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Zobniki - Evolventni valjasti zobnik in zobniške dvojice - Pojmi in geometrija

Gears - Cylindrical involute gears and gear pairs - Concepts and geometry

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Engrenages - Roues et engrenages cylindriques à développante - Concepts et géométrie

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**Gears — Cylindrical involute gears and
gear pairs — Concepts and geometry**

*Engrenages — Roues et engrenages cylindriques à développante —
Concepts et géométrie*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21771 was prepared by Technical Committee ISO/TC 60, *Gears*, Subcommittee SC 1, *Nomenclature and wormgearing*.

This first edition of ISO 21771 cancels and replaces ISO/TR 4467:1982, of which it constitutes a technical revision.

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Gears — Cylindrical involute gears and gear pairs — Concepts and geometry

1 Scope

This International Standard specifies the geometric concepts and parameters for cylindrical gears with involute helicoid tooth flanks. Flank modifications are included.

It also covers the concepts and parameters for cylindrical gear pairs with parallel axes and a constant gear ratio, which consist of cylindrical gears according to it. Gear and mating gear in these gear pairs have the same basic rack tooth profile.

The equations given are not restricted to the pressure angle, $\alpha_p = 20^\circ$.

The standard is structured as follows.

- Listing of symbols and nomenclature for a unique description of gears and gear pairs (see Clause 3).
- Equations and explanations of the relevant values for defining a cylindrical gear and its tooth system. The equations for determination of the nominal values for zero-deviation gear description parameters are stated for radial tooth dimensions (gear tooth heights), the distance between flanks of the same hand, the distance between flanks of opposite hand, as well as the tooth flank characterizing parameters (see Clause 4).
- Equations and explanations of the relevant values for defining cylindrical gear pairs. The equations for the essential parameters characterizing the engagement conditions of the unloaded gear pair are listed (see Clause 5).
- Equations and suggestions for desired flank modifications (see Clause 6).
- Concepts and recommendations needed for a unique geometrical definition of the intended results from manufacture (Clause 7).
- Equations for determination of the nominal values or the limiting values for the most used inspection methods for tooth thickness (see Annex A).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 53:1998, *Cylindrical gears for general and heavy engineering — Standard basic rack tooth profile*

ISO 1328-1:1995, *Cylindrical gears — ISO system of accuracy — Part 1: Definitions and allowable values of deviations relevant to corresponding flanks of gear teeth*

ISO 1328-2:1997, *Cylindrical gears — ISO system of accuracy — Part 2: Definitions and allowable values of deviations relevant to radial composite deviations and runout information*

3 Symbols, subscripts and units

3.1 Symbols

Symbol	Description	Used in
a_w	centre distance of a cylindrical gear pair	5.2.3
a_0	centre distance in the generating gear unit	7.5
a_L	centre distance for tooth flank engagement	A.8
b	facewidth	4.2.8
b_F	usable facewidth	4.2.8
b_M	contact line overlap (for measuring base tangent length)	A.2.1
b_w	active facewidth (the facewidth used)	5.4.7.2
c	tip clearance	5.2.7
c_F	form over dimension	5.4.4
d	reference diameter	4.2.4
d_a	tip diameter	4.5.3
d_{a0}	tip diameter of tool	7.5
d_{aM}	tip diameter of overcut cylindrical gears	A.9
d_b	base diameter	4.3.10
d_{b0}	base diameter of the pinion-type cutter	7.6
d_f	root diameter (nominal dimension)	4.5.4
d_{fE}	root diameter produced	7.5
d_{f0}	root diameter of the pinion-type cutter	A.9
d_v	V-circle diameter	4.5.1
d_w	working pitch diameter	5.2.5
d_y	Y-circle diameter	4.3.3
d_{Fa}	tip form diameter	7.6
d_{Fa0}	tip form diameter of the pinion-type cutter	7.6
d_{Ff}	root form diameter	7.6
d_K	diameter of circle through centre of ball	A.5
d_M	diameter of a measuring circle	A.2.1
d_{Na}	active tip diameter	5.4.1
d_{Nr}	start of active profile diameter (SAP diameter, active root diameter)	5.4.1
e_t	space width on the reference cylinder	4.7.3
e_{yt}	space width on the Y-cylinder	4.7.3

Symbol	Description	Used in
e_p	space width of the standard basic rack tooth profile	4.2.3
g_a	length of addendum path of contact	5.4.5.2
g_f	length of dedendum path of contact	5.4.5.2
g_α	length of path of contact	5.4.5.2
$g_{\alpha y}$	distance of a point Y from pitch point C	5.6.1
g_β	arc of contact	5.4.7.4
h	tooth depth (between tip line and root line)	4.6.1
h_a	addendum	4.6.2
h_{aP}	addendum of the standard basic rack tooth profile	Figure 4
h_{aP0}	addendum of the tool standard basic rack tooth profile	7.5
h_f	dedendum	4.6.2
h_{fP}	dedendum of the standard basic rack tooth profile	Figure 4
h_{fP0}	dedendum of the tool standard basic rack tooth profile	A.9
h_w	working depth of teeth in a gear pair	5.2.6
h_{FFP}	depth of dedendum form of the standard basic rack tooth profile	Figure 4
h_K	radius of the tip corner chamfering or tip corner rounding	6.1.2
h_P	tooth depth of standard basic rack tooth profile	Figure 4
inv	involute function	4.3.9
j_{bn}	contact backlash	5.5
j_r	radial backlash	5.5
j_t	circumferential backlash at the reference circle	5.5.2
j_{wt}	circumferential backlash at the pitch circle	5.5
k	number of teeth, spaces or pitches in a span (e.g. number of teeth spanned)	A.2.1
k	addendum modification coefficient	4.5.2
l_{max}	path of engagement	5.4.8
Σl	sum of path of contact	5.4.8
m_n	normal module	4.2.7
m_t	transverse module	4.2.7
m_x	axial module	4.2.7
n_a	number of revolutions of driving gear (rpm)	5.2.2
n_b	number of revolutions of driven gear (rpm)	5.2.2
p	pitch, pitch on the reference cylinder	Figure 4

Symbol	Description	Used in
p_{bn}	normal pitch on the base cylinder	4.4.5
p_{bt}	transverse pitch on the base cylinder	4.4.5.1
p_{en}	normal base pitch on the path of contact	4.4.5.2
p_{et}	transverse base pitch on the path of contact	4.4.5.1
p_n	normal pitch	4.4.2.2
p_t	transverse pitch	4.4.2.1
p_x	axial pitch	4.4.4
p_{yn}	normal pitch on the Y-cylinder	4.4.3
p_{yt}	transverse pitch on the Y-cylinder	4.4.3
p_z	lead	4.3.2
q	machining allowance on tooth flank	7.2
q_{Fs}	undercut	Figure 24
s_{aK}	residual tooth thickness at tip with tip corner chamfering or tip corner rounding	6.1.2
s_{bn}	normal tooth thickness on the base circle	A.2.2
s_n	normal tooth thickness on the reference circle	4.7.5
s_{ni}	minimum normal tooth thickness on the reference circle	7.3
s_{ns}	maximum normal tooth thickness on the reference circle	7.3
s_t	transverse tooth thickness on the reference circle	4.7.1
s_{yn}	normal tooth thickness on the Y-cylinder	4.7.5
s_{yt}	transverse tooth thickness on the Y-cylinder	4.7.1
s_p	tooth thickness of the standard basic rack tooth profile	4.2.3
u	gear ratio	5.2.1
v_g	sliding speed	5.6.1
v_{ga}	sliding speed at the addendum	5.6.1
v_{gf}	sliding speed at the dedendum	5.6.1
v_n	normal speed	5.6.1
x	profile shift coefficient	4.2.9
x_E	generating profile shift coefficient	7.4
x_{Emin}	generating profile shift coefficient at undercut limit	7.7
x_L	profile shift coefficient of master gear	A.8
z	number of teeth	4.1.5
z_a	number of teeth of driving gear	5.2.2

Symbol	Description	Used in
z_b	number of teeth of driven gear	5.2.2
z_L	number of teeth of master gear	A.8
z_0	number of teeth of pinion-type cutter	7.6
A	starting point of meshing	5.4.3
B	starting point of single tooth contact on driving gear	5.4.5.1
C	pitch point, depth of relief for modifications	5.4.3
C_{ay}	modification of the profile	6.5
$C_{\beta y}$	modification of the flank line	6.5
$C_{\Sigma y}$	modification of the flank surface	6.5
$C_{\alpha a}$	amount of tip relief	6.2.1
$C_{\alpha f}$	amount of root relief	6.2.1
C_{Ea}	tip amount of triangular end relief modification	6.4.2
C_{Ef}	root amount of triangular end relief modification	6.4.2
$C_{i,j}$	amount of modification at point (i,j)	6.4.1
$C_{H\alpha}$	amount of transverse profile slope modification	6.2.2
C_{α}	amount of profile crowning (barrelling)	6.2.3
$C_{\beta I}, C_{\beta II}$	amount of end relief	6.3.1
C_{β}	amount of flank line crowning	6.3.3
$C_{H\beta}$	amount of flank line slope modification	6.3.2
D_M	measuring ball or measuring cylinder diameter	A.5
D	end point of single tooth contact point on driving gear	5.4.5.1
E	end point of meshing	5.4.3
E_{sn}	normal tooth thickness deviation limit (or allowance)	A.9
E_{sni}	lower deviation limit for tooth thickness	7.3
E_{sns}	upper deviation limit for tooth thickness	7.3
K_g	sliding factor	5.6.2
K_{ga}	sliding factor at tooth tip	5.6.2
K_{gf}	sliding factor at tooth root	5.6.2
L_{AE}	roll length	6.2
L_{Ca}	tip relief roll length	6.2.1
L_{Cf}	root relief roll length	6.2.1
L_{CI}, L_{CII}	length of end relief	6.3.1
L_{Ea}	tip roll length of triangular end relief modification	6.4.2

Symbol	Description	Used in
L_{Ef}	root roll length of triangular end relief modification	6.4.2
M_{dK}	dimension over balls	A.7
M_{dZ}	dimension over cylinders	A.7.1
M_{rK}	radial single-ball dimension	A.5
M_{rZ}	radial single-cylinder dimension	A.6
N	number of tooth or pitch	4.1.6
O	centre of a circle	Figure 10
S_{α}	twist of the transverse profile	6.4.3
S_{β}	twist of the flank line	6.4.3
T_{sn}	tooth thickness tolerance	Figure 37
T	contact point of tangent (lines of engagement) at base circle	Figure 10
U	involute point of origin	4.3.7
W_k	base tangent length over k measured teeth or measured spaces	A.2.1
Y	any point on a tooth flank or involute	4.3.5
α_n	normal pressure angle	4.3.6
α_t	transverse pressure angle	4.3.5
α_{wt}	working transverse pressure angle of gear pair	5.2.4
α_{wt0}	working transverse pressure angle in the generating gear unit	7.6
α_{yn}	normal pressure angle at the Y-cylinder	4.3.6
α_{yt}	transverse pressure angle at the Y-cylinder	4.3.5
α_{Ff}	pressure angle at root form circle	7.6
α_K	pressure angle at circle through centre of ball	A.5
α_{Kt}	transverse pressure angle at a point at circle through centre of ball	A.5
α_{Mt}	transverse pressure angle at a point at measuring circle	A.5
α_p	pressure angle of the standard basic rack tooth profile	4.3.6
α_{p0}	pressure angle of the tool basic rack tooth profile	7
α_L	working transverse pressure angle for double-flank engagement	A.8
α_{vt}	transverse pressure angle at the V-cylinder	A.5
β	helix angle	4.3.3
β_b	base helix angle	4.3.3
β_y	helix angle at Y-cylinder	4.3.3
δ_w	angle of rocking for span measurement	A.2.1

Symbol	Description	Used in
γ	lead angle at reference cylinder	4.3.3
γ_y	lead angle at Y-cylinder	4.3.3
ε_α	transverse contact ratio	5.4.7.1
ε_β	overlap ratio	5.4.7.3
ε_γ	total contact ratio	5.4.7.5
ζ	specific sliding	5.6.3
ζ_f	specific sliding at end points of path of contact	5.6.3
η	space width half angle at reference circle	4.7.4
η_b	base space width half angle	4.7.4
η_y	space width half angle at Y-circle	4.7.4
ξ_y	rolling angle of the involute at point Y	4.3.7
ξ_{Fa0}	rolling angle at tip form circle of pinion-type cutter	7.6
ξ_{Ff}	rolling angle at root form circle	7.6
ξ_{Na}	rolling angle at active tip circle	5.4.1
ξ_{Nf}	rolling angle at active root circle	5.4.1
ρ_{fP}	root radius on the standard basic rack tooth profile	Figure 4
ρ_y	radius of curvature of the involute at point Y	4.3.8
τ	angular pitch	4.4.2
φ_j	backlash angle	5.5.2
φ_α	transverse angle of transmission	5.4.7.1
φ_β	overlap angle	5.4.7.3
φ_γ	total angle of transmission	5.4.7.5
ψ	tooth thickness half angle at reference circle	4.7.2
ψ_b	base tooth thickness half angle	4.7.2
ψ_y	tooth thickness half angle at Y-circle	4.7.2
ω_a	angular velocity of driving gear	5.2.2
ω_b	angular velocity of driven gear	5.2.2
Σx	sum of profile shift coefficients	5.3
Σx_E	sum of profile shift coefficient, non-zero backlash	5.3

3.2 Subscripts

Subscript	Description	Used in ^b
—	a	
a	for quantities associated with the tip of a tooth or for the driving gear	5.2.2
b	for quantities associated with the base cylinder	4.3.10
b	for quantities associated with the driven gear	5.2.2
e	for quantities associated with the plane of action	
f	for quantities associated with the root	
g	for “sliding”	
i	for the lower limit in the case of deviations	
k	for a number of teeth, spaces, pitches or spans	
l	for “left-hand”	
m	for a mean value	
max	for a maximum value	
min	for a minimum value	
n	for quantities in a normal section	4.2.6.2
r	for “right-hand”	
s	relating to “tooth thickness”, for the upper limit in the case of deviations	
t	for quantities in a transverse section	4.2.6.1
v	for quantities associated with the V-cylinder	4.5.1
w	for quantities associated with the pitch cylinder and working values of a gear pair	
x	for quantities in an axial section	4.2.6.3
y	for values at a point Y (on the Y-cylinder)	
E	relating to “generating” (e.g. quantities generated on the cylindrical gear) or “generator”	
F	for quantities determining form circles and maximum usable flank area	
K	for quantities resulting from corner chamfering or for ball dimensions	
L	for designating a master gear	
L	for designating left flanks	4.1.8.2
M	for designating a measured value	
N	for active circles	
P	for quantities of the standard basic rack tooth profile	
P0	for quantities of the tool standard basic rack tooth profile	
R	for designating right flanks	4.1.8.2
V	for working side, for rough gear cutting	
W	for measuring base tangent length	

Subscript	Description	Used in ^b
Z	for quantities associated with cylinder dimensions	
α	for quantities associated with contact	
β	for quantities associated with a tooth trace	
γ	for total contact ratio	
Σ	for "sum"	
0	for quantities associated with the generating tool or the generating gear unit	7
1	for quantities associated with the pinion (smaller gear) of a gear pair	5.1.3
2	for quantities associated with the wheel (larger gear) or internal gear, used for designating a coefficient relating to the module	5.1.3
I	for locating face	4.2.1
II	for the face opposite the locating face	4.2.1
^a No subscript designates quantities associated with the reference cylinder. ^b Used with the symbols listed in 3.1 or as additions.		

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3.3 Units

The quantities dealt with in this International Standard are to be stated in the following units:

- modules, lengths and linear dimensions in millimetres (mm);
- angles which are to be used in equations in radians (rad);
- angles which can be used for entries or to display results in degrees (°);
- angular velocity in radians per second (rad/s).

NOTE The notation $|z|$, denotes the absolute value, which is always positive, e.g. $|-50| = +50$. The expression $\frac{z}{|z|}$ is used to extract the sign of the tooth number and is convenient for programming. In particular, it is used often to determine the appropriate sign for an element of an expression; the result is 1 for external gears and -1 for internal gears.