

ISO 21771-1:2024-10 (E)

Cylindrical involute gears and gear pairs - Part 1: Concepts and geometry

Contents

| | Page |
|--|-----------|
| Foreword..... | vii |
| 1 Scope..... | 1 |
| 2 Normative references..... | 1 |
| 3 Terms, definitions, symbols, subscripts and units..... | 1 |
| 3.1 Terms and definitions..... | 1 |
| 3.2 Symbols..... | 2 |
| 3.3 Subscripts..... | 9 |
| 3.4 Units and conventions..... | 10 |
| 3.4.1 Units..... | 10 |
| 3.4.2 Conventions..... | 10 |
| 4 Individual cylindrical gears..... | 10 |
| 4.1 General..... | 10 |
| 4.2 Concepts for an individual gear..... | 11 |
| 4.2.1 Gear, cylindrical gear, external gear and internal gear..... | 11 |
| 4.2.2 Tooth system, external teeth and internal teeth..... | 11 |
| 4.2.3 Tooth and tooth space..... | 11 |
| 4.2.4 Tooth system parameters..... | 11 |
| 4.2.5 Number of teeth and sign of number of teeth..... | 11 |
| 4.2.6 Tooth number..... | 12 |
| 4.2.7 Top land and bottom land..... | 12 |
| 4.2.8 Tooth flanks and flank sections..... | 12 |
| 4.3 Reference surfaces, datum lines and reference quantities..... | 13 |
| 4.3.1 Reference surface and datum face..... | 13 |
| 4.3.2 Reference rack..... | 13 |
| 4.3.3 Basic rack tooth profile for involute gear teeth..... | 14 |
| 4.3.4 Reference cylinder, reference circle and reference diameter..... | 15 |
| 4.3.5 Gear axis..... | 15 |
| 4.3.6 Sections through a cylindrical gear..... | 15 |
| 4.3.7 Module..... | 16 |
| 4.3.8 Diametral pitch..... | 16 |
| 4.3.9 Facewidth..... | 16 |
| 4.3.10 Profile shift, profile shift coefficient and sign of profile shift..... | 17 |
| 4.4 Involute helicoids..... | 18 |
| 4.4.1 Generator of involute helicoids..... | 18 |
| 4.4.2 Base cylinder, base circle and base diameter..... | 19 |
| 4.4.3 Transverse pressure angle at a point and transverse pressure angle..... | 19 |
| 4.4.4 Normal pressure angle at a point and normal pressure angle..... | 20 |
| 4.4.5 Involute function..... | 20 |
| 4.4.6 Lead..... | 21 |
| 4.4.7 Helix angle and lead angle..... | 21 |
| 4.4.8 Hand of helix..... | 22 |
| 4.4.9 Roll angle of the involute..... | 23 |
| 4.4.10 Radius of curvature of the involute and length of roll..... | 23 |
| 4.4.11 Length of involute profile, L_{yt} | 23 |
| 4.5 Angular pitch and pitches..... | 23 |
| 4.5.1 Angular pitch..... | 23 |
| 4.5.2 Pitches on the reference cylinder..... | 23 |
| 4.5.3 Pitches on any cylinder..... | 24 |
| 4.5.4 Axial pitch..... | 25 |
| 4.5.5 Base pitch..... | 25 |

| | | |
|----------|---|-----------|
| 4.6 | Diameters of gear teeth..... | 25 |
| 4.6.1 | General..... | 25 |
| 4.6.2 | V-cylinder and V-circle diameter..... | 26 |
| 4.6.3 | y-cylinder and y-circle diameter..... | 26 |
| 4.6.4 | Tip alteration coefficient..... | 26 |
| 4.6.5 | Tip cylinder, tip circle and tip diameter..... | 26 |
| 4.6.6 | Profile control diameter, d_{cf} | 26 |
| 4.6.7 | Root cylinder, root circle and root diameter..... | 26 |
| 4.7 | Gear tooth depth..... | 27 |
| 4.7.1 | Tooth depth..... | 27 |
| 4.7.2 | Addendum, working addendum, dedendum and working dedendum..... | 27 |
| 4.8 | Tooth thickness and space width..... | 27 |
| 4.8.1 | General..... | 27 |
| 4.8.2 | Transverse tooth thickness..... | 27 |
| 4.8.3 | Transverse tooth thickness half angle..... | 28 |
| 4.8.4 | Transverse space width..... | 29 |
| 4.8.5 | Transverse space width half angle..... | 29 |
| 4.8.6 | Normal tooth thickness..... | 29 |
| 4.8.7 | Normal space width..... | 29 |
| 4.9 | Radii of curvature of the tooth flanks in different planes..... | 30 |
| 4.10 | Tilt angle of contact line..... | 31 |
| 5 | Parallel axis cylindrical gear pairs..... | 32 |
| 5.1 | General..... | 32 |
| 5.2 | Concepts for a gear pair..... | 32 |
| 5.2.1 | Mating gear and mating flank..... | 32 |
| 5.2.2 | Working flank and non-working flank..... | 32 |
| 5.2.3 | External gear pair..... | 32 |
| 5.2.4 | Internal gear pair..... | 33 |
| 5.3 | Mating quantities..... | 33 |
| 5.3.1 | Gear ratio..... | 33 |
| 5.3.2 | Driving gear, driven gear and transmission ratio..... | 33 |
| 5.3.3 | Line of centres and centre distance..... | 33 |
| 5.3.4 | Working transverse pressure angle..... | 34 |
| 5.3.5 | Working pitch point, pitch cylinders, pitch circles, pitch diameter and pitch axis..... | 34 |
| 5.3.6 | Working helix angles..... | 36 |
| 5.3.7 | Working depth..... | 36 |
| 5.3.8 | Tip clearance..... | 36 |
| 5.3.9 | Calculation of tip alteration coefficient k (for parallel axis gear)..... | 37 |
| 5.4 | Calculation of the sum of the profile shift coefficients..... | 38 |
| 5.5 | Tooth engagement..... | 38 |
| 5.5.1 | General..... | 38 |
| 5.5.2 | Active area of the tooth flanks, start of active profile and active tip diameters..... | 38 |
| 5.5.3 | Plane of action, zone of action and contact line..... | 40 |
| 5.5.4 | Line of action, path of contact and point of contact..... | 41 |
| 5.5.5 | Form over dimension..... | 41 |
| 5.5.6 | Designations and values relating to the line of action..... | 41 |
| 5.5.7 | Radii of curvature of the tooth flanks in a transverse plane..... | 42 |
| 5.5.8 | Tooth interference..... | 43 |
| 5.5.9 | Mesh geometry parameters..... | 45 |
| 5.5.10 | Contact line and sum of the contact line lengths..... | 47 |
| 5.6 | Backlash..... | 49 |
| 5.6.1 | General..... | 49 |
| 5.6.2 | Transverse backlash..... | 49 |
| 5.6.3 | Circumferential backlash..... | 49 |
| 5.6.4 | Normal backlash..... | 49 |
| 5.6.5 | Radial backlash..... | 50 |
| 5.6.6 | Angular backlash..... | 50 |
| 5.7 | Velocities and sliding conditions at the tooth flanks..... | 51 |
| 5.7.1 | Angular velocity..... | 51 |
| 5.7.2 | Circumferential velocity..... | 51 |
| 5.7.3 | Normal velocity..... | 51 |
| 5.7.4 | Rolling velocity..... | 52 |

| | | |
|----------|--|-----------|
| 5.7.5 | Sliding velocity..... | 52 |
| 5.7.6 | Sliding factor..... | 53 |
| 5.7.7 | Specific sliding..... | 54 |
| 6 | Crossed axis cylindrical gear pairs..... | 54 |
| 6.1 | General..... | 54 |
| 6.2 | Concepts for a gear pair..... | 55 |
| 6.3 | Mating quantities..... | 56 |
| 6.3.1 | Gear ratio..... | 56 |
| 6.3.2 | Driving gear, driven gear and transmission ratio..... | 56 |
| 6.3.3 | Working pitch surfaces and working pitch point..... | 56 |
| 6.3.4 | Line of centres and working centre distance..... | 56 |
| 6.3.5 | Skew angle..... | 57 |
| 6.3.6 | Intermeshing racks at working pitch cylinders..... | 57 |
| 6.3.7 | Working transverse pressure angles..... | 59 |
| 6.3.8 | Working transverse tooth thicknesses..... | 59 |
| 6.3.9 | Basic rack profile to generate each part of the gear pair..... | 60 |
| 6.3.10 | Profile shift coefficients..... | 60 |
| 6.3.11 | Base space width half angle..... | 61 |
| 6.3.12 | Working conditions at minimum centre distance..... | 61 |
| 6.3.13 | Working conditions with backlash..... | 62 |
| 6.3.14 | Working depth..... | 62 |
| 6.3.15 | Tip clearance..... | 62 |
| 6.3.16 | Calculation of tip alteration coefficient k (for crossed axis gear)..... | 62 |
| 6.4 | Tooth engagement..... | 62 |
| 6.4.1 | General..... | 62 |
| 6.4.2 | Line of action, path of contact and point of contact..... | 63 |
| 6.4.3 | Active area of the tooth flanks, start of active profile and active tip diameters..... | 64 |
| 6.4.4 | Form over dimension..... | 65 |
| 6.4.5 | Designations and values relating to the line of action..... | 65 |
| 6.4.6 | Tooth interference..... | 66 |
| 6.4.7 | Mesh geometry parameters..... | 67 |
| 6.5 | Backlash..... | 67 |
| 6.5.1 | General..... | 67 |
| 6.5.2 | Normal base backlash..... | 68 |
| 6.5.3 | Backlash angle and circumferential backlash..... | 68 |
| 6.6 | Sliding conditions at the tooth flanks..... | 69 |
| 6.6.1 | General..... | 69 |
| 6.6.2 | Angular velocities vectors..... | 69 |
| 6.6.3 | Velocity vectors of a point of contact along path of contact..... | 70 |
| 6.6.4 | Sliding velocity..... | 71 |
| 7 | Principal radii of curvature of the tooth flanks..... | 71 |
| 7.1 | General..... | 71 |
| 7.2 | Angle between the principal radius of curvature at point of contact..... | 72 |
| 7.3 | Particularities for crossed axis helical involute gear..... | 73 |
| 7.4 | Equivalent radii of curvature at point of contact..... | 74 |
| 8 | Tooth flank modifications..... | 75 |
| 8.1 | General..... | 75 |
| 8.2 | Tooth modifications which restrict the usable flank..... | 75 |
| 8.2.1 | Pre-finish flank undercut..... | 75 |
| 8.2.2 | Tip corner chamfering, tip corner rounding..... | 75 |
| 8.3 | Transverse profile modifications..... | 77 |
| 8.3.1 | General..... | 77 |
| 8.3.2 | Tip and root relief, $C_{\alpha a}$ $C_{\alpha f}$ | 77 |
| 8.3.3 | Transverse profile slope modification, $C_{H\alpha}$ | 77 |
| 8.3.4 | Profile crowning (barrelling), C_{α} | 78 |
| 8.4 | Flank line (helix) modifications..... | 79 |
| 8.4.1 | Flank line end relief, $C_{H\beta}$ | 79 |

| | | | |
|-----------|--------|--|------------|
| | 8.4.2 | Helix angle modification, $C_{H\beta}$ | 79 |
| | 8.4.3 | Flank line (helix) crowning, C_{β} | 80 |
| 8.5 | | Flank face modifications..... | 80 |
| | 8.5.1 | Topographical modifications..... | 80 |
| | 8.5.2 | Triangular end relief..... | 81 |
| | 8.5.3 | Flank twist..... | 82 |
| 8.6 | | Descriptions of modifications by functions..... | 82 |
| 9 | | Geometrical limits..... | 83 |
| | 9.1 | General..... | 83 |
| | 9.2 | Counterpart rack tooth profile and rack tool profile..... | 84 |
| | 9.2.1 | Counterpart rack tooth profile..... | 84 |
| | 9.2.2 | Rack tool profile..... | 87 |
| | 9.3 | Machining allowance..... | 91 |
| | 9.4 | Limits of normal tooth thickness..... | 91 |
| | 9.5 | Generating profile shift, generating profile shift coefficient..... | 92 |
| | 9.6 | Generated root diameter..... | 93 |
| | 9.7 | Usable area of the tooth flank, tip and root form diameter..... | 93 |
| | 9.8 | Undercut..... | 95 |
| | 9.9 | Overcut..... | 96 |
| | 9.10 | Minimum tooth thickness at the tip circle of a gear..... | 96 |
| 10 | | Start of involute for hob or rack type cutters..... | 96 |
| | 10.1 | Formulae of involute and trochoid..... | 96 |
| | 10.2 | Undercut conditions..... | 98 |
| | 10.3 | Determination of start of involute..... | 99 |
| | 10.4 | Determination of radius of curvature of trochoid..... | 101 |
| 11 | | Start of involute calculation in case of pinion-type cutter..... | 103 |
| | 11.1 | Geometry of pinion-type cutter..... | 103 |
| | 11.1.1 | General..... | 103 |
| | 11.1.2 | Pinon-type cutter without protuberance..... | 105 |
| | 11.1.3 | Pinon-type cutter with protuberance..... | 106 |
| | 11.2 | Undercut condition..... | 107 |
| | 11.3 | Determination of start of involute when no undercut exists..... | 108 |
| | 11.4 | Start of involute when there is undercut..... | 108 |
| | 11.4.1 | Residual fillet undercut (transverse plane)..... | 108 |
| | 11.4.2 | Angle centre line of gear pair to centre point of tooth tip rounding:..... | 108 |
| | 11.4.3 | Point Q (tangent point of cutter tip fillet and generated gear root fillet)..... | 109 |
| | 11.4.4 | Determination of start of involute..... | 109 |
| | 11.4.5 | Determination of radius of curvature of trochoid..... | 112 |
| | | Annex A (informative) Form diameters when a circular arc in a transverse plane is used for tooth tip corner radius or tooth root fillet radius..... | 114 |
| | | Annex B (informative) Tip form radius when tooth tip corner radius is defined on normal surface with pinion type cutter..... | 123 |
| | | Annex C (informative) Supplementary information for crossed axes cylindrical gears..... | 131 |
| | | Annex D (informative) Geometry of surfaces in contact..... | 138 |
| | | Annex E (informative) Projection of transverse profile of the tooth to other planes..... | 148 |
| | | Annex F (informative) Interface for geometry of involute worms defined with ISO 10828..... | 156 |
| | | Bibliography..... | 159 |