



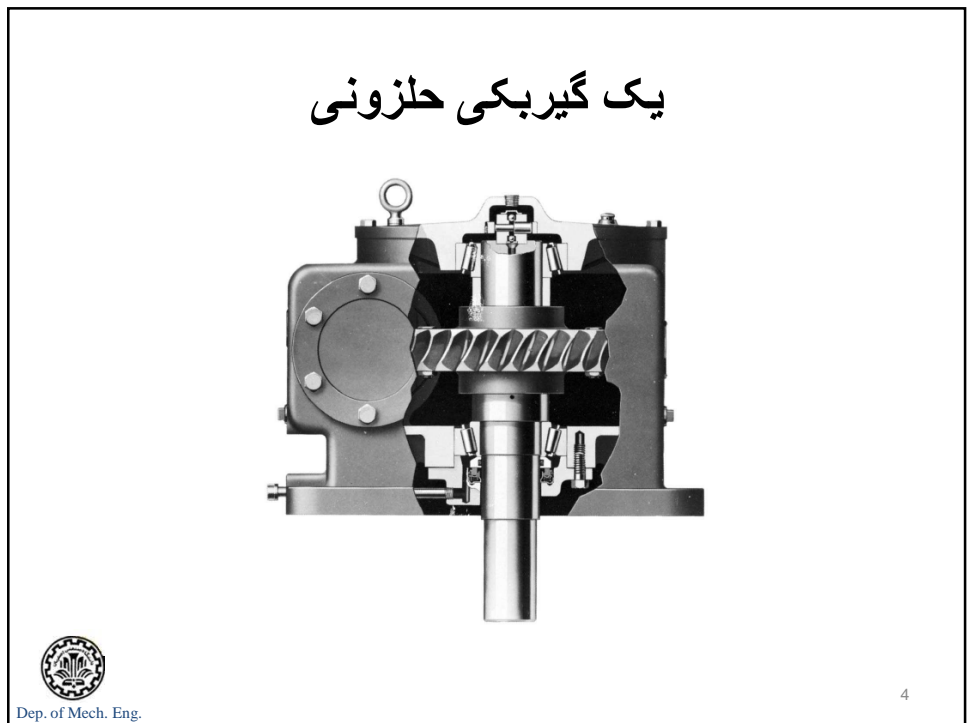
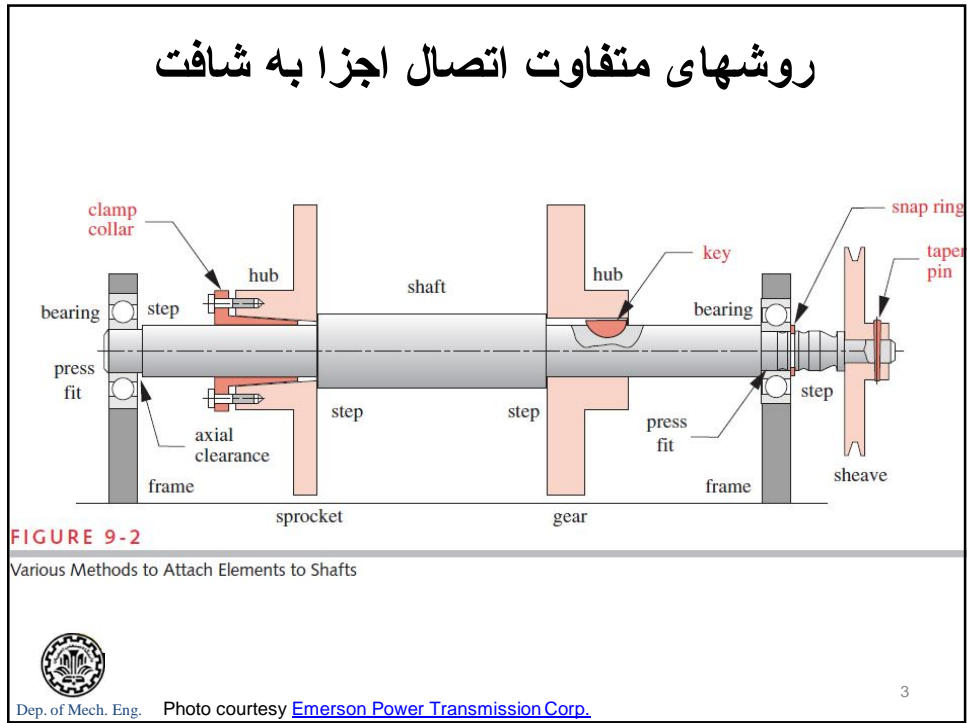
مقدمه

محور یا شافت:
 عضوی چرخشی یا ثابت، و معمولاً با مقطع دایره ای برای انتقال توان یا حرکت از دستگاه محرک، نظیر یک موتور الکتریکی، به یک مصرف کننده
 بر روی شافت معمولاً چرخدنده، پولی و چرخ زنجیر نصب گردیده که انتقال حرکت چرخشی و توان را توسط دنده های درگیر، تسمه و زنجیر میسر می سازند

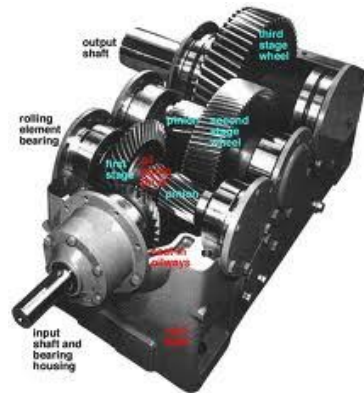


Dep. of Mech. Eng. Photo courtesy [Emerson Power Transmission Corp.](#)

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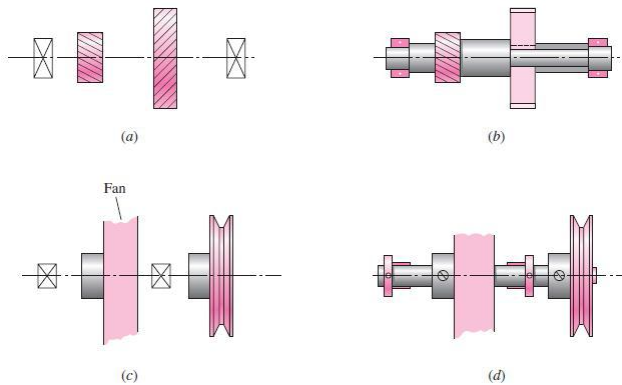
مجموعه های گیربکس



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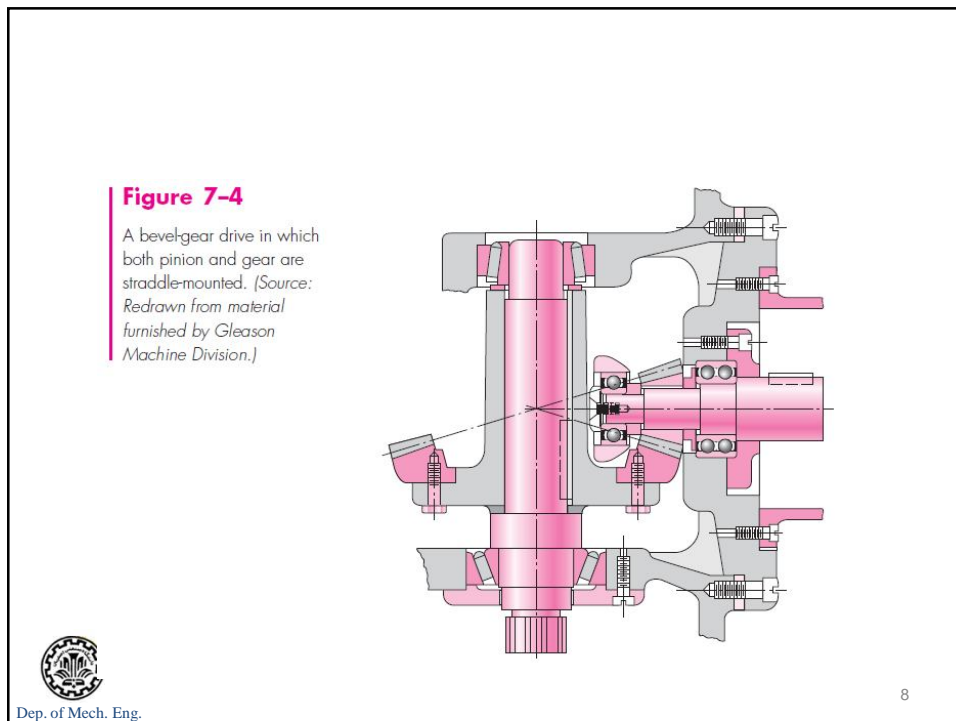
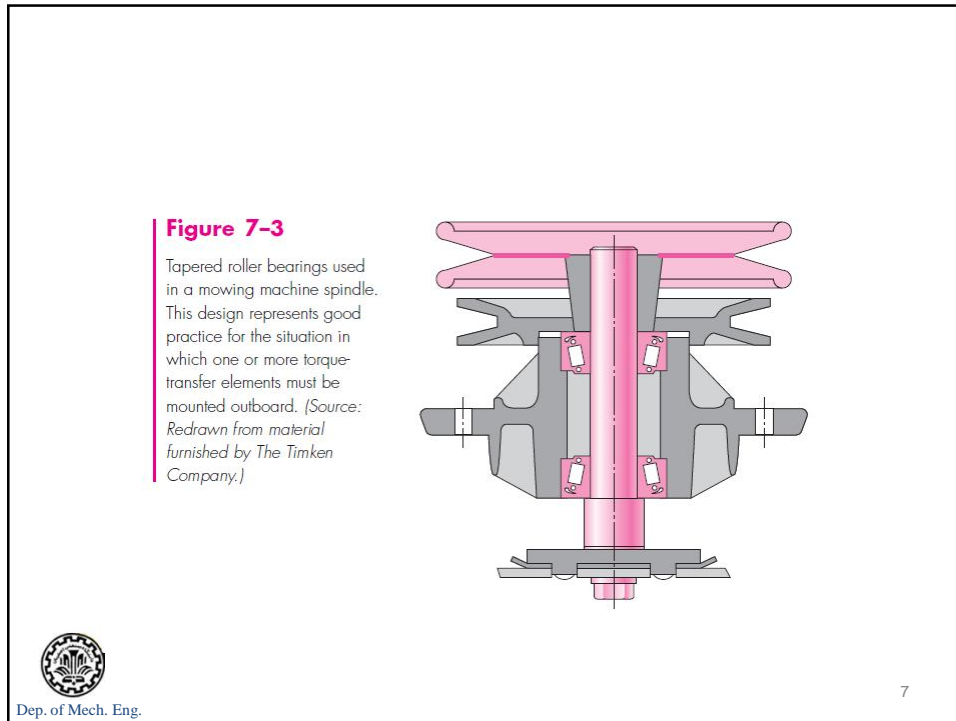
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طرح شافت



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Gears

Figure 13-1

Spur gears are used to transmit rotary motion between parallel shafts.

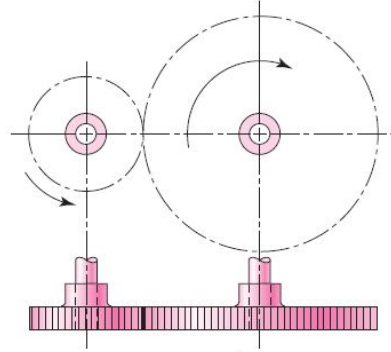


Figure 13-2

Helical gears are used to transmit motion between parallel or nonparallel shafts.

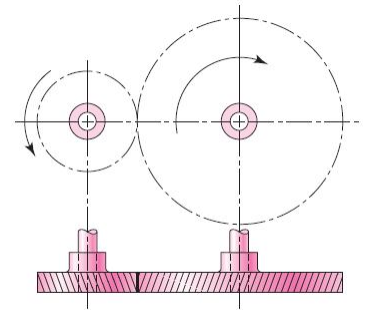


Figure 13-3

Bevel gears are used to transmit rotary motion between intersecting shafts.

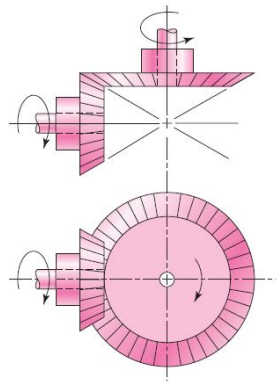
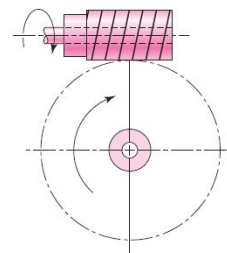


Figure 13-4

Worm gearsets are used to transmit rotary motion between nonparallel and nonintersecting shafts.

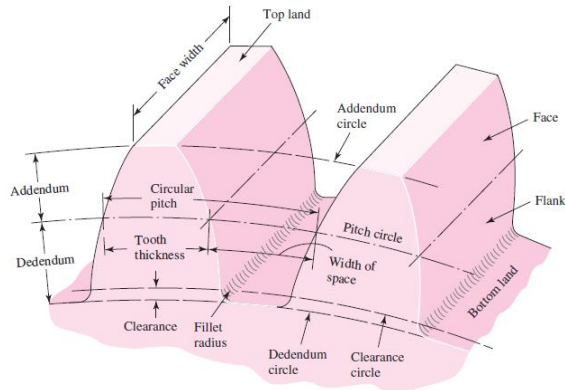


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نامگذاري چرخنده ساده

Figure 13-5

Nomenclature of spur-gear teeth.

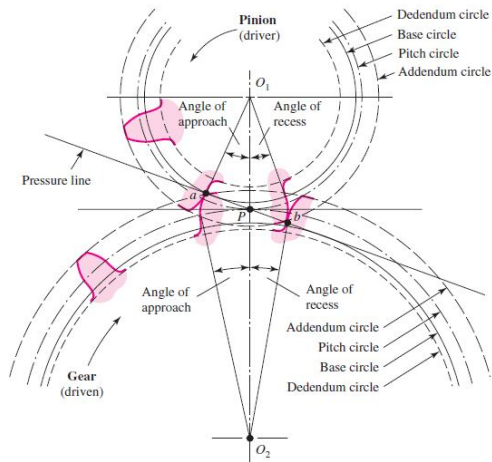


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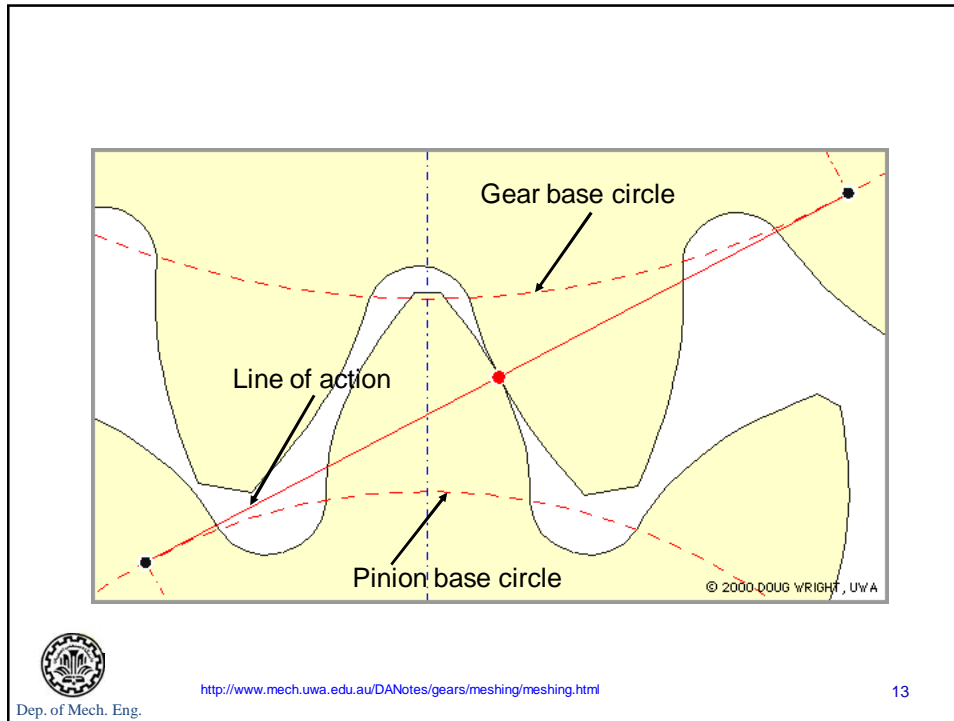
Figure 13-12

Tooth action.

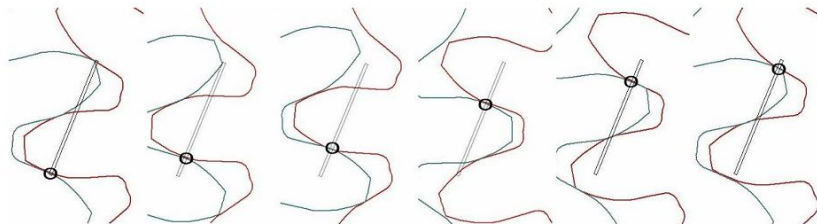


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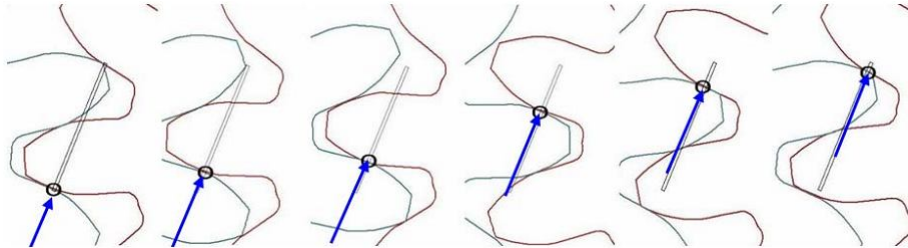
تماس دو چرخنده ساده



نقطه تماس همواره بر روی خط عمل قرار دارد.



جهت نیرو در تماس بین دو چرخنده ساده



راستای اعمال نیرو در جهت خط عمل قرار دارد.



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Figure 13-28

A two stage compound gear train.

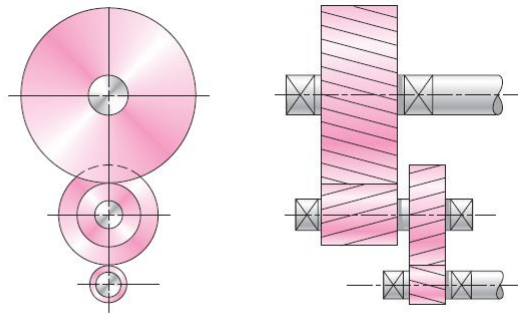
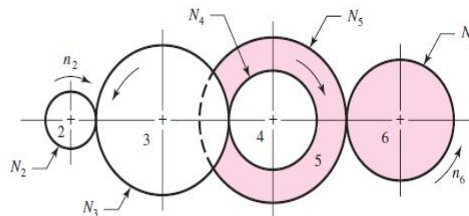


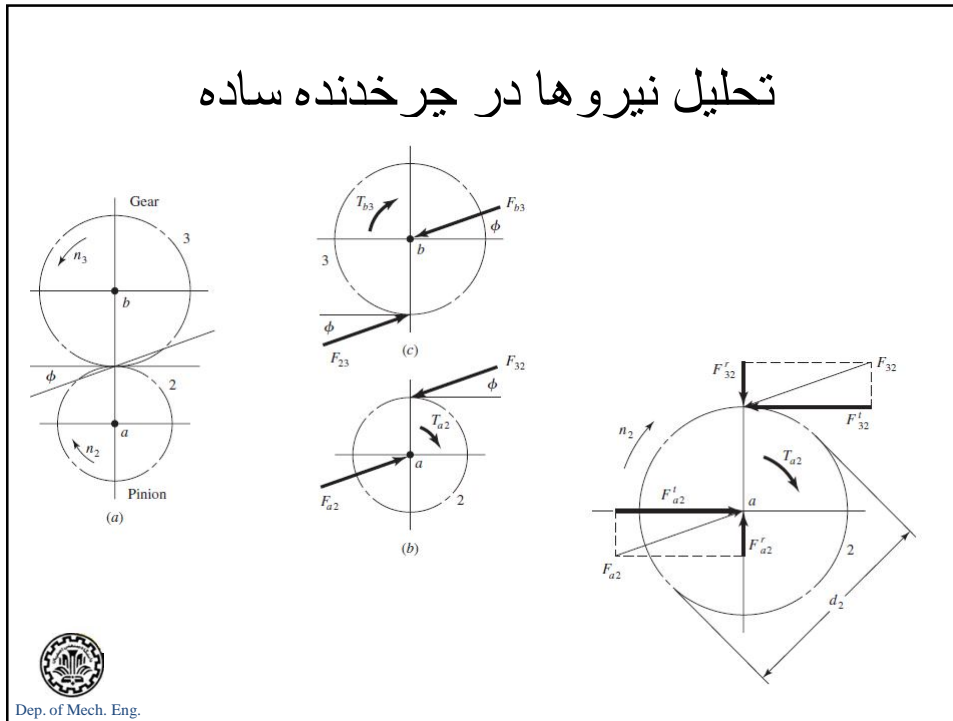
Figure 13-27

A gear train.



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تحلیل نیروها در چرخنده ساده



نیروهای وارده بر چرخنده ساده

$$W_t = \frac{T}{D/2}$$

$$\text{Power transmitted : } hp = \frac{T \times n}{63000}$$

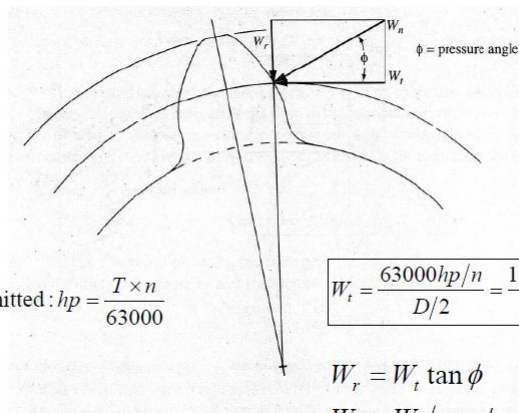
$$T : \text{lb} \cdot \text{in}$$

$$n : \text{rpm}$$

$$W_t = \frac{63000 hp / n}{D/2} = \frac{126000 hp}{nD} \quad (\text{lb})$$

$$W_r = W_t \tan \phi$$

$$W_n = W_t / \cos \phi$$

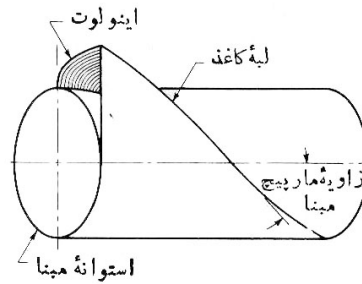
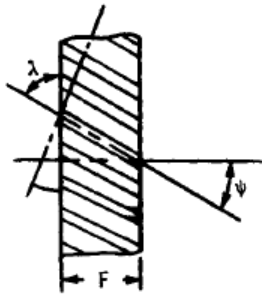


چرخنده مارپیچ موازي

يك جفت چرخنده خارجي: زاويه مارپیچ يكسان ولي در خلاف جهت يكد يگر

$$\Sigma = \Psi_1 \pm \Psi_2 ; \quad \Sigma = 0 \rightarrow \Psi_1 - \Psi_2 = 0 \rightarrow \Psi_1 = \Psi_2$$

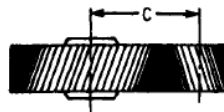
شکل دندانها: مارپیچ وار اينولوت



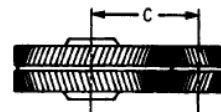
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انواع چرخنده هاي مارپیچ موازي



(a)



(b)



(c)

- (a) Single-helix gear
- (b) Double-helix gear
- (c) Types of double-helix:
 - Left: conventional
 - Centre: staggered
 - Right: continuous or herringbone

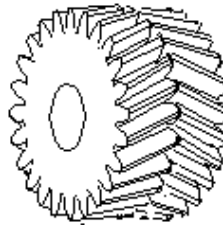


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چرخنده های جنافی

- To avoid axial thrust, two helical gears of opposite hand can be mounted side by side, to cancel resulting thrust forces
- Herringbone gears are mostly used on heavy machinery.



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چرخنده مارپیچ موازی--مشخصه ها

نحوه تماس: خط - نقطه - خط:

- درگیری تدریجی دندانه ها
- انتقال آرام بار
- توانایی انتقال بارهای سنگین در سرعتهای بالا
- اهمیت کم نسبت تماس

زاویه مارپیچ:

ایجاد مولفه نیرویی محوری (علاوه بر شعاعی)
با افزایش ψ ایجاد سروصدا کاهش می یابد (انتقال قدرت
یکنواخت تر)
با افزایش ψ نیروی محوری افزایش می یابد
عموماً 15, 23, 30 و 45°



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تحمل بار چرخنده مارپیچ

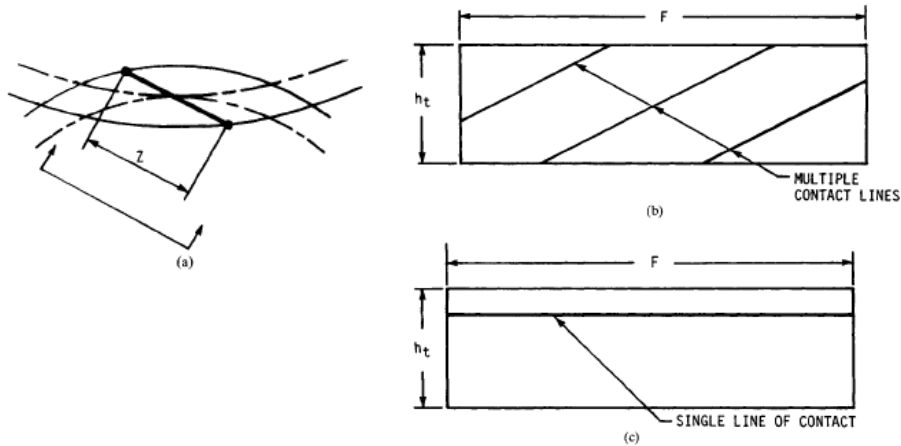


FIGURE 35.3 Comparison of spur and helical contact lines. (a) Transverse section; (b) helical contact lines; (c) spur contact line.

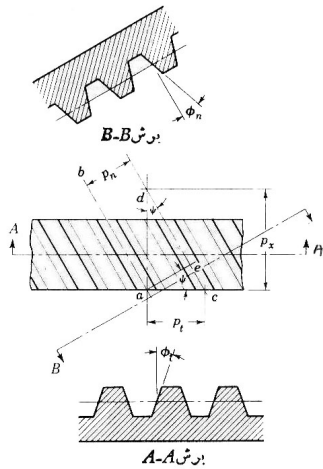


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نامگذاری چرخنده های مارپیچ

- گام دایره ای: گام دایره ای عرضی (گام دایره ای) - P_t
- گام دایره ای عمودی - P_n
- گام دایره ای عرضی (گام محوری) - P_x
- مدول عرضی (مدول) - m
- مدول عمودی - m_n



$$P_n = P_t \cos \Psi$$

$$P_t = \pi \cdot m$$

$$P_x = \frac{P_t}{\tan \Psi}$$

$$P_n = \pi \cdot m_n$$

$$m_n = m \cos \Psi$$

$$\cos \Psi = \frac{\tan \Phi_n}{\tan \Phi_t}$$

شکل ۱۴-۳ نامگذاری چرخنده های مارپیچ.

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تحلیل نیروهای چرخنده های مارپیچ

$W_r = W \sin \phi_n$
 $W_t = W \cos \phi_n \cos \psi$
 $W_a = W \cos \phi_n \sin \psi$

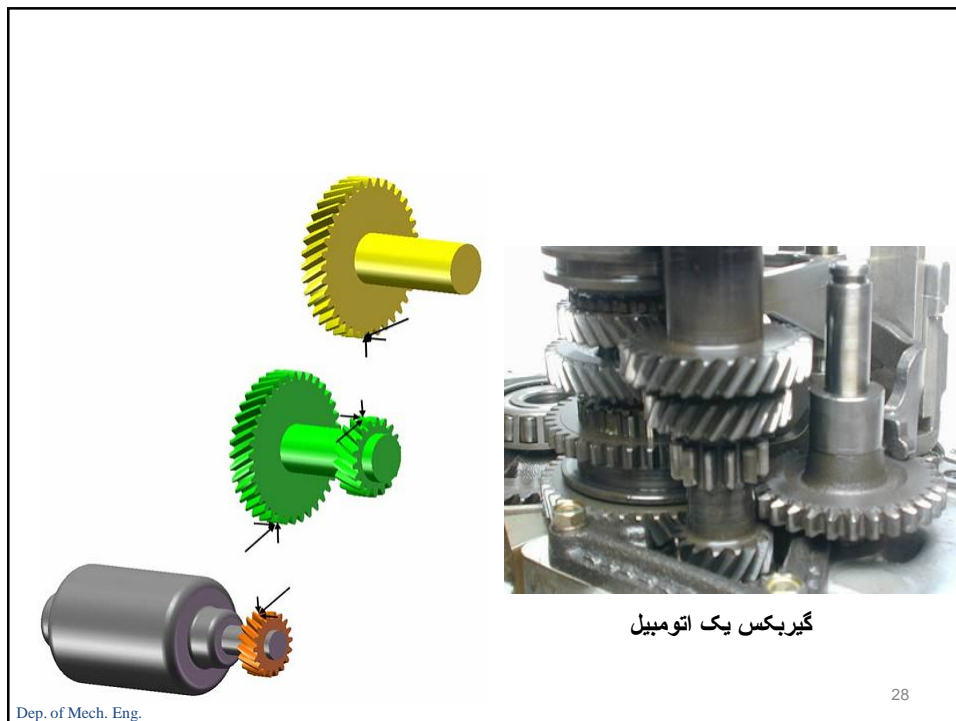
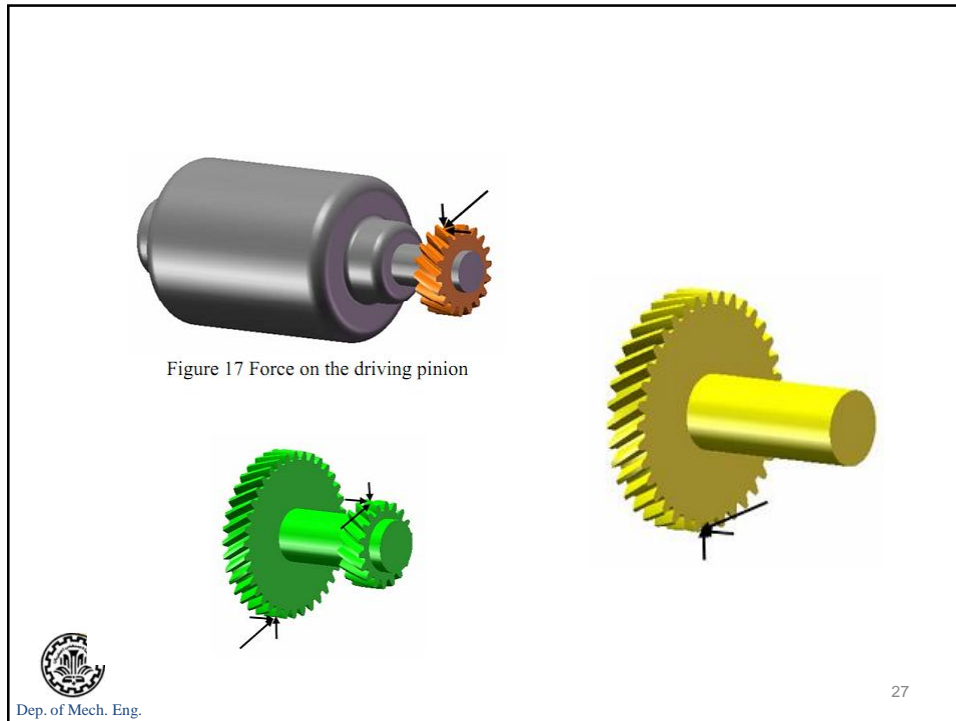
Total force
 Radial component
 $W_t =$ tangential component, also called transmitted load
 $W_a =$ axial component, also called thrust load

$$W_r = W_t \tan \Phi_t \quad W_a = W_t \tan \Psi \quad W = \frac{W_t}{\cos \Phi_n \cos \Psi}$$

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دیگرام آزاد نیروهای اعمال شده به چرخنده های مارپیچ

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چرخنده مارپیچ ضربدری

شکل ۱۱-۱۴ بار محوری، چرخش، و رابطه چپگردی یا راستگردی چرخنده‌های مارپیچ ضربدری.


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چرخنده حلزونی

شکل ۱۲-۱۴ حلزون و چرخنده حلزونی با پوش یک‌جانبه.


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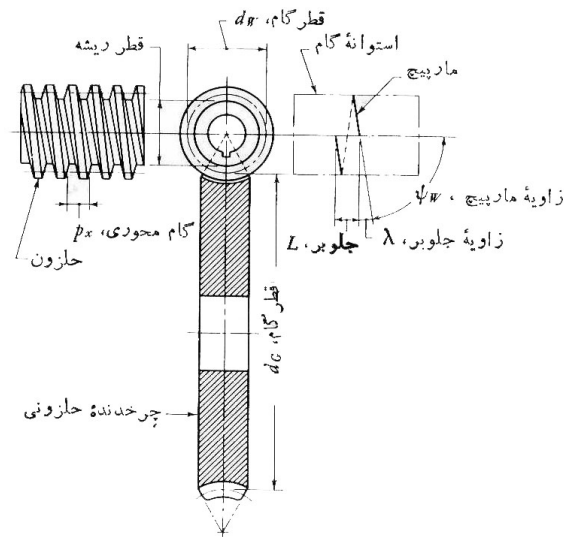
WORM AND WORM GEAR

- **Worm gears** are used when large gear reductions are needed. It is common for worm gears to have reductions of 20:1, and even up to 300:1 or greater
- Many worm gears have an interesting property that no other gear set has: the worm can easily turn the gear, but the gear cannot turn the worm
- Worm gears are used widely in material handling and transportation machinery, machine tools, automobiles etc



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WORM AND WORM GEAR

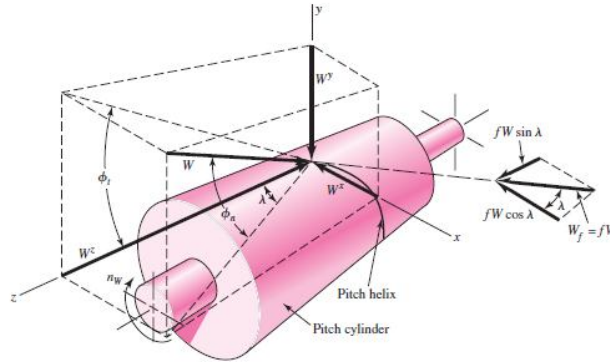


شکل ۱۳-۱۴ نامگذاری مجموعه چرخنده حلزونی با پوش یک جانبه.



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آنالیز نیرویی حلزون و چرخ حلزون



$$\begin{aligned} W^x &= W \cos \phi_n \sin \lambda \\ W^y &= W \sin \phi_n \\ W^z &= W \cos \phi_n \cos \lambda \end{aligned}$$

$$\begin{aligned} W_{Wt} &= -W_{Ga} = W^x \\ W_{Wr} &= -W_{Gr} = W^y \\ W_{Wa} &= -W_{Gt} = W^z \end{aligned}$$

$$\begin{aligned} W^x &= W(\cos \phi_n \sin \lambda + f \cos \lambda) \\ W^y &= W \sin \phi_n \\ W^z &= W(\cos \phi_n \cos \lambda - f \sin \lambda) \end{aligned}$$



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آنالیز نیرویی حلزون و چرخ حلزون

$$W_f = fW = \frac{f W_{Gt}}{f \sin \lambda - \cos \phi_n \cos \lambda} \quad (13-44)$$

A useful relation between the two tangential forces, W_{Wt} and W_{Gt} , can be obtained by equating the first and third parts of Eqs. (13-42) and (13-43) and eliminating W . The result is

$$W_{Wt} = W_{Gt} \frac{\cos \phi_n \sin \lambda + f \cos \lambda}{f \sin \lambda - \cos \phi_n \cos \lambda} \quad (13-45)$$

Efficiency η can be defined by using the equation

$$\eta = \frac{W_{Wt}(\text{without friction})}{W_{Wt}(\text{with friction})} \quad (a)$$

Substitute Eq. (13-45) with $f = 0$ in the numerator of Eq. (a) and the same equation in the denominator. After some rearranging, you will find the efficiency to be

$$\eta = \frac{\cos \phi_n - f \tan \lambda}{\cos \phi_n + f \cot \lambda} \quad (13-46)$$



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راندمان حلزون و چرخ حلزون

$$\eta = \frac{\cos \phi_n - f \tan \lambda}{\cos \phi_n + f \cot \lambda}$$

Table 13-6

Efficiency of Worm
Gearsets for $f = 0.05$

Helix Angle ψ , deg	Efficiency η , %
1.0	25.2
2.5	45.7
5.0	62.0
7.5	71.3
10.0	76.6
15.0	82.7
20.0	85.9
30.0	89.1



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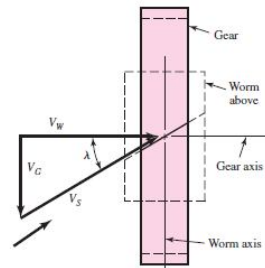
راندمان حلزون و چرخ حلزون

Many experiments have shown that the coefficient of friction is dependent on the relative or sliding velocity. In Fig. 13-41, V_G is the pitch-line velocity of the gear and V_W the pitch-line velocity of the worm. Vectorially, $V_W = V_G + V_S$; consequently, the sliding velocity is

$$V_S = \frac{V_W}{\cos \lambda} \quad (13-47)$$

Figure 13-41

Velocity components in worm gearing.



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Bevel gears

- **Bevel gears** are useful when the direction of a shaft's rotation needs to be changed
- They are usually mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well
- The teeth on bevel gears can be **straight, spiral** or **hypoid**
- locomotives, marine applications, automobiles, printing presses, cooling towers, power plants, steel plants, railway track inspection machines, etc.



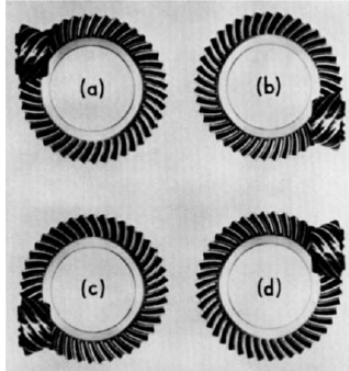
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Straight and Spiral Bevel Gears

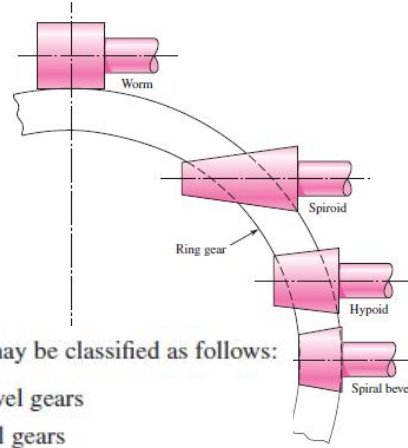


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Bevel Gears Types



15-4
 of intersecting
 shaft bevel-type
 from Gear
 by Darle W.
 52, p. 2-24.]



Bevel gears may be classified as follows:

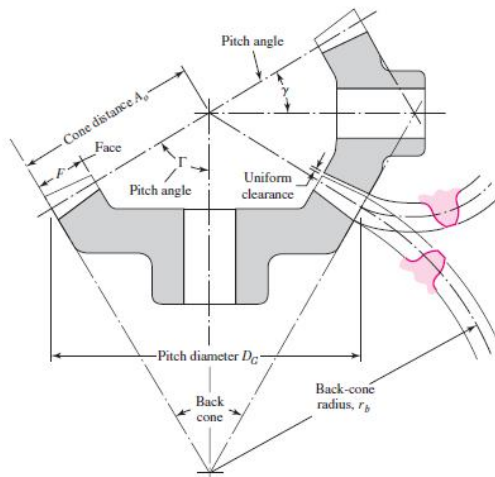
- Straight bevel gears
- Spiral bevel gears
- Zerol bevel gears
- Hypoid gears
- Spiroid gears

FIGURE 34.15 Hypoid offset. To determine the direction of offset, always look at the gear with the pinion at the right. Thus the gear sets of (a) and (b) are both offset below center; similar reasoning shows that (c) and (d) are offset above center. (Gleason Machine Division.)



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نامگذاری چرخدنده مخروطی

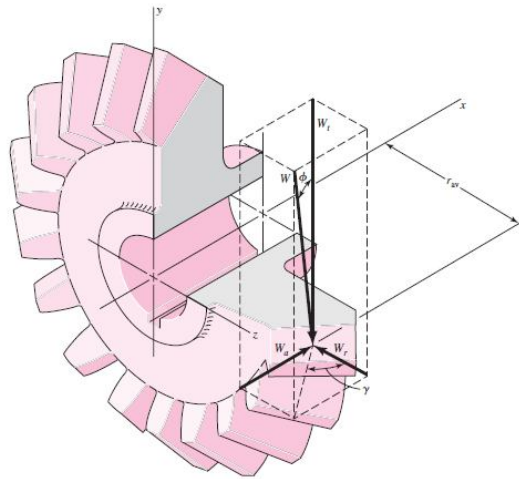


$$\tan \gamma = \frac{N_P}{N_G} \quad \tan \Gamma = \frac{N_G}{N_P}$$



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آنالیز نیرویی چرخدنده مخروطی ساده



$$W_t = \frac{T}{r_{av}}$$

$$W_r = W_t \tan \phi \cos \gamma$$

$$W_a = W_t \tan \phi \sin \gamma$$



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