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Basic quantities in cutting and grinding —

Part 5 :
Basic terminology for grinding processes using grinding wheels

Grandeurs de base en usinage et rectification —

Partie 5 : Terminologie de base propre au meulage

Reference number
ISO 3002-5 : 1989 (E)

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 3002-5 was prepared by Technical Committee ISO/TC 29, *Small tools*.

ISO 3002 will consist of the following parts, under the general title *Basic quantities in cutting and grinding*:

— *Part 1: Geometry of the active part of cutting tools — General terms, reference systems, tool and working angles, chip breakers*

— *Part 2: Geometry of the active part of cutting tools — General conversion formulae to relate tool and working angles*

— *Part 3: Geometric and kinematic quantities in cutting*

— *Part 4: Forces, energy, power*

— *Part 5: Basic terminology for grinding processes using grinding wheels*

— *Part 6: Quantity as a function of time*

Annex A of this part of ISO 3002 is for information only.

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Basic quantities in cutting and grinding —

Part 5 : Basic terminology for grinding processes using grinding wheels

1 Scope

The aim of this part of ISO 3002 is to apply the basic terminology defined in ISO 3002, parts 1 to 4, specifically to grinding operations and to define additional quantities specific to grinding.

NOTE — In addition to terms used in the three official ISO languages (English, French and Russian), this part of ISO 3002 gives the equivalent terms in the German, Italian and Dutch languages; these are published under the responsibility of the member bodies for Germany, F.R. (DIN), Italy (UNI), the Netherlands (NNI) and Belgium (IBN). However, only the terms given in the official languages can be considered as ISO terms.

For the purposes of this part of ISO 3002 the meaning of the word grinding is considered in a limited sense as a material removal operation in which the tool is a grinding wheel.

The primary motion[1] is the rotation of the grinding wheel which causes a considerable peripheral speed in the contact area with the workpiece.

A feed motion[1] is applied to the tool or workpiece to obtain a continuation of the removal of workpiece material in the form of small chips by the action of individual cutting edges[1].

The feed motion may consist of several components. The machine surface is generated by the combined effect of the shape of the grinding wheel and the path of the motion components.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 3002. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 3002 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 841 : 1974, *Numerical control of machines — Axis and motion nomenclature.*

ISO 3002-1 : 1982, *Basic quantities in cutting and grinding — Part 1: Geometry of the active part of cutting tools — General terms, reference systems, tool and working angles, chip breakers.*

ISO 3002-2 : 1982, *Basic quantities in cutting and grinding — Part 2: Geometry of the active part of cutting tools — General conversion formulae to relate tool and working angles.*

ISO 3002-3 : 1984, *Basic quantities in cutting and grinding — Part 3: Geometric and kinematic quantities in cutting.*

ISO 3002-4 : 1984, *Basic quantities in cutting and grinding — Part 4: Forces, energy, power.*

3 General conventions

3.1 Symbols and suffixes

Except when otherwise specified, the basic symbols defined in ISO 3002, parts 1 to 4, are used in grinding together with the following symbols:

— A = surface;

— l = length;

— b = width.

Where appropriate, a suffix is added; among others,

— s relates the quantity considered to the grinding wheel, e.g. v_s = peripheral speed of the grinding wheel;

— w relates the quantity considered to the workpiece, e.g. v_w = peripheral speed of the workpiece;

— m relates the quantity considered to the table or support of workpiece or grinding wheel (see 3.2);

— d relates the quantity considered to the dressing or truing operation or truing tool;

1) See ISO 3002-1 : 1982, 3.6.1 and 3.6.2.

— ′ (prime) expresses the quantity considered per unit of active width (4.6.2) or per unit of active profile length (4.6.1) of the grinding wheel, e.g. $F' = F/b$.

3.2 Table

In this part of ISO 3002 the term "table" is used for the machine element moving with respect to the base of the machine tool. The table may support either the grinding wheel or the workpiece.

Only in the case of cylindrical grinding (see 6.1.2) does the workpiece rotate continuously, relative to the table.

With this exception all motions other than the primary motion[1)] are considered to be provided by the table.

3.3 Nominal and real value

The nominal value of a parameter is that value set on the machine. The real value of a parameter is its actual value taking into account deformation of the workpiece, of the grinding wheel and of the machine and wear of the grinding wheel.

Where distinction is needed, the suffix "n" or "r" between parentheses may be added to the appropriate symbols, e.g. $h_{(n)}$ and $h_{(r)}$.

3.4 Reference system of planes (figures 2 to 7)

The reference systems of planes are defined in ISO 3002-1.

In grinding, planes are referred to the grinding principal point "D" (4.7) and take into account the direction of the principal feed motion (5.2.1).

In the case where the direction of the primary motion[1)] and the direction of the principal feed motion (5.2.1) in the grinding principal point "D" coincide, the orientation of the working plane[1)] shall be taken perpendicular to the axis of rotation of the grinding wheel.

3.5 Machine axis convention

The direction of machine axes, whenever it can be applied, should be in accordance with the basic principles of ISO 841.

Some cases may need further specification.

4 Characteristic dimensions of grinding wheels and workpieces (figure 1)

4.1 Grinding wheel and workpiece diameter: d_s, d_w respectively.

4.2 Peripheral length of grinding wheel and workpiece: πd_s, πd_w respectively.

4.3 Width of the grinding wheel measured parallel to the wheel axis: b_s (see figure 1).

4.4 Surfaces on the grinding wheel

4.4.1 geometric grinding wheel surface: The portions of the grinding wheel surfaces which are prepared or dressed to remove material.

4.4.2 active grinding wheel surface: That portion of the geometric grinding wheel surface which effectively removes material during a revolution of the grinding wheel.

4.4.3 geometric grinding contact surface: The idealized surface of contact between grinding wheel and workpiece which would be determined or calculated by ignoring deformation, wear of the grinding wheel, roughness of grinding wheel and workpiece, and tangential feed motion.

4.4.4 kinematic grinding contact surface: The grinding contact surface which would be determined or calculated by ignoring deformation, roughness of grinding wheel and workpiece, and wear of the grinding wheel, but taking into account the tangential feed motion.

4.4.5 real grinding contact surface: The grinding contact surface which exists when considering feed motions[2)] together with deformations and surface characteristics of both grinding wheel and workpiece.

4.5 Profiles of the grinding wheel

4.5.1 geometric grinding wheel profile: The curve formed by the intersection of the geometric grinding wheel surface and a plane containing the axis of rotation of the grinding wheel.

4.5.2 active grinding wheel profile: The curve formed by the intersection of the active grinding wheel surface and a plane containing the axis of rotation of the grinding wheel.

4.5.3 real grinding wheel profile: The curve formed by the intersection of the real grinding contact surface and a plane containing the axis of rotation of the grinding wheel and which is perpendicular to the machined surface.

For cases where this definition cannot be applied directly, the method used to determine the real grinding wheel profile shall be clearly specified.

4.6 Dimensions of the active grinding wheel profile

4.6.1 active grinding wheel profile length l_D (figure 1): The length of the curve of the active grinding wheel profile.

1) See ISO 3002-1 : 1982, 3.6.1 and 4.2.2.
2) See ISO 3002-1 : 1982, 3.6.2.

In certain cases, such as in plunge grinding (6.4.4) with a formed wheel, there may be more than one element of the active grinding wheel profile and in such cases the active grinding wheel profile length is the sum of these individual lengths.

4.6.2 active grinding wheel width b_D (figure 1): The length of the perpendicular projection of the active grinding wheel profile onto the axis of rotation of the grinding wheel.

This concept is usually only applied to peripheral grinding operations (6.2.1).

4.7 grinding principal point D (figures 1 to 7): A particular point of the active grinding wheel profile used to locate a reference system to define basic geometric quantities, velocities and force components.

It is recommended that the grinding principal point be located in a plane containing the axis of rotation of the grinding wheel and perpendicular to the direction of the principal feed motion (5.2.1) and at the position which divides the length of the active grinding wheel profile into two equal parts.

NOTE — In face grinding (6.2.2), these conditions may be impossible to achieve and the grinding principal point may have to be located elsewhere in which case it should be designated by D' and its position clearly identified.

4.8 Grinding arc in peripheral grinding

The following definitions can be applied only to peripheral grinding operations (6.2.1).

4.8.1 geometric grinding arc: The curve formed by the intersection of the geometric grinding contact surface and a plane perpendicular to the grinding wheel axis and passing through the grinding principal point.

4.8.2 kinematic grinding arc: The curve formed by the intersection of the kinematic grinding contact surface and a plane perpendicular to the grinding wheel axis and passing through the grinding principal point.

4.8.3 real grinding arc: The curve formed by the intersection of the real grinding contact surface and a plane perpendicular to the grinding wheel axis and passing through the grinding principal point.

4.9 Contact length in peripheral grinding

The following definitions can be applied only in peripheral grinding operations (6.2.1).

The contact lengths defined are the lengths of the grinding arcs defined in 4.8.

4.9.1 geometric contact length l_g (figure 4): The length of the geometric grinding arc.

For practical purposes and assuming that f_r is small in relation to both d_s and d_w, and that v_w is small compared with v_s,

$$l_g = \sqrt{2 f_r \cdot r_{eq}}$$

which represents the chord of the geometric grinding arc and where r_{eq} is the equivalent grinding wheel radius (see 4.10).

4.9.2 kinematic grinding length l_k: The length of the kinematic grinding arc.

$$l_k = l_g \left(1 + \frac{1}{|q|} \right)$$

where $|q|$ is the absolute value of the speed ratio defined in 5.3.3.

4.9.3 real contact length l_e: The length of the real grinding arc.

4.10 equivalent grinding wheel radius r_{eq}: The radius of an imaginary grinding wheel which, if engaged with a flat workpiece, would give the same geometric contact length as a grinding wheel of radius r_s engaged with a workpiece of radius r_w in peripheral grinding operations.

It is a function of the radius of the workpiece r_w and the radius of the grinding wheel r_s at the grinding contact surface and is evaluated from the relationship

$$r_{eq} = \frac{r_w \cdot r_s}{r_w \pm r_s}$$

The positive sign is used if the centre of the curvature of the transient surface[1] and the centre of the grinding wheel are on opposite sides of the grinding contact surface, e.g. in external cylindrical grinding (see 6.1.2 and 6.3.1).

The negative sign is used if the centre of the curvature of the transient surface and the centre of the grinding wheel are on the same side of the grinding contact surface, e.g. in internal cylindrical grinding (see 6.1.2 and 6.3.2).

5 Motions and speeds (figures 2 to 7 and table 1)

All motions and speeds are considered at a certain instant in time at a selected point of the active grinding wheel profile. Usually the selected point is the grinding principal point "D" (4.7). Whenever any other point is selected for determining motions and speeds, then its location shall be clearly specified.

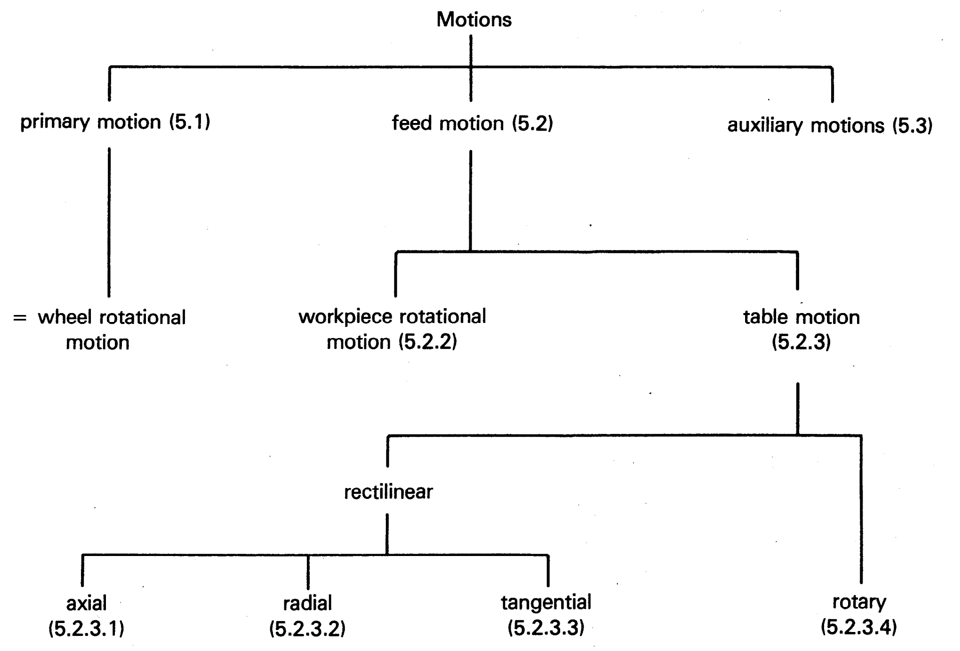
A schematic layout of the motions is given in table 1.

5.1 Primary motion and related quantities

The primary motion[2] is the rotary motion of the grinding wheel.

1) See ISO 3002-1 : 1982, 3.1.3.
2) See ISO 3002-1 : 1982, 3.6.1.

Table 1 — Schematic representation of relative motions between grinding wheel and workpiece



5.1.1 cutting speed v_c: The tangential velocity of the grinding wheel at a selected point of the grinding contact surface and measured relative to the grinding wheel support [recommended unit: metre per second (m/s)].

5.1.2 grinding wheel peripheral speed v_s: The tangential velocity of the grinding wheel at the wheel periphery measured at the maximum diameter and relative to the grinding wheel support [recommended unit: metre per second (m/s)].

5.1.3 grinding wheel rotational frequency n_s: The number of revolutions of the grinding wheel per unit of time measured relative to the grinding wheel support [recommended unit: second to the power minus one (s^{-1})].

5.2 Feed motion and related quantities

The definition of feed motion given in ISO 3002-1 : 1982, 3.6.2, applies also in grinding. However, in grinding the feed motion often results from the combination of different independently controlled motions of the workpiece and machine elements, which need to be considered separately.

The feed motion components may be continuous or discontinuous (per stroke or per pass[1)] or per revolution) and may be produced by the rotation of the workpiece with respect to the table or/and by the motion of the table with respect to the base of the machine tool.

NOTES

1 To conform with ISO 3002-1, the suffix "f" may be used, followed by a second suffix indicating the component considered. However, for the sake of simplicity, the index "f" for feed can be omitted when no confusion is possible.

2 Feed may be specified and measured in terms of displacement per stroke, per pass or per revolution of the workpiece relative to the table or of the table relative to the base of the machine tool. Feed speeds are established in terms of displacement per unit of time.

5.2.1 principal feed motion: The continuous feed motion which has the highest feed speed for the grinding operation considered.

In certain grinding operations the direction of principal feed motion may change and therefore the principal feed motion may require further specification.

5.2.2 workpiece rotational motion (figure 2 and table 1): The rotation of the workpiece around its axis, relative to the table, in the case of cylindrical grinding.

5.2.2.1 workpiece peripheral speed v_w: The instantaneous velocity of the workpiece periphery relative to the table at the selected point [recommended unit: millimetre per second (mm/s)].

NOTE — In surface grinding (6.1.1) and/or cylindrical grinding (6.1.2), when the workpiece is fixed upon the table, only the table motion v_m should be considered and $v_w = 0$.

5.2.2.2 workpiece rotational frequency n_w: In cylindrical grinding (6.1.2) the number of revolutions per unit of time of the workpiece relative to the table [recommended unit: second to the power minus one (s^{-1})].

1) See ISO 3002-3 : 1984, 8.1.

5.2.3 table motions and related quantities

Table motions are considered to be motions of that machine element upon which the grinding wheel or workpiece is mounted relative to the base of the machine.

These motions are designated as table feed motions and may be rectilinear or rotary.

Rectilinear table feed motions are designated according to their orientation with respect to the grinding wheel: axially, radially, or tangentially.

The rotary table feed motion is defined as such (see 5.2.3.4).

5.2.3.1 axial table feed motion: That motion of the table, considered at the selected point, which is in a direction parallel to the grinding wheel axis.

5.2.3.1.1 axial table feed speed v_{fa} (figures 1 to 3): The velocity of the axial table feed motion relative to the machine base [recommended unit: millimetre per second or micrometre per second (mm/s or µm/s)].

5.2.3.1.2 axial table feed f_a (figures 2 and 4): The displacement of the table relative to the machine base caused by the axial table feed motion and measured per revolution of the workpiece or per stroke.

In the case of cylindrical grinding (6.1.2), the recommended units are millimetre per revolution of the workpiece or micrometre per revolution of the workpiece.

In the case of surface grinding (6.1.1), the axial table feed motion may be discontinuous and takes place at the end of every stroke; in this case, it is called axial table feed per stroke, or axial incremental table feed per stroke (recommended unit: millimetre per stroke or micrometre per stroke).

5.2.3.2 radial table feed motion: The motion of the table, considered at the selected point, which is in a direction perpendicular to the grinding wheel axis.

5.2.3.2.1 radial table feed speed v_{fr} (figures 1, 2, 3, 5 and 6): The velocity of the radial table feed motion relative to the machine base (recommended unit: millimetre per second (mm/s)].

5.2.3.2.2 radial table feed f_r (figures 3, 5, 6 and 7): The displacement of the table relative to the machine base caused by the radial table feed motion and measured per revolution of the workpiece or per stroke, or per pass[1].

In the case of cylindrical grinding (6.1.2), the recommended units are millimetre per revolution of the workpiece or micrometre per revolution of the workpiece.

In the case of surface grinding (6.1.1), the radial table feed motion may be discontinuous and takes place when a further layer of material is to be removed; it is then called "incremental radial infeed" (recommended unit: millimetre per pass or micrometre per pass).

5.2.3.3 tangential table feed motion: That motion of the table, considered at the selected point, which is parallel to the grinding wheel peripheral speed.

5.2.3.3.1 tangential table feed speed v_{ft} (figures 2, 3 and 4): The velocity of the tangential table feed motion relative to the machine base at the selected point.

5.2.3.3.2 tangential table feed f_t: The table displacement relative to the machine base caused by the tangential table feed motion and measured per revolution of the workpiece or per stroke.

In the case of cylindrical grinding (6.1.2), the recommended units are millimetre per revolution or micrometre per revolution.

5.2.3.4 rotary table feed motion: The motion of the table around its axis.

5.2.3.4.1 table rotational frequency n_m (of the rotary table feed motion): The number of revolutions per unit of time the table performs relative to the base of the machine [recommended unit: second to the power minus one (s^{-1})].

5.2.3.5 principal table feed motion: The component of the continuous table feed motion which has the highest velocity at the selected point.

5.2.3.6 incremental feed: The discontinuous displacement of the grinding wheel which takes place at the end of a stroke or a pass[1] in a plane tangential to the machined surface[2] (recommended unit: millimetre per stroke or per pass or micrometre per stroke or per pass).

5.2.3.7 incremental infeed: The discontinuous displacement of the grinding wheel perpendicular to the transient surface[2] in order to remove a further layer of material over the whole machined surface[2] (recommended unit: millimetre per stroke or micrometre per stroke).

5.2.4 total length of table feed motion l_{fH}: The total length of the table feed motion travelled during a particular operation. These lengths can be related to the directions of the table feed motions. The symbol l should have an appropriate suffix to indicate the direction of measurement.

5.2.4.1 active length of table feed motion l_{fa}: The length of the table feed motion travelled during a particular operation while actual grinding takes place.

5.2.4.2 idle length of table feed motion l_{fo}: The part of the length of the table feed motion travelled during a particular operation during which no actual grinding takes place.

NOTE: $l_{fH} = l_{fa} + l_{fo}$

1) See ISO 3002-3 : 1984, 8.1.

2) See ISO 3002-1 : 1982, 3.1.2 and 3.1.3.

5.3 Auxiliary motions and other quantities

5.3.1 approach motion: The motion which positions the grinding wheel in the proximity of the workpiece immediately prior to grinding taking place.

5.3.2 compensation motion: The continuous or discontinuous motion provided in order to compensate for grinding wheel wear, thermal deformation, elastic deformation or similar variations.

5.3.3 speed ratio q: The ratio between the cutting speed[1] and the feed speed[1] relative to the machine base and measured in a tangential direction through the selected point.

In cylindrical grinding (6.1.2):

$$q = v_c / v_w$$

In surface grinding (6.1.1):

$$q = v_c / v_{ft}$$

5.3.4 overlap [traverse overlap] U in surface or cylindrical grinding with axial feed: The ratio between the active grinding wheel width and the axial table feed:

$$U = \frac{b_D}{f_a}$$

6 Terminology of common grinding operations (table 2)

For clarification of what follows, there is a need to define the basic terminology of grinding operations.

The principal operations can be identified according to the following criteria, the order of which is not necessarily related to their importance:

- the type of surface produced;
- the active part of the grinding wheel;
- the relative positions of workpiece and grinding wheel;
- the direction of the principal feed motion of the workpiece with respect to the grinding wheel;
- the relative orientation of the tangential velocities of the grinding wheel and workpiece at the selected point;
- special features.

6.1 Terminology considering the shape and method of generating the transient surface[2]

6.1.1 surface grinding: A grinding operation which produces a flat surface.

6.1.2 cylindrical grinding: A grinding operation which produces a cylindrical surface.

6.1.3 grinding on a rotary table: A grinding operation in which the principal table feed motion is a rotation.

6.1.4 shape grinding: The generic term for grinding operations which produce surfaces which are neither flat, nor cylindrical, i.e. thread grinding, gear grinding, etc.

6.1.4.1 generative grinding: A shape grinding operation in which the profile of the workpiece is mainly produced by controlling the feed motions (e.g. copying, or NC, etc.).

6.1.4.2 grinding with a profiled grinding wheel: A shape grinding operation in which the profile of the grinding wheel corresponds with the profile to be ground.

6.2 Terminology based on the part of the grinding wheel which is active

6.2.1 peripheral grinding: A grinding operation in which the cylindrical periphery of the grinding wheel, or a significant part of it, is performing the major part of the grinding operation.

6.2.2 face grinding: A grinding operation in which the major part of the grinding is performed by a surface of the grinding wheel which can be considered as perpendicular or slightly skew with respect to the axis of the grinding wheel.

6.3 Terminology based on the position of the grinding wheel relative to the workpiece

6.3.1 external grinding: A grinding operation which produces an external surface of a workpiece.

6.3.2 internal grinding: A grinding operation which produces an internal surface of a workpiece.

6.4 Terminology based on the direction of the principal table feed motion relative to the grinding wheel

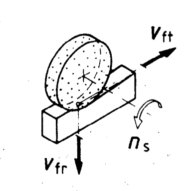
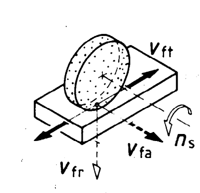
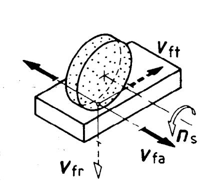
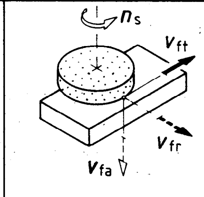
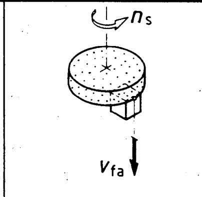
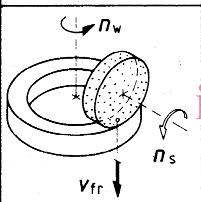
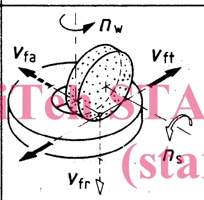
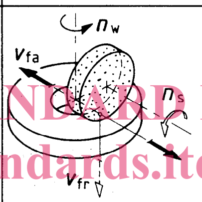
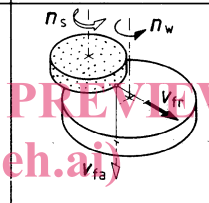
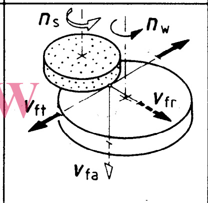
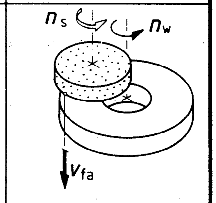
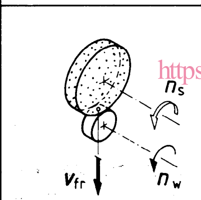
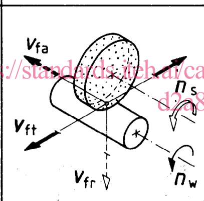
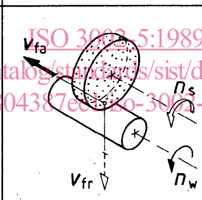
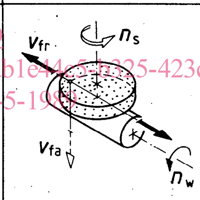
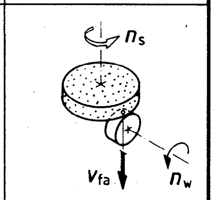
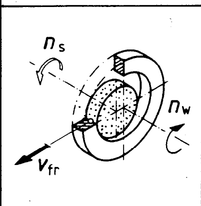
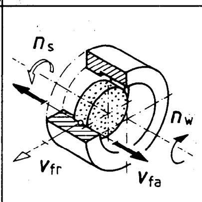
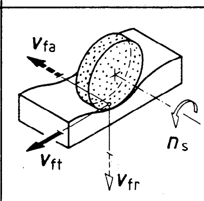
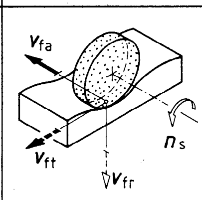
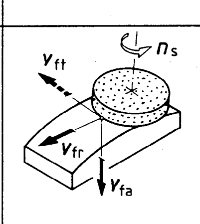
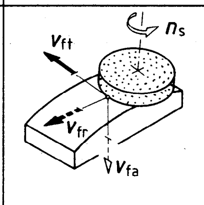
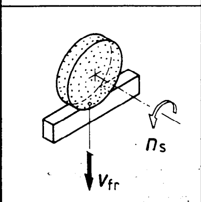
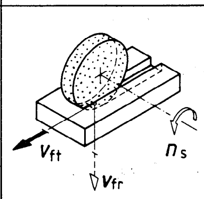
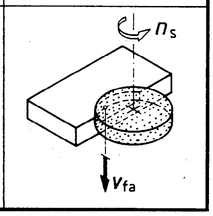
6.4.1 axial grinding: A grinding operation in which the principal table feed motion is oriented parallel to the axis of the grinding wheel.

6.4.2 tangential grinding: A grinding operation in which the principal table feed motion is parallel to the grinding wheel peripheral speed, at the grinding principal point D.

6.4.3 radial grinding: A grinding operation in which the principal table feed motion, at the grinding principal point D, is oriented radially to the grinding wheel.

1) See ISO 3002-1 : 1982, 3.6.1.2 and 3.6.2.2.
2) See ISO 3002-1 : 1982, 3.1.3.

Table 2 — Basic grinding operations

			Grinding operation					
			Peripheral			Face		
			radial (plunge)	tangential	axial	radial	tangential	axial (plunge)
Grinding operation	Surface	rectilinear table motion						
		rotary table motion						
	Cylindrical	external						
		internal						
	Shape	generative						
		profile						

6.4.4 Plunge grinding

6.4.4.1 peripheral plunge grinding: A peripheral grinding operation in which there is a continuous radial table feed motion.

6.4.4.2 face plunge grinding: A face grinding operation in which there is a continuous axial table feed motion.

6.5 Terminology based on the relative orientation of grinding wheel and workpiece velocities at the grinding principal point "D" (4.7)

6.5.1 up grinding: A grinding operation in which the tangential motions of the grinding wheel and workpiece relative to the machine base and considered through the grinding principal point have opposite directions.

6.5.2 down grinding: A grinding operation in which the tangential motions of the grinding wheel and workpiece relative to the machine base and considered through the grinding principal point have the same direction.

6.6 Additional terminology

6.6.1 reciprocating grinding: A grinding operation in which an incremental table feed is given at both ends of the stroke.

6.6.2 alternating grinding: A grinding operation in which an incremental table feed is given at one end of the stroke.

6.6.3 cut-off grinding: A peripheral grinding operation used to cut pieces into parts.

6.6.4 creep feed grinding: A peripheral grinding operation with a relatively slow principal feed speed and in which a relatively large contact surface exists.

6.6.5 oblique grinding: A cylindrical or surface grinding operation where the axis of the grinding wheel is neither parallel nor perpendicular with respect to either the axis of the workpiece or the workpiece surface [see figures 1c), 1d) and 6].

Oblique grinding can be a plunge grinding or a tangential grinding operation.

7 Wheel engagement and related quantities

(figures 3 to 7)

7.1 engagement of a grinding wheel a: The distance measured between two planes perpendicular to the chosen direction and respectively passing through two points of the geometric grinding contact surface and so located that the distance between the two planes is a maximum in the chosen direction.

7.2 working engagement a_e: The engagement of the grinding wheel measured in the working plane (see 3.4) and in a direction perpendicular to the direction of principal feed motion.

7.3 back engagement a_p: The engagement of the grinding wheel measured perpendicularly to the working plane (see 3.4).

7.4 feed engagement a_f: The engagement of the grinding wheel measured parallel to the direction of principal feed motion.

NOTE — Engagement can further be related to any other direction specified, e.g.

a) to wheel and related directions:

— radial engagement a_r,

— tangential engagement a_t,

— axial engagement a_a;

b) to the machine reference system a_x, a_y, a_z;

c) etc.

8 Material removal — Wheel wear

All definitions in this clause can be considered for the active grinding wheel surface as a whole or for any portion of it. The actual portion considered shall be clearly specified.

8.1 material removal V_w: The volume of workpiece material removed during a certain period of time.

8.1.1 material removal per unit active grinding wheel width V'_w: The material removal divided by the active grinding wheel width:

$$V'_w = \frac{V_w}{b_D}$$

8.1.2 material removal per unit active grinding wheel profile length V'_{wD}: The material removal divided by the active grinding wheel profile length:

$$V'_{wD} = \frac{V_w}{l_D}$$

8.1.3 material removal rate Q_w: The volume of workpiece material removed per unit of time, at a certain instant in time:

$$Q_w = \frac{\Delta V_w}{\Delta t}$$

8.1.4 material removal rate per unit active grinding wheel width Q'_w: The material removal rate divided by the active grinding wheel width:

$$Q'_w = \frac{Q_w}{b_D}$$

8.1.5 material removal rate per unit active grinding wheel profile length Q'_{wD}: The material removal rate divided by the active grinding wheel profile length:

$$Q'_{wD} = \frac{Q_w}{l_D}$$

8.2 volumetric grinding wheel wear V_s: The volume of grinding wheel material lost during a certain period of time.

8.2.1 volumetric grinding wheel wear per unit active grinding wheel width V'_s: The volumetric grinding wheel wear divided by the active grinding wheel width:

$$V'_s = \frac{V_s}{b_D}$$

8.2.2 volumetric grinding wheel wear per unit active grinding wheel profile length V'_{sD}: The volumetric grinding wheel wear divided by the active grinding wheel profile length:

$$V'_{sD} = \frac{V_s}{l_D}$$

8.2.3 grinding wheel wear rate Q_s: The volume of the grinding wheel material lost per unit of time:

$$Q_s = \frac{\Delta V_s}{\Delta t}$$

8.2.4 grinding wheel wear rate per unit active grinding wheel width Q'_s: The grinding wheel wear rate divided by the active grinding wheel width:

$$Q'_s = \frac{Q_s}{b_D}$$

8.2.5 grinding wheel wear rate per unit active grinding wheel profile length Q'_{sD}: The grinding wheel wear rate divided by the active grinding wheel profile length:

$$Q'_{sD} = \frac{Q_s}{l_D}$$

8.3 grinding ratio G: The ratio of material removal and volumetric grinding wheel wear during the same period of time:

$$G = \frac{V_w}{V_s}$$

8.4 grinding wheel radial wear Δr_s: The decrease of grinding wheel radius due to the grinding wheel wear.

8.5 grinding wheel axial wear Δb_s: The decrease of active grinding wheel width measured parallel to the axis of rotation of the grinding wheel.

9 Forces, energy and power

The definitions given in ISO 3002-4 can be applied directly to grinding operations, provided that the term "principal point" is replaced by "grinding principal point" and the term "nominal width of cut" is replaced by "active grinding wheel width".

All definitions in this clause can be considered for the active grinding wheel surface as a whole or for any portion of it. The actual portion considered shall be clearly specified.

The following terms 9.1 and 9.2 are defined in addition to those given in ISO 3002-4.

9.1 grinding force per unit active grinding wheel width F': The grinding force divided by the active grinding wheel width:

$$F' = \frac{F}{b_D}$$

9.2 grinding force per unit active grinding wheel profile length F'_D: The grinding force divided by the active grinding wheel profile length:

$$F'_D = \frac{F}{l_D}$$

10 Equivalent grinding thickness

(figures 3 and 8)

All definitions in this clause can be considered for the active grinding wheel surface as a whole or for any portion of it. The actual portion considered shall be clearly specified.

10.1 equivalent grinding thickness per unit active grinding wheel width h_{eq}: The ratio of material removal rate per unit active grinding wheel width Q'_w and the cutting speed v_c:

$$h_{eq} = \frac{Q'_w}{v_c}$$

10.2 equivalent grinding thickness per unit active grinding wheel profile length h_{eqD}: The ratio of material removal rate per unit active grinding wheel profile length Q'_{wD} and the cutting speed v_c:

$$h_{eqD} = \frac{Q'_{wD}}{v_c}$$

NOTE — The equivalent grinding thickness can be represented as the thickness of a continuous ribbon of material flowing away along the grinding wheel at the cutting speed v_c and the volume of which is equal to that of the material removal V_w during the same time period. The ribbon can be seen along the active grinding wheel width (10.1) or along the active grinding wheel profile length (10.2).

11 Grain count

11.1 static grain count at a certain depth N_{st}: The number of grains counted at a certain depth in a band situated under the grinding wheel periphery when measured by a quasi-stationary method (stylus, thermocouple, microscope).