NUM 1060 G

CYLINDRICAL GRINDING PROGRAMMING MANUAL

en-938930/1

Despite the care taken in the preparation of this document, NUM cannot guarantee the accuracy of the information it contains and cannot be held responsible for any errors therein, nor for any damage which might result from the use or application of the document.

The physical, technical and functional characteristics of the hardware and software products and the services described in this document are subject to modification and cannot under any circumstances be regarded as contractual.

The programming examples described in this manual are intended for guidance only. They must be specially adapted before they can be used in programs with an industrial application, according to the automated system used and the safety levels required.

Table of Contents

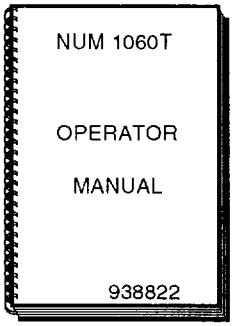
Record of Revisions

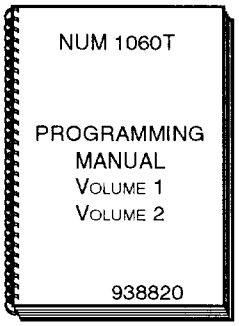
DOCUMENT REVISIONS		
Date	**Revision**	**Reason for Revision**
09-94	0	Creation of provisional document
12-95	1	Revision of manual

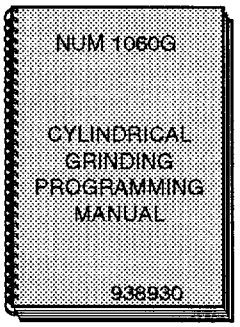
Structure of the NUM 1060 Product Documentation

User Documents

These documents describe operation of the CNC.

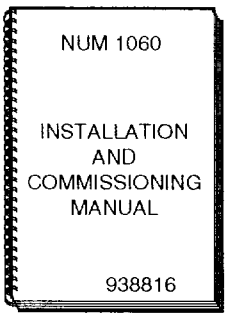


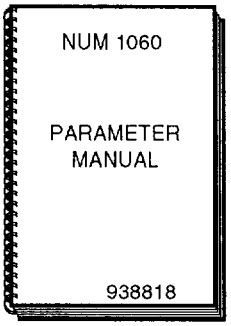


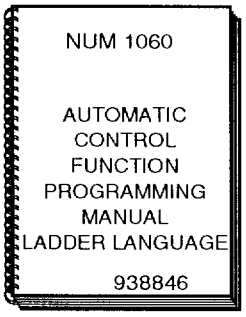


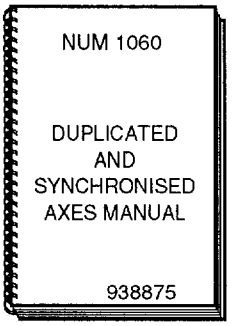
Integrator Documents

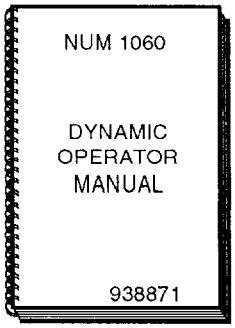
These documents describe setting up the CNC on a machine

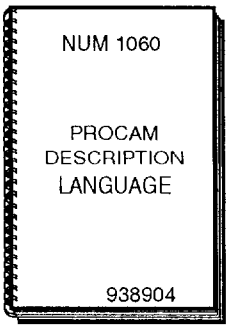


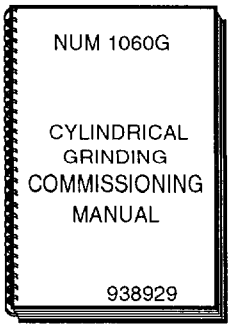






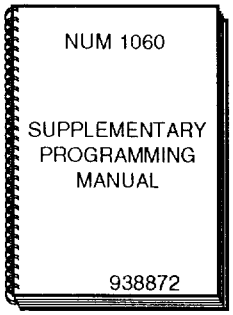


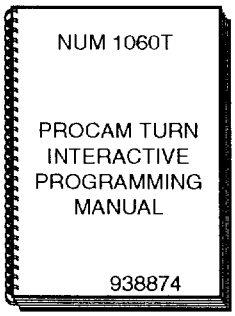


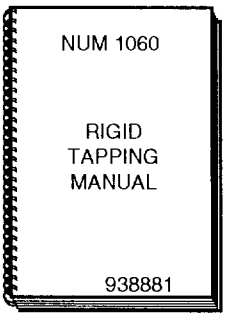


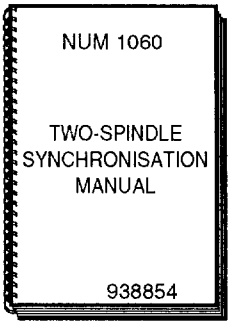
Special Programming Documents

These documents describe special CNC programming applications.

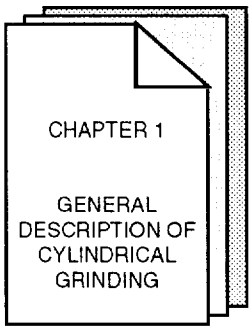




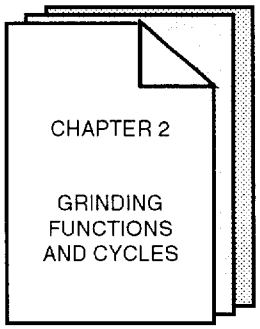




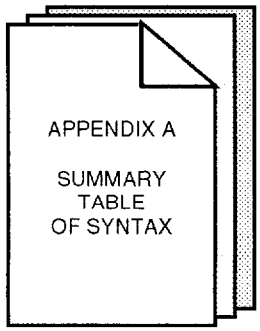
Programming Manual



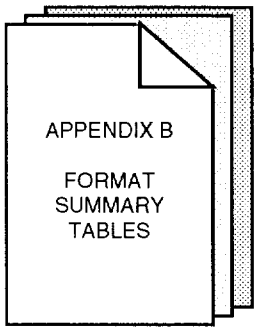
Description of the machine environment:
- grinding axes,
- origins and shifts,
- wheel profiles,
- cylindrical grinding possibilities,
- preliminary operations before starting a cycle.



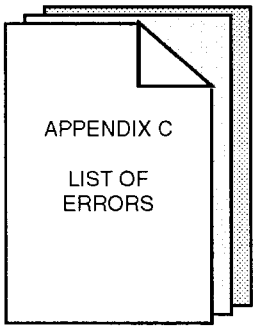
Description of the internal and external grinding functions and cycles.



Tables giving the cycle syntax:
- external grinding cycle syntax,
- internal grinding cycle syntax.



Tables listing the arguments and their formats:
- external grinding cycle argument formats,
- internal grinding cycle argument formats,
- miscellaneous function argument formats.



Tables listing the grinding error codes and descriptions.

Using the Programming Manual

Function syntax writing conventions

Grinding programme lines (blocks) include functions and/or arguments.

A special syntax is used with each of the functions described herein. The syntax rules determine how the programme blocks are written.

The following conventions are used in writing the syntax:
- the related function is highlighted in boldface characters,
- the arguments between square brackets [...],
- «/» offers a choice between several terms (equivalent to «or»),
- «..» after a letter replaces a numerical value,
- «...» replaces a character string.

Example

Syntax for cycle G206

The syntax for cycle G206 includes two blocks. The first block contains the cycle call arguments, and the second contains the in-cycle arguments. Function G206 must not appear in the second block.

Syntax

G206 X_ Z_ D_ EZ_ EP_ [ER_] F_ [EE_] [EF_] [EA_] [P_] [EC_] [EH_] [S_] [X_] [EI_] [EJ_] [F_] [EG_] [EM_] [EK_] [ED_] [ET_] / [EN_] EB_

CNC Operating Modes

Some of the CNC operating modes are mentioned in this manual when they are directly associated with the use of the ISO code function. Refer to the Operator Manual for further information on these modes.

List of G and M functions

Lists (yellow pages) at the beginning of the manual indicate the pages on which the G and M functions are found.

Agencies

The list of the NUM agencies is given at the end of the volume.

Questionnaire

To help us improve the quality of our documentation, we kindly ask you to return the questionnaire at the end of this volume.

List of G Functions

List of M Functions

1 General Description of Cylindrical Grinding

This manual is intended for programming CNCs integrated on external/internal cylindrical grinding machines.

It defines the special grinding functions and cycles to be programmed. The other functions that may be used comply with standard use for turning applications; for further information refer to the following manuals:
- turning operator manual,
- turning programming manual.

REMARK *Variables L900 to L951 are reserved for NUM programmes. They must not be used in user programmes. It should also be noted that programming of functions M200 to M255 is prohibited in G2XX grinding cycle blocks. These functions can however be programmed between two blocks.*

1.1 Description of the Grinding Axes

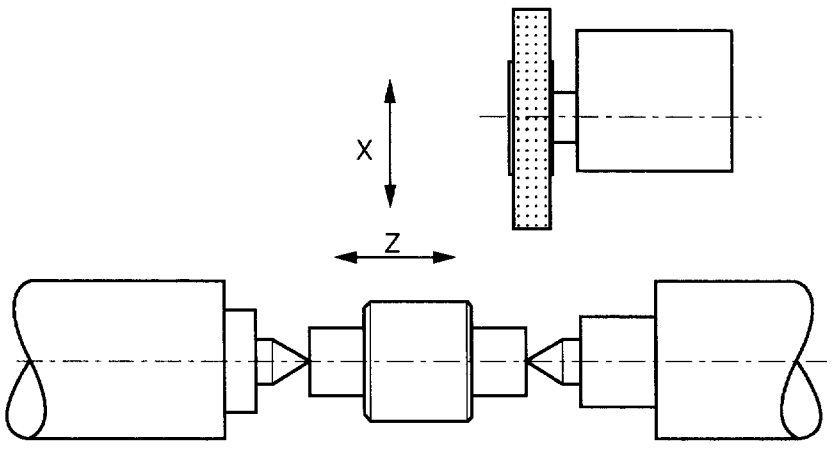
1.1.1 Axes and Spindles

The axes and spindles are defined as follows:
X: primary radial grinding axis,
Z: primary axial grinding axis.
One workpiece-holder spindle.
One or more wheelhead spindles.

The machine can be defined with B and C axes as well if necessary:
B: rotary wheelhead axis for grinding with wheel on inclined axis,
C: measured rotary workpiece holder axis which replaces a spindle.

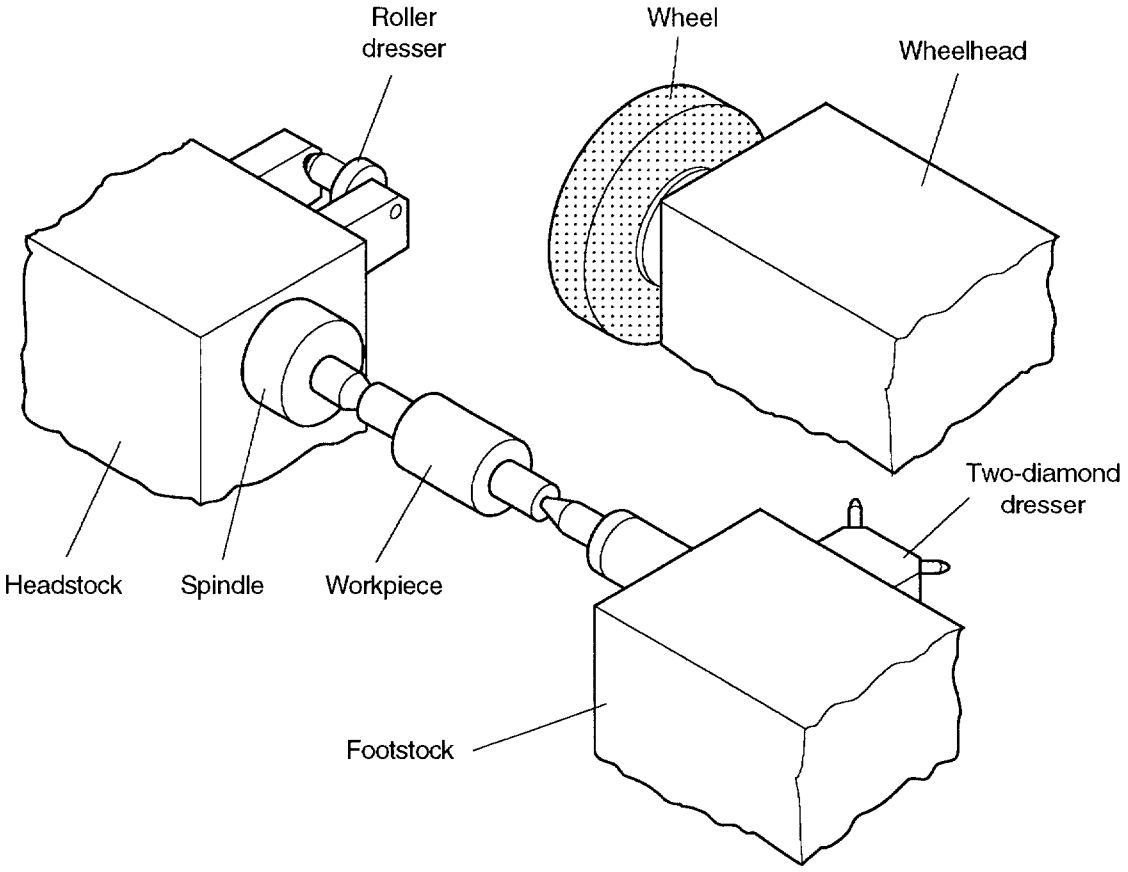
X and Z axes

There can be many grinding machine configurations, but the movements of the X and Z axes are generally defined using the convention shown in the diagram below.



1.1.2 Schematic Illustration of a Grinding Machine

External cylindrical grinding machine



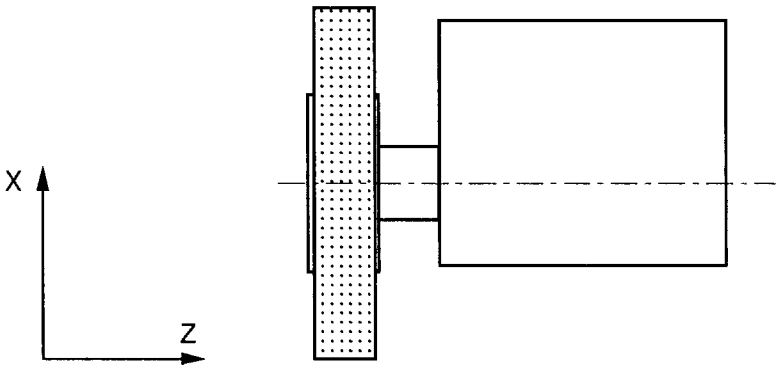
1.1.3 Wheelhead Configurations

Depending on the type of grinding machine and the grinding technique used, the wheelhead can be configured:

- straight,
- on inclined axis.

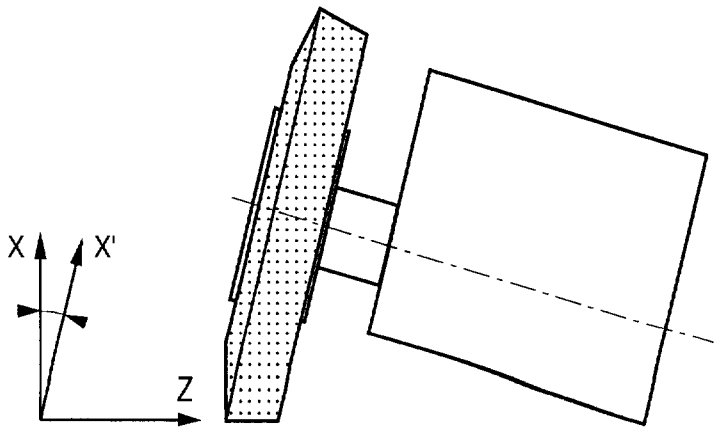
1.1.3.1 Wheelhead (X axis) Straight

The wheel axis is parallel with the Z axis.



1.1.3.2 Wheelhead (X axis) on Inclined Axis

The wheelhead X axis is tilted at the angle specified in machine parameter E69001 (or variable [WD(31)]).



1.1.4 Wheel Dressing Tools

Two types of dresser are generally used on grinding wheels:
- fixed two-diamond dresser,
- roller dresser.

1.1.4.1 Fixed Two-Diamond Dresser

This type of dresser can be used to dress:
- the wheel left and right sides and its peripheral cutting face (with a radius or chamfer if necessary),
- a complex wheel shape with a special profile.

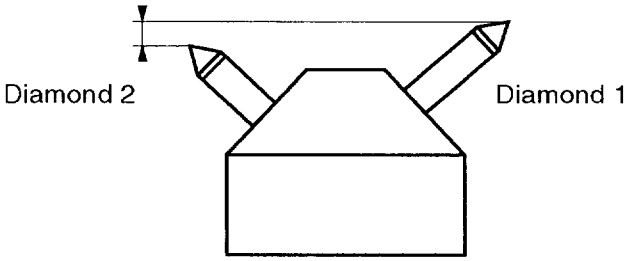
Limitations associated with the geometry of the fixed two-diamond dresser

All the shaping and dressing cycles performed with the fixed two-diamond dresser are based on the following principle:
- diamond 1 (right) is used for dressing the wheel peripheral face and its left side,
- diamond 2 (left) is used for dressing the right side of the wheel.

Two-diamond dresser

Since diamond 1 dresses the wheel peripheral face, diamond 2 must be lower than diamond 1. In this case the difference between the two diamonds is negative. Only this case is considered.

Diamonds 1 and 2 are offset with respect to one another.

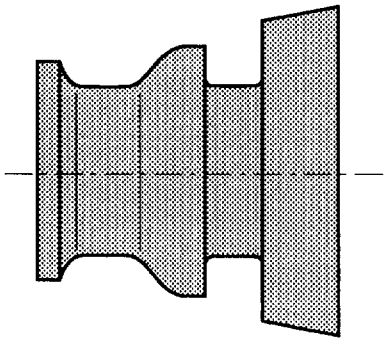


1.1.4.2 Roller Dresser

A roller dresser is a profiled tool used to dress a wheel to the complementary profile.

The roller dresser is rotated by an auxiliary spindle.

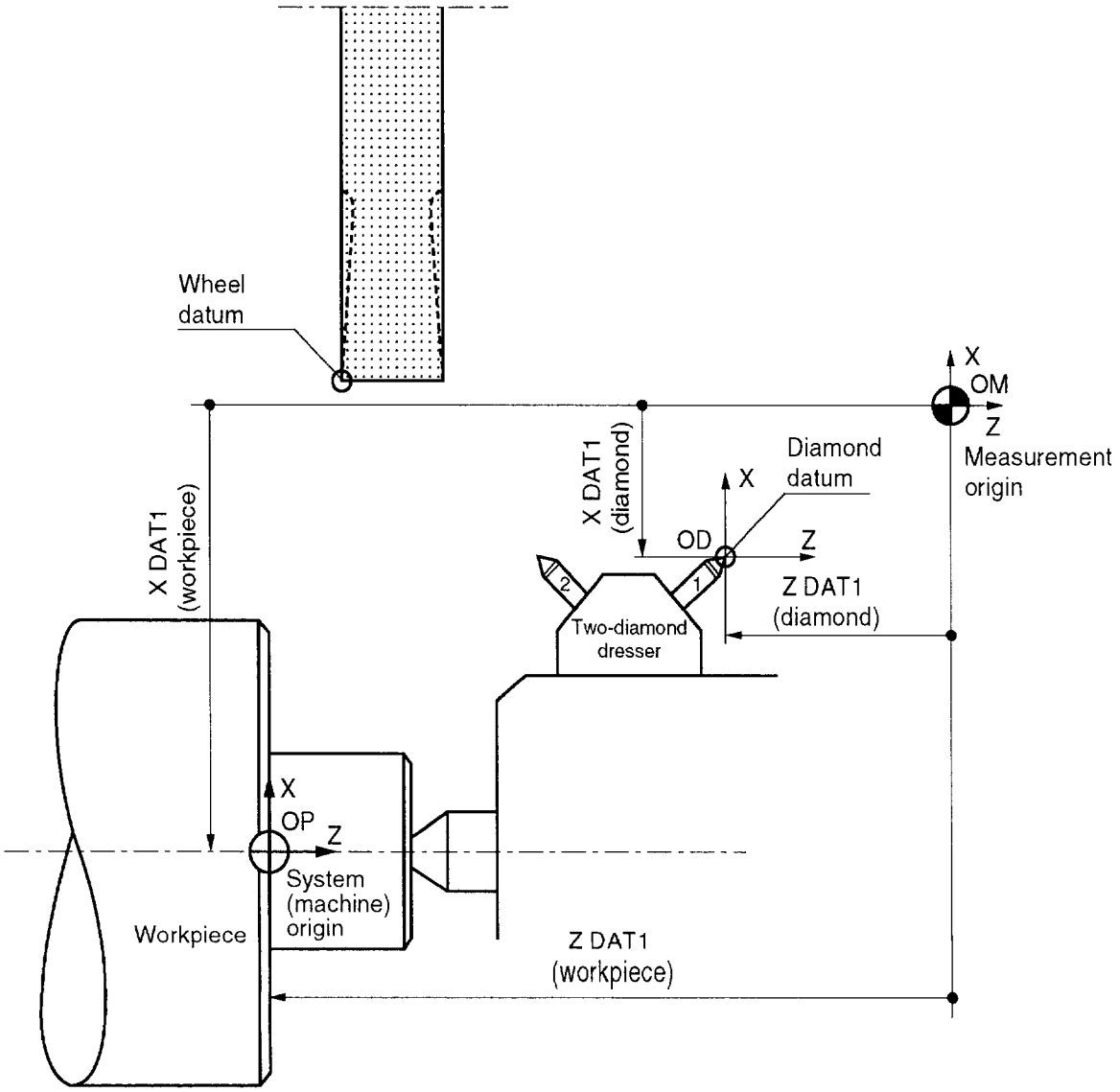
Example of roller dresser



1.2 Setting Origins and Shifts

1.2.1 Machine Origins and Shifts

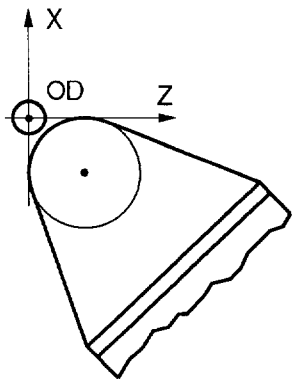
External grinding reference system



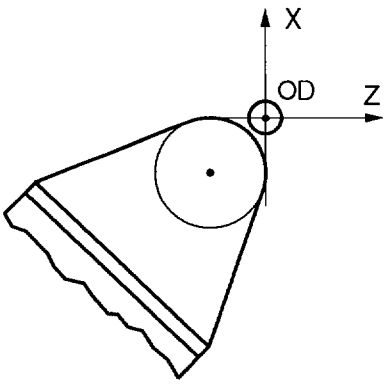
1.2.2 Dresser Origins

1.2.2.1 Fixed Two-Diamond Dresser (Diamonds 1 and 2) Origins

Diamond 2 origin



Diamond 1 origin



1.2.2.2 Roller Dresser Origin

The roller dresser origin can be positioned with respect to the reference side of the wheel (left or right side).

1.3 Wheel Profiles

Flat wheels can be dressed to obtain a number of wheel profiles.

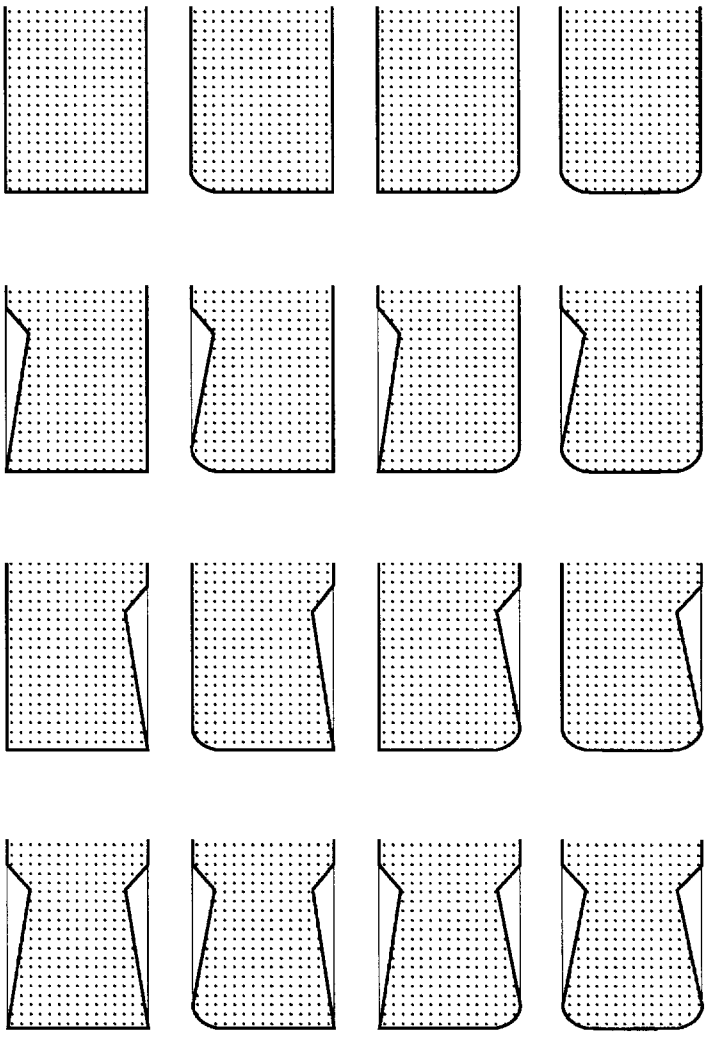
The wheel profiles are:
- standard,
- special.

1.3.1 Standard Profiles

Standard profiles are cut using a shaping function (G245).

1.3.1.1 Obtainable Standard Profiles

The following profiles can be defined with a fillet or chamfer:



1.3.1.2 Standard Profiles Cut with Diamond 1

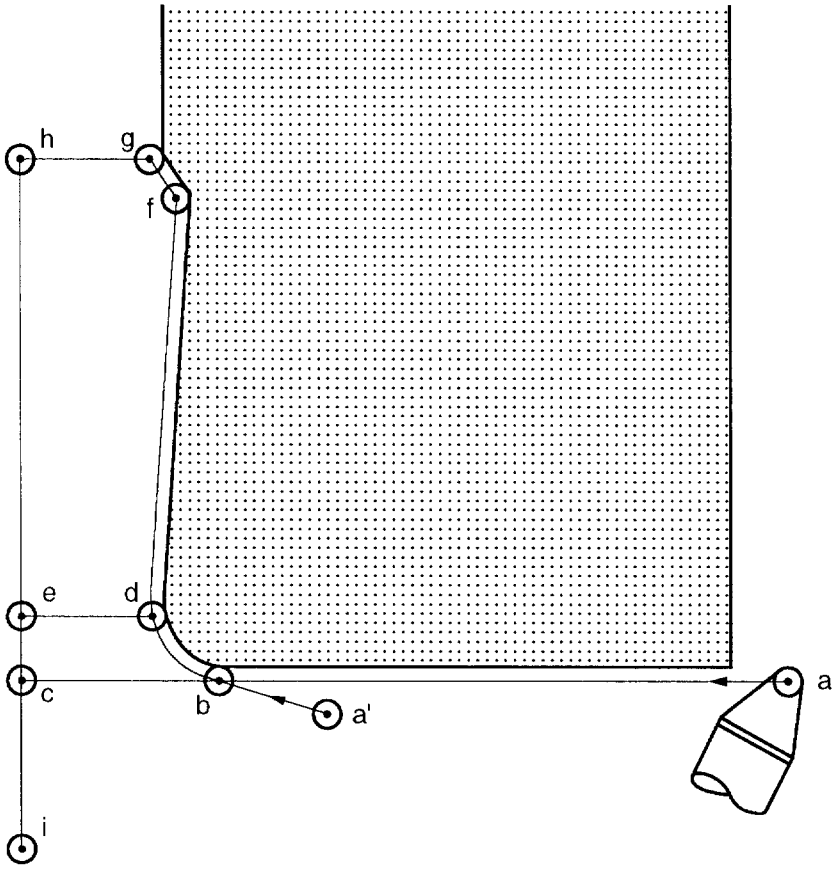
Profile breakdown

Dressing of wheel peripheral face without radius: a, b, c, i

Dressing of wheel peripheral face with radius: a, b, d, e, c, i

Dressing of wheel peripheral face, left side and radius: a, b, d, f, g, h, i

Dressing of wheel radius and left side: a', b, d, f, g, h, i

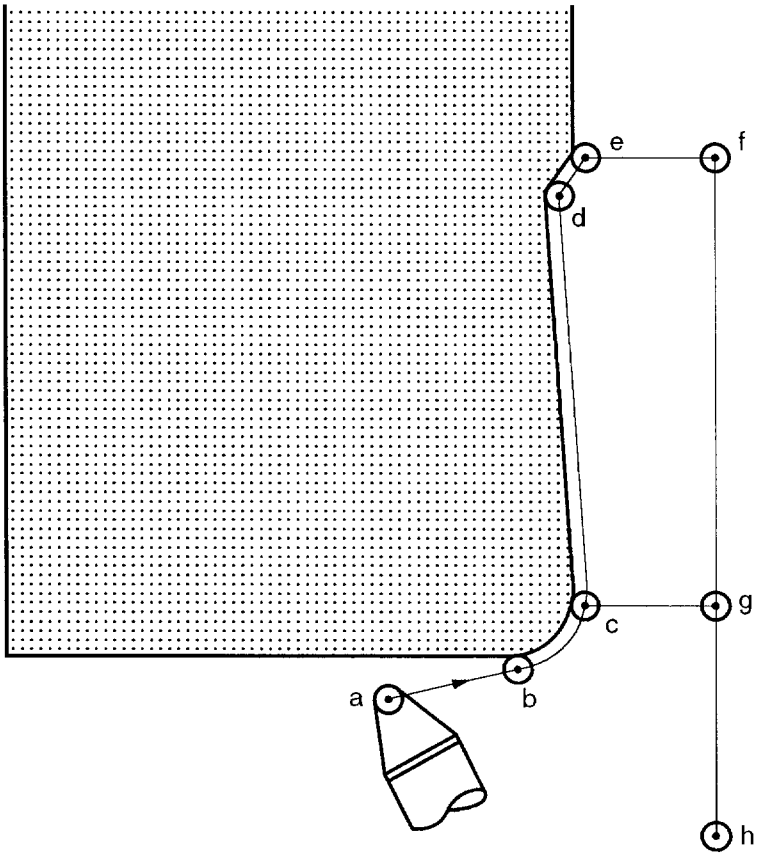


1.3.1.3 Standard Profiles Cut with Diamond 2

Profile breakdown

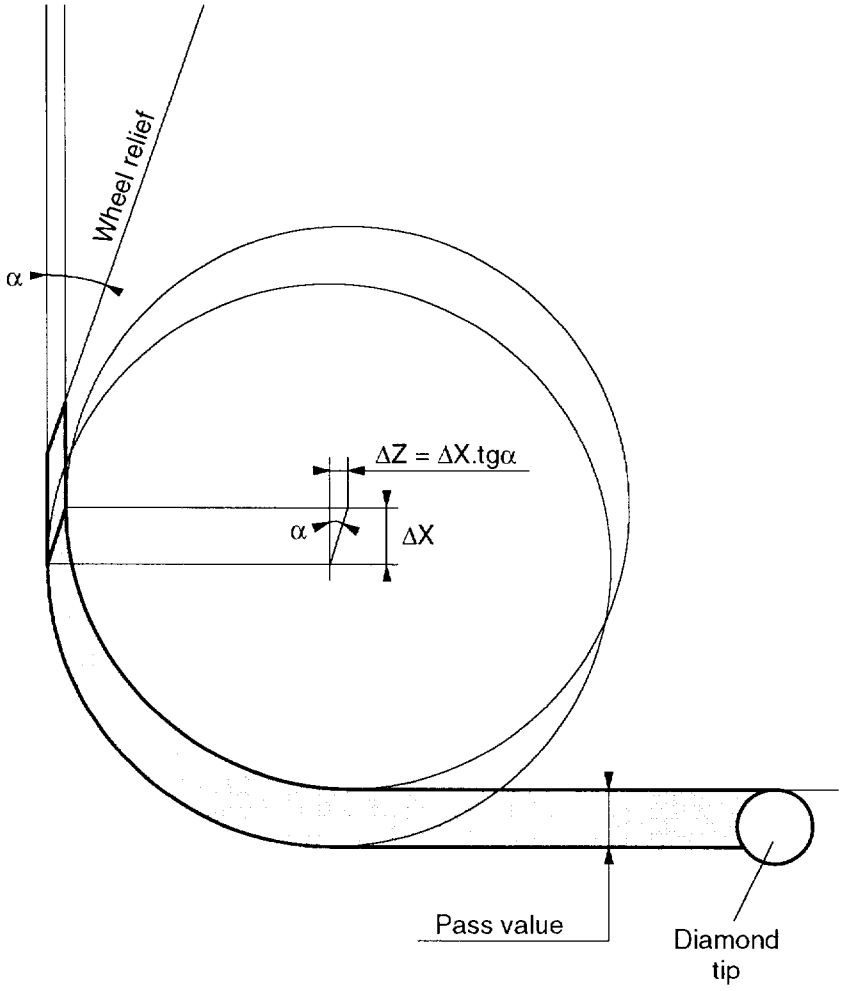
Dressing of radius: a, b, c, g, h

Dressing of wheel radius and right side: a, b, c, d, e, f, g, h

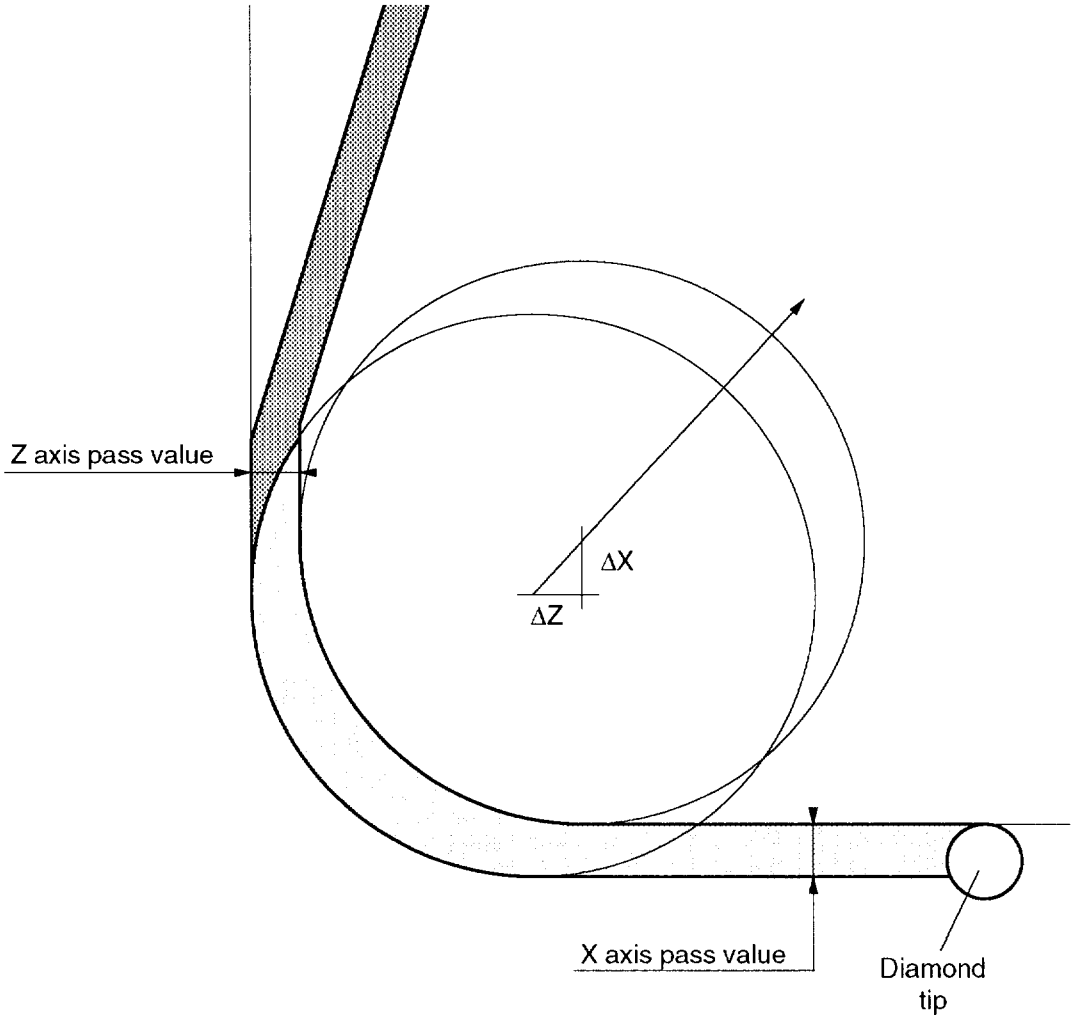


1.3.1.4 Detail of Radius Dressing

Dressing Wheel Radius and Periphery (with diamond 1)



Dressing Wheel Radius, Periphery and Wall (with diamond 1)

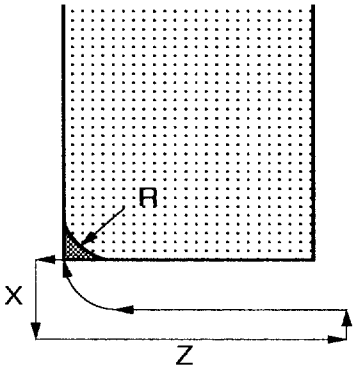


1.3.1.5 Axis Movement during Dressing

The figures below show the movements executed during the cycles.

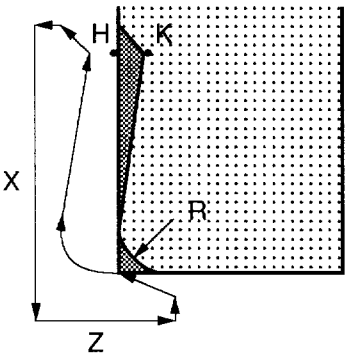
Dressing of

- peripheral face,
- left radius.



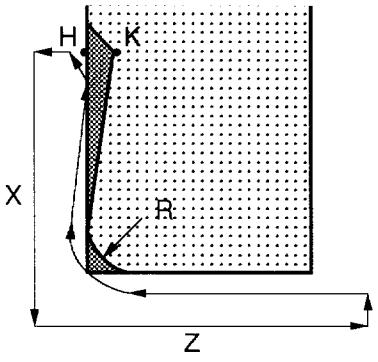
Dressing of

- wheel left side,
- left radius.



Dressing of

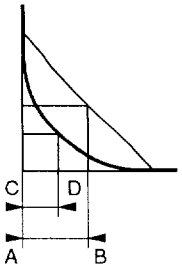
- peripheral face,
- left radius,
- wheel left side.



Detail of the radius

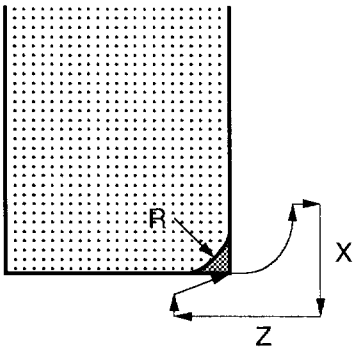
Comparison between HK and:

- A B,
- CD (with radius).



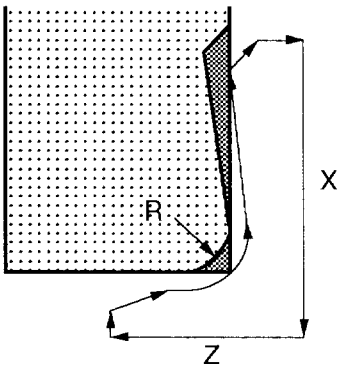
Dressing of

- right radius.



Dressing of

- right radius,
- right side.



1.3.1.6 Calculation of Shift for Dressing the Profile

Shift value

The test is performed on the value AB and:

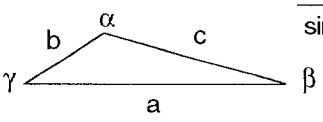
K'H' for a chamfer,

KH for a radius.

Shift calculation

- $\boxed{K'H' = R/2}$
- $KH = (R \cdot 1.41 - R) / 1.41 = \boxed{R = 0.41/1.41}$
- $AB =$

$$\frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma}$$



$$\frac{DC}{\sin \widehat{DBC}} = \frac{DB}{\sin\theta}$$

$$DB = \frac{DC}{\sin \widehat{DBC}} \cdot \sin\theta$$

$$AB = DB \cdot \sin 30\,°$$

$$\boxed{AB = \left(\frac{DB}{\sin\,(150 - \theta)} \cdot \sin\theta\right) \cdot \frac{1}{2}}$$

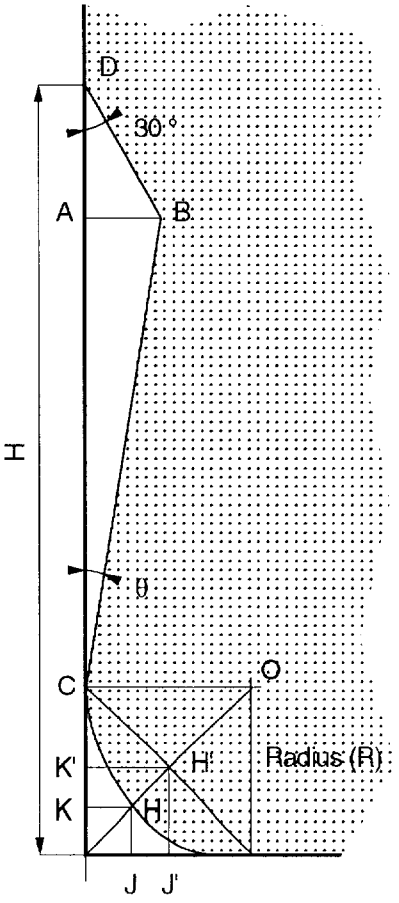
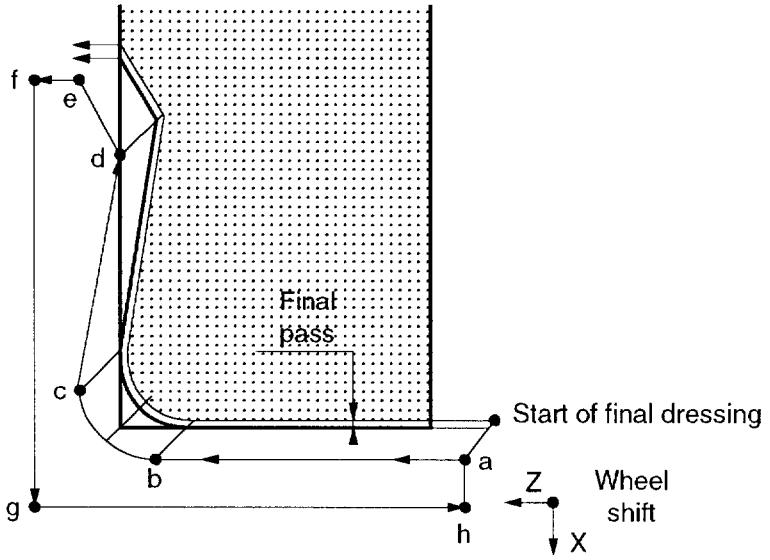


Illustration of profile

The profile is dressed following points a, b, c, d, e, f, g, h.

The subsequent passes are made by shifting the wheel on the X and Z axes.



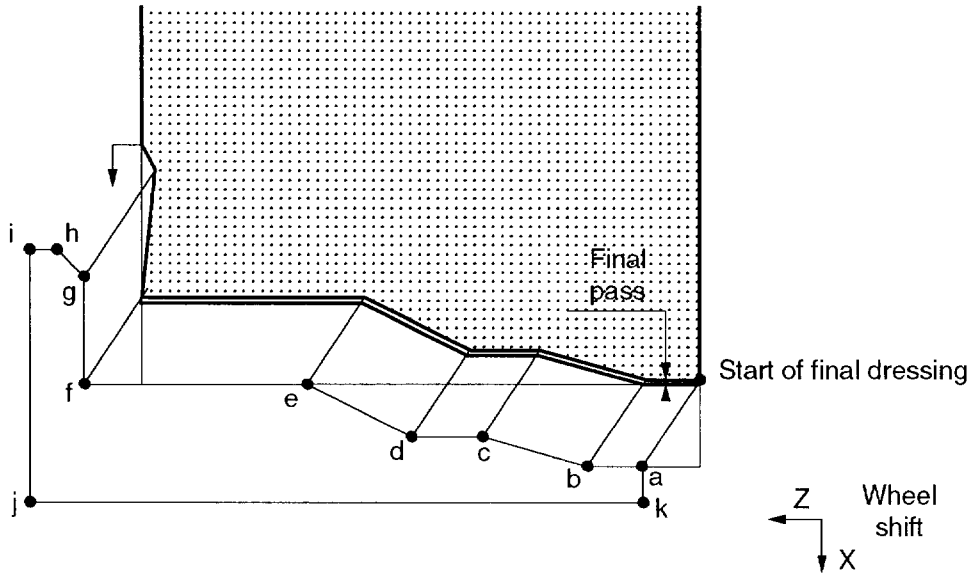
1.3.2 Special Wheel Profile

A special wheel profile can be obtained in two ways:
- By defining the special profile in a subroutine, or
- By using a roller dresser whose shape corresponds to the profile.

1.3.2.1 Example of a Special Wheel Profile Cut with a Two-Diamond Dresser

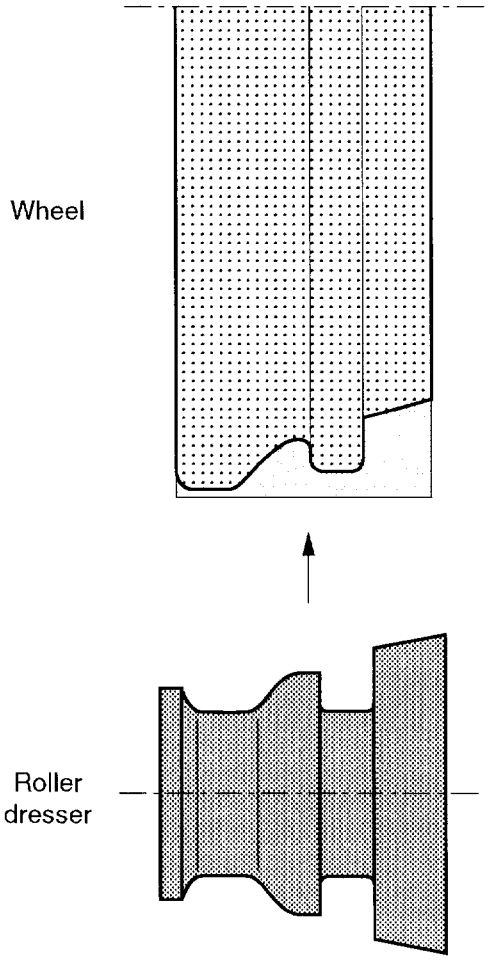
The successive passes are made by shifts on the X and Z axes.

For example:



1.3.2.2 Example of a Special Wheel Profile Cut with a Roller Dresser

The roller is moved on the U axis to cut the profile.



1.4 Cylindrical Grinding Capabilities

The following grinding capabilities are available:
- wheel dressing,
- grinding cycles,
- Part measurement during the cycle or manual intermediate measurement.

1.4.1 Wheel Dressing

Wheel dressing can be programmed before or during the grinding cycle (see the machine manufacturer's manual for further information).

Types of dressing considered:
- shaping a new wheel,
- periodic dressing during a grinding production run,
- dressing programmed in the grinding cycle,
- dressing requested by the user.

1.4.2 Grinding Cycles

Internal and external grinding cycles are initiated by programming a G2xx function (see «Grinding Functions and Cycles» chapter).

Grinding cycles considered:
- plunge or multiplunge cycle,
- angular plunge cycle with shoulder,
- plunge or multiplunge cycle with oscillations,
- cylindrical traverse cycle,
- profile grinding cycle,
- taper traverse cycle,
- shoulder plunge cycle with oscillations,
- shoulder traverse cycle,
- shoulder profile grinding.

1.4.3 Measuring the Part During the Cycle or Manual Intermediate Measurement

When measuring the part during the cycle, the part diameter is measured by a gauge and a measurement command:
- Contact outputs,
- BCD outputs.

Gap elimination is the first grinding phase. It is used to measure and adjust the difference in dimensions between parts to be ground.

During an intermediate manual measurement, the part diameter is measured by the operator.

The two measurement possibilities are as follows:
- Programmed manual intermediate measurement,
- Manual intermediate measurement requested by the user from the keyboard.

1.5 Preliminary Operations before Starting a Cycle

The following operations must be carried out before starting a cycle:
- set the measurement origin,
- select the wheel,
- set the dresser origin,
- start rotating the wheel,
- dress and/or shape the wheel,
- clamp the part and set the part origin,
- write the part grinding programme.

1.5.1 Setting the Measurement Origin

The measurement origin is set on the X and Z axes (only at power on) in accordance with the instructions defined by the machine manufacturer.

1.5.2 Selecting the Wheel

The wheel and working environment are selected by programming function M06 Tx (see «Grinding Functions and Cycles» chapter).

1.5.3 Setting the Dresser Origins

The dresser X and Y origins are set by function M140 (see «Grinding Functions and Cycles»). This is required only after changing the wheel.

1.5.4 Starting Wheel Rotation

The speed of wheel rotation is programmed by function G230 or by M03/M04 S.. M65 (see «Grinding Functions and Cycles» chapter).

1.5.5 Dressing the Wheel

The wheel is dressed by one of functions G245 (shaping) or G240 (dressing) (see «Grinding Functions and Cycles» chapter).

For wheel dressing, the choice of T1 determines the association with corrections D1, D2, D3 and D4.

For example:

D1 X.. Z.. R.. H1
- X.. X dimension (E50001)
- Z.. Z dimension (E51001)
- R.. Radius (E52001)

1.5.6 Setting the Workpiece Origin

The workpiece origin (Op) is set by function M145 (see «Grinding Functions and Cycles» chapter).

1.5.7 Writing the Grinding Programme

General programme structure

Example:

Programme number	%500
Choice of wheel and environment	M06 T..
Wheel rotation speed	G230 S..
Periodic dressing or not	M160
Manufacturer's functions	M08 (example)
Workpiece rotation direction	M03/M04 S.. M40 (M64)
Cycle call with arguments	G2xx ...
Cycle phases	...
	...
	...
	...
	...
Spindle and coolant off	M05 M09
End of programme	M02

2 Grinding Functions and Cycles

2.1 General

Except for the dedicated grinding functions described in this chapter, other programming functions used comply with the standard uise for turning applications.

CAUTION

Variables L900 to L950 are reserved for NUM. Functions M200 to M255 are prohibited in the cycle blocks (but they can be placed between blocks).

The word formats specific to function and cycle programming are defined in Appendix B.

2.2 Setting the Dresser Origins

M140 Dresser setup.

This function is used to set the dresser origin. The operator is guided through the process by the messages displayed.

Two types of dressers can be used:
- fixed two-diamond dresser,
- roller dresser.

Syntax

[T..] **M140**

T..	Selected wheel number (default T1 if not specified).
M140	Dresser setup.

Notes

The dresser data are saved in file %9910.i (i = group number).

The dressing data will be saved in the %990x.x files (the value x.x is defined according to the active wheel number T).

Dresser origin setting

Two procedures are described:
- for a two-diamond dresser,
- for a roller dresser.

The dresser origin is the "workpiece origin" referred to during the dressing phase.

Two-Diamond Dresser Setup

Procedure

Select manual data input mode (MDI).

Programme dresser origin setting function M140 then press Enter.

Start the cycle by pressing the Cycle Start key on the machine panel twice.

The following message is displayed:
"FIXED DRESSER SETUP"

After two seconds, the following message is displayed:
"X ORIGIN: MOVE WHEEL ON DIAMOND 1"

The handwheels and axis jogs become operational (function M12 active).

Bring the wheel peripheral cutting face in contact with the tip of diamond 1 (see Figure 1).

Restart the cycle by pressing the Cycle Start key on the machine panel. The wheelhead position is stored in the CNC.

The following message is displayed:
"Z ORIGIN: MOVE WHEEL ON DIAMOND 1"

Bring the left side of the wheel in contact with the tip of diamond 1 (see Figure 2).

Start the cycle again by pressing the Cycle Start key on the machine panel. The position is stored in the CNC.

The following message is displayed:
"*** END OF DRESSER SETUP ***"

If the dressing data only provide for dressing the wheel peripheral face and left side, the CNC stops the procedure.

If the dressing data provide for dressing the right side or a radius on the right side, the CNC displays the following message:
"X ORIGIN: MOVE WHEEL ON DIAMOND 2"

Repeat the procedure described above (see Figures 3 and 4) can be carried out.

The following message is displayed:
"Z ORIGIN: MOVE WHEEL ON DIAMOND 2"

Bring the right side of the wheel in contact with the tip of diamond 2.

At the end of the procedure, the diamond dresser origin is defined in the left corner of the wheel.

Fixed two-diamond dresser origin setting

The origin can be set for diamond 1 or diamond 2.

Origin setting for diamond 1

Figure 1 (on X axis)

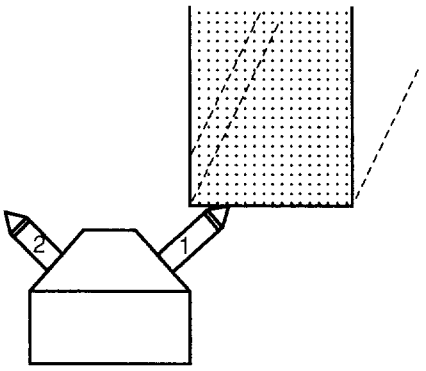
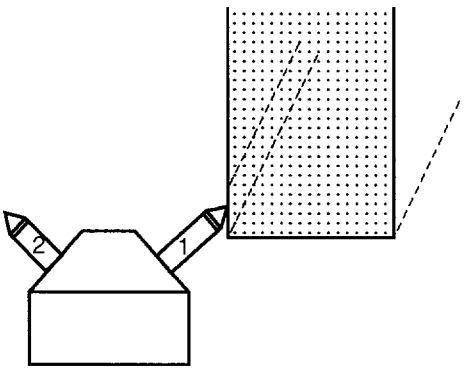


Figure 2 (on Z axis)



Origin setting for diamond 2

Values stored in machine data file:
- shift on X axis (a-b)
- shift on Z axis (c-d)

Figure 3 (on X axis)

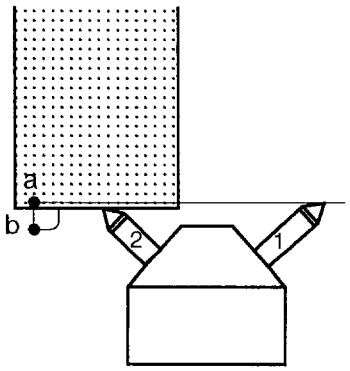
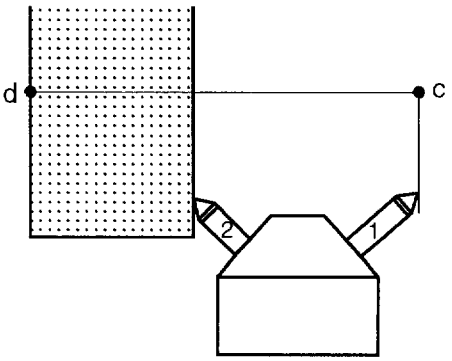


Figure 4 (on Z axis)



Roller Dresser Setup

The procedure is practically the same as for the two-diamond dresser, except that with a roller dresser, contact with the wheel is made by moving the roller dresser towards the wheel (function M12 active). The roller-wheel contact position is stored in the CNC, which sets the dresser origin to this position.

Example:

Programme the dresser setup for wheel 2.

```
T2 M140
```

Wheel 2 dresser setup. The dressing data are read from file %9900.2 and the dresser data from file %9910.x.

In this case the origins are stored in file %9910.i (i = group number).

2.3 Wheel Dressing Options

There are two possibilities for wheel dressing cycles:
- shaping,
- dressing.

Shaping the wheel

Shaping is performed when a new grinding wheel is fitted. The shaping cycle must always be programmed before a G2xx grinding cycle. This operation gives the wheel the desired profile.

Dressing the wheel

Dressing is performed to freshen the wheel surface after shaping. The dressing cycle can be programmed at the beginning or end of a grinding cycle.

There are three ways of performing dressing:
- periodic dressing for a series of workpieces,
- dressing programmed in the grinding cycle,
- manual dressing requested by the user.

2.3.1 Fixed Dresser Wheel Shaping Cycle

G245 Fixed dresser wheel shaping cycle.

The shaping cycle gives the required shape to a new wheel.

Syntax

G245 X.. EF..

G245	Fixed dresser wheel shaping cycle.
X..	X start point.
EF..	Wheel parts to be shaped defined in [WD(71)] EF0: Shaping not programmed EF1: Wheel periphery EF2: Left wall EF3: Periphery and left wall Ef4: Right wall EF5: Periphery and right wall EF6: Left wall and right wall EF7: Periphery and left and right walls.

CAUTION

The call to the G245 ... shaping cycle must be programmed before the call to function Tx M06 (see Sec. 2.4, "Selecting the Wheel and Setting Up the Working Environment").

2.3.2 Fixed or Roller Dresser Wheel Dressing Cycle

G240 Fixed or roller dresser wheel dressing cycle.

Dressing is performed to freshen the wheel after shaping. It can be carried out before, during or after a G2xx cycle.

General Syntax

G240 X.. EZ../EX.. ED..

G240	Fixed or roller dresser wheel dressing cycle.
X	Backoff on X.
EZ..	Return on Z.
EX..	Return on X.
ED..	Wheel surface to be dressed.

Programming Possibilities

`G240 ED..`	- dress
`G240 X.. ED..`	- move to X.. - dress
`G240 X.. EZ.. ED..`	- move to X.. - dress - return to work position: X = saved position + safety clearance Z = EZ..
`G240 X.. X.. ED..`	- back off on Z - move to X.. position - dressing - return to work position: Z = backoff X = EX..
`G240 X.. EX.. ED..`	- back off X Z - move to X.. position - dress - return to work position: Z = backoff X = backoff

2.3.2.1 Programmed Periodic Dressing

Dressing can be programmed to be carried out every x workpieces during production grinding runs.

Description

The periodic dressing operations are defined by function M160 at the beginning of the grinding cycle (see Sec. 2.7).

At the start of each cycle, function M160 increments a counter and compares its value with the value defined in the wheel data file under the heading "Number of workpieces between dressings".

When the two values are equal, the wheel dressing cycle is initiated. Dressing is based on the data from the wheel file, cutting speed, increment, etc.

2.3.2.2 Dressing Programmed in a Cycle

Each grinding phase programmed in a cycle can be interrupted by a programmed dressing phase.

Description

Dressing is defined by argument ED (choice of wheel dressing, peripheral face and/or side) programmed in a block of the cycle.

When argument ED is read in the block, the current cycle phase is stopped and the wheel is retracted. The dressing programme is executed.

2.3.2.3 Dressing Requested by the User

Certain programmed grinding phases can be interrupted for dressing requested by the user. However, the following phases cannot be interrupted for dressing:
- gap elimination (EG1),
- measurement during grinding cycle (G2xx),
- traverse cycle with discontinuous increment in Z and EZ (EC1).

Description

During the grinding phase, the user can request dressing, even if not already programmed. Dressing is initiated by pressing a button on the operator panel. The pushbutton change of state is sent to the PLC programme and loaded into parameter E20030. The current phase is stopped and the wheel is retracted. Dressing can then be performed.

2.4 Selecting the Wheel and Setting up the Working Environment

M06 Selecting the wheel and setting up the working environment.

This function is used to select the grinding wheel and set up the working environment.

Syntax

M06 T.. [ET..] [ER..] [EX..] [EZ..]

M06	Selecting the wheel and setting up the working environment.
T..	Wheel number selected (T1 to T8, default T1 if not specified).
ET..	Wheel file number (1 to 99).
ER1	Wheel retraction to rest position (if not specified, no return to rest position).
EX..	Shift on X axis (see Notes).
EZ..	Shift on Z axis (see Notes).

Notes

Function M06 calls subroutine %9910.0

If argument ET is present and is assigned a number from 1 to 99, it has priority and the wheel number assigned to T is ignored. (ETxx corresponds to subroutine %990x.x).

Shifts EX and EZ

When function M06 is called, two additional shifts can be taken into account if programmed. In this case their values are added to the existing DAT1s. Shifts EX and EZ allow the introduction of safety clearances for dummy grinding tests (no material) after dressing, without having to change the settings made when the workpiece origins were defined.
These shifts are corrections assigned to the third corrector of each wheel (see wheel corrections).
The X axis shift (EX) must be greater than -0.5 mm, and the Z axis shift (EZ) must be between -1 mm and +1 mm.

Wheel correctors

Each wheel uses four tool correctors from the corrector table.
For example:
- wheel 1: correctors D1 to D4
- wheel 2: correctors D5 to D8
  and so on, up to wheel 8 (D29 to D32).

Use of correctors for wheel 1:
- D1 defines the wheel left wall wear,
- D2 defines the wheel right wall wear,
- D3 contains shifts EX and EZ defined in the block with M06,
- D4 is reserved.

Files associated with the wheel

Three files are used by the selected wheel during the dressing operations:
- the machine data file,
- the wheel data file,
- the machine limits file.

The machine data file contains the dressing and wheel data:
- datum shifts (DAT1) for the dresser and the workpiece,
- the type of dressing performed,
- the dresser geometry,
- the wheel descriptions.

The block numbers concerning the eight possible wheels described are as follows (accessed by the wheel number programmed in block M06 Tx:
- wheel 1: blocks N100 to N113,
- wheel 2: blocks N200 to N213,
- wheel 3: blocks N300 to N313,
  and so on, up to wheel 8 (N800 to N813).

The wheel data file contains the general data required for wheel shaping and dressing.
The number of the file used is defined function M06 arguments T and ET.

The number of the file called can be defined by:
- the wheel number assigned to argument T (T1 to T8), or
- the number assigned to argument ET (if specified).

The symbolic variables used in this file are defined by [WD(xx)].

The machine limit files contain the maximum and minimum values of the wheel data (the limit data are defined by the machine manufacturer).

There are eight wheel files %992x, where x is the wheel number (%9921 to %9928).

It should be noted that the content of these files varies with the type of tool selected (wheel or roller dresser):

- straight wheel,
- angular wheel with inclined axis,
- special wheel,
- roller dresser.

2.5 Defining the Wheel Rotation Speed from the Surface Speed

G230 Wheel speed calculation.

This function calculates the wheel rotation speed from the wheel diameter.

The wheel speed can be programmed in three ways according to its location:
- before the cycle call,
- in the cycle call block (G2xx),
- in a subroutine.

Syntax

Syntax (before the cycle call)

G230 S..

G230	Calculation of the wheel rotation speed.
S..	Mandatory argument defining the cutting speed (m/s).

Syntax (in the cycle calling block G2xx)

G2xx .., S.. ...

G2xx	Grinding cycle
S..	Mandatory argument defining the cutting speed (m/s)

Syntax (in a subroutine)

S.. G77 H10230

S..	Mandatory argument defining the cutting speed (m/s).
G77	Subroutine call function.
H10230	Number of subroutine called (%10230).

Notes

It is mandatory to programme G230 S.. after programming T.. M06 at the beginning of a programme. The other two speed programming possibilities are optional. They are used to change the speed defined by G230 S..

Examples

Wheel speed calculation before cycle call

```
N.. ...
N.. T.. M06 ...                    Wheel speed calculation
N.. G230 S...
N.. ...
N.. ...
N.. G2xx ...                       Cycle
N.. ...
```

Wheel speed calculation in the G2xx cycle call block

```
N.. ...
N.. G2xx ... S.. ...               Cycle call
N.. ...
N.. ...
```

Speed calculation in a subroutine

```
N.. ...
N.. G2xx ... S.. ...               Cycle call
N.. ...
N.. S.. G77 H10230
N.. ...
```

2.6 Part Setup

M145 Part origin setting.

This function is used to set the part origin. The user is guided through the process by the messages displayed.

Syntax

[T..] **M145**

T..	Selected wheel number (default T1 if not specified)
M145	Part setup

Notes

Part setup procedure

Select manual data input mode (MDI).

Programme part setup function "M145".

Start the cycle by pressing the Cycle Start key on the machine panel.

The following message is displayed:
"*** PART SETUP ---------- OK"

The following message is displayed after 2 seconds:
"MOVE WHEEL ON THE REFERENCE DIAMETER"

The handwheels and axis jogs become operational (Function M12 active).

Bring the wheel in contact with the reference diameter.

Restart the cycle by pressing the Cycle Start key on the machine panel.

The following message is displayed:
"MEASURE THE PART AND START CYCLE"

The wheel is retracted from the workpiece to allow the reference diameter to be measured.

The following message is displayed:
"INPUT DIAMETER MEASURE"

Enter the measured diameter on the keyboard then press the CNC Enter key.

Start the cycle again by pressing the Cycle Start key on the machine panel.

The following message is displayed
"MOVE WHEEL ON THE REFERENCE SHOULDER"

The handwheels and axis jogs become operational (Function M12 active).

Bring the wheel left side in contact with the reference face of the standard workpiece.

The wheel is retracted from the workpiece to allow the standard face measurement to be read.

The following message is displayed:
"REFERENCE SHOULDER POSITION"

Enter the measured value on the keyboard then confirm by pressing the CNC Enter key.

Start the cycle again by pressing the Cycle Start key on the machine panel.

The following message is displayed:
"END OF PART SETUP"

Example:

Programme wheel 2 origin setting:

```
T02 M145
```

In this case the origins are stored in file %9910.i (i = group number).

Schematic illustration of workpiece origin setting

Workpiece origin on X axis

Wheel in contact with workpiece reference diameter.

Figure 1 (X axis straight)

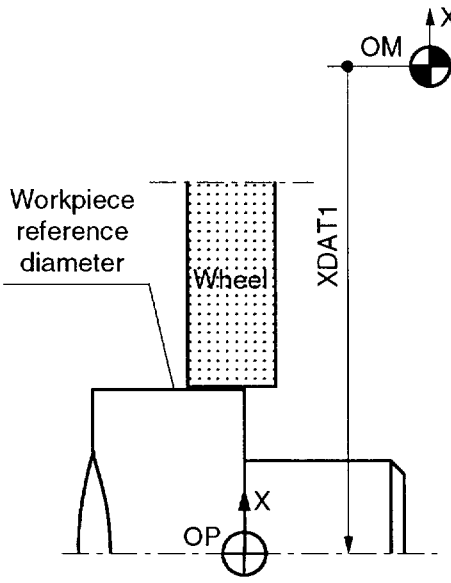
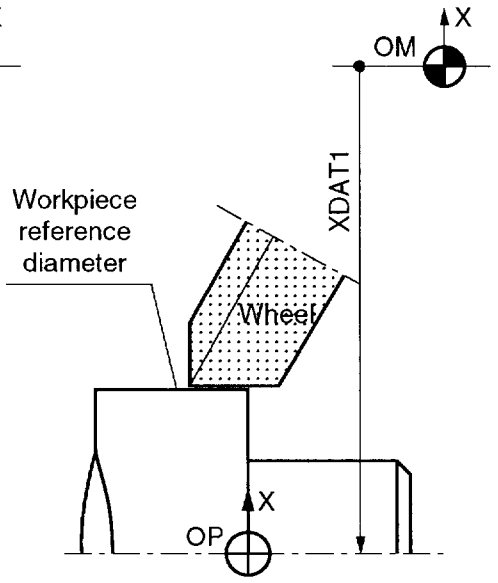


Figure 2 (X axis tilted)



Workpiece origin on Z axis

Wheel in contact with workpiece reference side.

Figure 3 (X axis straight)

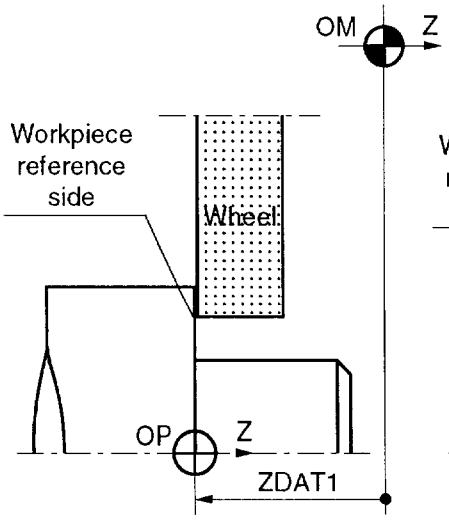
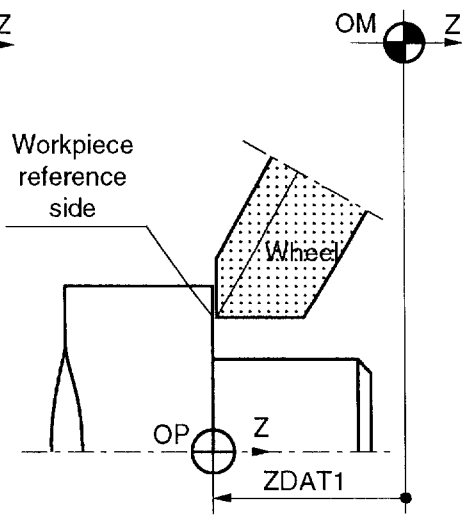


Figure 4 (X axis tilted)



2.7 Periodic Dressing Test Counter

M160 Periodic dressing test counter.

This function programmes wheel dressing every x workpieces in a production run.

Syntax

M160

M160 Periodic dressing test counter.

Notes

Function M160 tests the wheel data indicating the number of workpieces between two dressing operations. If the value is not zero, the corresponding counter (E560xx) is incremented and compared with the programmed value. When the counter value exceeds the programmed value, dressing is performed.

2.8 Passive Positioning (Axial Correction) Cycle

G231 Passive positioning (axial correction) cycle.

This cycle modifies the origin on the Z axis by adding a workpiece axial offset correction if the machine is equipped with the appropriate gauging system. The system takes into account the differences in position of each workpiece mounted on the workholder.

Syntax

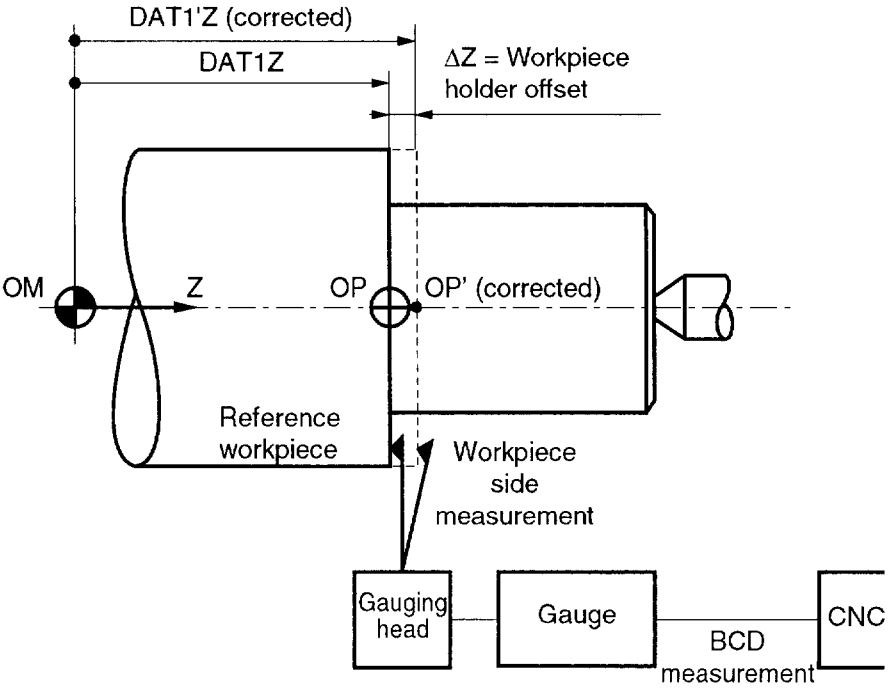
G231 ES.. EP..

G231	Passive positioning (axial correction) cycle.
ES..	Argument defining the speed of rotation in revolutions per minute (less than 100 rpm)
EP..	Direction of the gauging head. - EP0: gauging head on the left, - EP1: gauging head on the right (default).

Notes

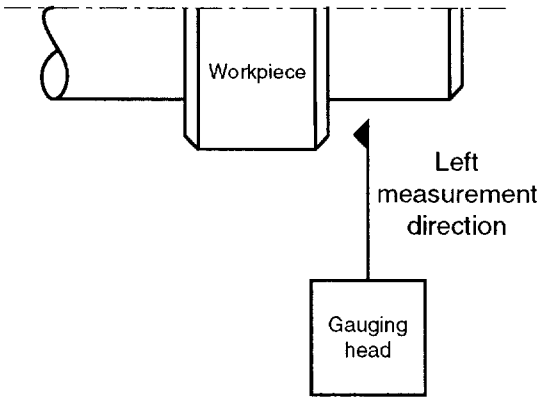
Function G231 must be programmed before calling the block containing the functions Tx M06 (wheel selection and working environment setup).

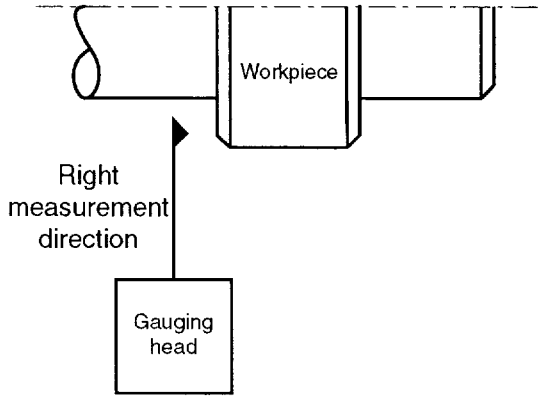
Schematic diagram of workpiece position check



Direction of measurement

The gauging head can be set to measure from the left or the right (see machine manufacturer's manual).





2.9 Intermediate Measurement

2.9.1 Manual Intermediate Measurement Programmed in a Cycle

Most programmed grinding phases (except gap elimination "EG1", part measurement "EG2/EG9" and discontinuous X-Z traverse cycle "EC1") can end with a manual measurement request.

CAUTION

When arguments EG1 to EG9 are programmed in a G2xx grinding cycle, functions M200 to M255 must not be used in this cycle. However, these functions can be programmed before or after the cycle.

Description

At the end of a programmed grinding phase containing EG99, the wheel retracts from the part and the cycle stops. The user can make the measurement then, according as EM0, EM1 or EM2 is programmed, new values of DAT1 are loaded (offset limited to +/- 0.05). Once the new DAT1 values have been loaded, the programmed is resumed.

It should be noted that with:
- EM1: the corrections are added to the existing DAT1 values,
- EM2: the corrections are added to the existing DAT1 values and stored in the machine data file.

2.9.2 Intermediate Measurement Requested by the User

Each programmed grinding phase containing EG98 can be interrupted by a measurement requested by the user.

Description

During the grinding phase, the user requests measurement by pressing a pushbutton on the machine panel.

When the PLC programme receives this input, it sets parameter E20031 to 1. The current cycle is then stopped and the wheel is retracted. The user can then make the measurement and also enter new DAT1 values if necessary.

The wheel retraction position is defined on X by argument EH (retraction diameter for dressing and manual measurement).

2.9.3 Intermediate Measurement Cycle

G232 Intermediate measurement cycle

The intermediate measurement cycle is used to check the part during G2xx grinding cycles.

General Syntax

G232 X . EZ . / EX . EM..

G232	Intermediate measurement cycle.
X..	Backoff on X.
EZ..	Return on Z.
EX..	Return on X.
EM..	Measurement.

Programming

G232 EM..	- Measure
G232 X.. EM..	- Move to X.. - Measure
G232 X.. EZ.. EM..	- Move to X.. - Measure - Return to work position: X = saved position + safety clearance Z = EZ..
G232 X.. EX.. EM..	- Back off on Z - Move to X.. - Measure - Return to work position: Z = backoff X = EX..
G232 X.. EX.. EM..	- Back off on X Z - Move to X.. - Measure -Return to work position: Z = backoff X = backoff

2.10 External Grinding Cycles

Grinding of the workpiece is achieved by initiating the appropriate grinding cycle. The cycle chosen is programmed by a G2xx function.

The external grinding cycles have the following numbers:
- G200, G202, G204, G206, G208, G210, G212, G214, G216.

External grinding cycles:
- G200: External plunge / multiplunge cycle,
- G202: Plunge cycle with inclined axis,
- G204: External oscillating plunge / multiplunge cycle,
- G206: External cylindrical traverse cycle,
- G208: External profile grinding cycle,
- G210: External conical traverse cycle,
- G212: External oscillating shoulder cycle,
- G214: External shoulder traverse cycle,
- G216: External interpolated shoulder cycle.

REMARK *The external and internal grinding cycles are identical as regards the programming of their arguments. They differ only by their call numbers.*

2.10.1 General

Cycles are programmed in two parts:
- the first part includes the G2xx function followed by the cycle call arguments,
- the second part includes the in-cycle arguments.

Cycle call arguments

These programming arguments define the engineering data relating to the final production of the workpiece.

They must always be included in the block containing the G2xx cycle call.

In-cycle arguments

These programming arguments define the characteristics associated with each grinding phase: rough grinding, finishing, sparkout, etc.

They must be programmed in the successive blocks defined after the cycle call block.

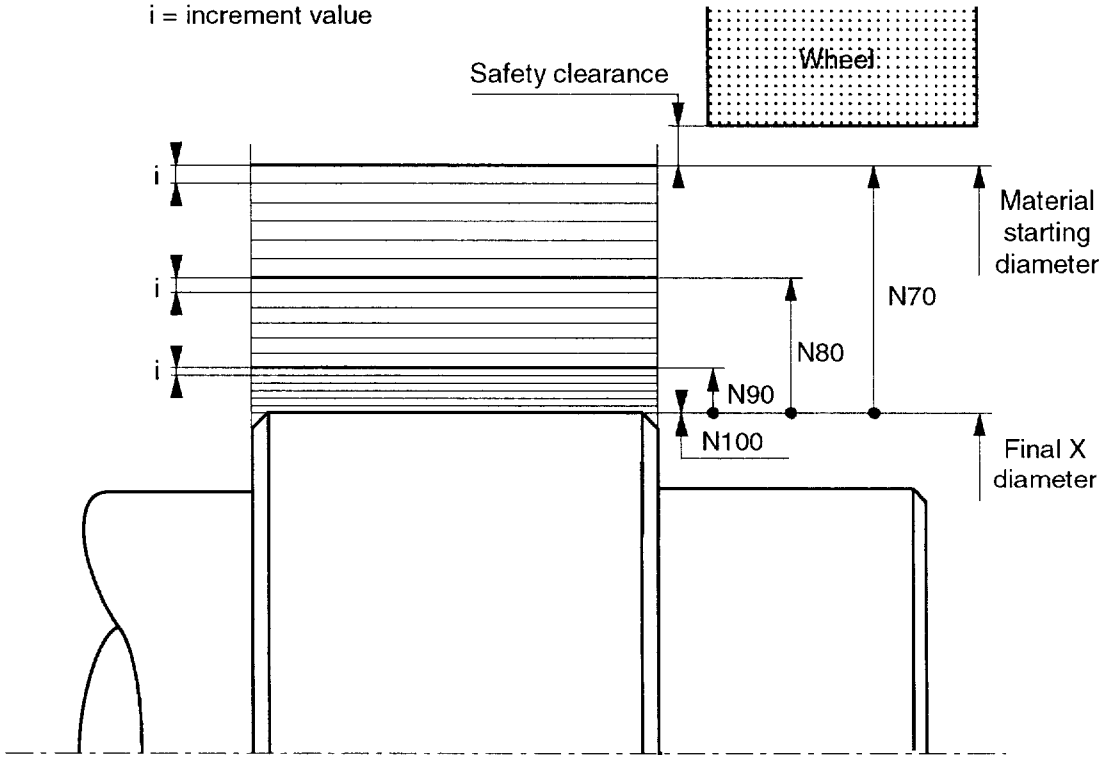
CAUTION

A G2xx cycle must always end with argument EB2 (end of cycle). Otherwise, certain modal arguments are applied during the following cycles.

Example of a cycle

```
%206
N10 T01 M06                 Selection of wheel
N20 G230 S...               Wheel speed calculation
N30 M160                    Periodic dressing
N40 M04 M40 S..             Workpiece rotation direction
N50 M08                     Coolant on
N60 G206 ...                External cylindrical traverse cycle and
                            cycle call arguments
N70 ...                     Roughing phase
N80 ...                     Semi-finishing phase
N90 ...                     Finishing phase
N100 ...                    Sparkout and end of cycle
N110 M05 M09                Spindle and coolant off
N120 M02                    End of programme
```

Schematic representation of the phases of a cylindrical traverse cycle

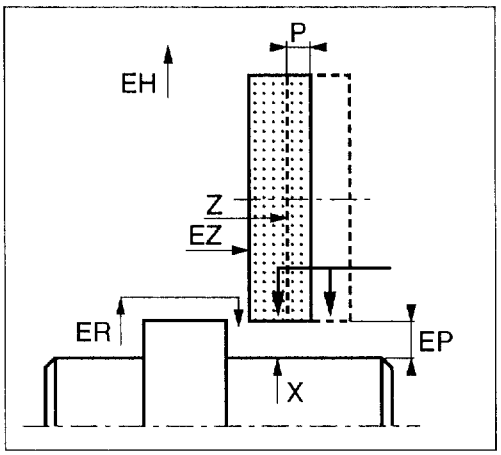


2.10.2 G200 - External plunge / multiplunge cycle

G200 External plunge / multiplunge cycle.

For single plunge, the cycle includes:
- positioning on Z followed by plunge on X.

For multiplunge, the cycle includes:
- initial positioning on Z followed by a first plunge on X and retraction on X
- a second positioning on Z (wheel width - overlap) followed by a plunge, etc. (until reaching the end point).



Syntax

G200 X.. Z.. D. [EZ..] EP.. [ER..] [EH..] [P..] [S..]
[X..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

Cycle call arguments

G200	External plunge / multiplunge cycle.
X..	Final diameter.
Z..	Plunge: plunge position on Z axis. Multiplunge: starting point on Z axis.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EZ..	Multiplunge: end point on Z.
EP..	Safety clearance on X axis (+ material allowance).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measuring.
P..	Multiplunge: wheel overlap value.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

X..	Allowance on final diameter.
F..	Feed rate on X (mm/min).
EG..	Measurement selection (default: no measurement). - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET..	Sparkout time (s).
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of X, EP, X, EK, EZ and ET must be greater than 0.

Multiplunge arguments:
- the value of P must be less than or equal to the wheel width. If P is not programmed its value is forced to 0,
- with D1 or D2 the wheel position does not change. It is the programme origin that is modified,
- movement only takes place when arguments Z and EZ are programmed,
- the difference between Z and EZ must be greater than the wheel width.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X + EP.

If only ER is programmed (without EH), in all cases: EH = ER.

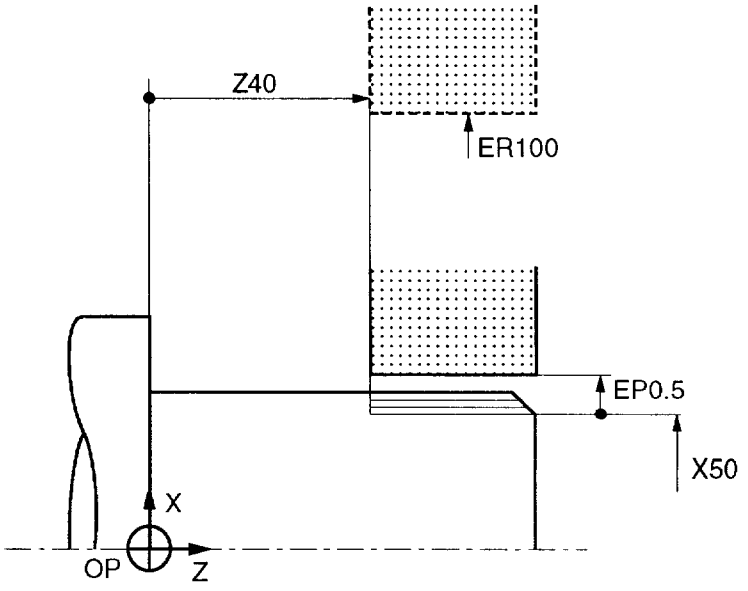
See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

Example

Plunge cycle (external)

```
...
G200 X50 Z40 D1 EP0.5 ER100        Cycle
X0.2 F2                            Phase
X0.1 F1                            Phase
X0 EK1 ET5 EB2 F0.5                Sparkout and end of cycle
...
```

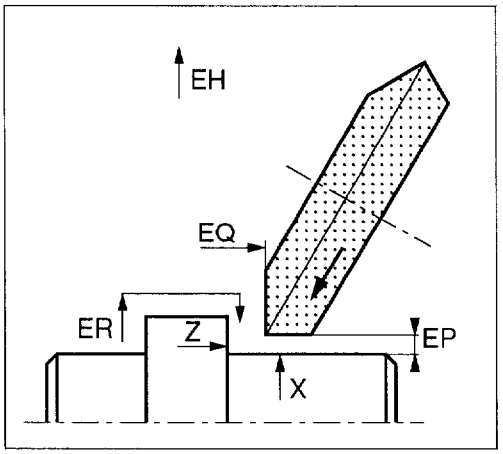
Schematic illustration of cycle



2.10.3 G202 - External plunge cycle with inclined axis

G202 External plunge cycle with inclined axis.

This cycle includes:
- positioning followed by plunge to simultaneously grind the part wall and shoulder.



Syntax

G202 X.. Z.. D.. EP.. EQ.. [ER..] [EH..] [S..] [X..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

Cycle call arguments

G202	Plunge cycle with inclined axis (external).
X..	Final diameter.
Z..	End point on Z axis.
D..	Selection of active wheel side. - D1: left side.
EP..	Safety clearance on X axis(+ material allowance).
EQ..	Safety clearance on Z axis (+ material allowance).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measuring.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

X..	Allowance on final diameter.
F..	Plunge feed rate (mm/min).
EG..	Measurement selection. - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET..	Sparkout time (s).
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of X, EP and EQ must be greater than 0.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH.

In this case:
- in a cycle on X axis: ER and EH = X + EP,
- in a cycle on Z axis: ER and EH = X.

If only ER is programmed (without EH), in all cases: EH = ER

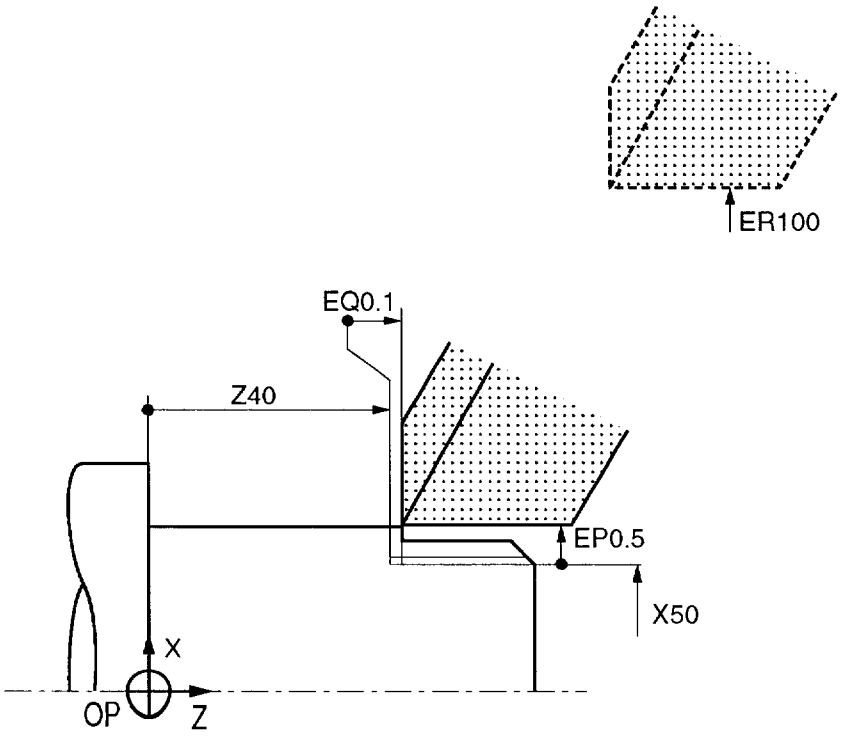
See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

Example

Plunge cycle with inclined axis (external)

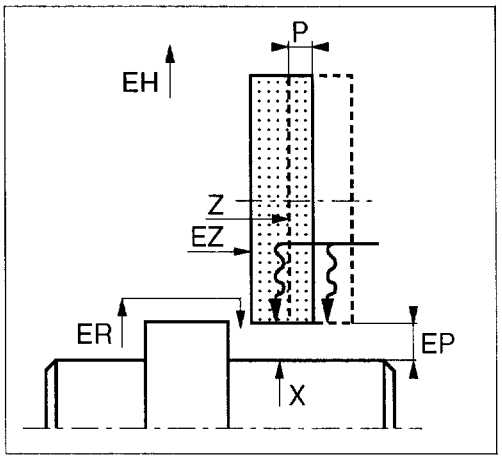
```
...
G202 X50 Z40 D1 EP1 EQ0.1 ER100        Cycle
X0.2 F2                                Phase
X0.1 F1                                Phase
X0 EK1 ET5 EB2 F0.5                    Sparkout and end of cycle
...
```

Schematic illustration of cycle



2.10.4 G204 - External oscillating plunge / multiplunge cycle

G204 External oscillating plunge / multiplunge cycle



For single plunge, the cycle includes:
- positioning on Z followed by plunge on X with oscillation.

For multiplunge, the cycle includes:
- initial positioning on Z followed by a first plunge on X with oscillation and retraction on X
- a second positioning on Z (wheel width - overlap) followed by plunge on X, etc. (until reaching the end point on z).

Syntax

G204 X.. Z.. D.. [EZ..] EP.. [ER..] [EH..] [P..] [S..]
[X..] [F..] [EZ..] [EO..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

Cycle call arguments

G204	External oscillating plunge / multiplunge cycle.
X..	Final diameter.
Z..	Plunge cycle: plunge position on Z axis.
	Multiplunge cycle: starting point on Z axis.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EZ..	Multiplunge: end point on Z
EP..	Safety clearance on X axis (+ material allowance).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measurement.
P..	Multiplunge: wheel overlap value.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

X..	Allowance on final diameter.
F..	Feed rate on X (mm/min).
EZ..	Oscillation amplitude.
EO..	Oscillation frequency (osc/min).
EG..	Measurement selection. - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET..	Sparkout time (s)
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of X, EP, ET, EK, EO and EZ must be greater than 0.

Multiplunge arguments

- the value of P must be less than or equal to the wheel width. If P is not programmed its value is forced to 0,
- with D1 or D2 the wheel position does not change. It is the programme origin that is modified,
- movement only takes place when arguments Z and EZ are programmed,
- the difference between Z and EZ must be greater than the wheel width.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X + EP.

If only ER is programmed (without EH), in all cases: EH = ER.

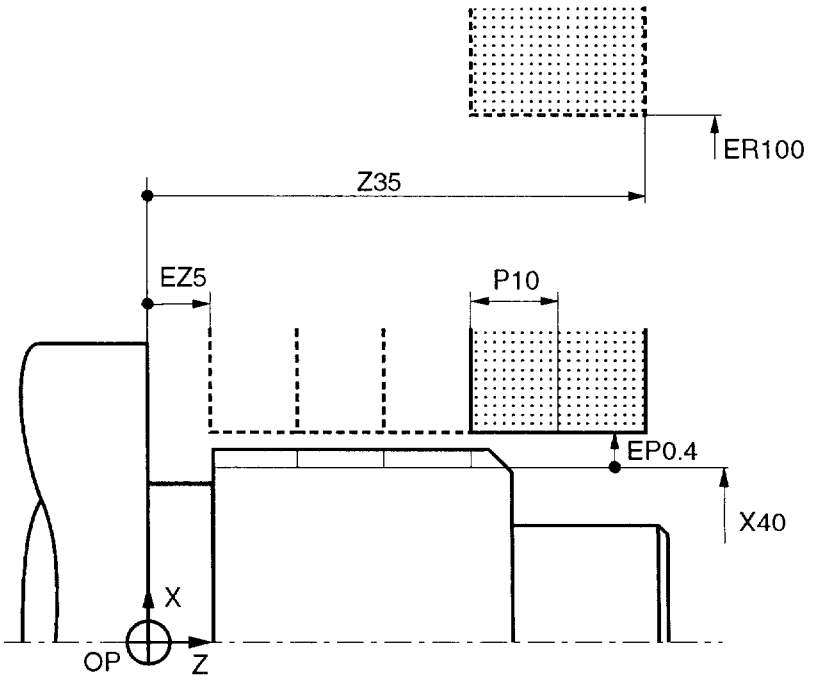
See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

Example

Multiplunge cycle with oscillations (external)

```
...
G204 X40 Z35 EZ5 D1 P10 EP0.4 ER100      Cycle
X0.2 EZ1 E010 F0.2                       Phase
X0 ET2 EK1 EB2 F0.1                      Sparkout and end of cycle
...
```

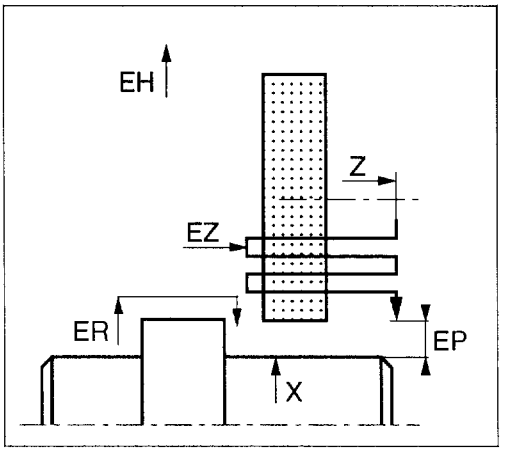
Schematic illustration of cycle



2.10.5 G206 - External cylindrical traverse cycle

G206 External cylindrical traverse cycle

This cycle includes:
- initial positioning on Z followed by a first increment on X and traverse up to the end position on Z
- a second increment on X followed by return traverse, etc.



Syntax

G206 X.. Z.. D.. EZ.. EP.. F.. [ER..] [EH..] [EA..] [P..] [EE..] [EF..] [EC..] [S..] [X..] [EI..] [EJ..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..] / [EN..] EB..

Cycle call arguments

G206	External cylindrical traverse cycle.
X..	Final diameter.
Z..	Starting point on Z.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EZ..	End position on Z.
EP..	Safety clearance on X axis (+ material allowance).
F..	Traverse feed rate (mm/min).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measurement.
EA..	Overtravel on Z and EZ during traverse (by P.. if P is programmed, otherwise by the wheel width). - EA0: wheel within traverse distance, no overtravel, - EA1: Overtravel by one wheel width or P to left, - EA2: Overtravel by one wheel width or P to right, - EA3: Overtravel by one wheel width or P to right and left.
P..	Overtravel (associated with EA).

EE.	Dwell time at start of traverse (s).
EF..	Dwell time at end of traverse (s).
EC..	Type of increment: - EC0: continuous increment, - EC1: discontinuous increment in Z and/or EZ.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

X..	Allowance on final diameter.
EI..	Increment at start of traverse.
EJ..	Increment at end of traverse.
F..	Feed rate increment (mm/min)
EG..	Measurement selection. - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement (with continuous increment), - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET.. / EN..	- ET: Sparkout time (s). - EN: Number of sparkout passes.
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of X, EK, EI and EJ must be greater than 0.

If P is not programmed, it is the wheel width that is taken into account.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X + EP.

If only ER is programmed (without EH), in all cases: EH = ER.

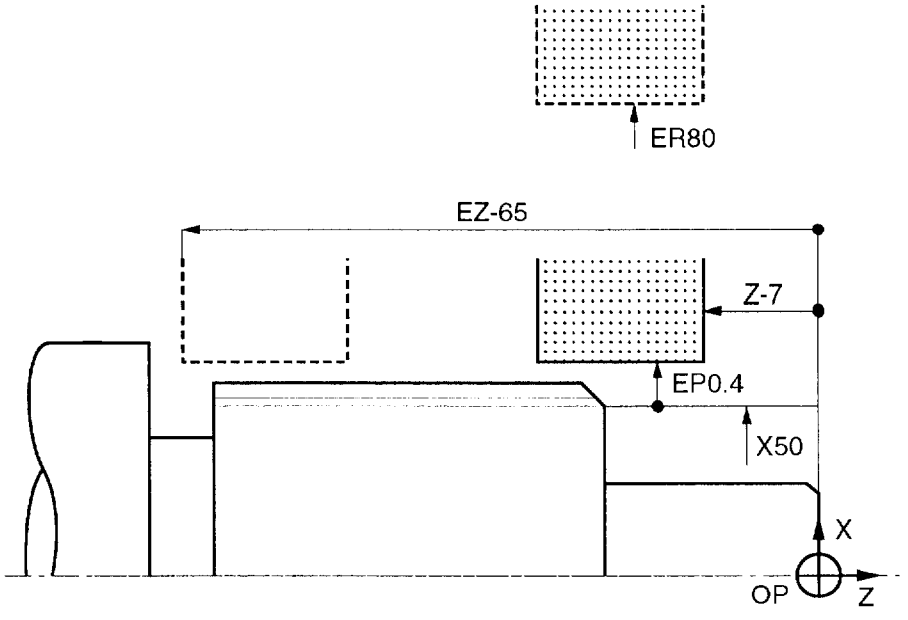
See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

Example

Cylindrical traverse cycle (external)

```
...
G206 X50 Z-7 EZ-65 ER80 EP0.4 F200 EE1 EF1 EA2 EC1 D2   Cycle
X0.2 EI0.04 EJ0.04 F3                                   Phase
X0 EI0.02 EJ0.02 EN6 EK1 EB2 F2                         Sparkout and end of cycle
...
```

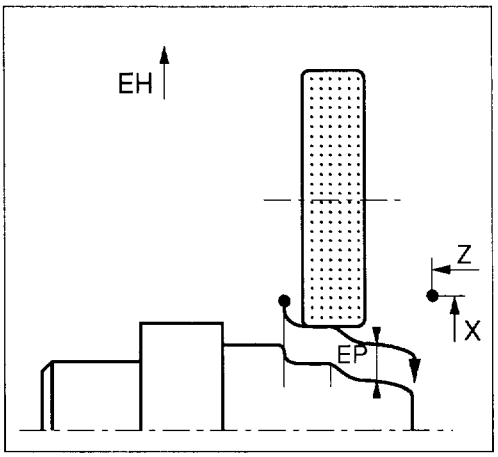
Schematic illustration of cycle



2.10.6 G208 - External profile grinding cycle

G208 External profile grinding cycle.

This cycle includes:
- Initial positioning on X and Z followed by grinding of the profile defined in a subroutine.



Syntax

G208 X.. Z.. D.. EP.. ES.. H.. N.. N.. F.. [EH..] [S..] [I..] [EI..] [EN..] [EK..] [ED..] EB..

Cycle call arguments

G208	External profile grinding cycle.
X..	Start diameter (X).
Z..	Starting point on Z axis.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EP..	Safety clearance on X of the profile (+ material allowance).
ES..	Wheel radius correction: - ES1: left radius offset (G41), - ES2: right radius offset (G42).
H..	Number of profile definition subroutine.
N.. N..	Profile start and end blocks.
F..	Feed rate along profile (mm/min).
EH..	Backoff diameter for dressing and measuring.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

I..	Allowance on final diameter.
EI..	Depth of pass.
EN..	Number of sparkout passes.
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
EB..	Cycle sequencing selection. . EB0: sequencing without stopping, . EB1: sequencing with stop, . EB2: end of cycle.

Notes

Notes on argument programming

The value of X must be greater than 0.

The starting point on X and Z must be outside the profile.

See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

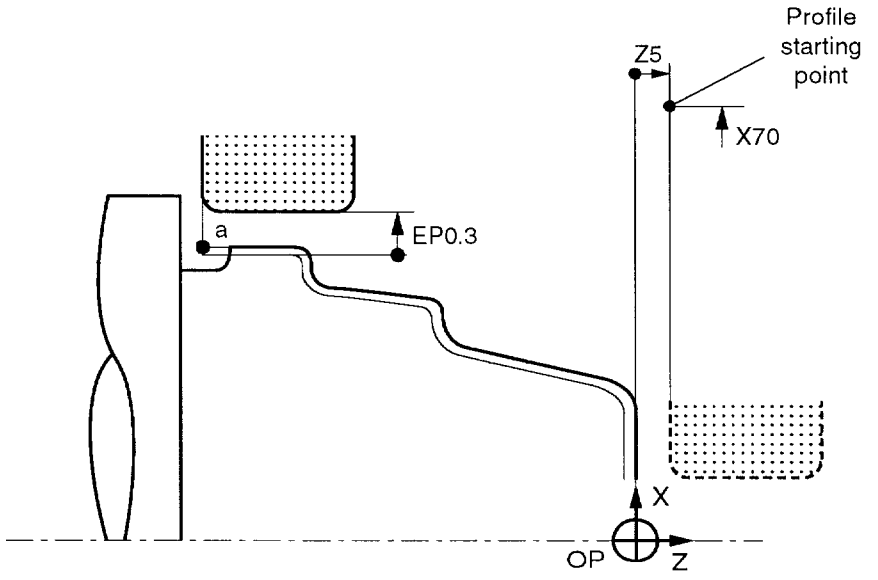
Example

Profile grinding cycle (external)

```
...
G208 X70 Z5 EP0.3 ES1 EH100 H222 N10 N70 F100 D1     Cycle
I0.2 EI0.1 EN2 F1                                    Phase
I0.02 EI0.01 EN2 EK1 EB2 F0.5                        Phase and end of cycle
...

%222 (PROFILE SUBROUTINE)
N10 Xa Za
N..
N..
N70 X.. Z..
```

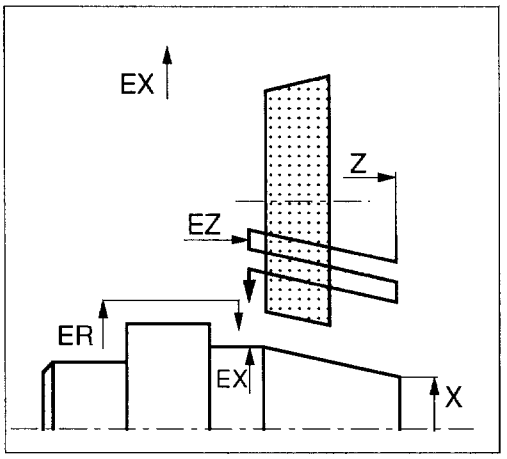
Schematic illustration of cycle



2.10.7 G210 - External conical traverse cycle

G210 External conical traverse cycle.

This cycle includes:
- Initial positioning on Z followed by increment on X then tapered traverse up to the end position on Z
- Increment on X and tapered return traverse on Z, etc.



Syntax

G210 X..EX../EU..Z..EZ..D..EP..F..[ER..][EE..][EF..][EA..][P..][EC..][EH..][S..] [X..][EI..]F..[EJ..][EK..][EG..]EM..[ED..][ET..]/[EN..]EB..

Cycle call arguments

G210	External conical traverse cycle.
X..	Final diameter at start of taper.
EX.. / EU ..	- EX: Final diameter at end of taper. - EU: Taper angle.
Z..	Starting point on Z.
EZ..	End point on Z.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EP..	Safety clearance on X of the taper (+ material allowance).
F..	Traverse feed rate (mm/min).
ER..	Skip diameter.
EE.	Dwell time at start of traverse (s).
EF..	Dwell time at end of traverse (s).

EA..	Traverse overtravel on Z and EZ (by P.. if P is programmed, otherwise by the wheel width). - EA0: wheel within the traverse travel, no overtravel, - EA1: Overtravel by one wheel width or P to the left, - EA2: Overtravel by one wheel width or P to the right, - EA3: Wheel overtravel or P to the right and left.
P..	Overtravel (related to EA).
EC..	Type of increment. - EC0: continuous increment, - EC1: discontinuous increment in Z and/or EZ.
EH..	Backoff diameter for dressing and measuring.
S..	Tangential wheel rotation speed (m/s).
In-cycle arguments	
X..	Allowance on final diameter.
EI..	Increment at start of traverse.
EJ..	Increment at end of traverse.
F..	Feed rate increment (mm/min).
EK..	Backoff distance.
EG..	Measurement selection. - EG0: no measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET.. / EN..	- ET: Sparkout time (s). - EN: Number of sparkout passes.

EB.. Cycle sequencing selection.
- EB0: sequencing without stopping,
- EB1: sequencing with stop,
- EB2: end of cycle.

Notes

Notes on argument programming

The values of X, EK, EI and EJ must be greater than 0.

The value of EU must be > -90° and < +90°.

Arguments EX and EU are mutually exclusive.

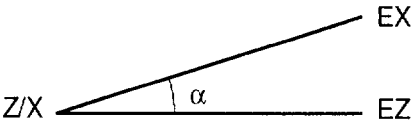
If P is not programmed, it is the wheel width that is taken into account.

Notes associated with arguments ER and EH

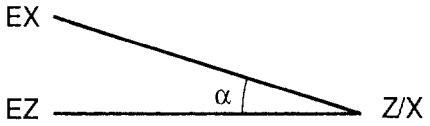
If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X + EP.
If only ER is programmed (without EH), in all cases: EH = ER.

Defining the taper angle

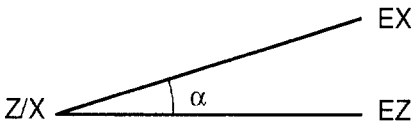
a) Z < EZ (X and EX defined)



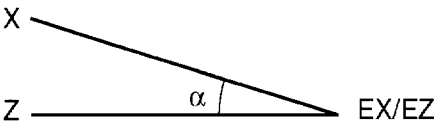
b) Z > EZ (X and EX defined)



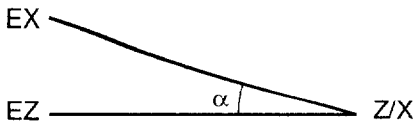
c) Z < EZ (X and positive EU defined)



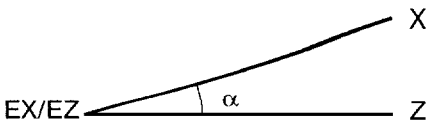
d) Z < EZ (X and negative EU defined)



e) Z > EZ (X and negative EU defined)



f) Z > EZ (X and positive EU defined)



In cases d and f, the value of X is defined as the largest radius of the taper and calculated value EX is the smallest radius.

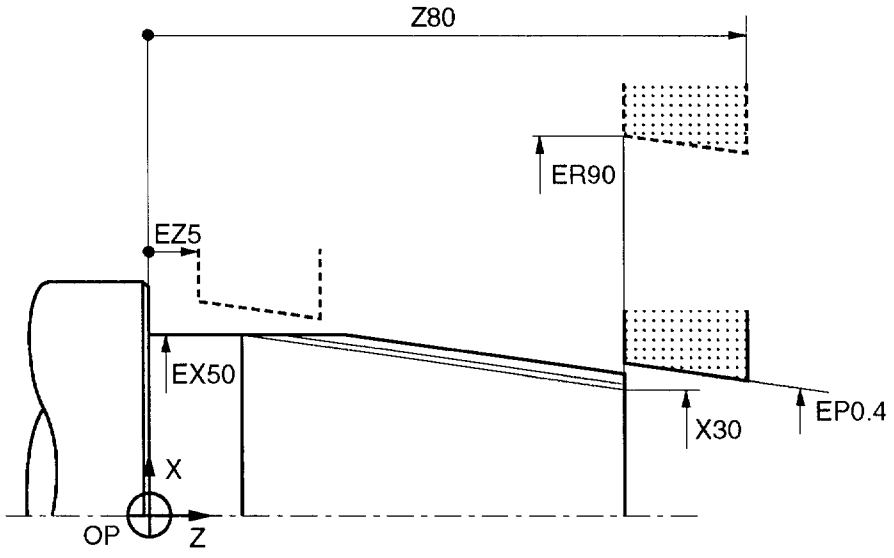
See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

Example

Taper traverse cycle (external)

```
...
G210 X30 EX50 Z80 EZ5 D1 F80 EP0.4 EE1 EF1 EA2 P5 EC1 ER90      Cycle
X0.2 EI0.05 EJ0.05 F4                                          Phase
X0.1 EI0.02 EJ0.02 F1 EK2                                      Phase
X0 ET5 EI0.01 EJ0.01 F0.05 EK2 EB2                             Sparkout and end
                                                               of cycle
...
```

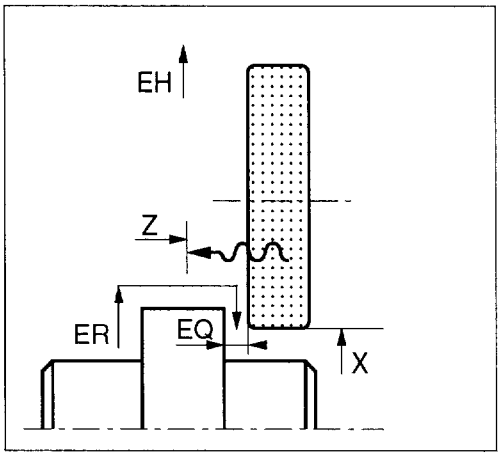
Schematic illustration of cycle



2.10.8 G212 - External Oscillating Shoulder Cycle

G212 External oscillating shoulder cycle.

This cycle includes:
- Initial positioning on X followed by grinding on Z with or without oscillations.



Syntax

G212 Z.. X.. D.. EQ.. [ER..] [EH..] [S..]
[Z..] [F..] [EM..] [EG..] [ET..] [EK..] [ED..] [EO..] [EX..] EB..

Cycle call arguments

G212	External oscillating shoulder cycle.
Z..	End point on Z.
X..	Shoulder start diameter.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EQ..	Safety clearance on Z (+ material allowance).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measurement.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

Z..	Allowance on Z end point.
F..	Feed rate on Z (mm/min).
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
EG..	Measurement selection. - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
ET..	Sparkout time (s).
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
EO..	Oscillation frequency (osc/min).
EX..	Oscillation amplitude.
EB..	Cycle sequencing selection. - EB0: sequencing with stop, - EB1: sequencing without stopping, - EB2: end of cycle.

Notes

Notes on argument programming

The value of X must be greater than 0.

Arguments EO and EX are prohibited if the cycle is to be performed without oscillations.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X.

If only ER is programmed (without EH), in all cases: EH = ER.

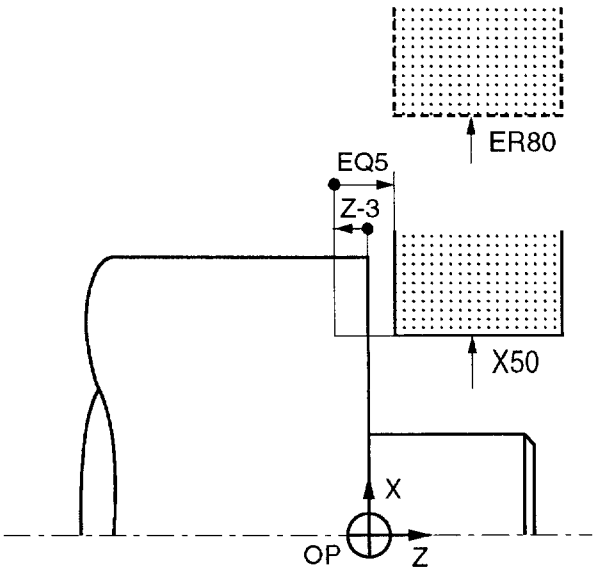
See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

Example

Shoulder plunge cycle with oscillations (external)

```
...
G212 Z-3 X50 D1 ER80 EQ5 S80          Cycle
Z0 E060 EX1 ET10 EB2 F2               Phase and end of cycle
...
```

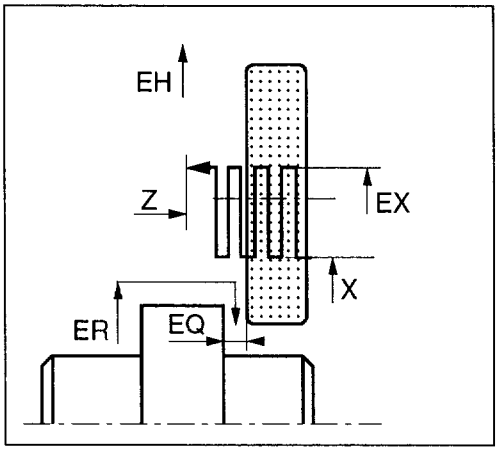
Schematic illustration of cycle



2.10.9 G214 - External shoulder traverse cycle

G214 External shoulder traverse cycle.

This cycle includes:
- initial positioning on X followed by increment on Z and traverse on X up to the end point on X
- increment on Z and return traverse on X, etc.



Syntax

G214 Z.. X.. EX.. D.. EQ.. F.. [ER..] [EH..] [EE..] [EF..] EC.. [S..] [Z..] [EI..] [EJ..] F.. [EG..] [EM..] [ED..] [ET..] / [EN..] [EK..] EB..

Cycle call arguments

G214	External shoulder traverse cycle.
Z..	End point on Z.
X..	Shoulder start diameter.
EX..	End point on X.
D..	Selection of active wheel side. - D1: left side, - D2: right side,
EQ..	Safety clearance on Z axis (+ material allowance).
F..	Traverse feed rate (mm/min).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measurement.
EE..	Dwell time at start of traverse (s).
EF..	Dwell time at end of traverse (s).
EC..	Increment type: - EC0: continuous increment, - EC1: discontinuous increment in X and/or EX.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

Z..	Allowance on final diameter.
EI..	Increment at start of traverse.
EJ..	Increment at end of traverse.
F..	Feed rate increment (mm/min).
EG..	Measurement selection. - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement (with continuous increment) - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET.. / EN..	- ET: Sparkout time (s). - EN: Number of sparkout passes.
EK..	Backoff distance.
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of Z, EK, EI and EJ must be greater than 0.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X.

If only ER is programmed (without EH), in all cases: EH = ER.

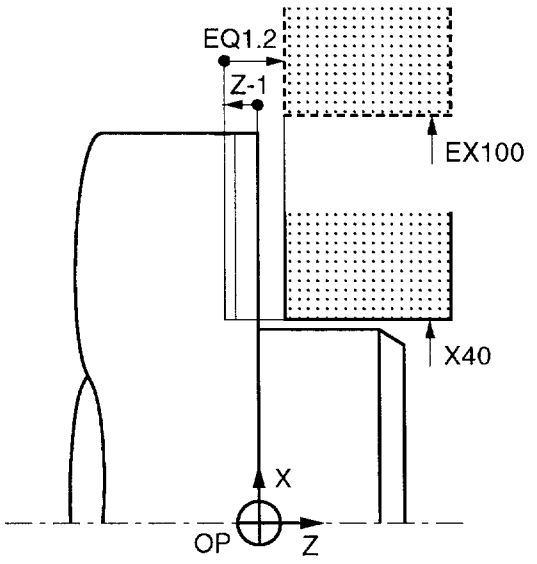
See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

Example

Shoulder traverse cycle (external)

```
...
G214 Z-1 X40 EX100 D1 EQ1.2 ER180 F98 EE1 EF1 EC0   Cycle
Z0.2 EI0.02 EJ0.02 F2                               Phase
Z0.1 EI0.01 EJ0.01 F0.5                             Phase
Z0 EN6 EK1 EB2 EJ0.05 EI0.05 F0.05                  Sparkout and end of cycle
...
```

Schematic illustration of cycle

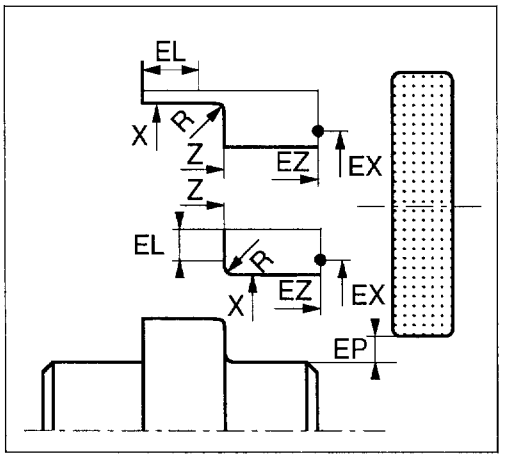


2.10.10 G216 - External Shoulder Cycle with Fillet/Chamfer

G216 External shoulder cycle with fillet/chamfer.

This cycle includes grinding of a fillet or chamfer between a cylindrical surface and a shoulder. It includes several phases:

- cylindrical grinding phase
- shoulder grinding phase
- shoulder/cylinder interface grinding phase
- wheel retraction phase with possible repeat of the cycle.



Syntax

G216 X.. Z.. D.. EX.. EZ.. EP.. ES.. EL.. R.. F.. [EH..] [S..] [I..] [EI..] [ED..] [EN..] EB..

Cycle call arguments

G216	External shoulder cycle with fillet/chamfer.
X..	Final diameter.
Z..	End point on Z.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EX..	Cycle starting point on X axis.
EZ..	Cycle starting point on Z axis.
EP..	Safety clearance on X axis (+ material allowance).
ES..	Radius correction. - ES1: left radius offset (G41), - ES2: right radius offset (G42).
EL..	Retraction on profile.
R..	Fillet between two surfaces.
F..	Feed rate on cylindrical surface/shoulder (mm/min).
EH..	Backoff diameter for dressing or measuring.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

I..	Allowance on final diameter.
EI..	Depth of pass.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
EN..	Number of sparkout passes.
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

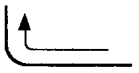
Notes on argument programming

The values of EL and R must be greater than 0.

The value of R must be greater than 1.

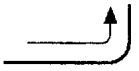
Case of figures with EX and EZ

Case 1 : EX > X
EZ > Z



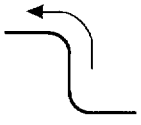
D1 and G42 active

Case 2 : EX > X
EZ < Z



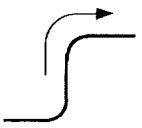
D2 and G41 active

Case 3 : EX < X
EZ > Z



D1 and G42 active

Case 4 : EX < X
EZ < Z



D2 and G41 active

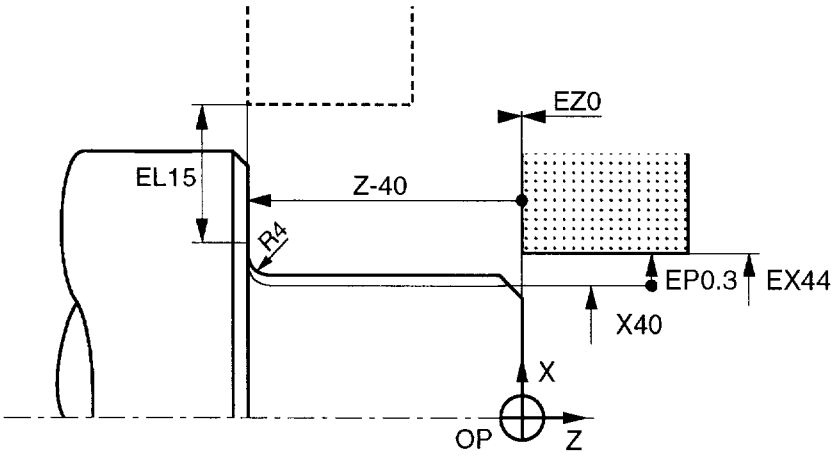
See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

Example

Shoulder profile grinding cycle (external)

```
...
G216 X40 Z-40 EX44 D1 EZ0 EP1 ES2 EL15 R4 F100      Cycle
I0.2 EI0.04                                         Phase
I0 EI0.02 EN2 EB2                                   Sparkout and end of cycle
...
```

Schematic illustration of cycle



2.11 Internal Grinding Cycles

Grinding of the workpiece is achieved by initiating the appropriate grinding cycle. The cycle chosen is programmed by a G2xx function.

The internal grinding cycles have the following numbers:
- G201, G203, G205, G207, G209, G211, G213, G215, G217.

Internal grinding cycles:
- G201: Internal plunge / multiplunge cycle,
- G203: Plunge cycle with shoulder,
- G205: Internal oscillating plunge / multiplunge cycle,
- G207: Internal cylindrical traverse cycle,
- G209: Internal profile grinding cycle,
- G211: Internal conical traverse cycle,
- G213: Internal oscillating shoulder cycle,
- G215: Internal shoulder traverse cycle,
- G217: Internal interpolated shoulder cycle.

REMARK *The external and internal grinding cycles are identical as regards the programming of their arguments. They differ only by their call numbers.*

2.11.1 General

Cycles are programmed in two parts:
- the first part includes the G2xx function followed by the cycle call arguments,
- the second part includes the in-cycle arguments.

Cycle programming arguments

Cycle call arguments

These programming arguments define the engineering data relating to the final production of the workpiece.

They must always be included in the block containing the G2xx cycle call.

In-cycle arguments

These programming arguments define the characteristics associated with each grinding phase: rough grinding, finishing, sparkout, etc.

They must be programmed in the successive blocks defined after the cycle call block.

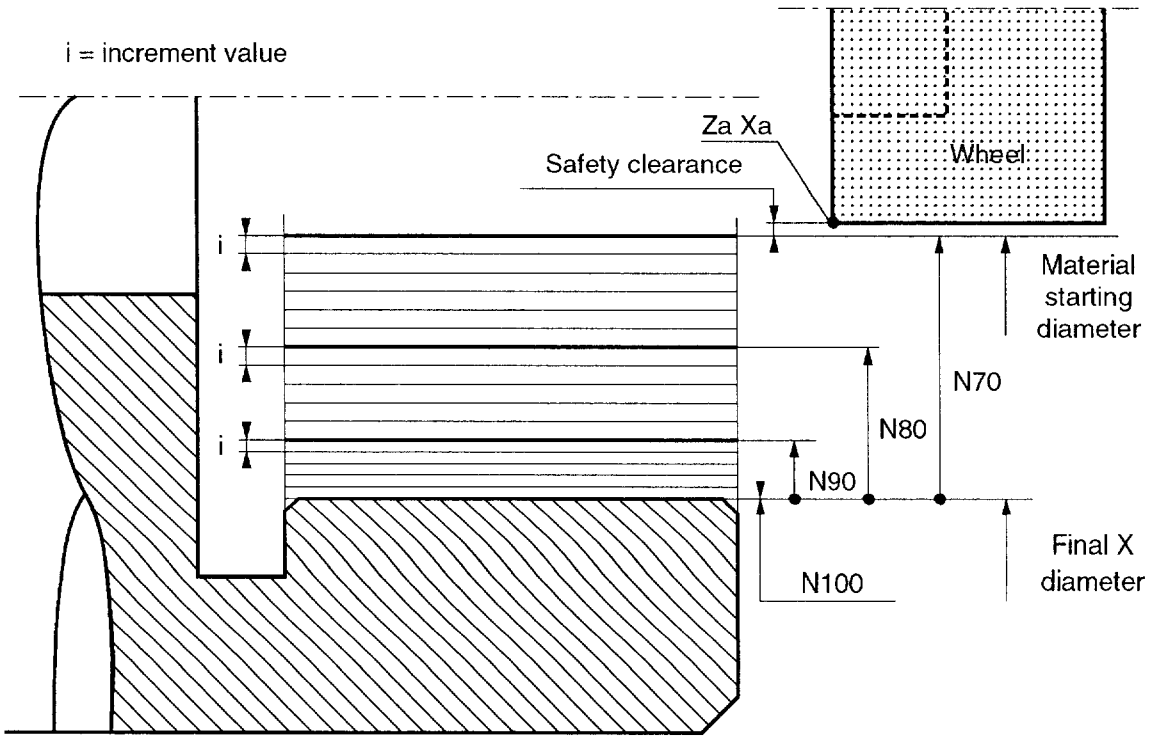
CAUTION

A G2xx cycle must always end with argument EB2 (end of cycle). Otherwise, certain modal arguments are applied during the following cycles.

Example of a cycle

```
%207
N10 T01 M06                 Selection of wheel
N20 G230 S...               Wheel speed calculation
N30 M160                    Periodic dressing
N40 M04 M40 S..             Workpiece rotation direction
N50 G00/G01 Za Xa M08       Z-X approach position and coolant on
N60 G207 ...                Internal cylindrical traverse cycle and
                            cycle call arguments
N70 ...                     Roughing phase
N80 ...                     Semi-finishing phase
N90 ...                     Finishing phase
N100 ...                    Sparkout and end of cycle
N110 Ze                     End point on Z outside the bore
N120 M05 M09                Spindle and coolant off
N130 M02                    End of programme
```

Schematic representation of the phases of a cylindrical traverse cycle

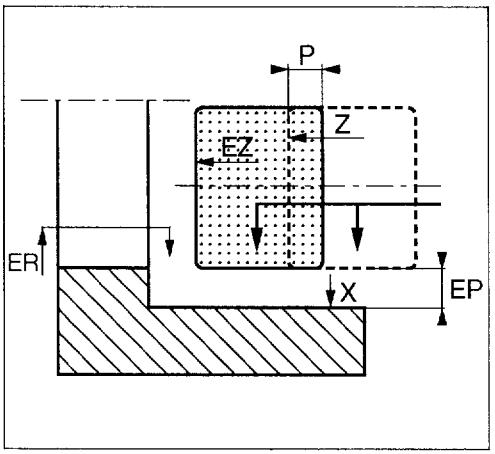


2.11.2 G201 - Internal plunge / multiplunge cycle

G201 Internal plunge / multiplunge cycle.

For single plunge, the cycle includes:
- positioning on Z followed by plunge on X.

For multiplunge, the cycle includes:
- initial positioning on Z followed by a first plunge on X and retraction on X
- a second positioning on Z (wheel width - overlap) followed by plunge, etc. (until reaching the end point).



Syntax

G201 X.. Z.. D.. [EZ..] EP.. [ER..] [EH..] [P..] [S..] [X..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

Cycle call arguments

G201	Internal plunge / multiplunge cycle.
X..	Final diameter.
Z..	Plunge: plunge position on Z axis. Multiplunge: starting point on Z axis.
D..	Selection of active wheel side. - D1 : left side, - D2 : right side.
EZ..	Multiplunge: end point on Z.
EP..	Safety clearance on X axis (+ material allowance).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measuring.
P..	Multiplunge: wheel overlap value.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

X..	Allowance on final diameter.
F..	Feed rate on X (mm/min).
EG..	Measurement selection (default: no measurement). - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET..	Sparkout time (s).
EB..	Cycle sequencing selection. - EB0: sequencing with stop, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of X, EP, X, EK, EZ and ET must be greater than 0.

Multiplunge arguments:
- the value of P must be less than or equal to the wheel width. If P is not programmed its value is forced to 0,
- with D1 or D2 the wheel position does not change. It is the programme origin that is modified,
- movement only takes place when arguments Z and EZ are programmed,
- the difference between Z and EZ must be greater than the wheel width.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X + EP.

If only ER is programmed (without EH), in all cases: EH = ER.

See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

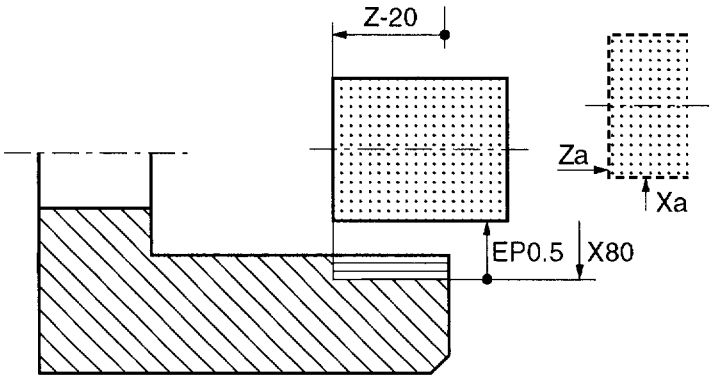
Example

Plunge cycle (internal)

```
...
G0/G1 Za                          Z approach position
Xa                                X approach position
G201 X80 Z-20 D1 EP0.5 ER10       Cycle
X0.2 F2                           Phase
X0.1 F1                           Phase
X0 EK1 ET5 EB2 F0.5               Sparkout and end of cycle
...
```

Schematic illustration of cycle

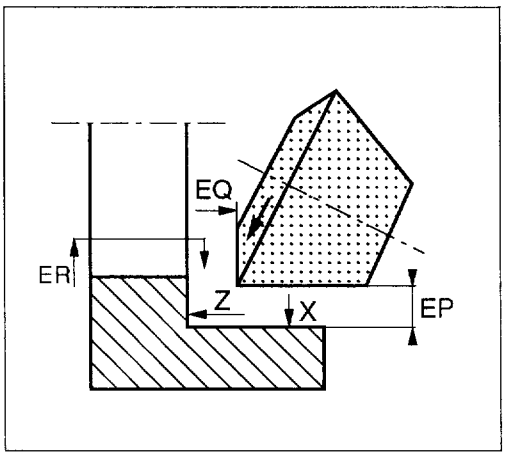
Z axis origin on face of workpiece.



2.11.3 G203 - Internal plunge cycle with inclined axis

G203 Internal plunge cycle with inclined axis.

This cycle includes:
- positioning followed by plunge to simultaneously grind the part wall and shoulder.



Syntax

G203 X.. Z.. D.. EP.. EQ.. [ER..] [EH..] [S..] [X..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

Cycle call arguments

G203	Plunge cycle with inclined axis (internal).
X..	Final diameter.
Z..	End point on Z.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EP..	Safety clearance on X axis (+ material allowance).
EQ..	Safety clearance on Z axis (+ material allowance).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measuring.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

X..	Allowance on final diameter.
F..	Feed rate on X and Z (mm/min).
EG..	Measurement selection. - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET..	Sparkout time (s).
EB..	Cycle sequencing selection. - EB0: sequencing with stop, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of X, EP and EQ must be greater than 0.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH.

In this case:

- in a cycle on the X axis: ER and EH = X + EP,
- in a cycle on the Z axis: ER and EH = X.

If only ER is programmed (without EH), in all cases: EH = ER.

See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

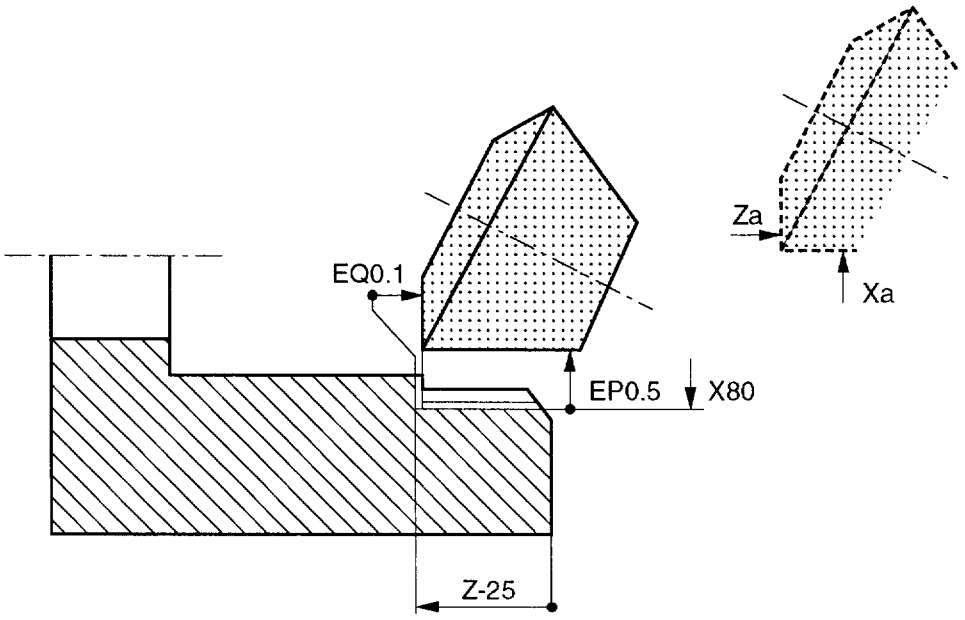
Example

Plunge cycle with inclined axis (internal)

...	
G0/G1 Za	Z approach position
Xa	X approach position
G203 X80 Z-25 D1 EP0.4 EQ0.1 ER10	Cycle
X0.2 F2	Phase
X0.1 F1	Phase
X0 EK1 ET5 EB2 F0.5	Sparkout and end of cycle
...	

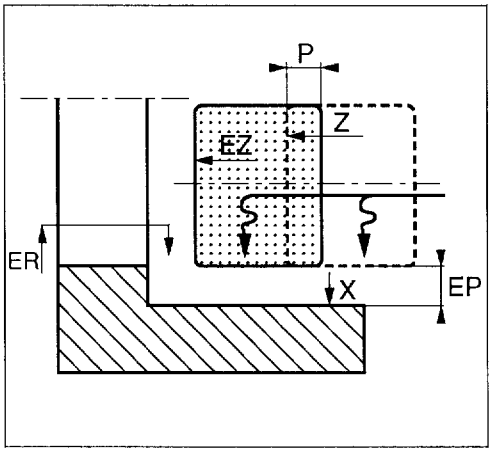
Schematic illustration of cycle

Z axis origin on workpiece face



2.11.4 G205 - Internal oscillating plunge / multiplunge cycle

G205 Internal oscillating plunge / multiplunge cycle



For single plunge, the cycle includes:
- Positioning on Z followed by plunge on Z (with oscillation).

For multiplunge, the cycle includes:
- initial positioning on Z followed by a first plunge on X with oscillation and retraction on X
- a second positioning on Z (wheel width - overlap) followed by plunge on X, etc. (until reaching the end point).

Syntax

G205 X.. Z.. D.. [EZ..] EP.. [ER..] [EH..] [P..] [S..] [X..] [F..] [EZ..] [EO..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

Cycle call arguments

G205	Internal oscillating plunge / multiplunge cycle.
X..	Final diameter.
Z..	Plunge cycle: plunge position on Z axis. Multiplunge cycle: starting point on Z axis.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EZ..	Multiplunge: end point on Z.
EP..	Safety clearance on X axis (+ material allowance).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measurement.
P..	Multiplunge: wheel overlap value.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

X..	Allowance on final diameter.
F..	Plunge feed rate (mm/min).
EZ..	Oscillation amplitude.
EO..	Oscillation frequency (osc/min).
EG..	Measurement selection. - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET..	Sparkout time (s).
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of X, EP, ET, EK, EO and EZ must be greater than 0.

Multiplunge arguments:

- the value of P must be less than or equal to the wheel width. If P is not programmed its value is forced to 0,
- with D1 or D2 the wheel position does not change. It is the programme origin that is modified,
- movement only takes place when arguments Z and EZ are programmed,
- the difference between Z and EZ must be greater than the wheel width.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X + EP.

If only ER is programmed (without EH), in all cases: EH = ER.

See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

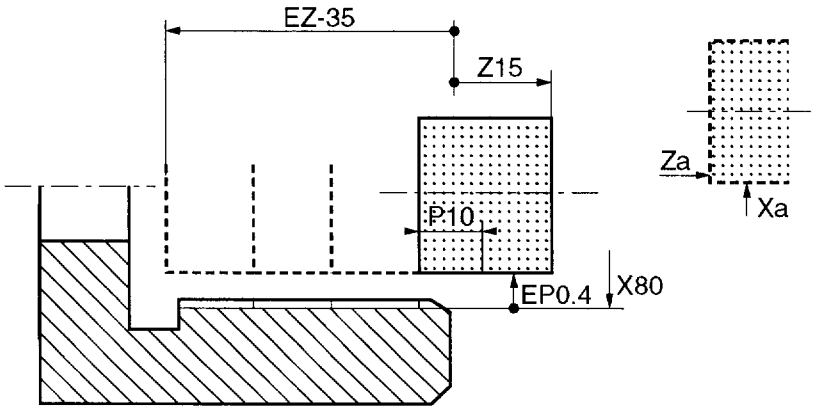
Example

Multiplunge cycle with oscillations (internal)

```
...
G0/G1 Za                              Z approach position
Xa                                    X approach position
G205 X80 Z15 EZ-35 D1 EP0.4 ER10 P10  Cycle
X0.2 EZ1 E010 F0.2                    Phase of cycle
X0 ET2 EK1 EB2 F0.1                   Sparkout and end of cycle
...
```

Schematic illustration of cycle

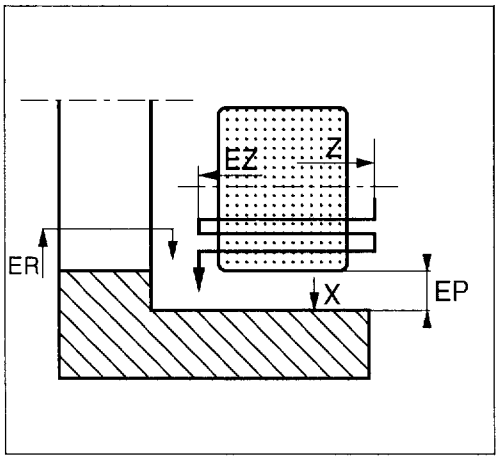
Z axis origin on workpiece face



2.11.5 G207 - Internal cylindrical traverse cycle

G207 Internal cylindrical traverse cycle.

This cycle includes:
- initial positioning on Z followed by a first increment on X and traverse up to the end position on Z
- a second increment on X followed by return traverse, etc.



Syntax

G207 X.. Z.. D.. EZ.. EP.. F.. [ER..] [EH..] [EA..] [P..] [EE..] [EF..] [EC..] [S..] [X..] [EI..] [EJ..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..] / [EN..] EB..

Cycle call arguments

G207	Internal cylindrical traverse cycle.
X..	Final diameter.
Z..	Starting point on Z.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EZ..	End position on Z.
EP..	Safety clearance on X axis (+ material allowance).
F..	Traverse feed rate (mm/min).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measurement.
EA..	Overtravel on Z and EZ during traverse (by P.. if P is programmed, otherwise by the wheel width). - EA0: wheel within traverse distance, no overtravel, - EA1: Overtravel by one wheel width or P to left, - EA2: Overtravel by one wheel width or P to right, - EA3: Wheel overtravel or P to right and left.

P..	Overtravel (associated with EA).
EE.	Dwell time at start of traverse (s).
EF..	Dwell time at end of traverse (s).
EC..	Type of increment: - EC0: continuous increment, - EC1: discontinuous increment in Z and/or EZ.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

X..	Allowance on final diameter.
EI..	Increment at start of traverse.
EJ..	Increment at end of traverse.
F..	Feed rate increment (mm/min).
EG..	Measurement selection. - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement (with continuous increment), - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET.. / EN..	- ET: Sparkout time (s). - EN: Number of sparkout passes.
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of X, EK, EI and EJ must be greater than 0.

If P is not programmed, it is the wheel width that is taken into account.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH.

In this case: ER and EH = X + EP.

If only ER is programmed (without EH), in all cases: EH = ER.

See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

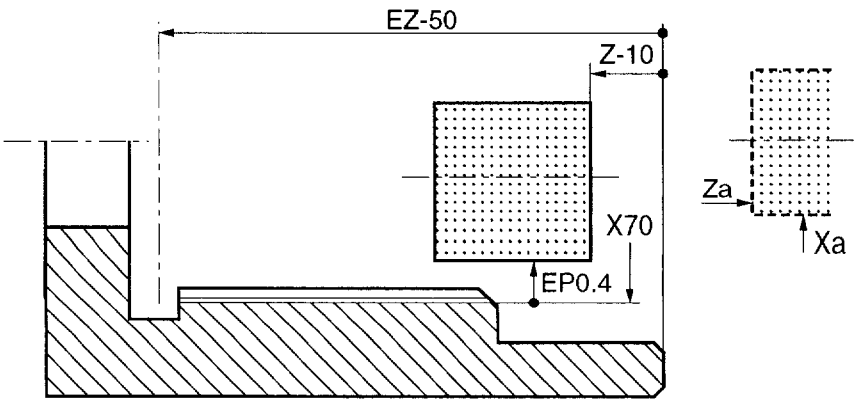
Example

Cylindrical traverse cycle (internal)

```
...
G0/G1 Za                                          Z approach position
Xa                                                X approach position
G207 X70 Z-10 EZ-50 EP0.4 ER10 F100 EE1 EF1 EA2 EC1 D2   Cycle
X0.2 EI0.04 EJ0.04 F3                             Phase
X0 EI0.02 EJ0.02 EN7 EK1 EB2 F0.2                 Sparkout and end of
                                                  cycle
...
```

Schematic illustration of cycle

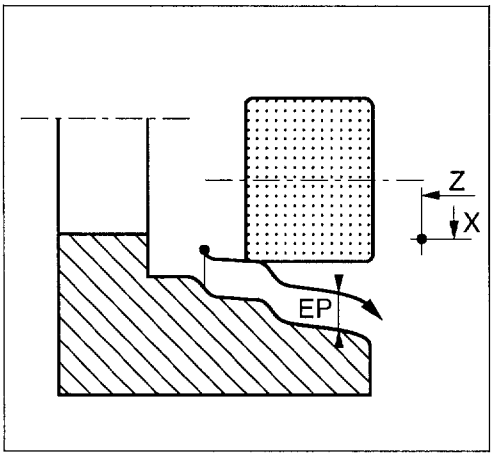
Z axis origin on workpiece face



2.11.6 G209 - Internal profile grinding cycle

G209 Internal profile grinding cycle.

This cycle includes:
- initial positioning on X and Z followed by grinding of the profile defined in a subroutine.



Syntax

G209 X.. Z.. D.. EP.. ES.. H.. N.. N.. F.. [EH..] [S..]
[I..] [EI..] [EN..] [EK..] [ED..] EB..

Cycle call arguments

G209	Internal profile grinding cycle.
X..	Start diameter (X).
Z..	Starting point on Z axis.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EP..	Safety clearance on X of the profile (+ material allowance).
ES..	Wheel radius correction: - ES1: left radius offset (G41), - ES2: right radius offset (G42).
H..	Number of profile definition subroutine.
N.. N..	Profile start and end blocks.
F..	Feed rate on profile (mm/min).
EH..	Backoff diameter for dressing or measurement.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

I..	Allowance on final diameter.
EI..	Depth of pass.
EN..	Number of sparkout passes.
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
EB..	Cycle sequencing selection. - EB0: sequencing without stopping. - EB1: sequencing with stop. - EB2: end of cycle.

Notes

Notes on argument programming

In cycle G209, the profile description points must have negative values.

The value of X must be greater than 0.

The starting point on X and Z must be outside the profile.

See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

Example

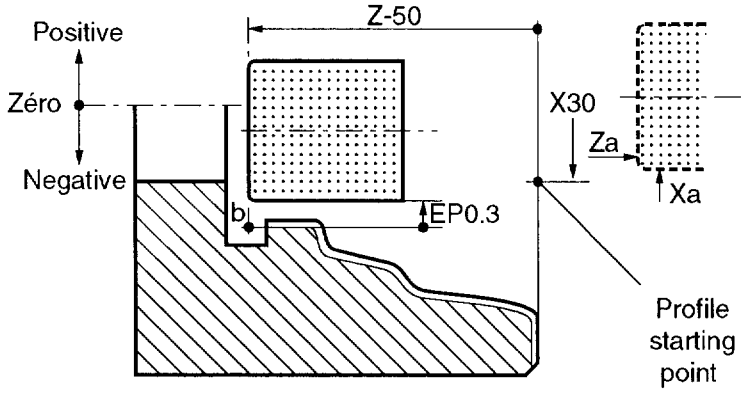
Profile grinding cycle (internal)

```
...
G0/G1 Za                                  Z approach position
Xa                                        X approach position
G209 X30 Z-50 EP0.3 ES1 H333 N10 N80 F100 D1  Cycle
I0.2 EI0.1 EN2 F1                         Phase
I0.02 EI0.01 EN2 EK1 EB2 F0.5             Sparkout and end of cycle
...

%333 (PROFILE SUBROUTINE)
N10 Xa Za
N..                                       Negative profile description points
N..
N80 X.. Z..
```

Schematic illustration of cycle

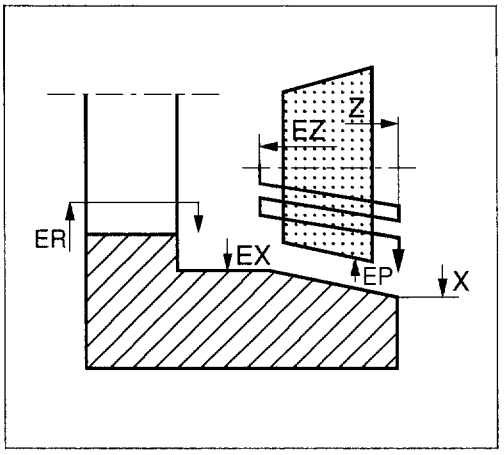
Z axis origin on workpiece face



2.11.7 G211 - Internal conical traverse cycle

G211 Internal conical traverse cycle.

This cycle includes:
- Initial positioning on Z followed by increment on X then tapered traverse up to the end position on Z
- Increment on X and tapered return traverse on Z, etc.



Syntax

G211 X.. EX.. / EU.. Z.. EZ.. D.. EP.. F.. [ER..] [EH..] [EE..] [EF..] [EA..] [P..] [EC..] [S..] [X..] [EI..] [EJ..] F.. [EK..] [EG..] EM.. [ED..] [ET..] / [EN..] EB..

Cycle call arguments

G211	Internal conical traverse cycle.
X..	Final diameter at start of taper.
EX.. / EU..	- EX: Final diameter at end of taper. - EU: Taper angle.
Z..	Starting point on Z axis.
EZ..	End point on Z.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EP..	Safety clearance on X of the taper (+ material allowance).
F..	Traverse feed rate (mm/min).
ER..	Skip diameter.
EH..	Backoff diameter for dressing and measuring.
EE.	Dwell time at start of traverse (s).
EF..	Dwell time at end of traverse (s).

EA..	Traverse overtravel on Z and EZ (by P.. if P is programmed, otherwise by the wheel width). - EA0: wheel within the traverse travel, no overtravel, - EA1: Overtravel by one wheel width or P to left, - EA2: Overtravel by one wheel width or P to right, - EA3: Wheel overtravel or P to right and left.
P..	Overtravel (related to EA).
EC..	Type of increment: - EC0: continuous increment, - EC1: discontinuous increment in Z and/or EZ.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

X..	Allowance on final diameter.
EI..	Increment at start of traverse.
EJ..	Increment at end of traverse.
F..	Feed rate increment (mm/min).
EK..	Backoff distance.
EG..	Measurement selection. - EG0: no measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET.. / EN..	- ET: Sparkout time (s). - EN: Number of sparkout passes.
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of X, EK, EI and EJ must be greater than 0.

The value of EU must be > -90° and < +90°.

Arguments EX and EU are mutually exclusive.

If P is not programmed, it is the wheel width that is taken into account.

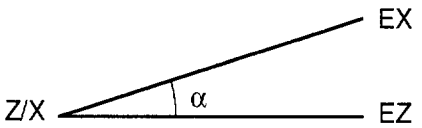
Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X + EP.

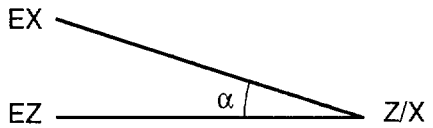
If only ER is programmed (without EH), in all cases: EH = ER.

Defining the taper angle

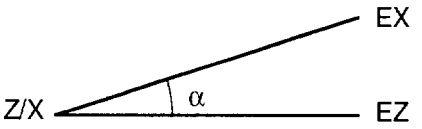
a) Z < EZ (X and EX defined)



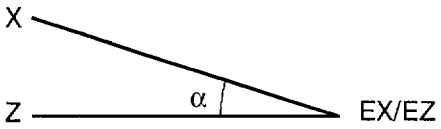
b) Z > EZ (X and EX defined)



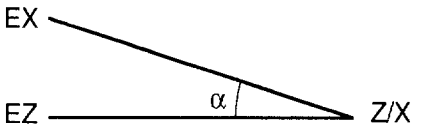
c) Z < EZ (X and positive EU defined)



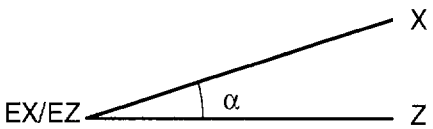
d) Z < EZ (X and negative EU defined)



e) Z > EZ (X and negative EU defined)



f) Z > EZ (X and positive EU defined)



In cases d and f, the value of X is defined as the largest radius of the taper and calculated value EX is the smallest radius.

See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

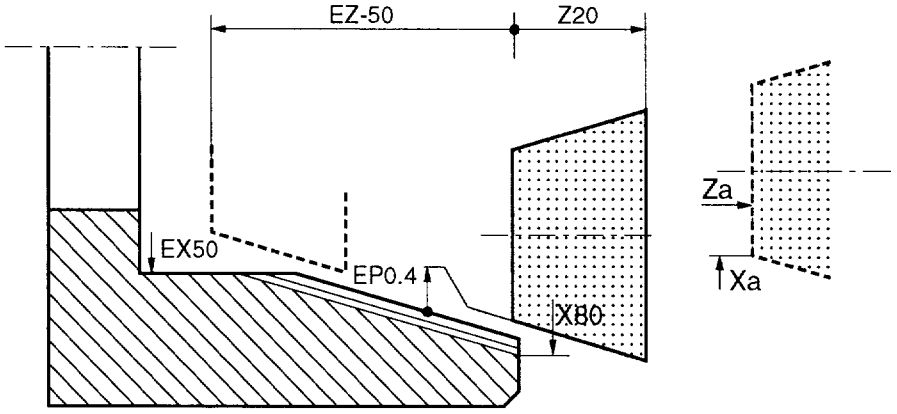
Example

Taper traverse cycle (internal)

```
...
G0/G1 Za                                                    Z approach position
Xa                                                          X approach position
G211 X80 EX50 Z20 EZ-50 ER10 D1 F100 EP0.4 EE1 EF1 EA0 EC1  Cycle
X0.2 EI0.05 EJ0.05 F4                                       Phase
X0.1 EI0.02 EJ0.02 F1 EK2                                   Phase
X0 ET5 EI0.01 EJ0.01 F0.05 EK2 EB2                          Sparkout and end of
                                                            cycle
...
```

Schematic illustration of cycle

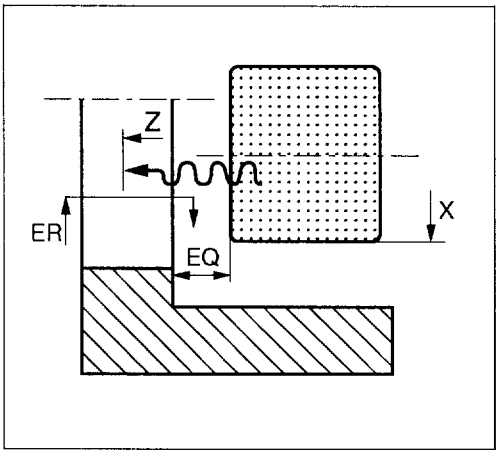
Z axis origin on workpiece face



2.11.8 G213 - Internal Oscillating Shoulder Cycle

G213 Internal oscillating shoulder cycle.

This cycle includes:
- Initial positioning on X followed by grinding on Z with or without oscillations.



Syntax

G213 Z.. X.. D.. EQ.. [ER..] [EH..] [S..]
[Z..] [F..] [EM..] [EG..] [ET..] [EK..] [ED..] [EO..] [EX..] EB..

Cycle call arguments

G213	Internal oscillating shoulder cycle.
Z..	End point on Z.
X..	Shoulder start diameter.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EQ..	Safety clearance on Z axis (+ material allowance).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measurement.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

Z..	Allowance on Z end point.
F..	Feed rate on Z (mm/min).
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
EG..	Measurement selection. - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
ET..	Sparkout time (s).
EK..	Backoff distance.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
EO..	Oscillation frequency (osc/min).
EX..	Oscillation amplitude.
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The value of X must be greater than 0.

Arguments EO and EX are prohibited if the cycle is to be performed without oscillations.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X.

If only ER is programmed (without EH), in all cases: EH = ER.

See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

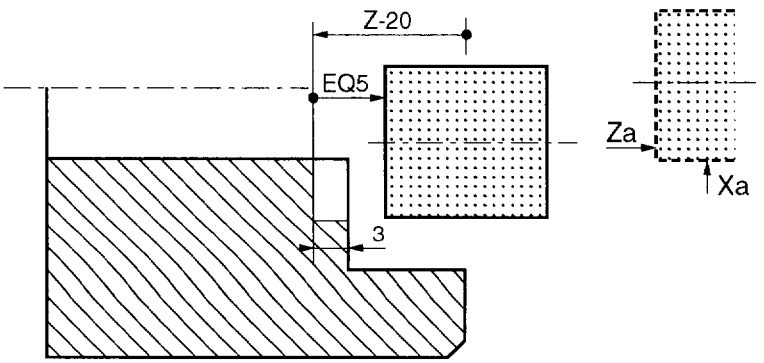
Example

Shoulder plunge cycle with oscillations (internal)

```
...
G0/G1 Za                          Z approach position
Xa                                X approach position
G213 Z-20 X70 D1 ER10 EQ5 S80     Cycle
Z0 EO60 EX1 ET10 EB2 F2           Phase and end of cycle
...
```

Schematic illustration of cycle

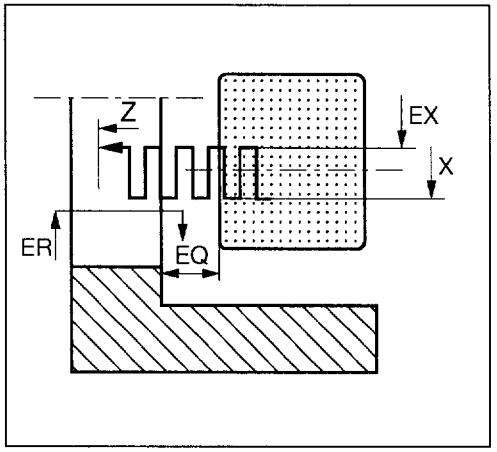
Z axis origin on workpiece face



2.11.9 G215 - Internal shoulder traverse cycle

G215 Internal shoulder traverse cycle.

This cycle includes:
- initial positioning on X followed by increment on Z and traverse on X up to the X end point
- increment on Z and return traverse on X, etc.



Syntax

G215 Z.. X.. EX.. D.. EQ.. F.. [ER..] [EH..] [EE..] [EF..] EC.. [S..] [Z..] [EI..] [EJ..] F.. [EG..] [EM..] [ED..] [ET..] / [EN..] [EK..] EB..

Cycle call arguments

G215	Internal shoulder traverse cycle.
Z..	End point on Z.
X..	Shoulder start diameter.
EX..	End point on X.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EQ..	Safety clearance on Z axis (+ material allowance).
F..	Traverse feed rate (mm/min).
ER..	Skip diameter.
EH..	Backoff diameter for dressing or measurement.
EE.	Dwell time at start of traverse (s).
EF..	Dwell time at end of traverse (s).
EC..	Increment type: - EC0: continuous increment, - EC1: discontinuous increment in X and/or EX.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

Z..	Allowance on final diameter.
EI..	Increment at start of traverse.
EJ..	Increment at end of traverse.
F..	Feed rate increment (mm/min).
EG..	Measurement selection. - EG0: no measurement, - EG1: gap elimination enable, - EG2 to EG9: in-cycle measurement, - EG98: conditional manual measurement call, - EG99: unconditional manual measurement call.
EM..	Offset modification selection (default: no modification). - EM0: no modification, - EM1: modification of DAT1, - EM2: modification of DAT1 and machine data.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
ET.. / EN..	- ET: Sparkout time (s). - EN: Number of sparkout passes.
EK..	Backoff distance.
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

Notes on argument programming

The values of Z, EK, EI and EJ must be greater than 0.

Notes associated with arguments ER and EH

If ER and EH are not programmed, programme %9970 calculates ER and EH. In this case: ER and EH = X.

If only ER is programmed (without EH), in all cases: EH = ER.

See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

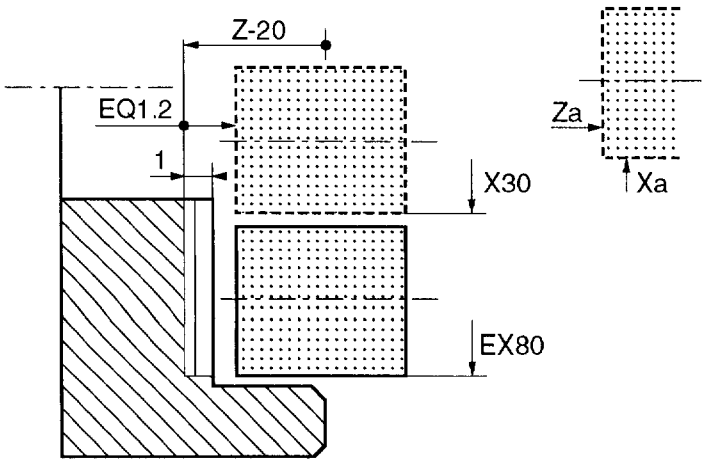
Example

Shoulder traverse cycle (internal)

```
...
G0/G1 Za                                          Z approach position
Xa                                                X approach position
G215 Z-20 X30 EX80 D1 EQ1.2 ER10 F100 EE1 EF1 EC0 Cycle
Z0.2 EI0.02 EJ0.02 F2                             Phase
Z0.1 EI0.01 EJ0.01 F0.5                           Phase
Z0 EN6 EK1 EB2 EJ0.05 EI0.05 F0.05                Sparkout and end of cycle
...
```

Schematic illustration of cycle

Z axis origin on workpiece face

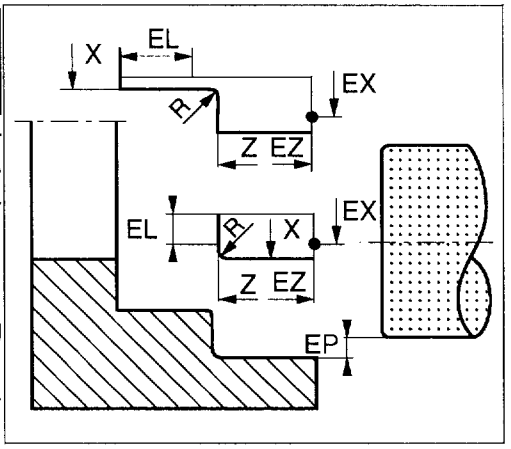


2.11.10 G217 - Internal Shoulder Cycle with Fillet/Chamfer

G217 Internal shoulder cycle with fillet/chamfer.

This cycle includes grinding of a fillet or chamfer between a cylindrical surface and a shoulder. It includes several phases:

- cylindrical grinding phase,
- shoulder grinding phase,
- shoulder/cylinder interface cutting phase,
- wheel retraction and repeat of cycle.



Syntax

G217 X.. Z.. D.. EX.. EZ.. EP.. ES.. EL.. R.. F.. [EH..] [S..] [I..] [EI..] [ED..] [EN..] EB..

Cycle call arguments

G217	Internal shoulder cycle with fillet or chamfer.
X..	Final diameter.
Z..	End point on Z.
D..	Selection of active wheel side. - D1: left side, - D2: right side.
EX..	Cycle starting point on X axis.
EZ..	Cycle starting point on Z axis.
EP..	Safety clearance on X axis (+ material allowance).
ES..	Radius correction. - ES1: left radius offset (G41), - ES2: right radius offset (G42).
EL..	Retraction on profile.
R..	Fillet or chamfer between two surfaces.
F..	Feed rate on cylindrical surface/shoulder (mm/min).
EH..	Backoff diameter for dressing or measurement.
S..	Tangential wheel rotation speed (m/s).

In-cycle arguments

I..	Allowance on final diameter.
EI..	Depth of pass.
ED..	Wheel dressing selection. - ED1: peripheral face, - ED2: left side, - ED3: peripheral face and left side, - ED4: right side, - ED5: peripheral face and right side, - ED6: left side and right side, - ED7: peripheral face and left and right sides.
EN..	Number of sparkout passes.
EB..	Cycle sequencing selection. - EB0: sequencing without stopping, - EB1: sequencing with stop, - EB2: end of cycle.

Notes

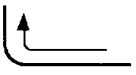
Notes on argument programming

The values of EL and R must be greater than 0.

The value of R must be greater than 1.

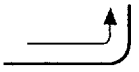
Case of figures with EX and EZ

Case 1 : EX > X
EZ > Z



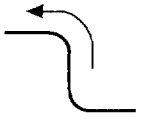
D1 and G42 active

Case 2 : EX > X
EZ < Z



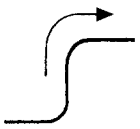
D2 and G41 active

Case 3 : EX < X
EZ > Z



D1 and G42 active

Case 4 : EX < X
EZ < Z



D2 and G41 active

See Sec. 2.12 for further information regarding the arguments present at cycle call or the arguments to be defined during the cycle.

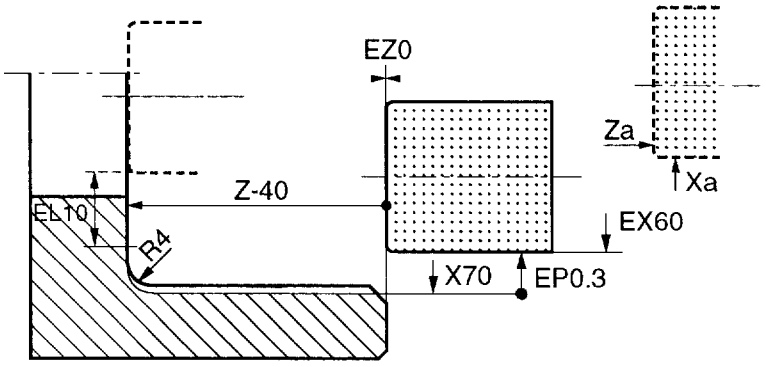
Example

Shoulder profile grinding cycle (internal)

```
...
G0/G1 Za                                        Z approach position
Xa                                              X approach position
G217 X70 Z-40 EX60 D1 EZ0 EP1 ES2 EL10 R4 F100  Cycle
I0.2 EI0.04                                     Phase
I0 EI0.02 EN2 EB2                               Sparkout and end of cycle
...
```

Schematic illustration of cycle

Z axis origin on workpiece face



2.12 Description of External/Internal Grinding Arguments

2.12.1 Description of Cycle Call Arguments

The arguments present when one of the G200 to G217 cycles is called are described below in alphabetical order.

D.. **Selection of active wheel side**

Selects the active wheel wall (D1 = left wall or D2 = right wall) as reference for wheel movements or positioning on the Z axis.

Notes on programming in plunge and traverse cycles

G200/G201-G204/G205-G206/G207-G210/G211

The cases described below concern programming of D1 or D2 with Z and EZ in the following cycles:

First possibility:
- D1: left side active,
- value of Z < EZ,
- Z: first plunge position,
- EZ: last plunge position (EZ - wheel width).

Second possibility:
- D2: right side active,
- value of Z < EZ,
- Z: first plunge position (Z + wheel width),
- EZ: last plunge position.

Third possibility:
- D1: left side active,
- value of Z > EZ,
- Z: first plunge position (Z - wheel width),
- EZ: last plunge position.

Fourth possibility:
- D2: right side active,
- value of Z > EZ,
- Z: first plunge position,
- EZ: last plunge position (EZ - wheel width).

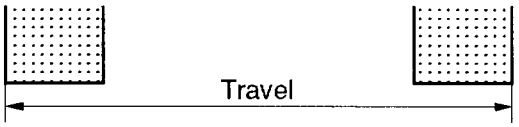
EA.. Overtravel Beyond Z and EZ in Traversing Pass

Cylindrical traverse (G206/G207-G210/G211)

The traverse travel can be exceeded by the value of the wheel width if one of arguments EA1, EA2 or EA3 is programmed. The overtravel amount can be limited to the value programmed with argument P if programmed.

Possibilities when P is not programmed: wheel width 20 mm.

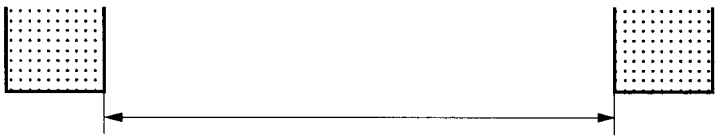
EA0 (wheel inside travel distance, no overtravel):



EA1 (overtravel to the left by one wheel width):

EA2 (overtravel to the right by one wheel width):

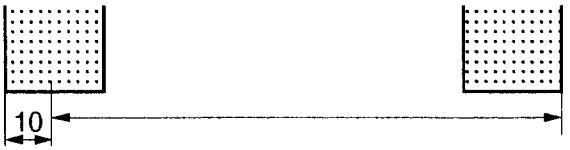
EA3 (overtravel to the left and right by one wheel width):



Possibilities when P is programmed: wheel width = 20 mm and P = 10.

EA0 (wheel inside travel distance, no overtravel)

EA1 (overtravel to left by 10 mm):



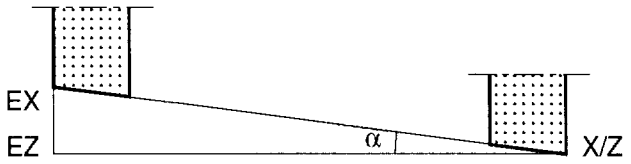
EA2 (overtravel to right by 10 mm):

EA3 (overtravel to right and left by 10 mm):

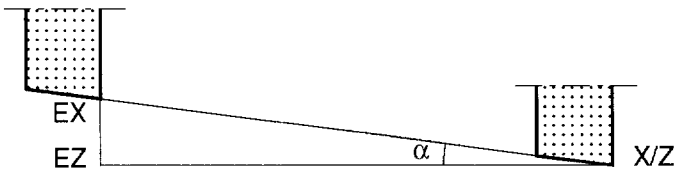
Taper traverse (G208/G209)

Wheel position at the start and end of traverse according to the programmed EA value.

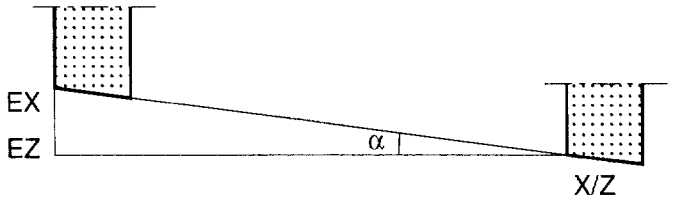
EA0



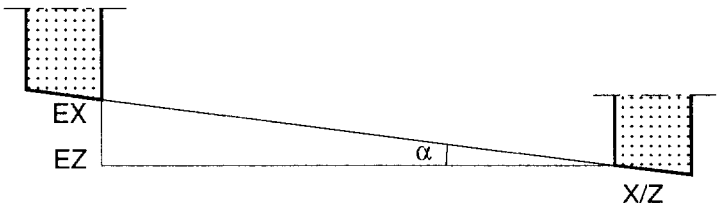
EA1



EA2



EA3

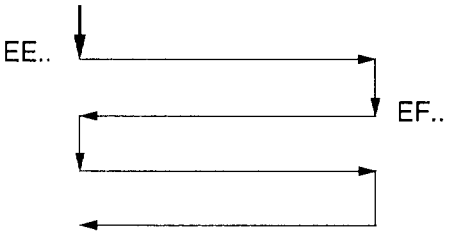


EC.. **Type of increment** (G206/G207-G210/G211-G214/G215)

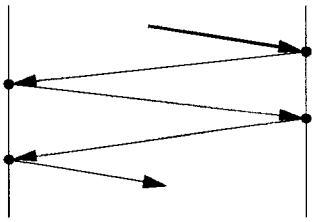
With discontinuous increment, the traverse passes are carried out in alternation.

With continuous increment, the traverse passes are carried out simultaneously on the X and Z axes.

Discontinuous increment



Continuous increment



EE.. **Dwell time at start of traverse** (G206/G207-G210/G211-G214/G215)

Dwell time at start of forward traverse phase.

EF.. **Dwell time at end of traverse** (G206/G207-G210/G211-G214/G215)

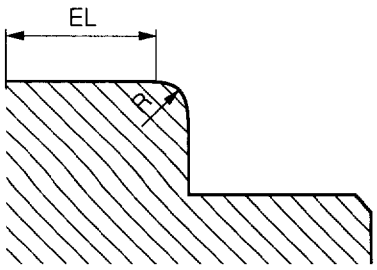
Dwell time at end of forward traverse phase.

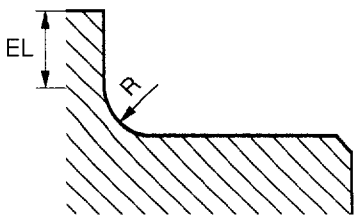
EH.. **Backoff diameter for dressing and measurement** (G200/G201 to G216/G217)

Wheel backoff diameter with respect to the workpiece for dressing or taking measurements.

EL.. **Retraction on profile** (G216/G217)

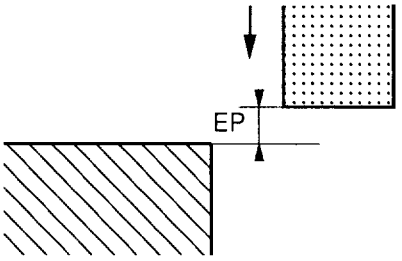
Specifies backoff on the profile (cylindrical or shoulder) at the end of the chamfer or fillet.





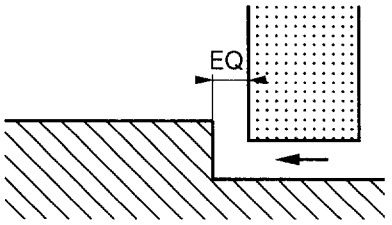
EP.. **Safety clearance on X** (G200/G201 to G210/G211-G216/G217)

Fast movement to the EP value, defined with respect to the final X diameter plus the material allowance on X axis.



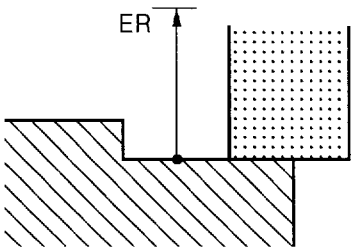
EQ.. **Safety clearance on Z** (G202/G203-G212/G213-G214/G215)

Fast movement to the EQ value, defined with respect to the final Z plus the material allowance on the Z axis after each phase of the cycle.



ER.. **Skip diameter** (G200/G201 to G206/G207-G210/G211 to G214/G215)

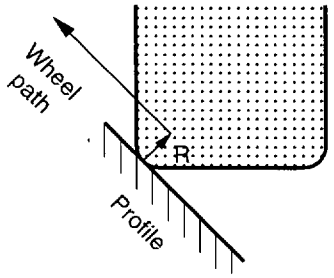
Diameter to which the wheel must move to allow movement on the Z axis.



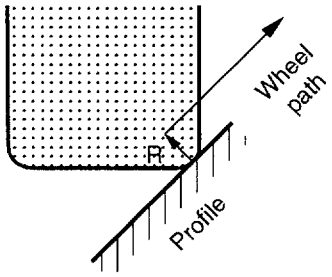
ES.. **Wheel radius offset** (G208/G209 to G216/G217)

Sets the wheel radius on the left or right of the ground profile with respect to the direction of travel.

Right radius offset

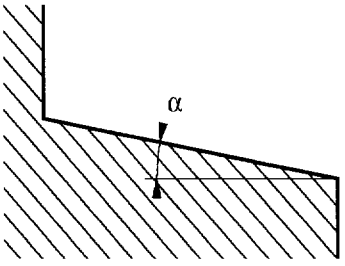


Left radius offset



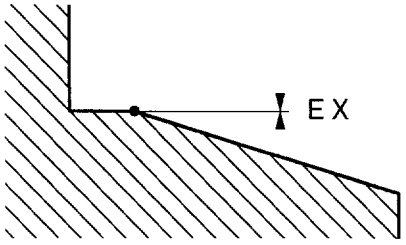
EU.. **Taper angle** (G210/G211)

Angle defining the tangent of the taper.



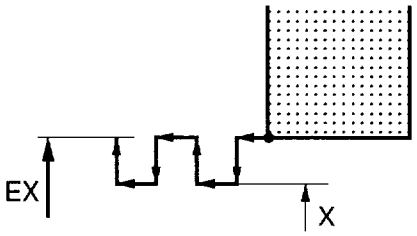
EX.. **Case 1: Final diameter at end of taper** (G210/G211)

Value of the final diameter after grinding the taper.



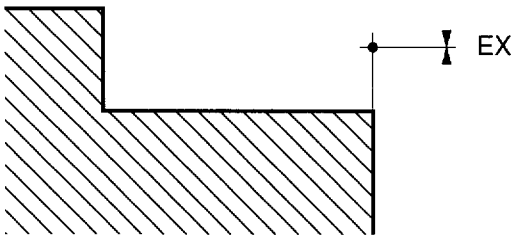
Case 2: End point on X (G214/G215)

Specifies the wheel end point on X for axial traverse.



Case 3: Start point on X (G216/G217)

Start point on the X axis for shoulder with radius.



EZ.. **Case 1: End point on Z for multiplunge** (G200/G201-G204/G205)

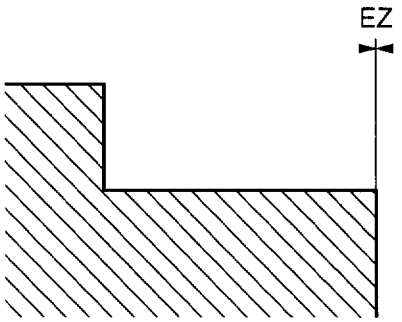
Case 2: End point on Z for cylindrical traverse (G206/G207)

Case 3: End point on Z for tapered traverse (G210/G211)

For cases 1, 2 and 3: end point on Z of the active wheel wall at the end of the cycle (see D..).

Case 4: Cycle start point on Z (G216 and G217)

Start point on the Z axis for a shoulder with radius.



F.. **Case 1: Traverse feed rate** (G206/G207-G210/G211-G214/G215)

Feed rate programmed on the traverse axis: Z for axial and X for radial.

Case 2: Feed rate on profile (G208/G209)

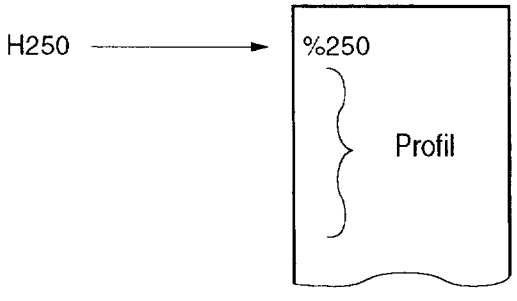
Tangential feed rate on the path of the profile to be ground.

Case 3: Feed rate on cylinder/shoulder (G216/G217)

Feed rate during the shoulder grinding cycle.

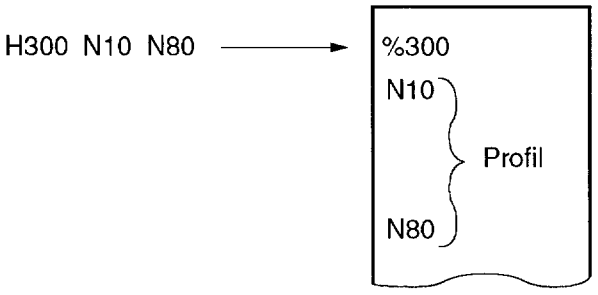
H.. **Number of profile definition subroutine** (G208/G209)

Indicates the number of the subroutine containing the definition of the profile to be ground.



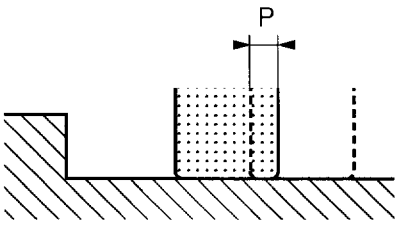
N.. N.. **Profile start and end blocks** (G208/G209)

Indicates the numbers of the first and last block defining the profile to be ground.



P.. **Case 1: Wheel overlap value** (G200/G201-G204/G205)

Multiplunge: overlap during consecutive plunges. If P is not programmed, the default value used is the wheel width (see EA..).

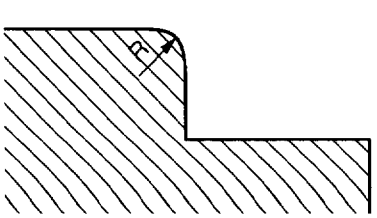


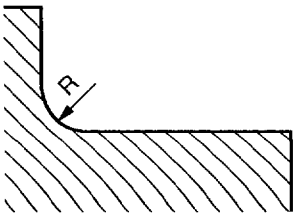
Case 2: Overtravel (G206/G207-G210/G211)

The overtravel can be limited to the value programmed in P if P is programmed. Otherwise, the overtravel corresponds to a wheel width (see EA..).

R.. **Radius** (G216/G217)

Value of the connection radius (chamfer or fillet) between the cylindrical surface and the shoulder.



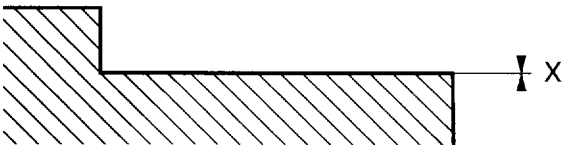


S.. **Tangential wheel rotation speed**

Value defining the tangential wheel speed in m/s.

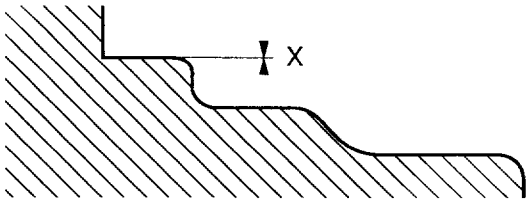
X.. **Case 1: Final diameter** (G200/G201 to G206/G207 and G216/G217)

Final part diameter.



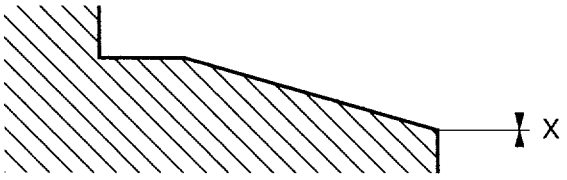
Case 2: Profile start diameter (G208/G209)

Start diameter of the profile to be ground. The X and Z start point specified must not lie on the profile.



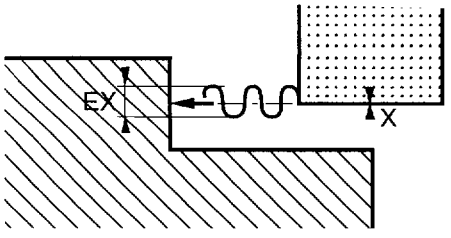
Case 3: Final diameter at start of taper (G210/G211)

Value of the diameter at the start of the taper to be ground.



Case 4: Shoulder start diameter (G212/G213-G214/G215)

Value of the diameter at the cycle start.



Z.. **Case 1: Plunge position on Z** (G200/G201 and G204/G205)

Single plunge: specifies the plunge Z position.

Multiplunge: specifies the Z start point of the first plunge.

Case 2: End point on Z (G202/G203-G212/G213-G214/G215-G216/G217)

Specifies the Z end point.

Case 3: Start point on Z (G206/G207-G208/G209-G210/G211)

Traverse: specifies the Z start point.

Case 4: Z Start point (G208/G209)

For profile grinding: specifies the profile Z start point. This point must always lie off the profile.

2.12.2 Description of In-Cycle Arguments

The in-cycle arguments that can be used in a G200 to G217 cycle are described in alphabetical order.

EB.. **Cycle sequencing selection** (G200/G201 to G216/G217)

Argument EB is used to specify the three cycle sequencing possibilities:
- EB0: sequencing without stopping
- EB1: sequencing with stop
- EB2: end of cycle.

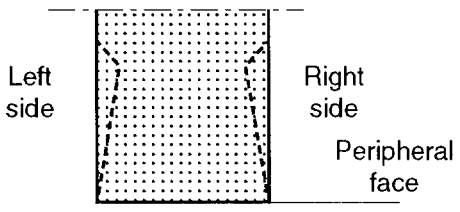
EB0: When G10 is active (e.g. in the case of a measurement during the cycle), EB0 is used to sequence the cycle phases on each interrupt without stopping movement. EB0 is automatically initialised when a cycle is called (in programme %9970).

EB1: must be programmed when stopping of movement is requested by the user (e.g. when the final dimension is reached).

EB2: must always be programmed at the end of each grinding cycle. It means the cycle is finished and forces function G80.

ED.. **Wheel dressing selection** (G200/G201 to G216/G217)

Indicates which parts of the wheel are to be dressed (peripheral face and/or sides). Dressing is performed at the start of the grinding phase in which argument ED is programmed.
- ED1: diameter,
- ED2: left side,
- ED3: peripheral face and left side,
- ED4: right side,
- ED5: peripheral face and right side,
- ED6: left side and right side,
- ED7: peripheral face and left and right sides.



EG.. **Measurement selection** (G200/G201 to G206/G207-G212/G213-G214/G215)

Possible definition of the conditions for a measurement to be made during grinding:
- EG0: no measurement during the cycle
- EG1: gap elimination enabled
- EG2-EG9: measurement during the cycle; the current phase is stopped by an interrupt numbered 2 to 9
- EG98: conditional call for manual measurement (by setting parameter E20030 to 1)
- EG99: unconditional call for manual measurement.

> CAUTION
>
> When arguments EG1 to EG9 are programmed during a G2xx grinding cycle, functions M200 to M255 must not be used during the cycle. However, these functions can be programmed before or after the cycle.

EI.. **Case 1: Increment at start of traverse** (G206/G207-G210/G211-G214/G215)

Movement on the axis (X or Z depending on cycle) at the start of a discontinuous traverse.

Case 2: Pass Depth (G208/G209-G216/G217)

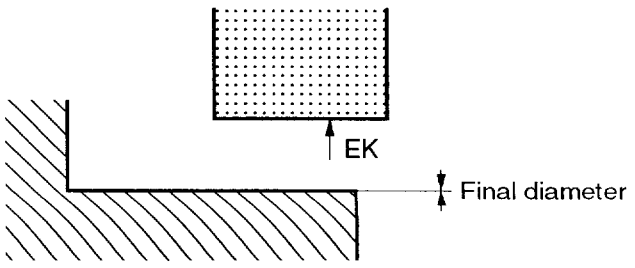
Depth of pass on the X axis.

EJ.. **Traverse end increment** (G206/G207-G210/G211-G214/G215)

Movement on the axis (X or Z depending on cycle) at the end of discontinuous traverse.

EK.. **Backoff distance** (G200/G201 to G216/G217)

Wheel backoff at the end of the current grinding phase.



EM.. **Offset modification selection** (G200/G201 to G206/G207-G210/G211-G214/G215)

Argument EM specifies whether or not the origin is to be shifted. It is used for compensating wheel wear. It takes into account the difference between the position of the axes and the measured dimensions. This parameter is meaningless unless the measurement system is active.

Argument EM is used to specify the three following possibilities:
- EM0: no modification
- EM1: modification of DAT1
- EM2: modification of DAT1 and the machine data.

It should be noted that if one of arguments EM1 or EM2 is programmed, both offsets (X and Z) can be modified (by intermediate measurement). However, during an in-cycle measurement, if only EM1 or EM2 is programmed, only the measured axis is corrected.

EM0: default value in programme %9970, no modification

EM1: DAT1 modified

EM2: modification of shift E60000 (X) or E62000 (Z) depending on the cycle as well as the DAT1 values in the machine data file.

EN.. **Number of sparkout passes** (G206/G207 to G210/G211-G214/G215-G216/G217)

Specifies the number of sparkout passes.

EO.. **Oscillation frequency** (G204/G205-G212/G213)

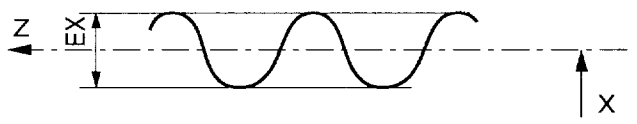
Oscillation frequency on X or Z (depending on the cycle). Expressed as a number of oscillations per minute (osc/min).

ET.. **Sparkout dwell time** (G200/G201 to G206/G207-G210/G211 to G214/G215)

Specifies the sparkout dwell time.

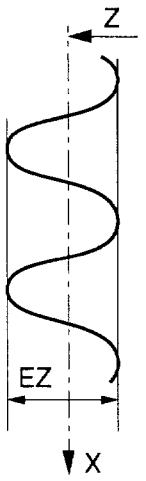
EX.. **Oscillation amplitude** (G212)

Amplitude of the oscillations on X.



EZ.. **Oscillation amplitude** (G214)

Amplitude of the oscillations on Z.



F.. **Case 1: Feed rate on X and/or Z** (G200/G201 to G204/G205-G212/G213)

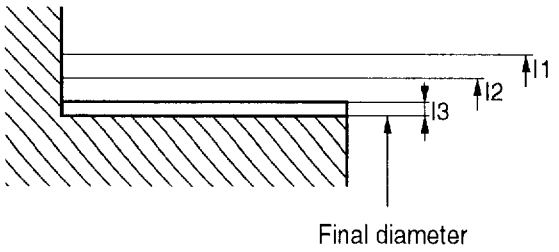
Wheel feed rate on X and/or Z (depending on the cycle).

Case 2: Incrementation feed rate (G206/G207-G210/G211-G214/G215)

Incrementation feed rate on X and/or Z (depending on cycle).

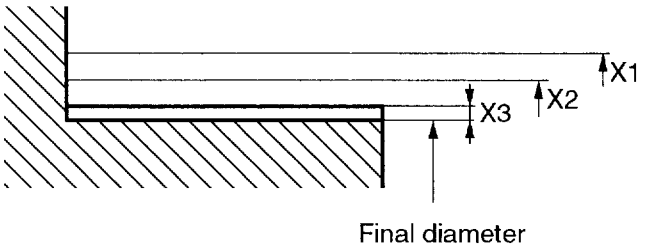
I.. **Allowance on final diameter** (G208/G209-G216/G217)

Allowance during the different phases of the cycle with respect to the final diameter on X (e.g. see figure below: roughing I1, semi-finishing I2 and finishing I3).



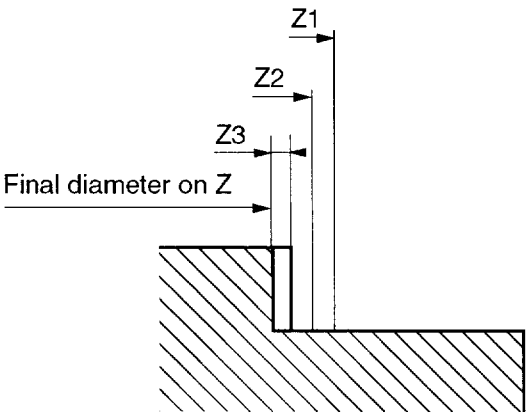
X.. **Allowance on final diameter** (G200/G201 to G206/G207-G210/G211)

Allowance during the different phases of the cycle with respect to the final diameter on X (e.g. see figure below: roughing X1, semi-finishing X2 and finishing X3).



Z.. **Allowance on final diameter on Z** (G212/G213-G214/G215)

Allowance during the different phases of the cycle with respect to the final diameter on Z (e.g. see figure below: roughing Z1, semi-finishing Z2 and finishing Z3).



Appendix A Summary Table of Syntax

A

A.1 Table of External Grinding Cycle Syntax

G200 : Plunge or multiplunge cycle (external) (see Sec. 2.10.2)

Syntax:
G200 X.. Z.. D.. [EZ..] EP.. [ER..] [EH..] [P..] [S..]
[X..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

G202 : Plunge cycle with inclined axis (see Sec. 2.10.3)

Syntax:
G202 X.. Z.. D.. EP.. EQ.. [ER..] [EH..] [S..]
[X..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

G204 : External oscillating plunge / multiplunge cycle (see Sec. 2.10.4)

Syntax:
G204 X.. Z.. D.. [EZ..] EP.. [ER..] [EH..] [P..] [S..]
[X..] [F..] [EZ..] [EO..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

G206 : External cylindrical traverse cycle (see Sec. 2.10.5)

Syntax:
G206 X.. Z.. D.. EZ.. EP.. F.. [ER..] [EH..] [EA..] [P..] [EE..] [EF..] [EC..] [S..]
[X..] [EI..] [EJ..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..]/[EN..] EB..

G208 : External profile grinding cycle (see Sec. 2.10.6)

Syntax:
G208 X.. Z.. D.. EP.. ES.. H.. N.. N.. F.. [EH..] [S..]
[I..] [EI..] [EN..] [EK..] [ED..] EB..

G210 : External conical traverse cycle (see Sec. 2.10.7)

Syntax:
G210 X.. EX.. / EU.. Z.. EZ.. D.. EP.. F.. [ER..] [EH..] [EE..] [EF..] [EA..] [P..] [EC..] [S..]
[X..] [EI..] [EJ..] F.. [EK..] [EG..] EM.. [ED..] [ET..] / [EN..] EB..

G212 : External oscillating shoulder cycle (see Sec. 2.10.8)

Syntax:
G212 Z.. X.. D.. EQ.. [ER..] [EH..] [S..]
[Z..] [F..] [EM..] [EG..] [ET..] [EK..] [ED..] [EO..] [EX..] EB..

G214 : External shoulder traverse cycle (see Sec. 2.10.9)

Syntax:
G214 Z.. X.. EX.. D.. EQ.. F.. [ER..] [EH..] [EE..] [EF..] EC.. [S..]
[Z..] [EI..] [EJ..] F.. [EG..] [EM..] [ED..] [ET..] / [EN..] [EK..] EB..

G216 :Shoulder cycle with fillet/chamfer (see Sec. 2.10.10)

Syntax:
G216 X.. Z.. EX.. D.. EZ.. EP.. ES.. EL.. R.. F.. [EH..] [S..]
[I..] [EI..] [ED..] [EN..] EB..

A.2 Tables of Internal Grinding Cycle Syntax

G201 : Internal plunge / multiplunge cycle (see Sec. 2.11.2)

Syntax:
G201 X.. Z.. D.. [EZ..] EP.. [ER..] [EH..] [P..] [S..]
[X..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

G203 : Plunge cycle with inclined axis (see Sec. 2.11.3)

Syntax:
G203 X.. Z.. D.. EP.. EQ.. [ER..] [EH..] [S..]
[X..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

G205 : Internal oscillating plunge / multiplunge cycle (see Sec. 2.11.4)

Syntax:
G205 X.. Z.. D.. [EZ..] EP.. [ER..] [EH..] [P..] [S..]
[X..] [F..] [EZ..] [EO..] [EG..] [EM..] [EK..] [ED..] [ET..] EB..

G207 : Internal cylindrical traverse cycle (see Sec. 2.11.5)

Syntax:
G207 X.. Z.. D.. EZ.. EP.. F.. [ER..] [EH..] [EA..] [P..] [EE..] [EF..] [EC..] [S..]
[X..] [EI..] [EJ..] [F..] [EG..] [EM..] [EK..] [ED..] [ET..]/[EN..] EB..

G209 : Internal profile grinding cycle (see Sec. 2.11.6)

Syntax:
G209 X.. Z.. D.. EP.. ES.. H.. N.. N.. F.. [EH..] [S..]
[I..] [EI..] [EN..] [EK..] [ED..] EB..

G211 : Internal conical traverse cycle (see Sec. 2.11.7)

Syntax:
G211 X.. EX.. / EU.. Z.. EZ.. D.. EP.. F.. [ER..] [EH..] [EE..] [EF..] [EA..] [P..] [EC..] [S..]
[X..] [EI..] [EJ..] F.. [EK..] [EG..] [EM..] [ED..] [ET..] / [EN..] EB..

G213 : Internal oscillating shoulder cycle (see Sec. 2.11.8)

Syntax:
G213 Z.. X.. D.. EQ.. [ER..] [EH..] [S..]
[Z..] [F..] [EM..] [EG..] [ET..] [EK..] [ED..] [EO..] [EX..] EB..

G215 : Internal shoulder traverse cycle (see Sec. 2.11.9)

Syntax:
G215 Z.. X.. EX.. D.. EQ.. F.. [ER..] [EH..] [EE..] [EF..] EC.. [S..]
[Z..] [EI..] [EJ..] [F..] [EG..] [EM..] [ED..] [ET..] / [EN..] [EK..] EB..

G217 : Shoulder cycle with fillet/chamfer (see Sec. 2.11.10)

Syntax:
G217 X.. Z.. EX.. D.. EZ.. EP.. ES.. EL.. R.. F.. [EH..] [S..]
[I..] [EI..] [ED..] [EN..] EB..

Appendix B Format Summary Tables

B.1 Argument Formats at Cycle Call - External Grinding Cycles

Format	Name	G2xx cycle	Unit or value
N05	Number of first and last profile block	G208	0 to 32767
H04	Number of profile subroutine	G208	0 to 9000
X053	Final diameter	G200 to G206, G216	mm
X053	Start point (X)	G208	mm
X053	Final diameter at start of taper	G210	mm
X053	Shoulder start diameter	G212, G214	mm
Z053	Plunge position on Z axis	G200, G204	mm
Z053	End point on Z axis	G202, G212, G214, G216	mm
Z053	Starting point on Z axis	G206, G208, G210	mm
EA01	Z and EZ overtravel during traverse	G206-G208-G210	0 to 3
EC01	Type of increment	G206 to G210, G214	0 or 1
EE022	Dwell time at start of traverse	G206, G210, G214	s
EF022	Dwell time at end of traverse	G206, G210, G214	s
EH053	Backoff diameter for dressing (or measurement)	G200 to G216	mm
EL053	Retraction on profile	G216	mm
EP053	Safety clearance on X axis (+ allowance)	G200 to G210, G216	mm
EQ053	Safety clearance on Z axis (+ allowance)	G202, G212, G214	mm
ER053	Skip diameter	G200 to G206-G210 to G214	mm
ES01	Radius offset	G208, G216	1 or 2
EU034	Angle	G210	Degrees
EX053	Final diameter at end of taper	G210	mm
EX053	End point on X axis	G214	mm
EX053	Starting point on X axis	G216	mm
EZ053	End point on Z axis	G200, G204, G206, G210	mm
EZ053	Starting point on Z axis	G216	mm

Format	Name	G2xx cycle	Unit or value
P053	Wheel overlap	G200, G204	mm
P053	Overtravel	G206, G210	mm
R053	Radius	G216	mm
F..	Traverse feed rate	G206, G210, G214	mm/min
F..	Feed rate along profile	G208	mm/min
F..	Feed rate along cylinder/shoulder	G216	mm/min
S..	Tangential wheel rotation speed	G200 to G216	m/s
D01	Choice of wheel side	G200 to G216	1 or 2

B.2 In-Cycle Argument Formats - External Grinding Cycles

Format	Name	G2xx cycle	Unit or value
X053	Allowance on final diameter	G200 to G206, G210	mm
Z053	Allowance on end point on Z axis	G212, G214	mm
I053	Allowance on final diameter	G208-G216	mm
EB01	Cycle sequencing selection	G200 to G216	0 to 2
ED01	Wheel dressing selection	G200 to G216	1 to 7
EG01	Measurement selection	G200 to G206, G212, G214	0 to 9, 98, 99
EI053 EI053	Increment at start of traverse Depth of pass	G206, G210, G214 G208, G216	mm mm
EJ053	Increment at end of traverse	G206, G210, G214	mm
EK053	Backoff distance	G200 to G216	mm
EM01	Offset modification selection	G200 to G206, G210 to G214	0 to 2
EN..	Number of sparkout passes	G206 to G210, G214, G216	ENn
EO..	Oscillation frequency	G204, G212	osc/min
ET022	Sparkout dwell time	G200 to G206, G210 to G214	s
EX053	Oscillation amplitude on X axis	G212	mm
EZ053	Oscillation amplitude on Z axis	G204	mm
F.. F..	Feed rate on X and/or Z Increment feed rate	G200 to G204, G212, G206, G210, G214	mm/min mm/min

B.3 Argument Formats at Cycle Call - Internal Grinding Cycles

Format	Name	G2xx cycle	Unit or value
N05	Number of first and last profile block	G209	0 to 32767
H04	Number of profile subroutine	G209	0 to 9000
X053	Final diameter	G201 to G207, G217	mm
X053	Start point on X axis	G209	mm
X053	Final diameter at start of taper	G211	mm
X053	Shoulder start diameter	G213, G215	mm
Z053	Plunge position on Z axis	G201, G205	mm
Z053	End point on Z axis	G203, G213, G215, G217	mm
Z053	Starting point on Z axis	G207, G209, G211	mm
EA01	Z and EZ overtravel during traverse	G207, G209, G211	0 to 3
EC01	Type of increment	G207 to G211, G215	0 or 1
EE022	Dwell time at start of traverse	G207, G211, G215	s
EF022	Dwell time at end of traverse	G207, G211,	s
EH053	Backoff diameter for dressing (or measurement)	G201 to G217	mm
EL053	Backoff on profile	G217	mm
EP053	Safety clearance on X axis (+ allowance)	G201 to G211, G217	mm
EQ053	Safety clearance on Z axis (+ allowance)	G203, G213, G215	mm
ER053	Skip diameter	G201 to G207, G211 to G215	mm
ES01	Radius offset	G209, G217	1 or 2
EU034	Angle	G211	Degrees
EX053	Final diameter at end of taper	G211	mm
EX053	End point on X axis	G215	mm
EX053	Starting point on X axis	G217	mm
EZ053	End point on Z axis	G201, G205, G207, G211	mm
EZ053	Starting point on Z axis	G217	mm

Format	Name	G2xx cycle	Unit or value
P053	End point on Z axis	G200, G204, G207, G211	mm
P053	Wheel overtravel limit	G217	
P053	Wheel overlap	G200, G204	mm
P053	Overtravel	G207, G211	mm
R053	Value of radius or fillet	G217	mm
F..	Traverse feed rate	G207, G211, G215	mm/min
F..	Feed rate along profile	G207	mm/min
F..	Feed rate along cylinder/shoulder	G217	mm/min
S..	Tangential wheel rotation speed	G201 to G217	m/s
D01	Choice of wheel side	G201 to G217	1 or 2

B.4 In-Cycle Argument Formats - Internal Grinding Cycles

Format	Name	G2xx cycle	Unit or value
X053	Allowance on final diameter	G201 to G207, G211	mm
Z053	Allowance on end point on Z axis	G213, G215	mm
I053	Allowance on final diameter	G209, G217	mm
EB01	Cycle sequencing selection	G201 to G217	0 to 2
ED01	Wheel dressing selection	G201 to G217	1 to 7
EG01	Measurement selection	G201 to G207, G213, G215	0 to 9, 98, 99
EI053 EI053	Increment at start of traverse Depth of pass	G207, G211 G215 G209, G217	mm mm
EJ053	Increment at end of traverse	G207, G211, G215	mm
EK053	Backoff distance	G201 to G217	mm
EM01	Offset modification selection	G201 to G207, G211 to G215	0 to 2
EN..	Number of sparkout passes	G207 to G211, G215, G217	ENn
EO..	Oscillation frequency	G205, G213	osc/min
ET022	Sparkout dwell time	G201 to G207, G211 to G215	s
EX053	Oscillation amplitude on X axis	G213	mm
EZ053	Oscillation amplitude on Z axis	G205	mm
F.. F..	Feed rate on X and/or Z Feed rate increment	G201 to G205, G213 G207, G211, G215	mm/min mm/min

Appendix C List of Errors

C.1 Error Messages in Measuring or Wheel Dressing Cycles

Error No.	Description
E301	DRESSER SETUP NOT EXECUTED
E302	PART SETUP NOT EXECUTED
E303	WHEEL NUMBER ERROR
E304	MACHINE DATA ERROR
E305	MACHINE MODE NOT EXECUTED
E306	PART COMPENSATION ERROR
E307	POSITIONING CYCLE - WORKHEAD SPEED ERROR
E308	CORRECTION VALUE OUT OF LIMITS
E309	MEASUREMENT OUT OF RANGE
E310	WHEEL LEFT SIDE NOT SHAPED
E311	WHEEL RIGHT SIDE NOT SHAPED
E320	WORKING WHEEL SIDE CODE NOT PROGRAMMED
E340	WHEEL GEOMETRICAL ERROR
E341	WHEEL DRESSING ERROR
E342	WHEEL SHAPING ERROR

C.2 Error Messages in External/Internal Grinding Cycles

Error No.	Description
E350	X: defining of X missing
E351	Z: definition of Z missing
E352	EP: plunge offset not programmed
E353	Wheel width zero
E354	Grinding distance < wheel width
E355	D: invalid tool correction number
E356	ER: invalid skip diameter
E357	EH: invalid safety diameter
E358	EC: invalid value
E359	EC: not programmed
E360	F: traverse feed rate not programmed
E361	EQ: stop distance not programmed
E362	EX: second X position not programmed
E363	EZ: second Z position not programmed
E364	EZ: oscillation amplitude not programmed
E365	R: not programmed
E366	EL: not programmed
E367	ES: invalid radius corrector
E368	ES: not programmed
E369	F: profile feed rate not programmed
E370	EX: oscillation amplitude not programmed
E371	F: plunge feed rate not programmed

Error No.	Description
E372	EI/EJ: increment not programmed
E373	ED: invalid dressing part
E374	EG: invalid measuring mode
E375	EB: invalid value
E376	S: cutting speed not programmed
E377	Maximum rotation speed exceeded
E378	T: tool nr must be [1-8]
E379	Wheel overlapping >= wheel width
E380	Part setup not executed
E381	Dressing setup not executed
E382	H: profile programme number not programmed
E383	N: profile sequence number not programmed
E384	Wheel size not correct
E385	Actual tool nr. <> initialised tool nr
E386	EU,EX: taper angle not correct
E387	Shoulder radius < stock
E389	Not enough space in dynamic operator table