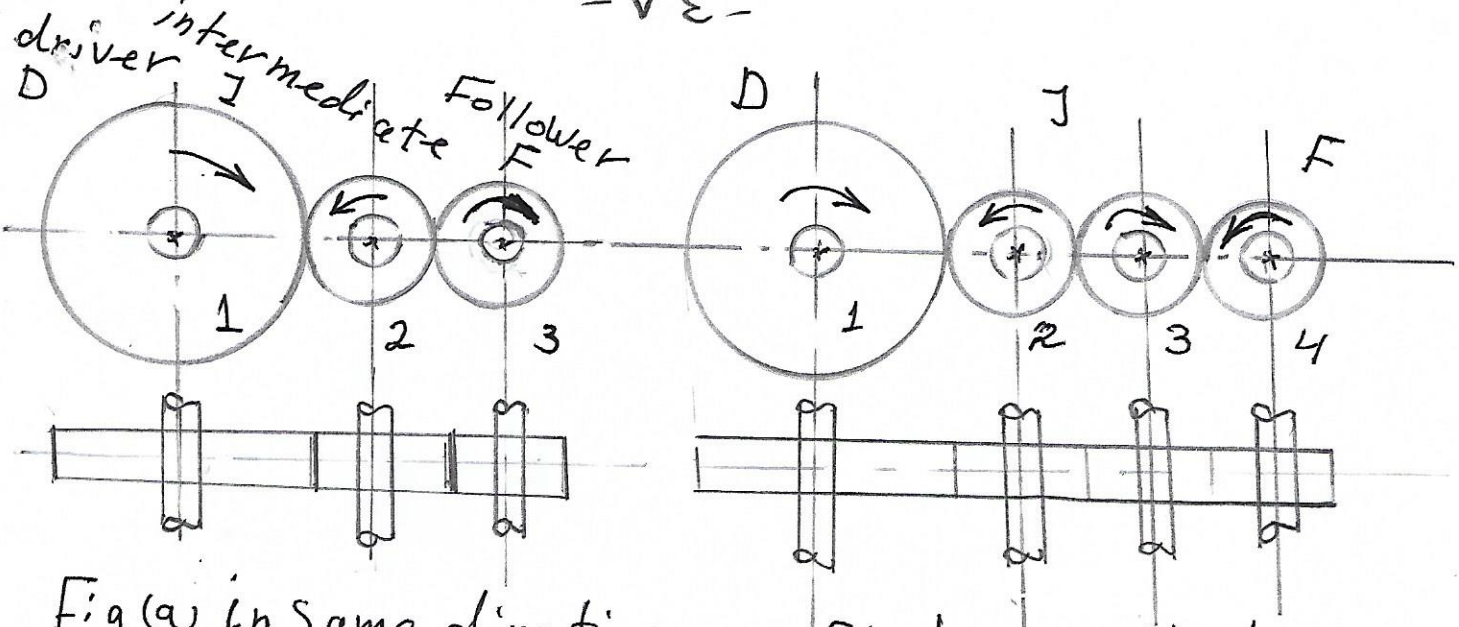
1) Simple gear trains
2) Compound gear trains
3) Reverted gear trains
4) Epicyclic gear trains

} In which the gear mounted on the fixed shafts.

} In which the mounted gears move relative to a fixed shafts.

I) Simple gear train

This type is used, when the distance between the driver and the follower is so larg, It done by adding intermediate gears between them instade of using large gears, which are expensive. The number of intermediate gears limits the direction of the transmitted motion, where the single number of them give us Same direction of follower, and double number give opposite direction, as



Fig(a) in Same direction fig(b, opposite direction

a) for fig(a) the transteted motion in same direction, and the velocity ratio be:

$$R_V = \frac{N_2}{N_1} = \frac{T_1}{T_2} = \frac{D_1}{D_2} \quad \text{---} (1)$$

also;

$$R_V = \frac{N_3}{N_2} = \frac{T_2}{T_3} = \frac{D_2}{D_3} \quad \text{---} (2)$$

By multiplying (2) by (1) we get

$$\frac{N_3}{N_2} * \frac{N_2}{N_1} = \frac{T_2}{T_3} * \frac{T_1}{T_2}$$

$$\therefore \boxed{R_V = \frac{N_3}{N_1} = \frac{T_1}{T_3}} \quad \text{---} (3)$$

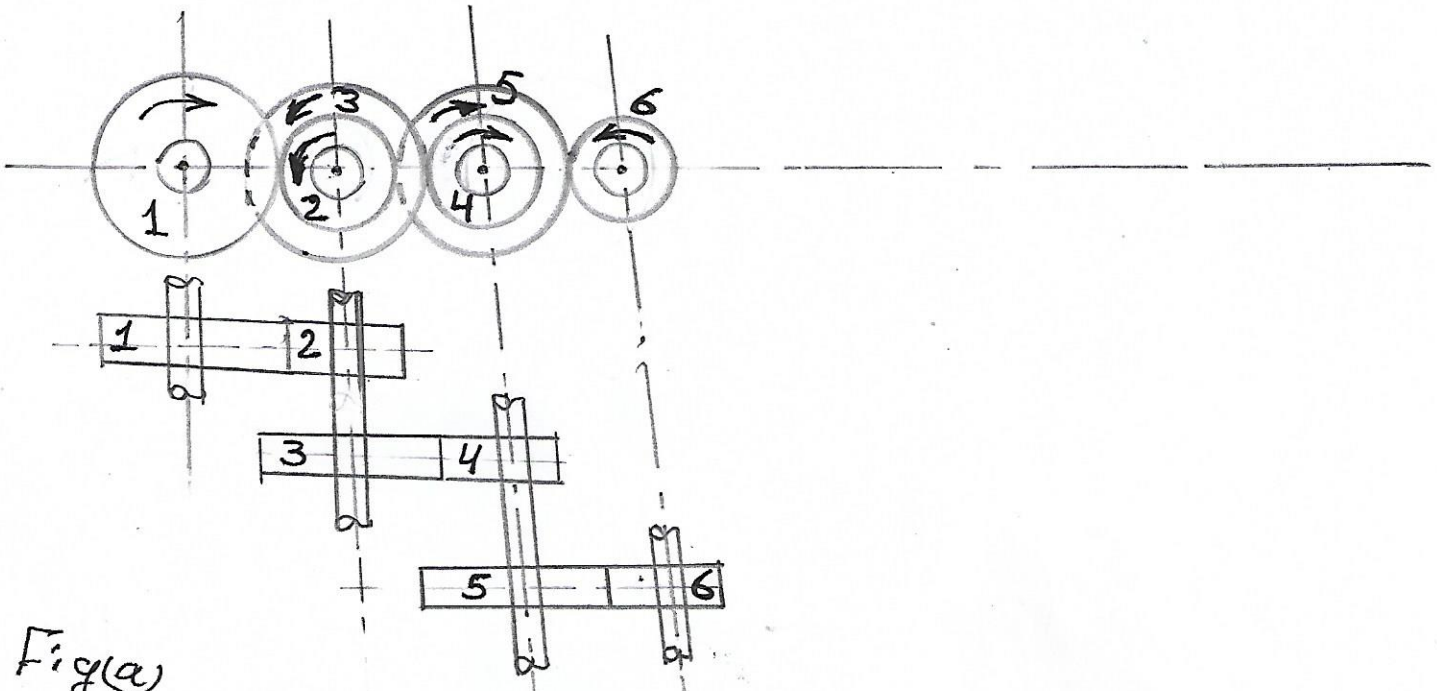
Note: equation (3) show as that the intermediates gears have no effect on the speed ratio, so they named as dead gears.

من هذا يتضح لنا ان التروس الوسطية ليس لها تأثير على نسبة السرعة ولهذا تسمى بالتروس الميتة.

II) Compound gear train. نظام التروس المركب

This type is used to transmit motion from driver, to the follower

تدريجي
gradually, For this purpose we mount two gears on the intermediate shafts, which be turn with same speed, as shown in fig(a)



Fig(a)
Compound gear train.

* from fig(a) the speed ratio be:

$$R_V = \frac{N_2}{N_1} = \frac{T_1}{T_2} \quad \text{---(1)}$$

Similarly:

$$R_V = \frac{N_4}{N_3} = \frac{T_3}{T_4} \quad \text{---(2)}$$

$$R_V = \frac{N_6}{N_5} = \frac{T_5}{T_6} \quad \text{---(3)}$$

By multiplying (1), (2) and (3) → we get

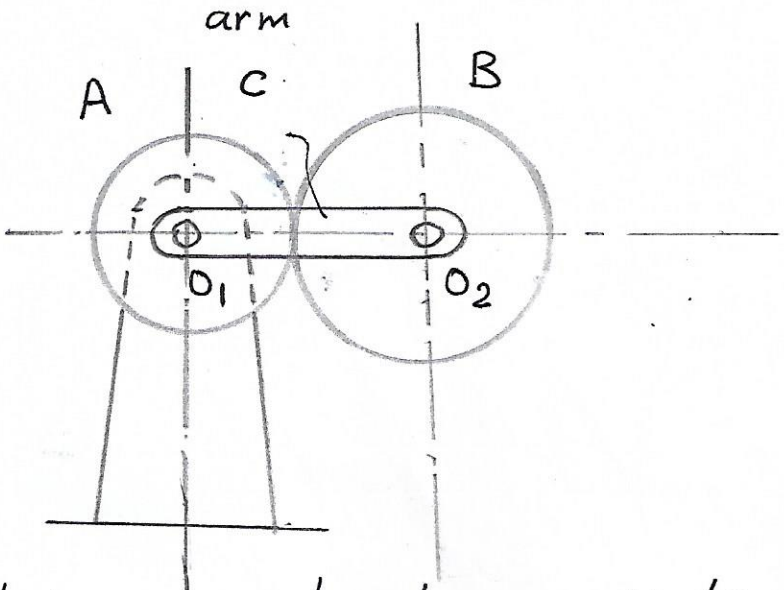
$$R_V = \frac{N_2}{N_1} * \frac{N_4}{N_3} * \frac{N_6}{N_5} = \frac{T_1}{T_2} * \frac{T_3}{T_4} * \frac{T_5}{T_6}$$

Because $N_2 = N_3$, $N_4 = N_5$ → by assuming

$$\therefore \boxed{R_V = \frac{N_6}{N_1} = \frac{T_1 * T_3 * T_5}{T_2 * T_4 * T_6}} \quad \text{---(4)}$$

IV Simple Epicyclic gear train (النظام الفلكي (العوفي) او المدوري البسيط)

In this type we have arm, which join the turning gear in one side and in other side is joining with a gear of fixed shaft, in order to take planet motion, as shown in fig(a).



Fig(a) show Simple Epicyclic train.

The speed ratio in this type may be determine by two methods:

1) Tabular method:

In this method we assume that the arm (C) is Fixed, thene fore the sysbem may be take as Simple type as in table (1)

No. step	Condition of motion	Revolution of elemnts		
		Arm C	Wheel A	Wheel B
1-	Arm (C) is fixed, wheel A rotates through (+1) revolution anti-clock wise	0	+1	$-\frac{T_A}{T_B}$
2.	Arm (C) is fixed, wheel (A), rotates through (+X) revolution	0	+X	$-X\frac{T_A}{T_B}$
3-	Add (+y) revolution to all elements	+y	+y	+y
4-	Total motion	+y	X+y	$y-X\frac{T_A}{T_B}$

∴ The speed ratio.

$$R_V = \frac{N_B}{N_A} = \frac{T_A}{T_B} \quad \text{---(1) for Simple train}$$

when $N_A = 1$ revolution.

$$\therefore N_B = \frac{T_A}{T_B} \quad \text{---(2)}$$

2- Algebric Method: الطريقة الجبرية

In this way we take the motion of every link of the system with respect to the arm(C). therefore we must form equations equal to the number of links, and solve them.

Let we take the arm(C) is fixed and the gear(A) move relative w.r.to (C)

∴ The relative speed of gear A w.r.to C

$$= N_A - N_C$$

and the relative speed of gear B w.r.to C

$$= N_B - N_C$$

But the gear A and B are in mesh, therefore they turn in opposite direction

$$\therefore \frac{N_B - N_C}{N_A - N_C} = -\frac{T_A}{T_B} \quad \text{---(1)}$$

But when arm (C) is fixed, there Speed = 0

$$\therefore N_C = 0 \text{ , and}$$

$$\frac{N_B}{N_A} = -\frac{T_A}{T_B} \quad \text{---(2)}$$

and when gear A is fixed

$$\therefore N_A = 0 \text{ , and}$$

$$\frac{N_B - N_C}{0 - N_C} = -\frac{T_A}{T_B}$$

or $\frac{N_B}{N_C} = 1 + \frac{T_A}{T_B}$ (

* Compound Epicyclic gear train. (Sun and planet gear)

This type is consist of two co-axial Shafts (S_1, S_2), fixed Annulus gear (A), Compound or (planet gears) B-C, Sungear D and arm H. The gear A mesh with B and C with D. The work of system be:

when A is fixed → D - drive
and when D is fixed A - drive } H-arm is follower in two cases

as shown in fig(a),

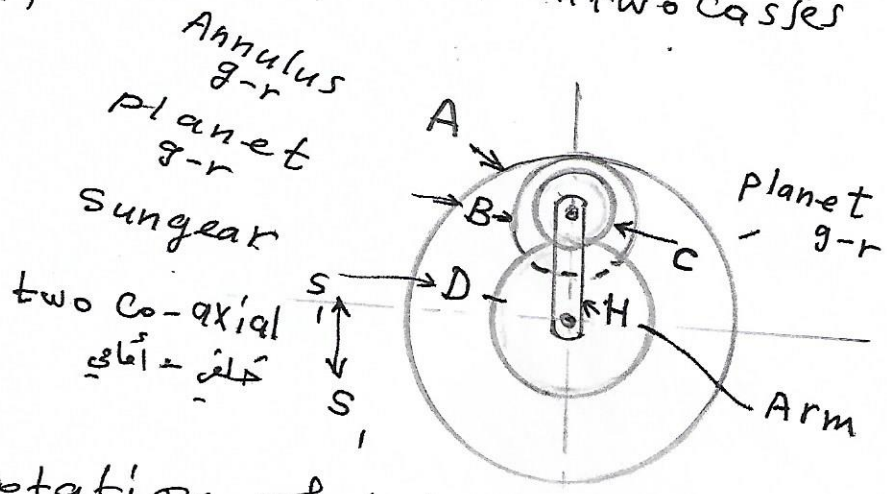


Fig (a) show Compound Epicycle geartrain.

The motion of rotation of this type may be tabulet in table (1) as below:

Step N.	Condition of motion	Revelution of elements			
		Arm	Gear D	Compound g-r B-C	Gear A
1-	Arm Fixed → gear D rotates through +1 Revolution	0	+1	$-\frac{T_D}{T_C}$	$-\frac{T_D}{T_C} * \frac{T_B}{T_A}$
2-	Arm fixed → gear D rotates through +X revolutions	0	+X	$-X * \frac{T_D}{T_C}$	$-X \frac{T_D}{T_C} * \frac{T_B}{T_A}$
3-	Add +y revolution to all elements	+y	+y	+y	+y
4-	Total motion	+y	X+y	$y - X * \frac{T_D}{T_C}$	$y - X * \frac{T_D}{T_C} * \frac{T_B}{T_A}$

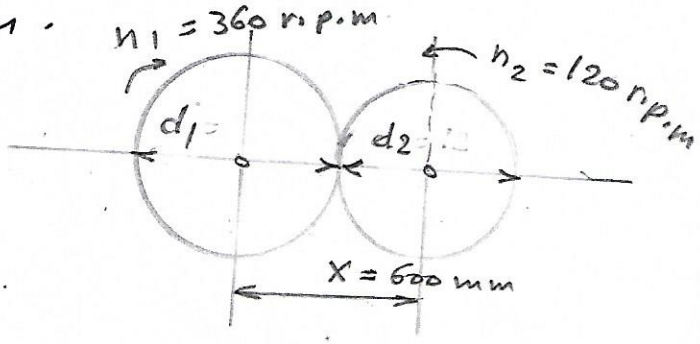
Gear and Gear trains

أمثلة تطبيقية على التروس والقطارات التروسية

Examples

example (1):

Two parallel shafts; about (600 mm) aparat are to be connected by spur gears. one shaft is to run at 360 r.p.m and the other at (120 r.p.m). Design the gears, if the circular pitch is to be 25 mm.



Solution:

$$R_V = \boxed{\frac{n_2}{n_1} = \frac{d_1}{d_2}} = \frac{z_1}{z_2}$$

$$\therefore \frac{n_2}{n_1} = \frac{d_1}{d_2} \Rightarrow \frac{d_1}{d_2} = \frac{120}{360} = \frac{1}{3} \Rightarrow d_2 = 3d_1 \quad -(1)$$

and $X = \frac{d_1 + d_2}{2} = 600 \Rightarrow d_1 + d_2 = 1200 \quad -(2)$

By substituting (2) in (1) we get

$$d_1 + 3d_1 = 1200 \Rightarrow 4d_1 = 1200 \Rightarrow d_1 = \frac{1200}{4} = 300 \text{ mm}$$

and $d_2 = 3 * 300 = 900$ mm

$$P_c = \frac{\pi d}{T} \Rightarrow T = \frac{\pi d}{P_c}$$

$$\therefore T_1 = \frac{\pi d_1}{P_c} = \frac{3,14 * 300}{25} = 37,7 \approx 38$$

$$T_2 = \frac{\pi d_2}{P_c} = \frac{3,14 * 900}{25} = 113,1 \approx 38 * 3 = 114$$

$$\therefore \begin{cases} d_1 = \frac{T_1 * P_c}{\pi} = \frac{38 * 25}{\pi} = 302,36 \text{ mm} \\ d_2 = \frac{T_2 * P_c}{\pi} = \frac{114 * 25}{\pi} = 907.1 \text{ mm} \end{cases}$$

and

$$X = \frac{d_1 + d_2}{2} = \frac{302.36 + 907.1}{2} = 604.73 \text{ mm}$$

example (2) :

The gearing of a machine tool is shown in fig (1). The motor is connected to gear A and rotates at (975 r.p.m), The gear wheel B, ,C, D and E are fixed to parallel shafts rotating together, The final gear F is fixed on the output shaft. What is the Speed of gear F =? , The number of teeth on each gear are given below.

Gear	A	B	C	D	E	F
number of teeth	20	50	25	75	26	65

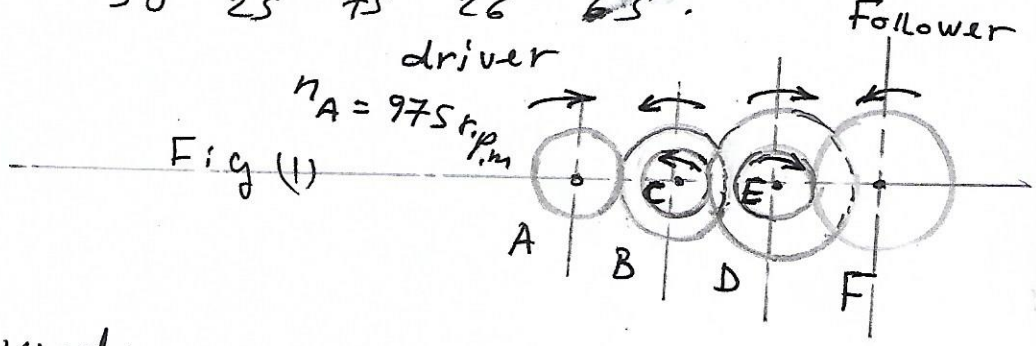


Fig (1)

Solution :

For the Compounde gear train as shown the velocity ratio be:

$$R_V = \frac{N_B}{N_A} * \frac{N_D}{N_C} * \frac{N_F}{N_E} = \frac{T_A}{T_B} * \frac{T_C}{T_D} * \frac{T_E}{T_F}$$

Because $N_B = N_C$, $N_D = N_E$ on the same shaft

$$\therefore R_V = \frac{N_F}{N_A} = \frac{T_A}{T_B} * \frac{T_C}{T_D} * \frac{T_E}{T_F} = \frac{20 * 25 * 26}{50 * 75 * 65} =$$

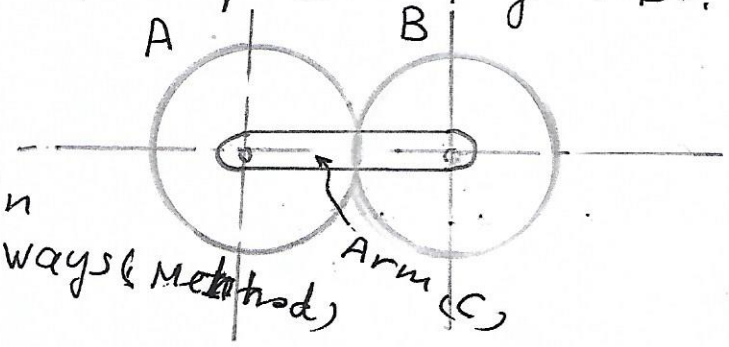
$$\therefore \frac{N_F}{N_A} = 0,05333$$

$$\therefore N_F = N_A * 0,05333 = 975 * 0,05333 = 52 \text{ r.p.m}$$

example (3).

In an epicyclic gear train, an arm Carries two gears A, B having 36 and 45 teeth respectively. If the arm rotates at 150 r.p.m in the anti clockwise direction about the Centre of gear A, which is fixed, determine the speed of gear B=? . If the gear A instead of being fixed makes 300 r.p.m. in the clockwise direction, what will be the speed of gear B=?

Solution



Simp APicycle gear train may be solved by two ways (Methods)

1) Tabular Method.

step N.	Condition of motion	Revolutions of elements		
		Arm C	gear A	Gear B
1-	Arm fixed - gear A rotates (+1) revolution clockwise	0	+1	$-\frac{T_A}{T_B}$
2-	Arm fixed - gear A rotates through (+X) revolution	0	+X	$-X*\frac{T_A}{T_B}$
3-	Add (+y) revolution to all elements	+y	+y	$y-X*\frac{T_A}{T_B}$
4-	Total motion	+y	X+y	$y-X*\frac{T_A}{T_B}$

(1) From row (4) → arm speed = 150 r.p.m anticlockwise

Speed: $N_C = y = +150$ r.p.m, when gear A is fixed

Speed: $N_A = X+y = 0 \Rightarrow X = -y = -150$ r.p.m

and the speed of gear B

$$N_B = y - X*\frac{T_A}{T_B} = 150 - (-150)*\frac{36}{45} = 270 \text{ r.p.m}$$

① when gear A make 300 r.p.m clockwise
∴ The speed of gear B from row (4) be
Speed of g-A $X+Y = -300 \Rightarrow X = 300 - Y = -300 - 150$
$= -450$ r.p.m

and speed of g-B $N_B = X - Y * \frac{T_A}{T_B} = 150 + 450 * \frac{36}{45} = +$
$= +150$ r.p.m anticlockwise

2) Algebric Method

By assuming arm C is fixed, then the velocity of A relative to C
$= N_A - N_C$
and the speed of g.B relative to arm C
$= N_B - N_C$
But the gears A, B are in mesh and turn in opposite direction.
∴ the speed ratio

$$\frac{N_B - N_C}{N_A - N_C} = \frac{T_A}{T_B} \quad \text{---} ①$$

But when gear A is fixed the arm rotates at 150 r.p.m, and for the speed of B
∴ $N_A = 0 \rightarrow N_C = +150$ r.p.m by sub in ①

$$\frac{N_B - 150}{0 - 150} = \frac{36}{45} = -0,8$$

∴ $N_B = (150 * -0,8) + 150 = 270$ r.p.m
and speed of g.B, when A makes 300 r.p.m clockwise

$$\therefore \frac{N_B - 150}{300 - 150} = \frac{36}{45} = 0,8$$

example (4) :

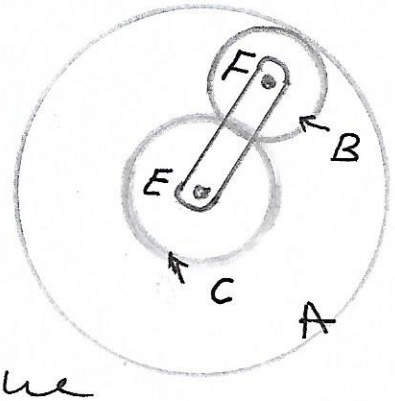
An epicyclic gear train consist of three gears A, B and C as shown in fig(A). The gear A has 72 internal teeth and gear C has 32 external teeth. The gear B meshes with both A and C, and is carried on an arm EF which rotates about the centre of A at 18 r.p.m. If the gear A is fixed. determine the speed of gears B and C.

Solution.

Given data are:

$T_A = 72$, $T_C = 32$

Arm Speed = 18 r.p.m



Fig(a)
Compound epicycle gear train

By taking relative motion of rotation, then Tabulate the motion.

∴ table of motion be.

Step No.	Condition of motion	Revolution of elements			
		Arm Ef	gear C	gear B	gear A
1-	Arm fixed - gear C rotates through (+1) revolution anticlockwise.	0	+1	$-\frac{T_C}{T_B}$	$-\frac{T_C}{T_B}*\frac{T_B}{T_A} = -\frac{T_C}{T_A}$
2-	Arm fixed - gear C rotates through (+X) revolution	0	+X	$-X*\frac{T_C}{T_B}$	$-X*\frac{T_C}{T_A}$
3-	Add (+y) revolution to all elements	+y	+y	+y	+y
4-	Total motion				

from row (4) of table be

① The speed of gear C

when the speed of arm Ef = 18 r.p.m

∴ +y = 18 r.p.m

and the gear A is fixed, and there fore

Speed of A ⇒ $y - X * \frac{T_C}{T_A} = 0 \Rightarrow 18 - X * \frac{32}{72} = 0$

∴ $X = 18 * \frac{72}{32} = 40.5$

and speed of gear C ⇒ X+y = 40,5+18 = 58.5 r.p.m in the direction of arm.

② Speed of gear B

assume the pitch diameter of gears A, B, C are d_B, d_C, d_A

∴ from fig (A)

$d_B + \frac{d_C}{2} = \frac{d_A}{2} \Rightarrow 2d_B + d_C = d_A$ — ①

and the number of teeth are proportional to the pitch diameter, there for

$2T_B + T_C = T_A \Rightarrow 2T_B + 32 = 72 \Rightarrow \boxed{T_B = 20}$

and for the speed of gear B. from row (4)

$= y - X * \frac{T_C}{T_B} = 18 - 40,5 * \frac{32}{20} = 46,8$ r.p.m

in to opposite direction of arm.