5.2 Involutes cylindrical gear

5.2.1 Rack and Basic Rack

Rack

When a flat or a straight bar contains a series of equidistant teeth, this kind of flat or straight bar is called rack. It can be divided into spur rack, helical rack and herringbone rack. For rack with straight line tooth profile, the tooth distance remain unchanged and is equal to πm in all the plane of parallel indexing plane; the pressure angle at each point of tooth profile is also unchanged and is equal to the standard value α.

Spur Rack

Spur rack refers to the rack whose tooth trace is vertical to the moving direction of tooth. It can also be said that the tooth trace of spur rack parallel to the axial line of its mating gear. See Figure 5-51.

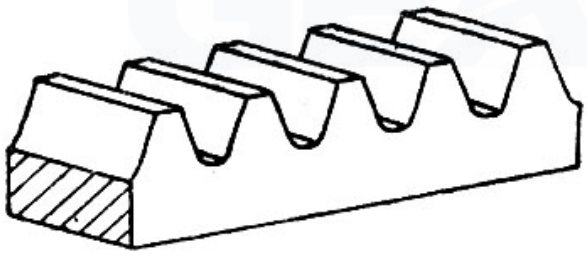


图 5-51

Helical Rack

Helical rack refers to the rack whose tooth trace is a straight line tilting to the moving direction of tooth, namely, the rack in which an acute angle would be formed between the tooth trace and the axial line of its mating gear. See Figure 5-52.

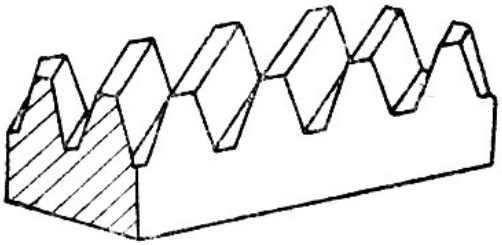


图 5-52

Basic Rack

In normal section, the imaginary rack with basic tooth profile is called basic rack. See Figure 5-53.

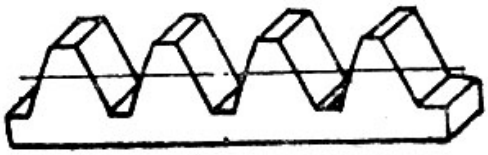


图 5-53

Counterpart Rack

Counterpart rack refers to the rack that can be closely connected with basic rack. The teeth of a counterpart rack can just fulfill the tooth space of another rack. In the process of manufacturing gear with generating method, counterpart rack refers to the imaginary rack of which the cutter and the manufactured gear meshed together, such as hobbing cutter and rack cutter, etc. See Figure 5-54.

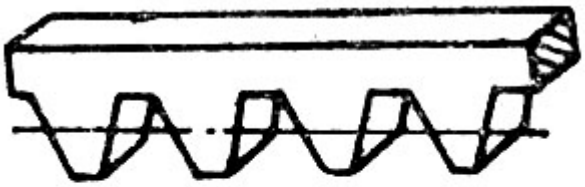


图 5-54

Generating Gear of a Gear

If an actual gear or an imaginary gear is used to judge gear under designing or manufacturing, then this gear is called generating gear of a gear. For example, manufacturing gear with rack cutter under generating method, the rack cutter, as tool gear, meshing with the manufactured gear, then the rack cutter is called the generating gear of manufactured gear. The purpose of bring forth generating gear of a gear is to simplify or deepen the research on gear meshing and manufacturing.

Generating Flank

The flank of generating gear is called generating flank. In some gear cutting technology, generating flank is the active face of tooling.

Basic Tooth Profile

Basic tooth profile refers to the tooth profile of basic rack (see Figure 5-55). Basic tooth profile serves as the foundation for the tooth size of some kinds of gear. “Basic tooth profile of involutes cylindrical gear” is set according to GBl356-87; “Basic shape of cylindrical worm” is set on GB10087-88. The basic tooth profile of spur gear, helical gear and bevel gear is still under approval. According to JB2940-81, the standard of the basic tooth profile of cylindrical worm has been set, so as to the standard of normal tooth shape of hobbing cutter of circular tooth gear.

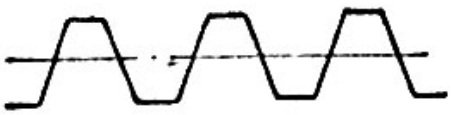


图 5-55

datum plane

Datum plane is an imaginary plane on basic rack or crown gear. Datum plane is parallel to addendum flank. On this imaginary plane, the ratio of tooth thickness and tooth space is a given standard value (generally, s/e=1). See Figure 5-56. As for tool rack, datum plane is also called mid-plane. Datum plane is overlapped with the reference flank of rack (or worm) in rack pair (or worm gear pair).

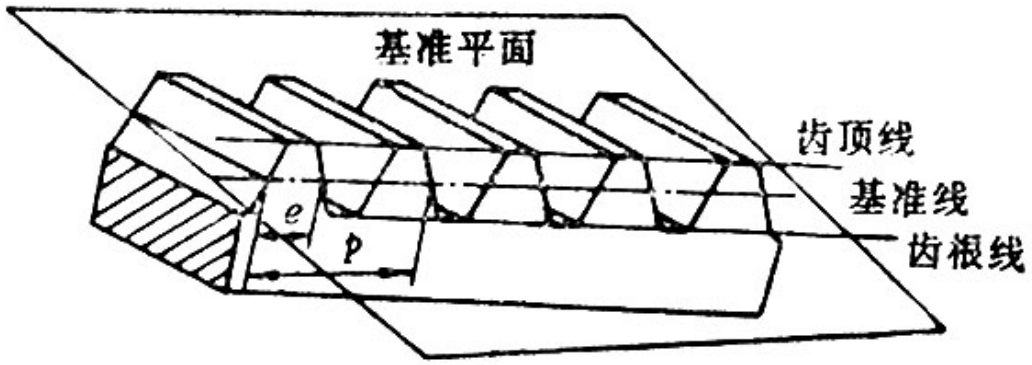


图 5-56

Datum Line

Datum line refers to the intersection line between normal flank and datum plane. See Figure 5-57. Datum plane is a straight line used to set the tooth size parameter of basic rack.

图 5-57

Tip Line

Tip line refers to the intersection line between addendum flank and transverse plane. See Figure 5-56.

Root Line

Root line refers to the intersection line between dedendum flank and transverse plane. See Figure 5-56.

5.2.2 Involutes Cylindrical Gear

Spur Cylindrical Gear

Spur cylindrical gear refers to cylindrical gear whose tooth line serves as the

generatrix of reference cylinder. It can also be called spur gear (see Figure 5-58).

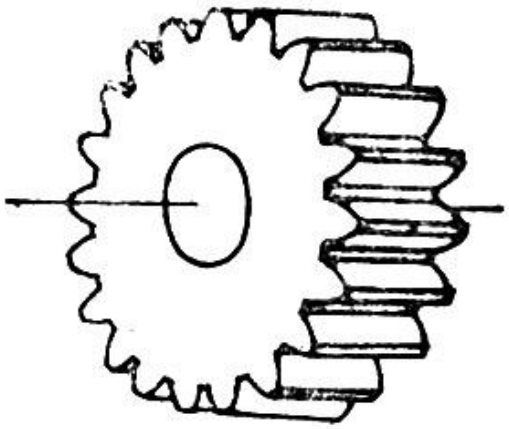


图 5-58

Types of Cylindrical Gears

There are many ways to clarify different cylindrical gear. According to the shape of profile, they are cylindrical gear and rack; according to the shape of tooth trace, they are spur gear, helical gear, herringbone gear and curved tooth gear; according to the location of addendum surface corresponding to dedendum surface, they are external gear and internal gear; according to the tooth profile curve, they are involutes gear, cycloid gear, circular tooth gear, double-circular tooth gear and curve tooth profile gear; according to the meshing system, they are line-based meshing gear, point-based meshing gear and line-and-point-based meshing gear; according to geometric size, they are modulus gear and pitch-based gear. See Figure 5-59.

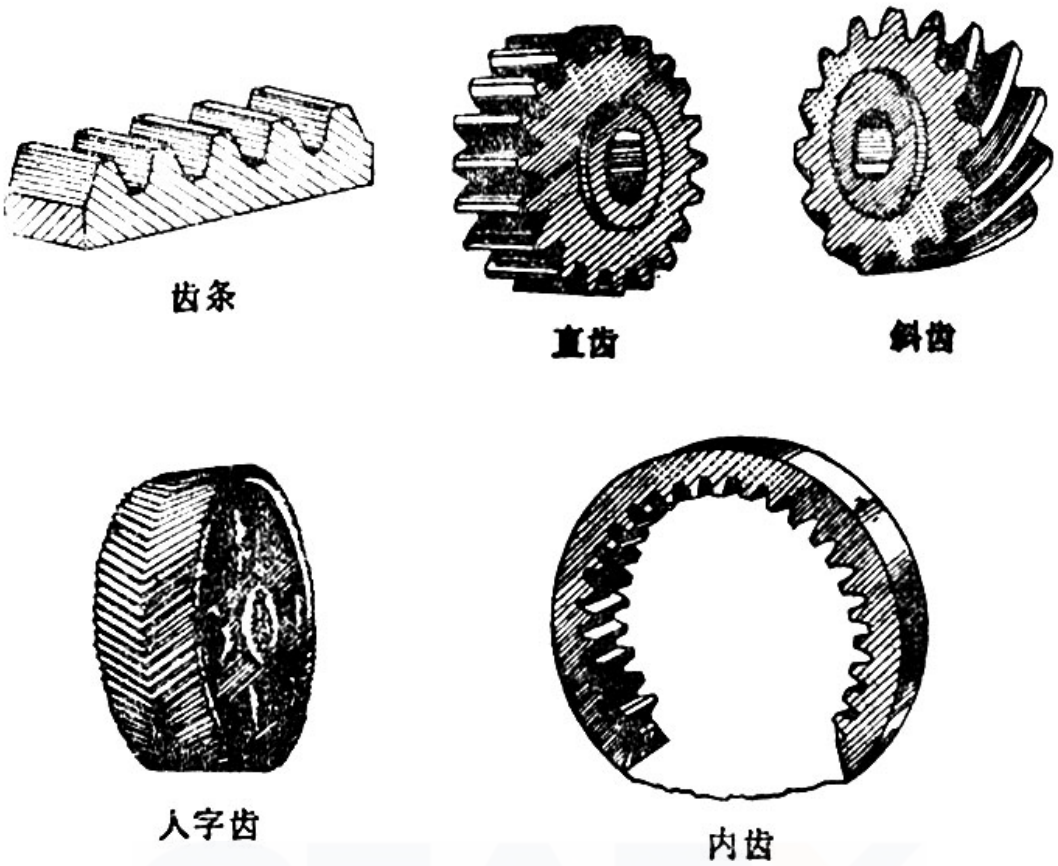
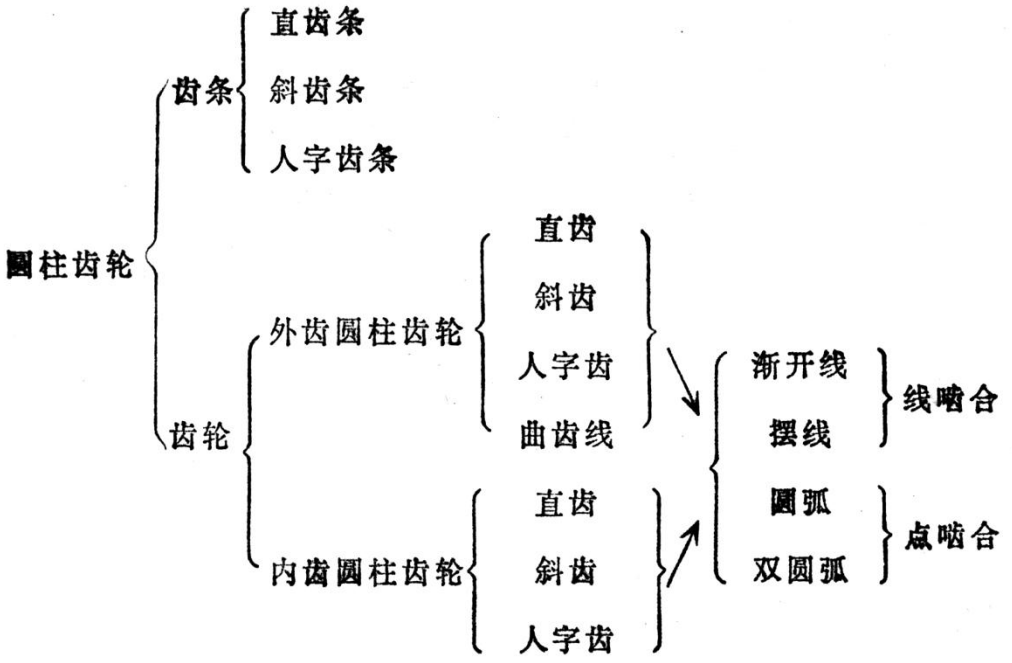


图 5-59

Specific types of cylindrical gear are listed as follows:



Involutes Gear

Gear presenting involute tooth profile in some cross section of gear tooth is called involute gear, which is the abbreviation of involutes cylindrical gear. At the moment, the widely used involute gears are listed as follows: involute cylindrical gear with straight tooth: external involute gear with straight gear, internal involte gear with straight tooth, spur rack; involute helical gear with helical tooth, external involute gear with helical tooth, helical rack; involute herringbone cylindrical gear: external herringbone involute gear, internal herringbone involute gear and herringbone rack; involute cylindrical worm; involute circular arc tooth line cylindrical gear; involute non-circular gear; involute intermittent gear; involute bevel gear; involute straight tooth bevel gear and involute curved-tooth bevel gear.

Involute Cylindrical Gear

Cylindrical gear whose available transverse or normal tooth profile is involute is called involute cylindrical gear.

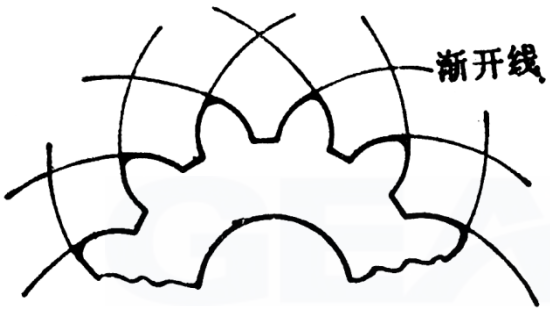


图 5-60

The Basic Parameter of Involute Cylindrical Gear

Parameters used to set the geometric size of involute cylindrical gear and the size of gear tooth is called basic parameter. Basic parameter refers to: module m_n (spur gear $m_n = m_t$), number z, pressure angle α, addendum coefficient h_α^*, top clearance coefficient c* and helical angle β (spur gear β=0).

Module of Involute Cylindrical Gear

The normal module of involute cylindrical gear is set by mm. GB1357—87 stipulate the first series and the second series （there are modules that not to be used as far as possible, which can be seen in the parenthesis）.

The first series：0.1，0.12，0.15，0.2，0.25，0，3，0.4，0.5，0.6，0.8，1，1，25，1.5，2，2.5，3，4，5，6，8，10，12，16，20，25，32，40，50；

The second series： 0.35，0.7，0.9，1.75，2.25，2.75，（3.25），3.5，（3.75），4.5，5.5，（6.5），7，9，（11），14，18，22，28, 36, 45.

Basic rack Tooth Profile of Involute Cylindrical Gear

Basic rack tooth profile of involute cylindrical gear is the normal straight line profile of basic rack. According to GB1356-87, basic tooth profile parameters of involute cylindrical gear applied when the module m≥1 are: tooth profile angle α=20°: addendum $h'=2m$, working depth of tooth $h'=2m$, bottom clearance c=0.25 m, whole depth $h=2.25m$, pitch $p=\pi m$, fillet radius $\rho_f=0.38m$. See Figure 5-61.

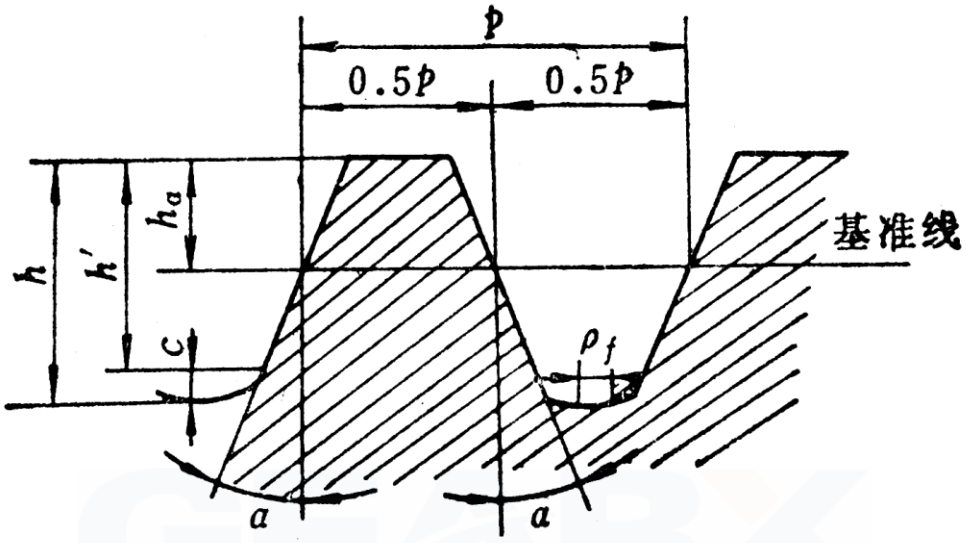


图 5-61

Helical Gear

Helical gear refers to cylindrical gear whose tooth trace is spiral line (Figure 5-62). Generally, helical gear is called involute helical cylindrical gear, whose abbreviation is helical gear. Helical gear is the standard parameter of helical cylindrical gear and it is set in the normal plane of tooth trace.

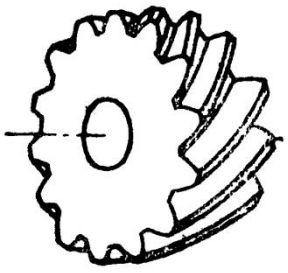


图 5-62

Douole-helical gear； Herringbone Gear

A cylindrical gear, half tooth width being right-hand teeth, half being left-hand teeth, whether these two parts have slot or not, is called herringbone gear (see Figure 5-63). In general, herringbone gear refers to involute herringbone gear. It can be divided into external gear and internal gear.

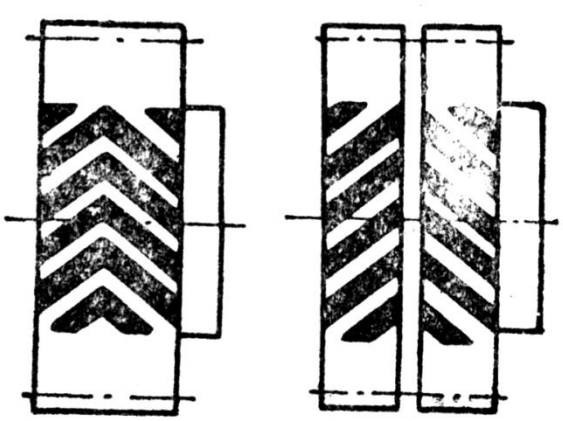


图 5-63

Virtual Gear； Virtual Spur Gear

The intersection line between a normal flank and reference cylinder on a point of the tooth trace of helical gear is an ellipse. Taking the largest curvature radius ρ_v of this ellipse as radius of reference circle and taking the normal parameter (m_n , a_n, h_{α}^{*}n, c_n^{*}) of helical gear as the imaginary spur gear of transverse parameter, then this is called virtual gear. See Figure 5-64. The transverse tooth profile of virtual gear can be compared to the normal tooth profile of helical gear.

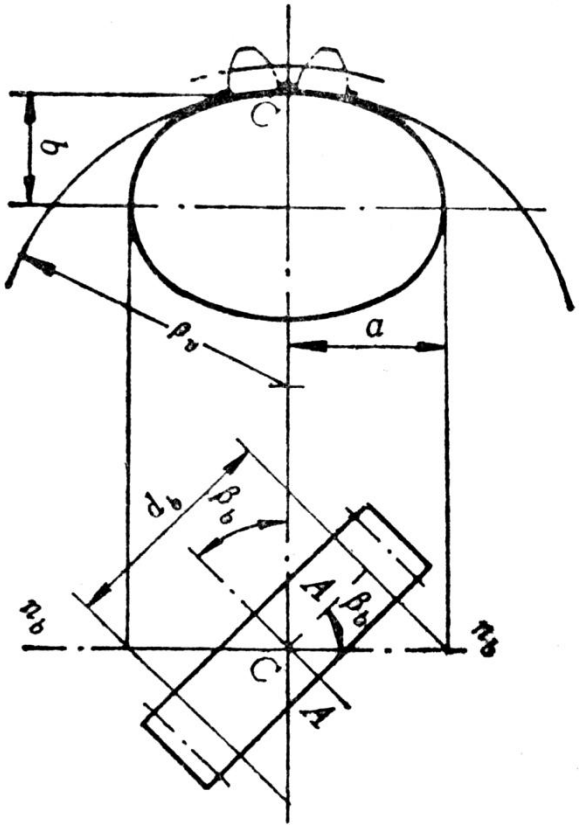


图 5-64

Equivalent Number of Teeth of Helical Gear

The imaginary teeth numbers of virtual gear are called quivalent number of teeth of helical gear. The relation between equivalent number of teeth of helical gear and the actual teeth number of helical gear is $z_v = z/\cos^3\beta$. Equivalent number should be used to choose the size of milling cutter when processing helical gear with forming method.

Helix Angle of Helical Gear

The helix angle of helical (or herringbone) cylindrical gear is: the helical angle of spiral line on reference cylinder. The relation between helix angle of helical gear and helical angle of base cylinder is $tg\beta = tg\beta_b/\cos\alpha_t$.

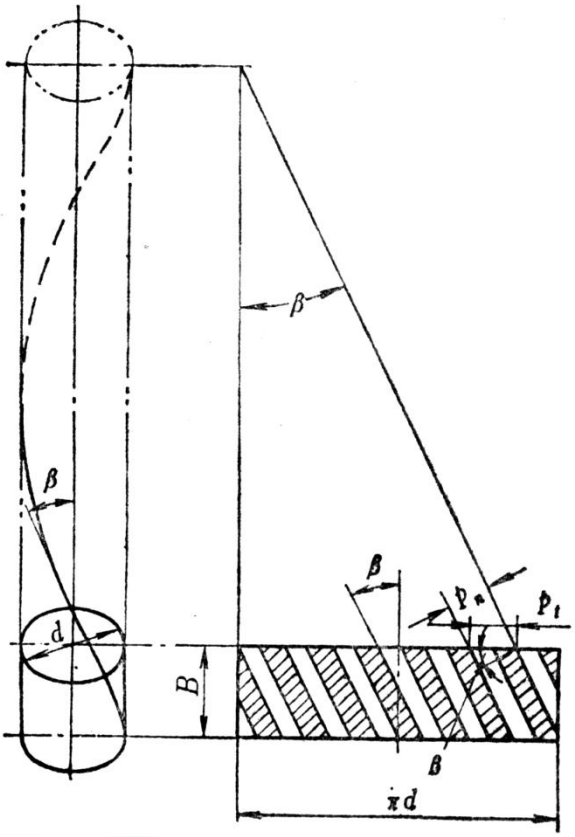


图 5-65

Lead Angle of Helical Gear

Lead angle of helical gear refers to the lead angle of the tooth trace of cylindrical worm of helical (or herringbone) cylindrical gear. As a common term used in worm gear, it is shown with γ in the Figure 5-66.

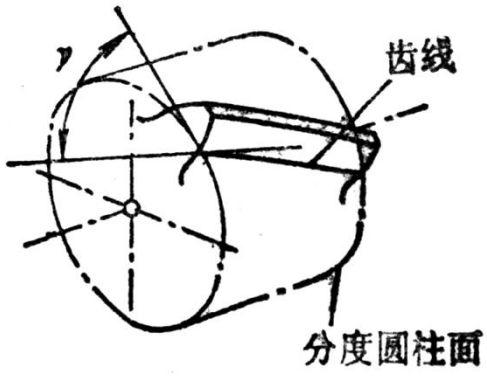


图 5-66

Reference Helix

The intersection line (tooth trace) between the reference cylinder and tooth flank of helical cylindrical gear, herringbone cylindrical gear and cylindrical worm is the helix line of reference cylinder, which is called reference helix. See Figure 5-67.

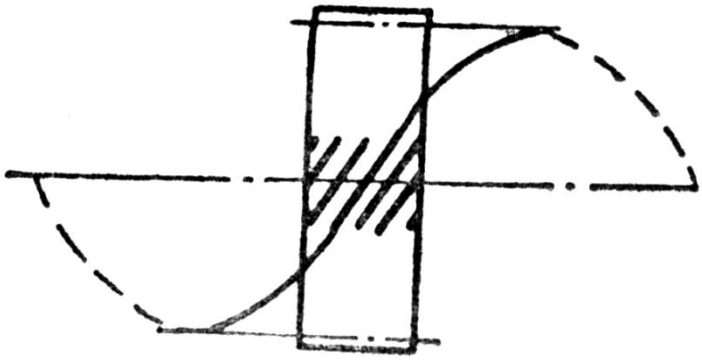


图 5-67

Normal Helix

On the same cylinder, there are two helixes towards converse direction. If the tangent at any of their intersection point is inter-vertical to one another, then the two helixes are called normal helix. See 5-68. They have complementary angle.

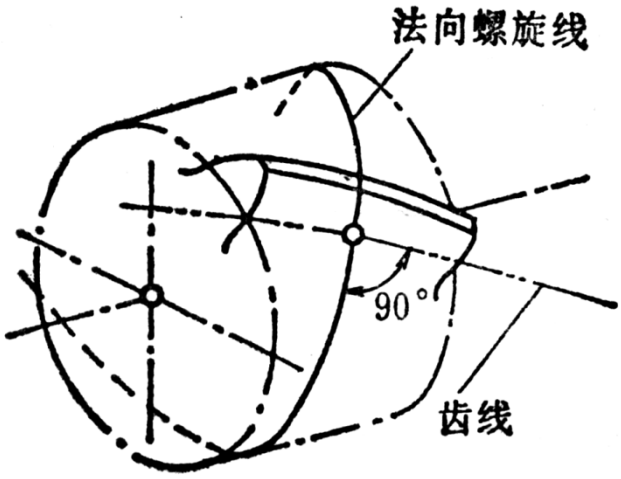
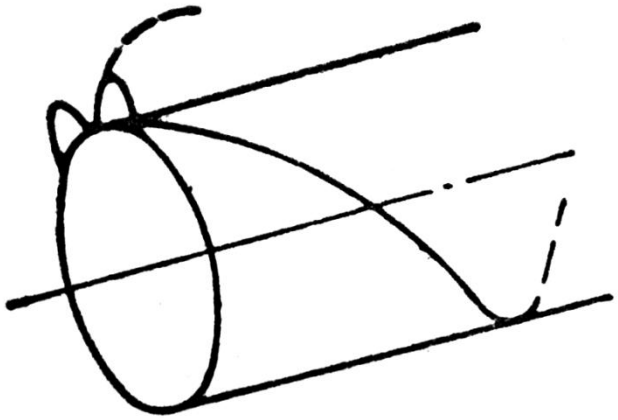


图 5-68

Base Helix

Base helix refers to the intersection line between the base cylinder and tooth flank of involute cylindrical gear or involute cylindrical worm. See Figure 5-69.



Base Helix Angle

The base helix angle of involute helical (or herringbone) cylindrical gear and involute cylindrical worm refers to the helix angle of spiral line of base cylinder. Base helix angle is the acute angle formed by the intersection of line of involute helix flank and the generatrix of base cylinder. See Figure 5-70. The relation between base helix angle and its helix angle is: $tg\beta_b = tg\beta \cdot \cos\alpha_t$.

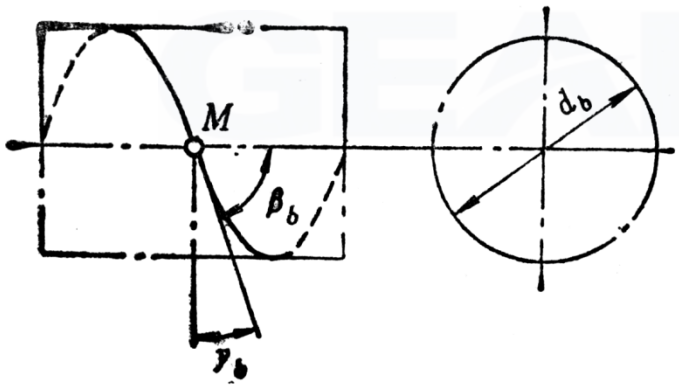


图 5-70

Base Lead Angle

The base lead angle of involute helical (or herringbone) cylindrical gear and involute cylindrical worm refers to the lead angle of spiral line on base cylinder. See Figure 5-70.