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Worms gears — Geometry of worm profiles

Engrenages à vis cylindriques — Géométrie des profils de vis

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International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
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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.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types :

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts ;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard ;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 10828, which is a Technical Report of type 3, was prepared by Technical Committee ISO/TC 60, *Gears*, Subcommittee SC1, *Nomenclature and wormgearing*.

Introduction

Thread forms of the worms of worm gear pairs are commonly related to the following machining processes:

— the type of machining process (turning, milling, grinding);

— the shapes of edges or surfaces of the cutting tools used;

— the tool position relative to an axial plane of the worm;

— where relevant, the diameters of disc type tools (grinding wheel diameter).

Worm gears — Geometry of worm profiles

1 Scope

In this Technical Report, thread profiles of the five most common types of worms at the date of publication are described and equations of their axial profiles are given.

The five worm types covered in this technical report are designated by the letters A, C, I, K and N.

2 References

ISO 701-1:—1), *International gear notation — Part 1: Symbols for geometrical data.*

ISO 1122-2: —2), *Vocabulary of gear terms — Part 2: Geometrical definitions of worm gears.*

3 General

3.1 Definitions

Type A	straight sided axial profile ;
Type C	concave axial profile formed by machining with a convex circular profile disc type cutter or grinding wheel ;
Type I	involute helicoid, straight generatrix in base tangent planes ;
Type N	straight profiles in normal plane of thread space helix ;
Type K	milled helicoid generated by biconical grinding wheel or milling cutter, convex profiles in axial planes.

3.2 Conventions relative to the equations

3.2.1 The worm threads are right-handed.

The equations in this Technical Report define the coordinates of the left flank of the axial profile of worm, i.e. in the plane XOY of figure 1.

To obtain the right flanks, it is necessary to draw a symetric profile to the left flank relative to a perpendicular axis to the worm axis.

1) To be published. (Revision of ISO 701:1976)
2) To be published.

3.2.2 The worm and wheel pairs operate as speed reducing gears with directions of rotation as shown in figure 1, thus the worm- thread left flanks contact the wheel teeth. These are the flanks studied in this report.

3.2.3 The wormwheel is above the worm.

3.2.4 With the origin O, the reference axes X Y Z, are mutually perpendicular (see figure 1):

- OX the worm axis coincides with the X axis;
- OY the common perpendicular to the worm and wheel axes coincides with the Y axis;
- OZ to complete the direct coordinate system.

A point is defined by its x, y, z coordinates. The following subscripts are used:

- x refers to the X-Y axial plane;
- D refers to an offset plane;
- n refers to the normal plane;
- t for any point refers to a transverse plane.

3.2.5 If the worm is driving, the worm gear is a reducer. If the worm wheel is driving the worm gear is an increaser.

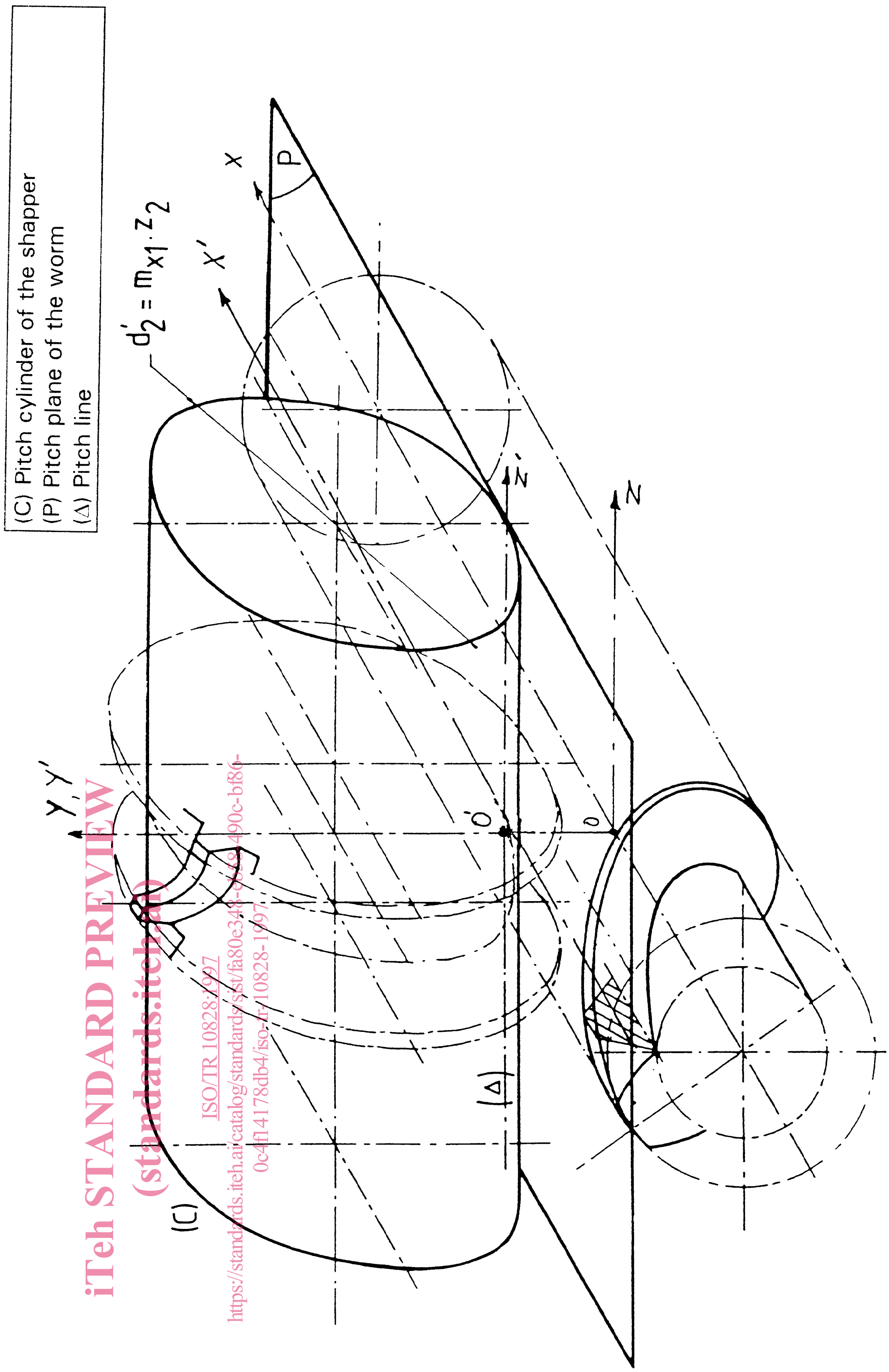

Figure 1 : Conventions used in equations

4 Profiles

4.1 Type A

4.1.1 Geometrical definition

The thread flanks of type A are generated as envelopes of straight lines in axial planes which are inclined at a constant angle : $\frac{\pi}{2} - \alpha_{ot}$ to the axis. This line as it is moved with simultaneous rotation about and translation along the axis X, defines the worm thread flank (figure 2). The form of which is commonly described as an Archimedean helix.

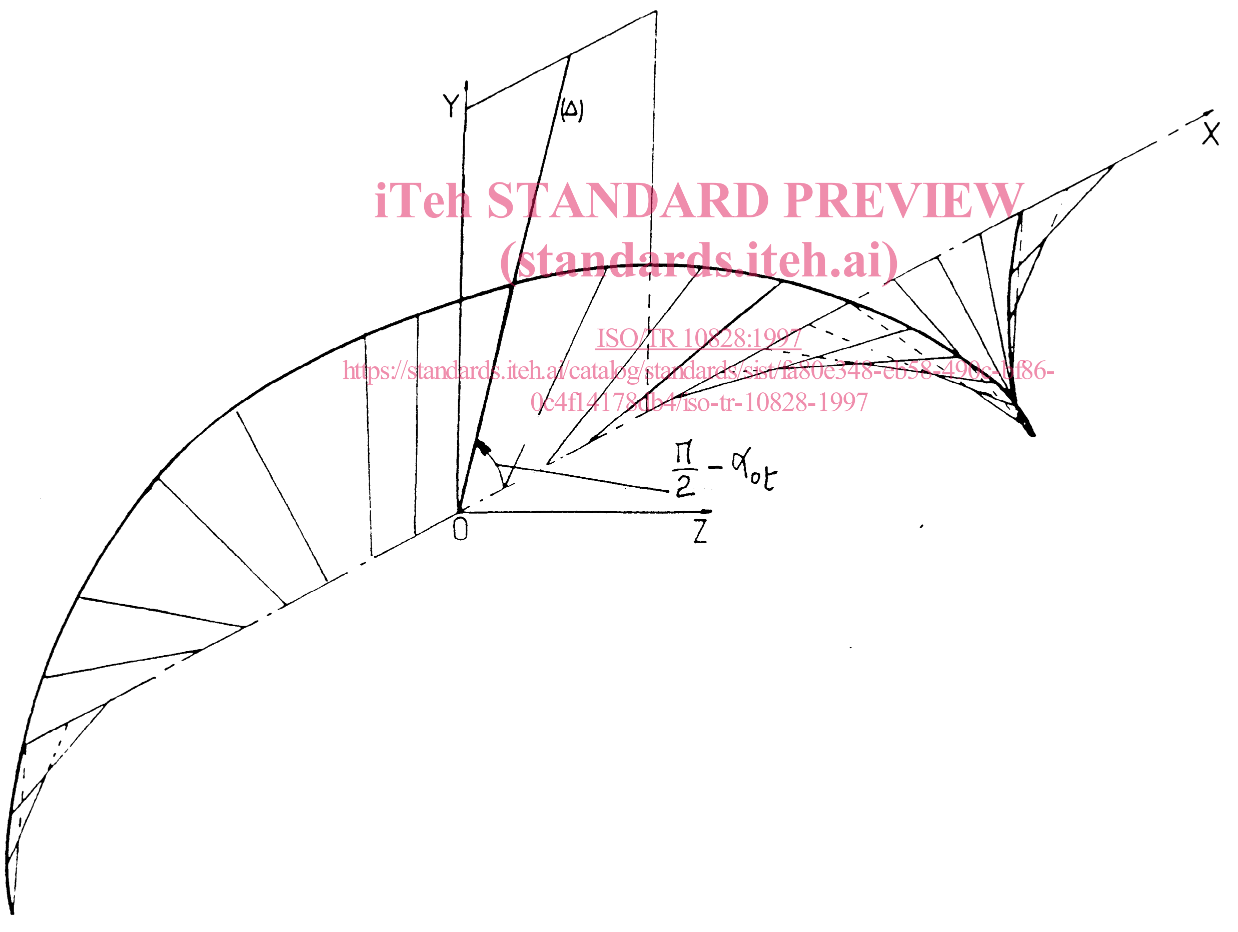

Figure 2 : Profile A : Theoretical Generation

4.1.2 Machining methods

The straight generatrix is always crossing the worm axis, the flank of thread in an axial plane is always a straight line ; so machining methods should ensure to generate this straight axial flank.

The threads may be cut on a lathe with a tool having straight edges, the cutting plane of which lies in an axial plane of the worm (figure 3 a)).

Both flanks of a thread space may be machined simultaneously by using a tool of trapezoidal form.

Another method which is an inversion of the process of cutting a helical gear with a rack cutter, involves the use of an involute shaper to produce the desired rectilinear rack profile in an axial plane of the worm.The cutting face must lie in that axial plane(figure 3 b)).

It is also necessary that the pitch circle of the shaper should roll without slip on the datum line of the rack profile. This coincides with a straight line generatrix of the worm pitch cylinder.

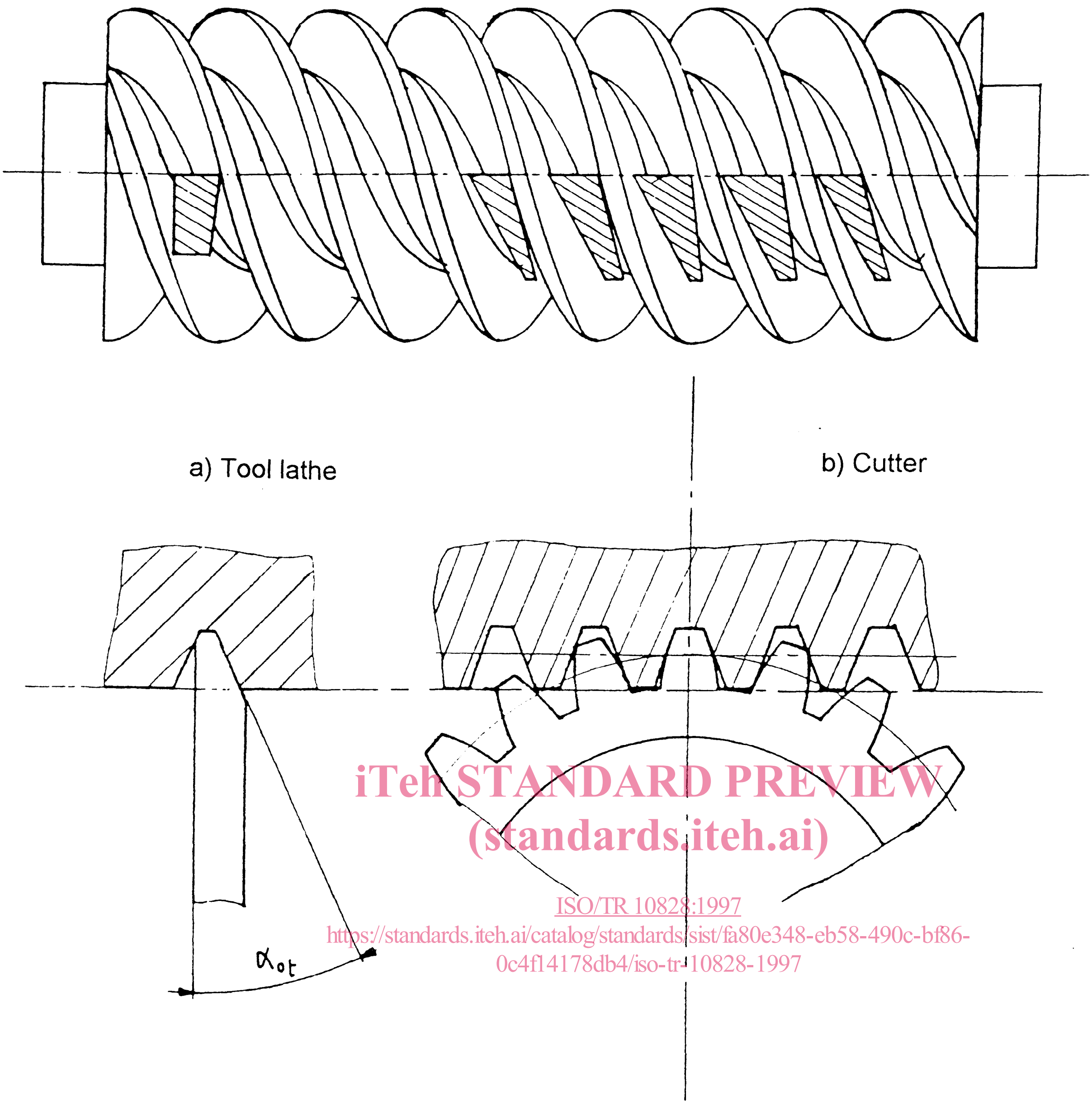

Figure 3 : Profile A- Machining Methods

4.1.3 Equations of the profile in the X-Y plane

Where :

α_{ot} is the transverse pressure angle of the cutter

α_{on} is the normal pressure angle of the cutter ;

γ_1 is the lead angle of threads.

For a point (x, y) at a distance y from the worm axis :

$$x_x = y_x \cdot \tan(\alpha_{ot}) = y_x \cdot \tan(\alpha_{on}) / \cos(\gamma_1) \qquad (1)$$

and

$$\tan(\alpha_x) = \tan(\alpha_{ot}) \qquad (2)$$

Type A profile is a straight line in any axial plane.

4.2 Type I

4.2.1 Geometrical definition

A flank of a type I worm is an involute helicoidal surface. The form of which may be generated by a base tangent (Δ) to a helix (H), which moves along this - the base helix lying on the base cylinder of the worm (C), which is concentric with the worm axis (figure 4).

A transverse profile (in a normal plane to the worm axis) of a flank is an involute to a circle.

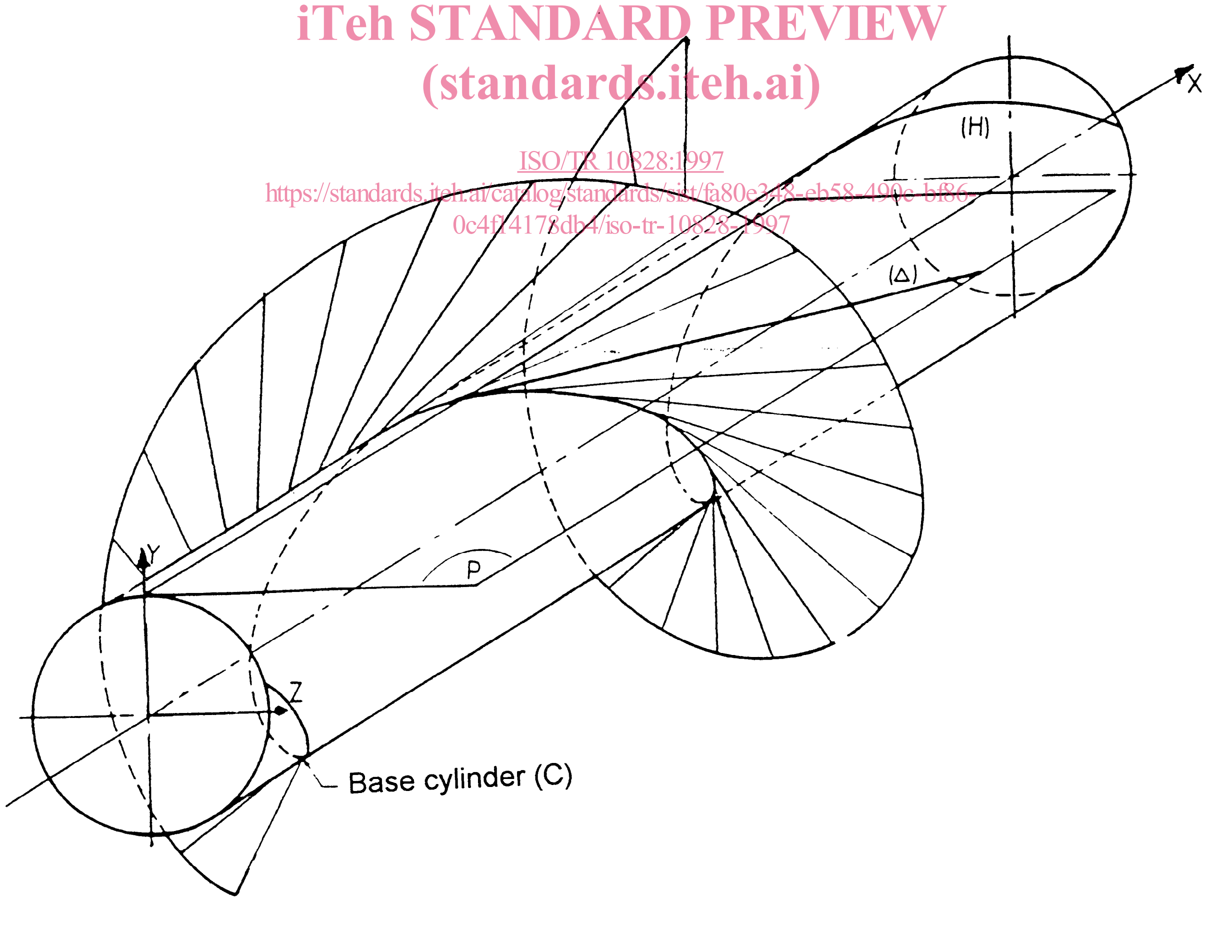

Figure 4 : Profile I - Theoretical generation

4.2.2 Machining methods

The straight generatrix is always tangential to the base helix in a plane which is tangential to the base cylinder, so the flank of the worm is a straight line in an offset plane which is tangential to the base cylinder. Machining methods should ensure this straight offset profile.

The involute helicoidal flanks of the threads can be generated by turning on a lathe using a knife tool with its straight edge aligned with the base tangent generatrix in a plane tangential to the base cylinder.

In order to machine both flanks of a thread simultaneously, it is necessary to set one left hand tool in one plane and one right hand tool in another plane as described above (figure 5).

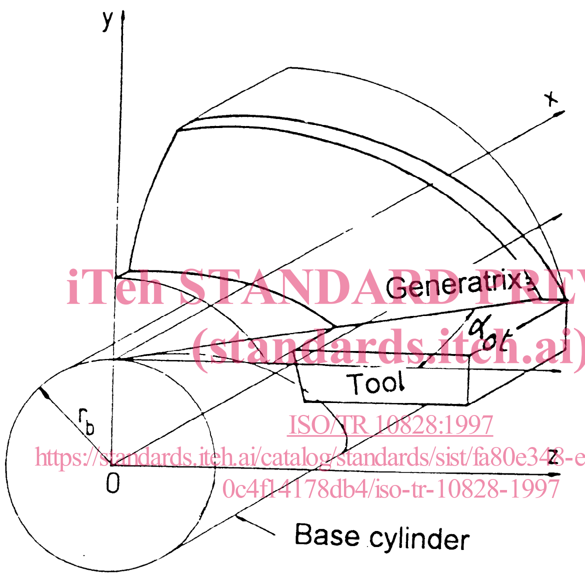

Figure 5 : Profile I - Machining method with a lathe

The thread flanks can be machined by milling or grinding using the plane side face of a disc type milling cutter or grinding wheel. The cutting face is to be so aligned that either its axis lies in a plane parallel to the X-Z plane and the base tangent generatrix of the flank lies in the cutting face (Figure 6); or the cutting face is aligned with the reference helix of the worm and in a plane perpendicular to the reference helix is set to the normal pressure angle of the flank α_{on} (figure 7).