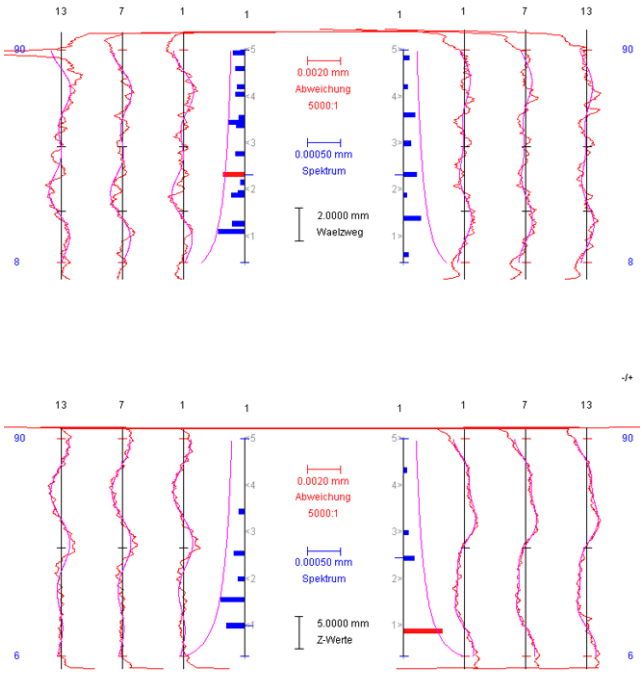
User Manual

KLINGELNBERG

Deviation Analysis Wave production

Software



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1 Introduction

1.1 Target Groups

Training by Klingelnberg-authorized professional trainers is a prerequisite for the safe operation of the program. Machine attendants must also have an appropriate understanding of gearing geometry and relevant production experience.

1.2 Conventions in This Manual

The following writing conventions are used in this document:.

Writing Convention	Used for	Meaning / Action
[F6] [OK]	Key, switch, button	– Press the “F6” key on the keyboard. – Click the [OK] button.
[CTRL] + [N]	Key combination	Press “CTRL” and “N” at the same time.
[Apply] / [OK]	Buttons	Press buttons one after the other.
«Workpiece»	Menu name, input window	– Select the “Workpiece” menu command. – A window called «Workpiece» opens.
«Workpiece» / «Data»	Sequences of menu commands	First point to the “Workpiece” menu, then choose the “Data” submenu.
<Number of teeth>	Input Field	Enter a value for the number of teeth in the “Number of teeth” input field.
<Run-out> – <Top> – <Bottom>	Selection field	For the “Runout” choice field, a choice must be made between <Top> and <Bottom>.
<Save changes?>	Program message	Requires a response.
–Coordinates–	Input block of the graphical user interface	Collective designation for fields that are grouped together in a frame.
Operation *Operation / Editing*	Cross references, chapter titles	See chapter titled *Operation*. See chapter titled *Operation*, *Editing* section.
File.xls	Proper name, file name, directory	The *file.xls* file is located …

Tab. 1 Conventions in this manual

1.2.1 General Operating Notes

This program makes use of the basic menu-navigation rules for Microsoft Windows programs; knowledge of these rules is therefore a prerequisite.

1.2.2 Calling a Menu or Function

Menus and functions are selected as shown below.

Select «xxxx» menu

Following the menu call is the GUI window or, in the case of a simple window layout, a list of the parameters to be entered.

1.2.3 Procedural Instructions

Procedural instructions describe steps that must be carried out in order:

- A result or intermediate result is shown with a check mark.
- The word “Result” indicates a final result achieved after a number of steps.

Example

1. First step
2. Second step
   ☑ *Intermediate result*
3. Third step

Result Endresult

1.2.4 Warning Labels

The NOTICE warning label indicates a situation that could result in damage to equipment or property.

NOTICE

Type and source of hazard!
Consequences if not observed
▶ Actions to avoid the hazard

1.2.5 Additional notices

Mandatory action notice

A mandatory action notice contains important information that is to be observed and can include the following:

- Technical regulation
- Important notice

Information that must be observed.

General notice

A general notice is a piece of information to improve understanding and can include the following:

- Background information
- Specific data

Information provided for better understanding.

2 Software Description

2.1 Scope of delivery

The program generally comes pre-installed on Klingelnberg gear measuring centers. Subsequent installations and add-ons are handled by Klingelnberg Service.

2.2 Intended Use

The *Deviation Analysis Wave Production* program is a sub-program of the *Deviation Analysis* program and is used for wave analysis in combination with a Klingelnberg gear measuring center and Klingelnberg measuring software. The program launches automatically following a measurement.

2.3 Description of the software function

The program processes data from a previous single-error test (such as cylindrical gear measurement), enabling the detection and description of waviness in a deviation curve.

Based on calculated deviation curves for the profile and tooth trace, a frequency spectrum is calculated and displayed for every curve. The largest local maximum is identified within an adjustable evaluation range of frequencies. This frequency is plotted on the deviation curve and output as a parameter in amplitude and wave number.

The next frequencies are then determined incrementally, whereby the output curve and maximum frequency are reduced each time. A new spectrum is calculated, and a new maximum frequency is determined from the remaining deviations.

The calculated frequencies are not just individual; they can also be represented as a cumulative curve to see how well the sine curves approximate the actual deviation curve.

2.4 Installation

The program comes pre-installed on Klingelnberg gear measuring centers.

Subsequent installations are handled by Klingelnberg Service.

2.4.1 General Operating Notes

This program makes use of the basic menu-navigation rules for Microsoft Windows programs; knowledge of these rules is therefore a prerequisite.

2.4.2 Data backup

The user is entitled to make one copy of the software for backup or archiving purposes, or to transfer the software to a single hard disk, provided the user keeps the original solely for backup or archiving purposes.

Data backup by the user:

- regular data backups are recommended.
- the data backup procedure is discussed during the training course for machine attendants. For any questions, please contact Klingelnberg Service.

2.4.3 Update

Carry out the steps below to update the software:

- Back-up data
- Copy the update files to the program folder. When you do this, all the old data is overwritten.

3 Operation

3.1 Automatic launch from measuring program

The *Deviation Analysis – Wave Production* program can be launched automatically from a measuring program (such as *Klingelnberg Cylindrical Gear Measurement*).

During an automatic launch from the*Cylindrical Gear Measurement* program, settings are configured for the overall system, which cannot be modified subsequently.
This includes the paths for configuration files (*.dst), for tolerance value files (*.tol) and for measured data to be loaded automatically.

Sequence

After a measurement is completed, the measured data are transferred automatically to the *Deviation Analysis – Wave Production* program. The program launches, performs the wave analysis and is then exited directly. The results of the wave analysis are provided as a printout, a PDF file, or both, depending on the settings.

The PDF file is stored in the same location (the path is fixed) under the same name as the measurement, but with the extension *_WA*.

Example:

File name for measurement	*TEST-Wave_20140131102258.pdf*
File name for wave analysis	*TEST-Wave_20140131102258_**WA**.pdf*

3.1.1 Wave analysis settings for automatic launch

The evaluation parameters are defined and the wave analysis takes place within the program itself. This requires the *Wave Production* program to be launched separately and the configuration to be saved once the settings have been changed.

It is important to save the configuration file in the fixed path (see chapter *«File» main menu / Loading and saving the configuration*). This configuration file must be selected in the *Cylindrical Gear Measurement* program to launch Wave Production. The same applies for the file with the tolerance values (see chapter *Wave analysis / Wave settings*, section *Tolerances / Tolerance file*).

To launch the *Wave Production* program, the *Cylindrical Gear Measurement* program requires a defined memory location for configuration and for the tolerance values. The *Wave Production* also requires a defined memory location for automatic loading of the measured data.

The defined memory location is set up by Klingelnberg Service. Changes to the path or name of the memory location will cause errors in the program execution.

3.1.2 Settings in the Cylindrical Gear Measurement program

The configuration file (*.dst) and the file with the tolerance values (*.tol) that will be used to launch the *Wave Production* program must be selected in the measuring program. The files must first be saved in the fixed path.

Settings

1. In the *Cylindrical Gear* main menu, select «Export».
   ☑ *«Export» menu is displayed*

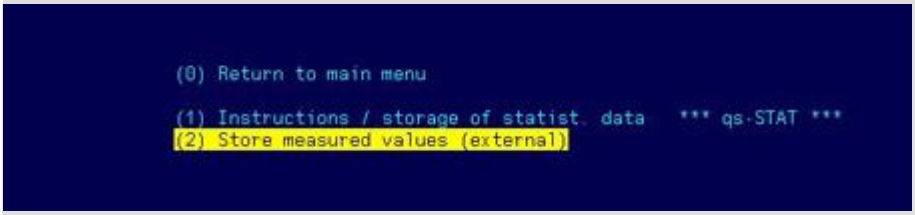

Fig. 1 «Export» menu

2. Select «(2) Store measured values (external)»
   ☑ *The «(2) Store measured values (external)» menu is displayed.*

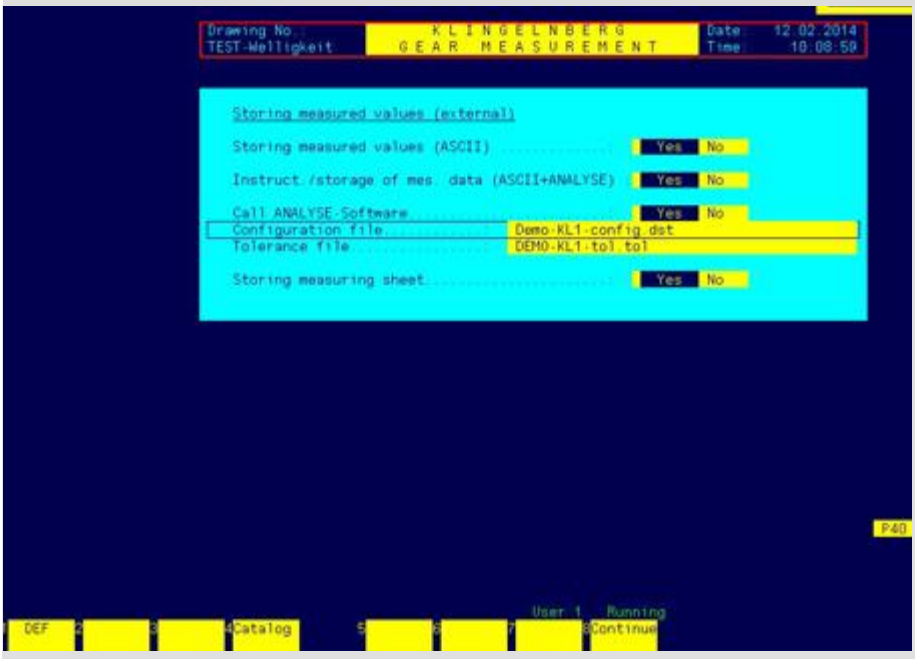

Fig. 2 «Store measured values (external)» menu

☑ *All settings are set to <yes>.*

3. Select the <Configuration file> entry and select the desired file.

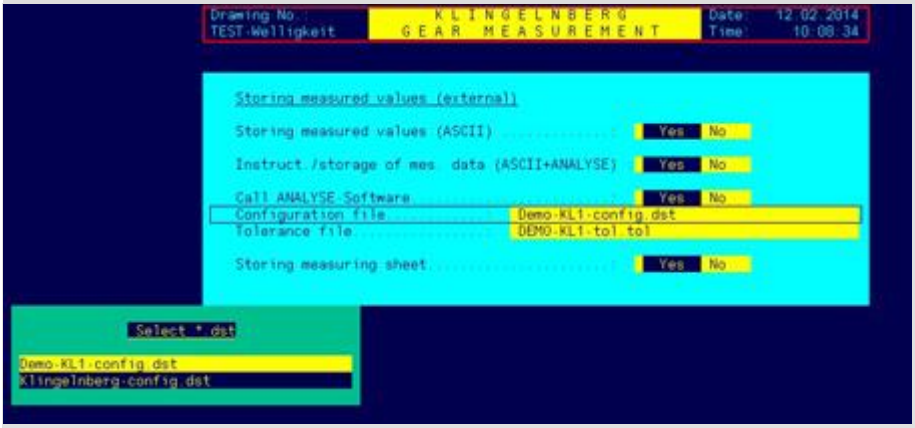

Fig. 3 Selecting the configuration file

4. Select the <Tolerance file> entry and select the desired file.

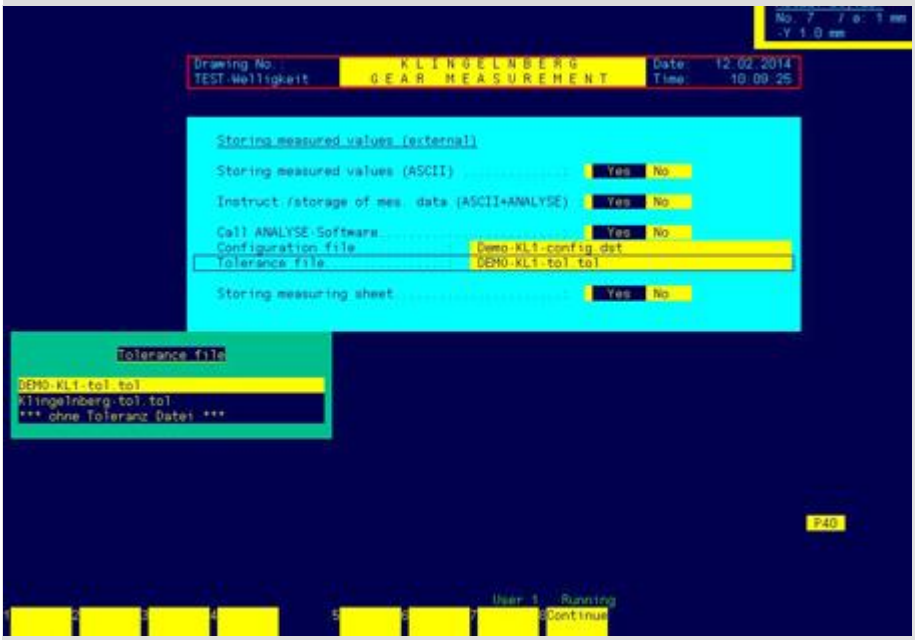

Fig. 4 Selecting the file with the tolerance values

5. Return to the main menu.

Result The settings are saved.

3.2 Graphical User Interface

Once the program has started up, the graphical user interface (GUI) is displayed with the following layout.

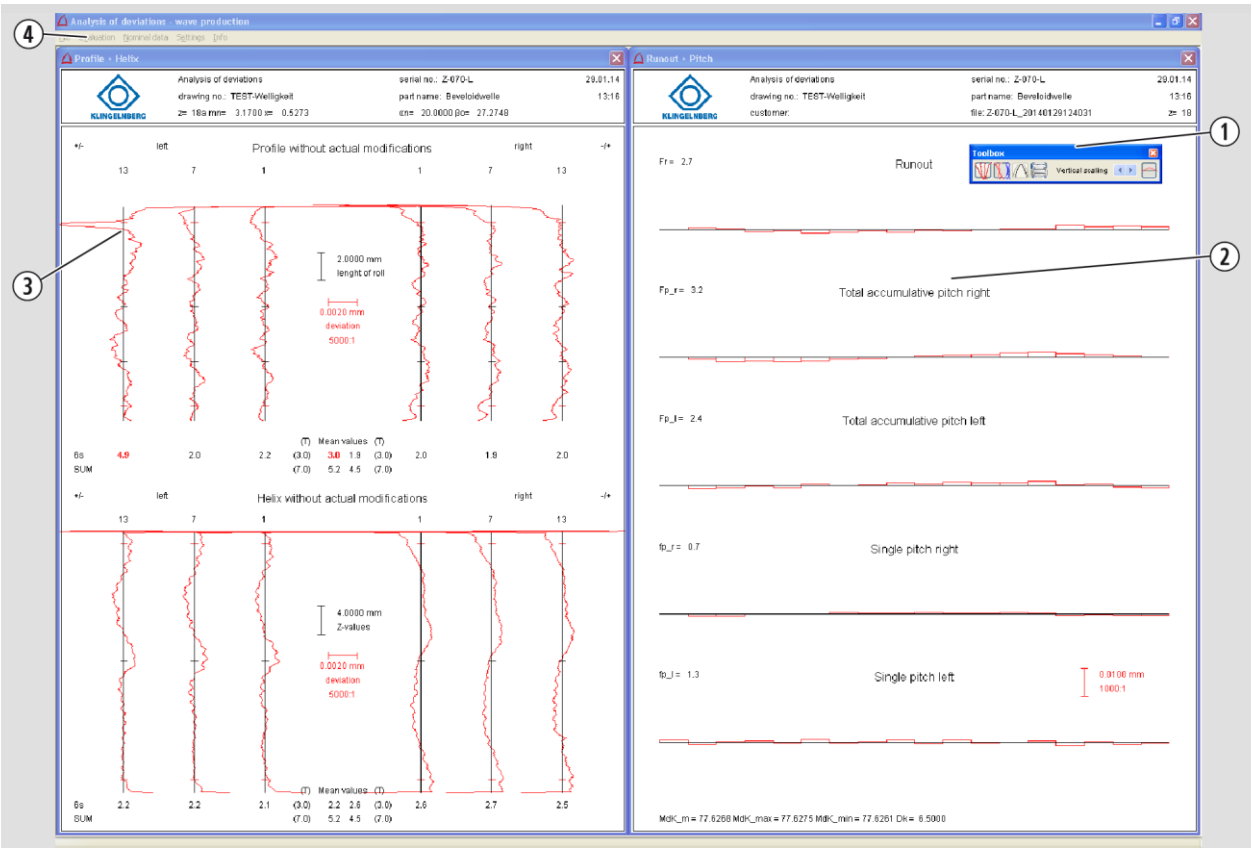

Fig. 5 GUI overview

① *Toolbox*

② *Waviness and pitch diagram*

③ *Profile and lead diagram*

④ *Main menu*

3.2.1 Profile and lead diagram

The profile is measured in the transverse section of the gearing. The lead is measured as a line on a fixed diameter or as a helix for helical gearing. Both measurement types give a dimension for the shape of individual teeth.

Profile deviations are plotted as a curve over the rolling path; the deviation of the lead is plotted over the Z height in the direction of the axis. A perpendicular line is produced if there are no deviations from the nominal values.

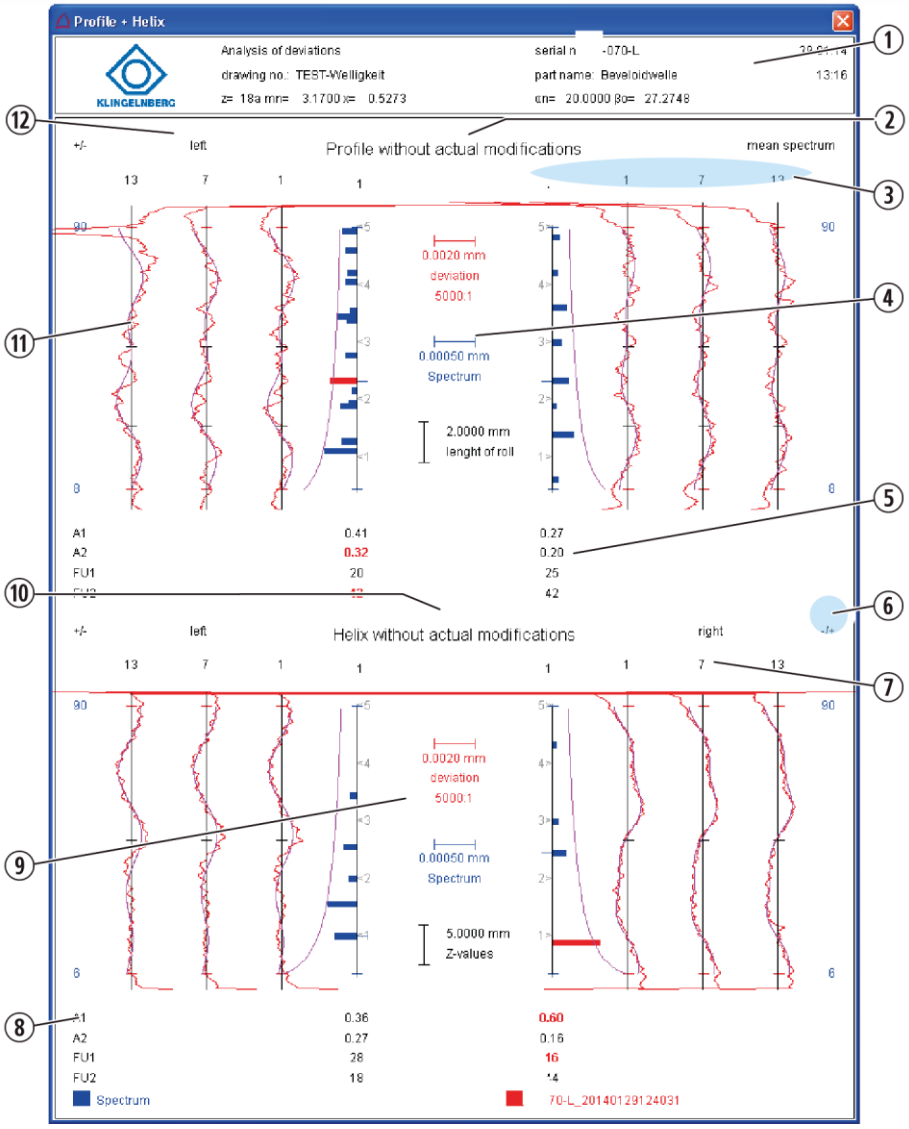

Fig. 1 Profile and lead diagram

①	Workpiece and protocol head data (also for concentricity and pitch)	– Number of teeth z – Normal module mn – Pressure angle an = αn – Addendum modification coefficient x – Helix angle βo
②	Diagram	Deviations of the profile or lead
③	Tooth number	Number of the tooth whose deviation will be displayed
④	Scale	– vertical: profile along the rolling path – horizontal: deviations from the reference line / spectrum
⑤	Profile parameters	– A = amplitude – F = frequency over the evaluation range – FR = frequency per revolution – L = wavelength – FL = wavelength per mm
⑥	+ / -	Material display: too much (+), too little (-)
⑦	Tooth number	Number of the tooth whose deviation will be displayed
⑧	Lead parameters	– A = amplitude – F = frequency over the evaluation range – FR = frequency per revolution – L = wavelength – FL = wavelength per mm
⑨	Scale	– vertical: lead over the Z height – horizontal: deviations from the reference line / spectrum
⑩	Diagram	Tooth trace deviations
⑪	Nominal values	Nominal values, black line; measured values, red; compensation curve, pink
⑫	Tooth flank	Tooth flank is indicated by <right> and <left>

Information on parameters can be found in the chapter titled *Parameters used*.

3.2.2 Runout and wave diagram

The position of the teeth with respect to one another is analyzed with a measurement of the pitch. This is done by probing the tooth flanks in the transverse section.

Deviations are plotted as a horizontal curve over all teeth. Pitch deviations are shown separately for the right and left flank. The individual pitch variation describes the deviation of two adjacent tooth flanks on the same side. The cumulative pitch deviation is obtained by adding up the individual deviations. It describes the rotation error between the teeth of the gear.

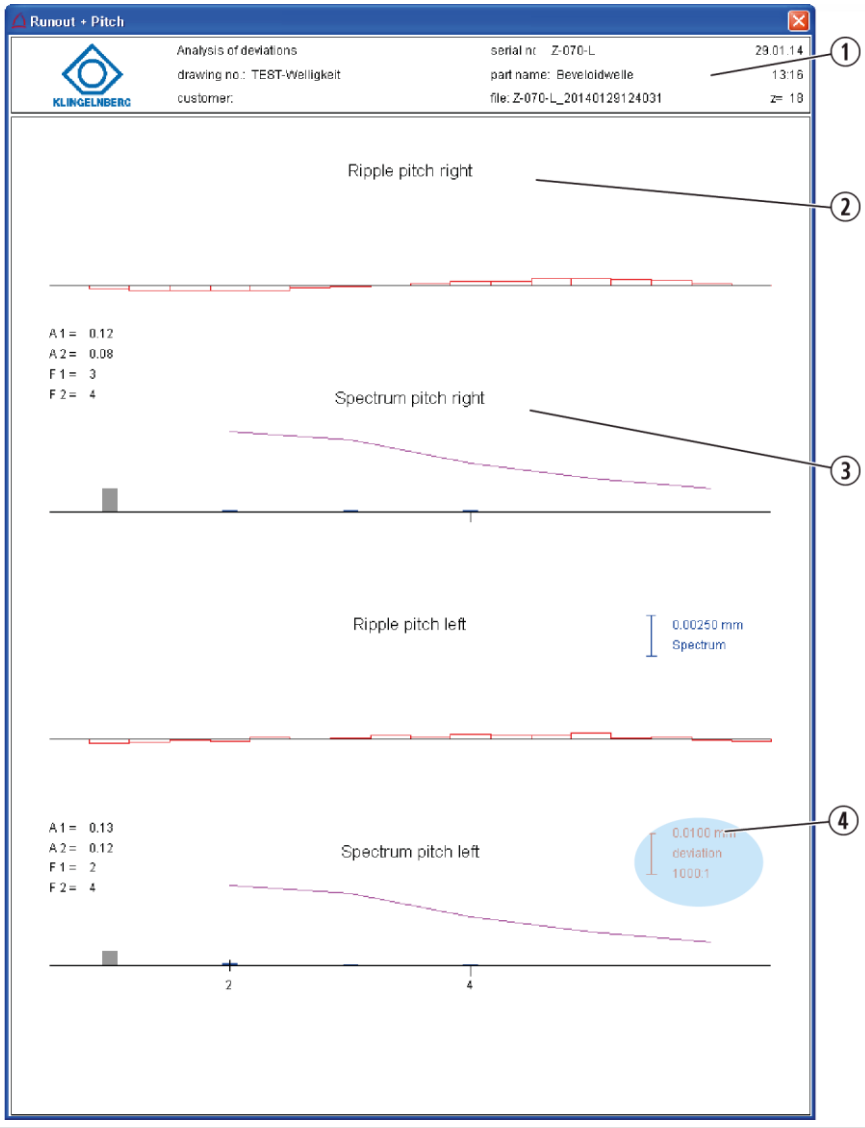

Fig. 1 Runout and wave diagram

①	Workpiece data	– Workpiece number, customer number, order – Date and time of the measurement – Name of measured data file
②	Pitch wave	Accumulative tooth spacing
③	Pitch spectrum	– Spectrum and compensation curve
④	Scale	Scale for deviations from the reference line / spectrum

3.2.3 Main menu

When a main menu command is clicked, the submenu opens.

«File»	– Loading measured data – Print – Save – Export characteristic values of wave – Load and save configuration – Close the program
«Evaluation»	– Wave analysis
«Nominal data»	– Edit nominal data with involute
«Settings»	Define program settings for representation, language, import / export, sequence and evaluation
«About»	Information on manufacturer and program version

Tab. 1 Main menus and sub-menus

Certain menus can be opened by means of a key combination, for example, Print = [CTRL]+[P].

3.2.4 Help Text

For certain functions and input fields, a help text appears when the mouse pointer pauses over them.

After a brief time, the help text on the mouse pointer disappears; however, the system still displays it at the bottom left edge of the screen.

3.2.5 Toolbox

Tool box functions change the way the measuring curves are displayed.

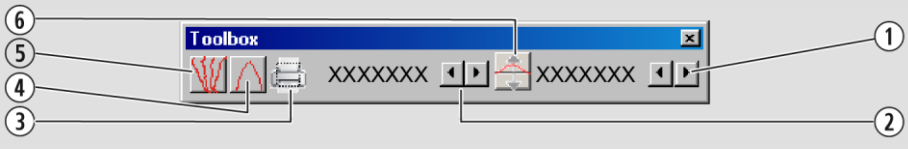

Fig. 2 Toolbox

①	<Simulation step>: The [>] and [<] buttons increase and decrease the scale of the representation, respectively. Notice: The system always displays the current pitch in the help text for these buttons
②	<Vertical scaling>: The [>] and [<] buttons and the [+] and [-] keys increase and decrease the scale of the representation, respectively. The mouse wheel performs the same function.
	③ Print current representation
	④ Move curve by tooth thickness deviation Moves the curves by the tooth thickness deviation that was measured for the pitch. Clicking the button again displays the status prior to the move. Prerequisite: The pitch has been measured.
	⑤ Show teeth one on top of the other or individually – When the button is pressed, it changes appearance and thus symbolizes 2 states. – The function can also be switched back and forth via the menu sequence «Settings» / «Display» –Draw– <Combined curves>.
	⑥ Button for separating the pitch – Active = Scaling factor is only used on the profile – Not active = Scaling factor is used on the profile and the pitch
	Measuring curves for each tooth are drawn one next to the other.
	Measuring curves for each tooth are drawn one on top of the other.

The location of the tool box on the graphical user interface is stored in the configuration.
The tool box opens automatically when the program starts. If it is closed by clicking [x], it will appear again the next time the program starts.

3.2.6 Error Message

If an error message is displayed, do the following:

- Find and fix the problem
- Perform the function again

If an unexplainable error occurs, proceed as follows.

1. In the «Settings» menu, choose «General».
2. Select the <Process file> field.
   ☑ *This generates a file that will save every entry from this point on.*
3. Send the *verlauf.log* (process.log) file, the *.dst configuration file, and the used measured data file to Klingelnberg Service.

Result The error is analyzed.

3.3 Closing the Program

The program can be exited as follows:

- Select the «File» main menu, then point to «Exit».
- Click the [x] button at the top right.
- Enter the key combination [ALT]+[F4].

3.4 «File» main menu

Measured data can be loaded and measurement results can be printed here. The current program setting can be saved as a configuration and reloaded, and the wave parameters can be exported.

«File» main menu

Menu command	Meaning
«Load measured data»	Loads data in **mka* format. Optional loading of GDE files in **.xml* format
«Print»	Prints the displayed results. Notice: The PDF printer is selected in the «Settings» «General» <Printer PDF output> menu.
«Export characteristic values of wave»	The system saves the characteristic values of wave analysis to a file in the desired format (e.g. *.csv) that corresponds to the Wave settings.
«Load configuration» «Save configuration»	A configuration with the program settings can be saved for each job. This configuration is reloaded for identical or similar jobs.
«Save configuration as»	Saves the configuration file under a new name or location
«Exit»	Closes the program.

Tab. 1 «File» main menu

3.4.1 Loading measured data

Measured data are transferred by the measuring program following the measurement on the Klingelnberg precision measuring center. The program then launches with the measured data, performs the wave analysis and is then exited directly. The results of the wave analysis are provided as a printout, a PDF file, or both, depending on the settings.

The evaluation parameters are defined and the wave analysis takes place within the program itself. This requires the *Wave Production* program to be launched separately and the configuration to be saved once the settings have been changed.

Settings for the evaluation sequence are configured in the following menu:

«Settings» / «Sequence» menu

GDE data

The GDE data option is available only in conjunction with the 7.x cylindrical gear software. A GDE format is not available for Klingelnberg's standard cylindrical gear software.

3.4.2 Loading and Saving the Configuration

Positions of the displayed windows and settings for the *Deviation analysis* program are stored in the configuration file.

A configuration file should be created for each job and saved along with the respective measured data.

The directory in which the configuration was saved or the set import directory is displayed automatically when measured data is loaded. If the configuration was saved near the measured data, the path to the measured data can easily be found.

The configuration has the extension **.dst*.

<Load configuration>

1. In the «File» menu, select «Load configuration».
2. Find the directory for the configuration.
3. Select the configuration with the left mouse button.
4. Click the [Open] button.
   ☑ *The configuration opens.*

<Save configuration>

In the «File» menu, select «Save configuration».

☑ *The current configuration is saved. This overwrites the previous configuration.*

<Save configuration as>

1. In the «File» menu, select «Save configuration as».
2. Find the directory for the configuration.
3. Enter the file name for the configuration.
4. Click the [Save] button.
   ☑ *The configuration is saved under a new name.*

<Reverse configuration changes>

In the «File» menu, select «Reverse configuration changes».

☑ *Resets the configuration to its status at the start of the program or the last time the configuration was loaded.*

3.4.3 Exporting Characteristic Values of Ripple

You can save the results of a ripple analysis to a file in accordance with the Ripple settings in the desired format.

«File» / «Export characteristic values of ripple» menu

1. In the «File» menu, select «Export characteristic values of ripple».
   ☑ *The Windows file save window opens.*
2. Specify a path and file name.
3. Click [Save].

Result The system saves a file containing all specifications for spectrum and ripple.

3.4.4 Print

Printout of all diagrams.

«File» / «Print» menu

1. Select the menu sequence.
   ☑ *The «Print» window opens in Windows.*
2. Select a printer and specify settings if necessary.
3. Click [OK].

Result Diagrams are printout out.

3.5 «Evaluation» main menu

3.5.1 Start of evaluation

Prerequisites

The following criteria must be fulfilled:

- at least four teeth should be measured.

«Evaluation» / «Wave analysis» menu

1. Select the «Evaluation» «Wave analysis» menu (if not started automatically).
   ☑ *The wave is calculated and displayed according to the settings («Settings» / «Wave» sequence of menu commands).*
   ☑ *A frequency spectrum with the 10 (default value) greatest amplitudes is calculated. The sine function with the greatest <Wave 1> amplitude is plotted on the deviation curves.*
   ☑ *The «Wave analysis» window opens.*

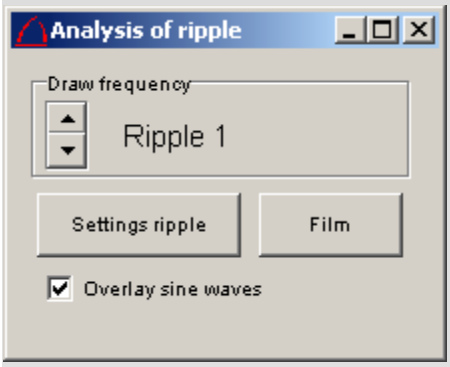

Fig. 1 «Wave analysis» window

–Draw frequency–	
<Wave 1>	Select a frequency for the wave (1 – 10) to be used to represent the sine wave.
[Settings wave]	Opens the settings window for wave analysis.
[Film]	Shows profile and lead deviations in rapid sequence. Any changes in the phase position of the wave from one tooth to the next can be seen here.
<Overlay sine waves>	If selected, the approximated sine curves in the diagram for the profile and leads of each wave are superimposed to form a combined curve. If not selected, the curves from previous evaluations are removed, and only the latest evaluation is shown.

Tab. 1 «Wave analysis» functions

3.5.2 Compensating Sine Wave

The first dominant frequency with the greatest amplitude is called f1 (–Draw frequency– field <Ripple 1>). A compensating sine wave with this frequency and amplitude is plotted in lilac on the measuring curve.

Here is an example:

- Left flank: f1 = 31 Hz, amplitude = 0.29 µm
- Right flank: f1 = 27 Hz, amplitude = 0.29 µm

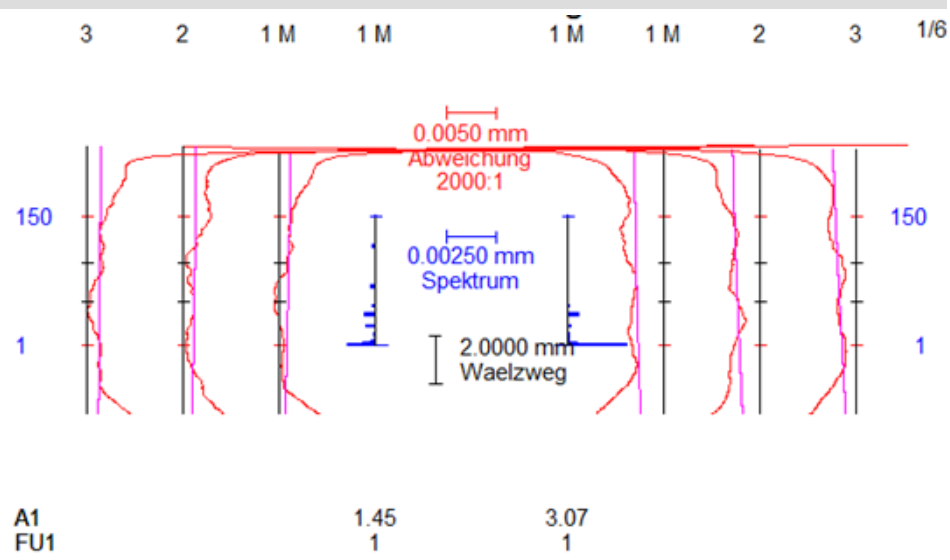

Fig. 2 Ripple with compensating sine wave f1

By clicking the arrows in the –Draw frequency– field, you can decrease the curve by the dominant frequency. A new maximum frequency and the spectrum are determined from the remaining deviations (–Draw frequency– field <Ripple 2>).

If the <Overlay sine waves> box is selected, a compensating sine wave obtained from the sine functions of the other frequencies is plotted as a lilac curve. The overlaid sine function approximates the deviation curve as the order increases.

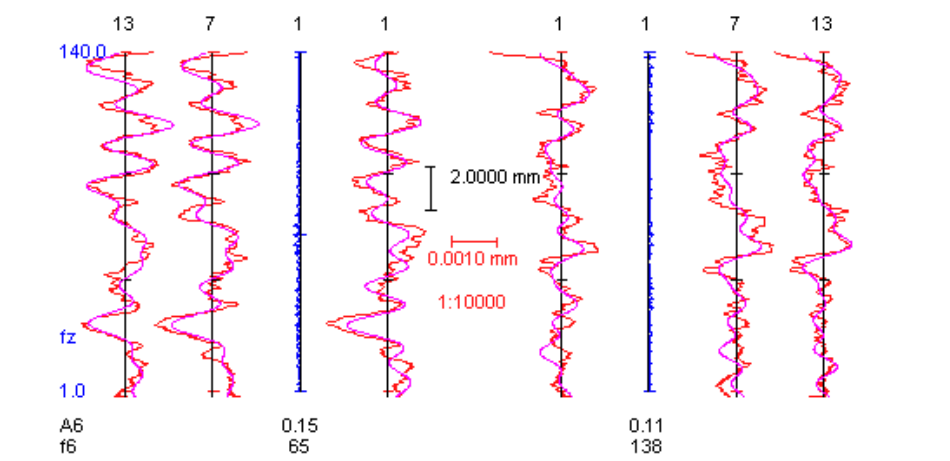

Fig. 3 Ripple with 6 overlaid sine functions

3.6 «Nominal data» main menu

Nominal data correspond to the nominal geometry of a workpiece and are included in the measured data, Measured data are always compared against nominal data, and the deviation is calculated.

3.6.1 Editing Nominal Data

Individual gear parameters and evaluation ranges are modified to observe the effects on the measurement results. Necessary corrections can be determined in this way. For example, a localized evaluation can be performed without first measuring the crowning.

«Setpoint» / «Process involute» menu

1. On the «Setpoint» menu, select «Process involute».
   ☑ *The «Process involute» window opens. The setup and parameters are described in the next section.*
   ☑ *The values in the input fields correspond to the gear data that was used for the measurement.*
2. Enter the desired modifications.
3. Press [Proposal] to calculate and display a proposal for the evaluation range and the ball diameter for the 2-ball dimension.
4. Click [OK] to accept the data.
5. Click [Cancel] to discard the changes.
   ☑ *Parameters and curves are calculated and displayed.*

Result The nominal data has been edited.

3.6.2 Nominal Data / Involute Parameters

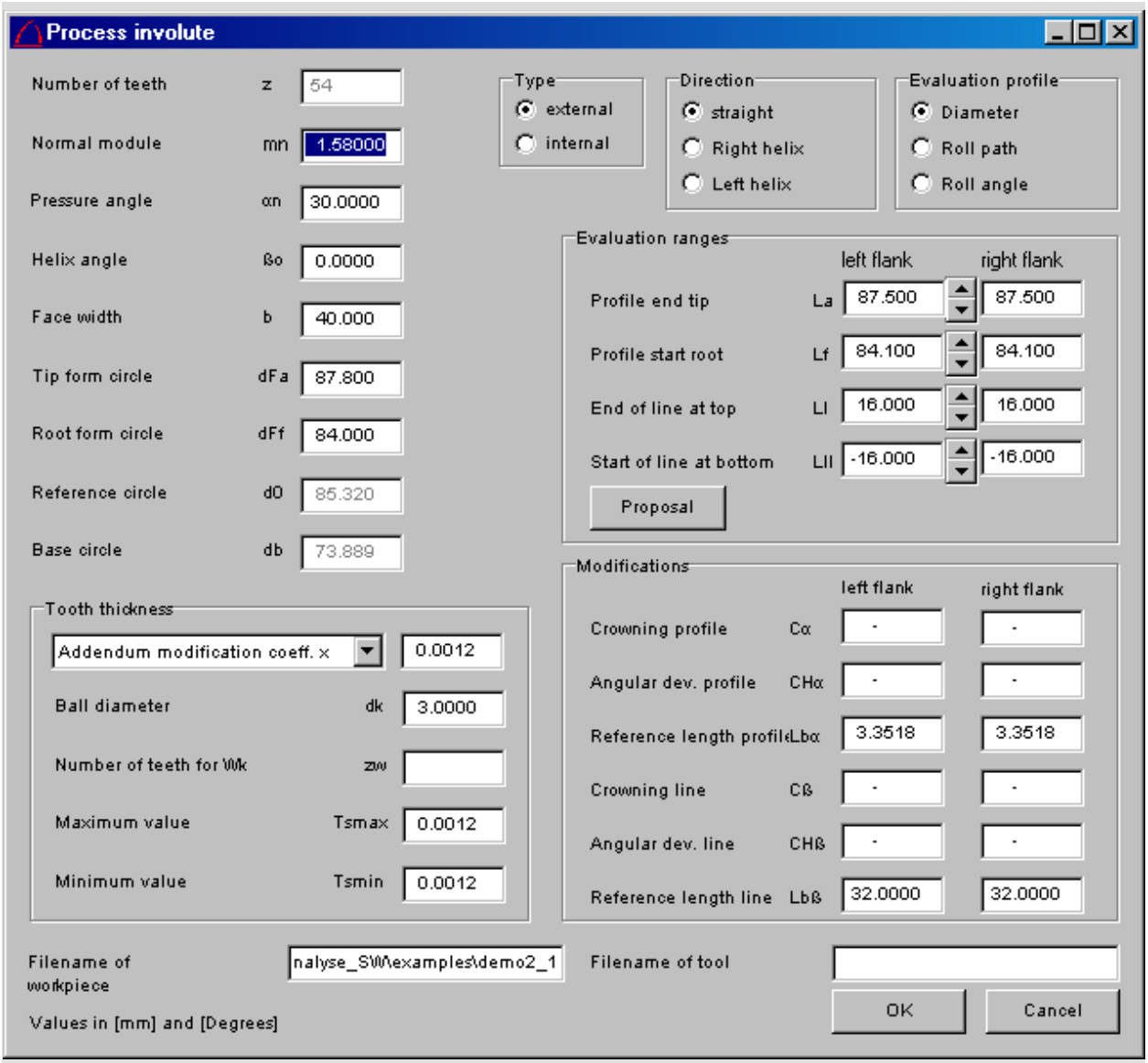

Fig. 1 «Edit involute» window

Input field	Meaning
<Number of teeth> z	Number of teeth on the workpiece
<Normal module> mn	Normal module
<Pressure angle> αn	Pressure angle
<Helix angle> β0	Helix angle
<Face width> b	Face width
<Tip form circle> dFa	Tip form circle
<Root form circle> dFf	Root form circle

Input field	Meaning
<Reference circle> d0	Reference circle
<Base circle> db	Base circle
–Type–	Type of gearing: – <External> – <Internal>
–Direction–	Direction of gearing: – <straight> – <right helix> – <left helix>
–Evaluation profile–	Specification of the type of description of evaluation ranges for the profile: – <Diameter> – <Roll path> – <Roll angle> Notice: When you change the type of description, the system converts the ranges online.
–Tooth thickness–	Nominal values and tolerance for tooth thickness
Selection: – <Addendum modification co-eff.> x – <2-ball dimension> MdK – <Base tangent length> Wk – <Normal tooth thickness> sn – <Radial tooth thickness> st	Parameters based on the definition of how the tooth thickness is evaluated. Notice: When you change the parameters, the system converts the tooth thickness values online.
<Ball diameter> dk	Diameter of measuring ball for calculating concentricity and 2-ball dimension
<Number of teeth for Wk> zw	Number of measured teeth for calculating the base tangent length
<Maximum value> Tsmax	Maximum value for the tooth thickness tolerance
<Minimum value> Tsmin	Minimum value for the tooth thickness tolerance
–Evaluation range–	Evaluation ranges on the left and right tooth flank. See *Evaluation range* drawing. Notice: If you use the arrow keys to change the evaluation ranges (refer to the toolbox for the pitch), all the characteristic values and graphics are changed online. This makes it possible to view the effect of changes to the evaluation ranges.
<Profile end tip> La	End of profile evaluation at tooth tip
<Profile start root> Lf	Start of profile evaluation at tooth root
<End of line at top> Ll	End of lead evaluation at top, in relation to tooth center
<Start of line at bottom> Lll	Start of lead evaluation at bottom, in relation to tooth center
[Proposal]	A proposal for the evaluation range is calculated from the tip and root diameter and face width and entered in the input fields in the --Evaluation range-- group. In the --Tooth thickness-- group, a suggestion is entered for <Ball diameter> and <Number of teeth base tangent length>.
–Modifications–	Planned deviations from the nominal form of the involute
<Crowning profile> Cα	The planned deviation is a crowned profile from
<Profile angle deviation> CHα	The planned deviation is a slope of the nominal form
<Reference length profile> Lbα	Length along the rolling path to which the profile modification applies
<Crowning line> Cβ	The planned deviation is a crowned lead form

Input field	Meaning
<Line angle deviation> CHβ	The planned deviation is a slope of the nominal form
<Reference length line> Lbβ	Length on the lead in the axial direction to which the modification applies
<Filename of workpiece>	Path and name of file containing the workpiece nominal data
<Filename of tool>	In preparation
<Values in>	Specifies the units used to define lengths and angles.

Nominal data / involute parameters

Measurement units for lengths and angles are defined using the «Settings» / «General» sequence of menu commands.

Evaluation range

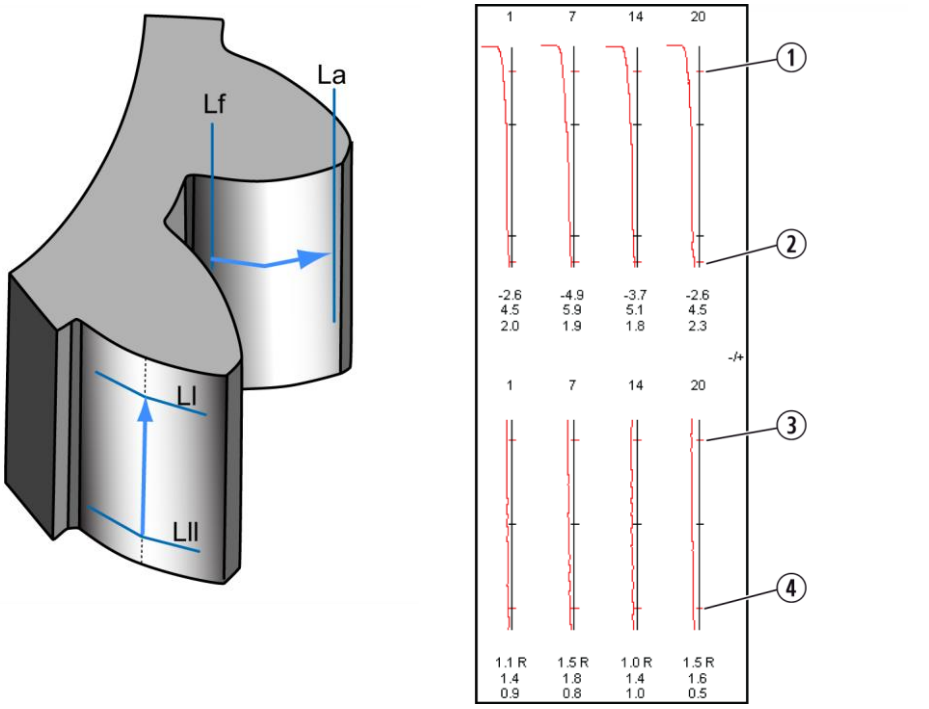

Fig. 2 Evaluation range

①	*La, profile end tip*	③	*LI, top tooth trace*
②	*Lf, profile end root*	④	*LII, bottom tooth trace*

Horizontal black lines in the diagram indicate the reference circle or V-circle that differ due to the addendum modification coefficient (with the lead, half the gear width).

3.7 «Settings» main menu

Basic settings for the representation and function of the program and the wave analysis are made in the «Settings» main menu.

«Settings» main menu

Sub-menus	Meaning
«Display»	Graphics display type
«General»	Language for GUI and for printouts, units, and font sizes
«Sequence»	Automatic calculations that take place when a measured data file is opened.
«Wave»	Option: Parameters for wave analysis
«Import / Export»	Importing of measured data in GDE format

Tab. 1 «Settings» main menu sub-menus

3.8 Customizing the Presentation

Customizing the graphics presentation.

«Settings» / «Display» menu

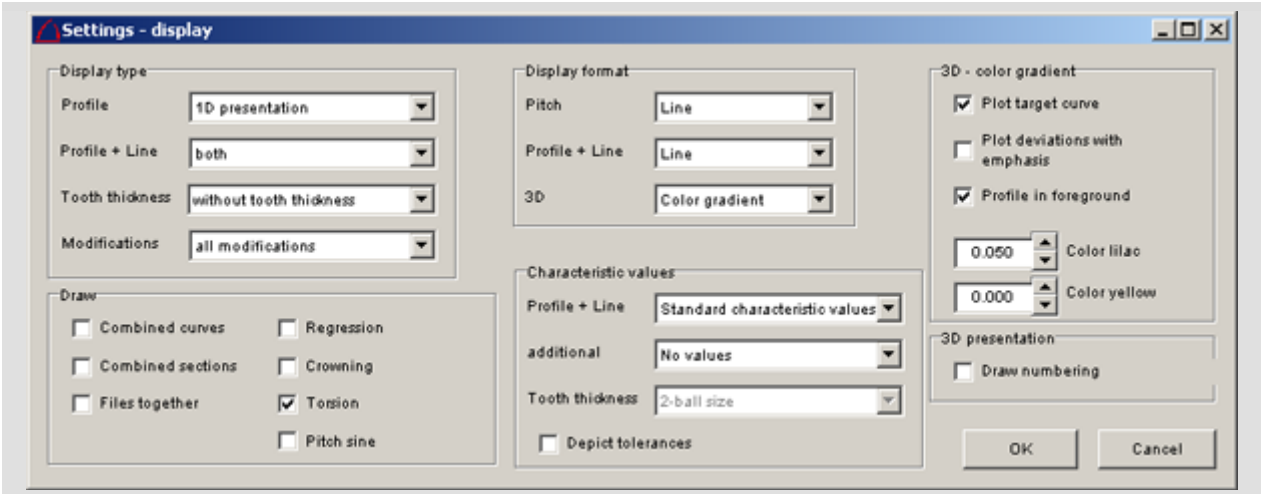

Fig. 1 «Settings - Display» window

–Display type–	Choice for evaluation: – Presentation in 1D or 2D – Profile only, lead only, or both – With or without tooth thickness, material and tolerance – Without target modifications or actual modifications – All modifications
–Display format–	Presentation of deviations: – Line diagram or block diagram for pitch deviation – Lines or filled-in areas for profile and leads – Lines, filled in or with color gradients for 3D presentation
–Characteristic values–	– Output profile + line with standard values or with 6σ distribution or 6σ distribution with total. – Output additional average values, maximum values, or a range of values – Output actual values of tooth thickness with two-ball dimension or base tangent length – Display tolerances, if present
–Drawing–	– <Combined curves> Present curves of individual teeth one on top of the other – <Combined sections> Present curves of individual measurement sections one on top of the other – <Files together> Present deviations of individual files for all teeth one on top of the other – <Regression> Plot a best-fit line on the measuring curve

	– <Crowning> Plot crowning on the measuring curve – <Torsion> Plot all the sections in the case of torsion or the topography – <Pitch sine> Insert a sine wave in the concentricity diagram and the pitch diagram
–3D color gradient–	– <Plot target curve>: Plot the target curve in black – <Plot deviations with emphasis>: Show deviations magnified in 3D – <Profile in foreground>: If cuts on both profiles and leads have been measured (torsion), the profile cuts are shown in the foreground. – <Color lilac> / <Color yellow>: Associate the color lilac/yellow with a specific deviation. Use the zoom button or mouse wheel to change the association between colors and deviations.
–3D presentation–	Plot tooth and cut numbers in 3D

Tab. 1 List boxes in the «Display» window

Examples of these settings can be found on the following pages.

3.8.1 Display type: 1D / 2D

The profile can be displayed in 1D or 2D.

«Settings» / «Display» menu
–Display type– <Profile>

<1D>

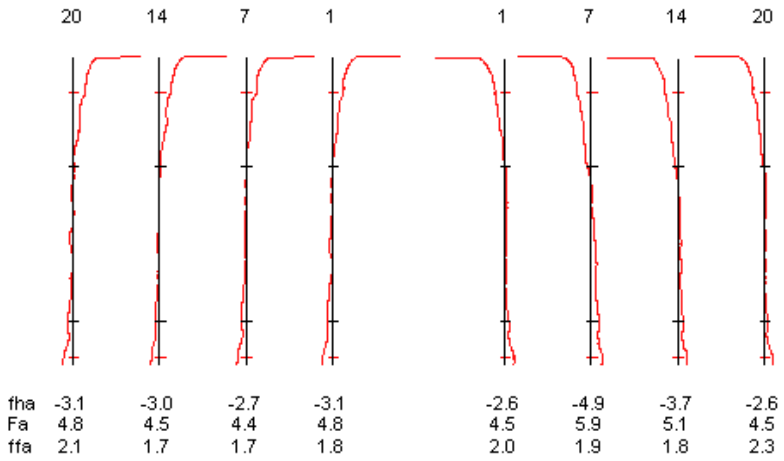

Fig. 2 <1D presentation> profile

The profile is plotted via the roll angle. The black nominal profile is a perpendicular line.

<2D>

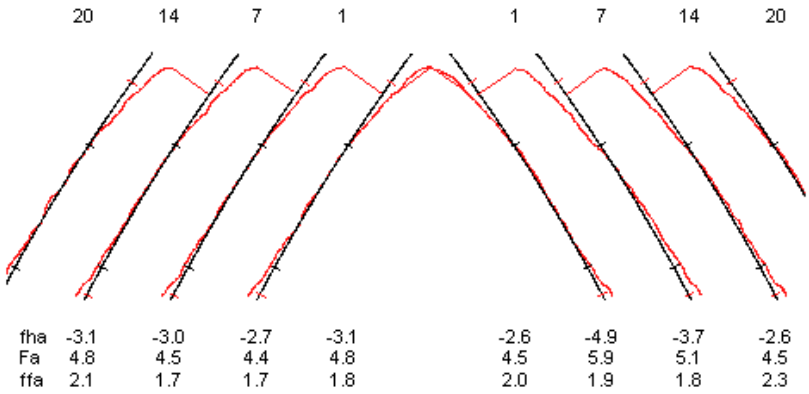

Fig. 3 <2D presentation> profile

The nominal profile corresponds to the tooth form and shows the involute as a black nominal line.

3.8.2 Display type: Profile + Line

The profile and flank line can be shown individually or combined.

«Settings» / «Display» menu
–Display type– <Profile + Line>

<Profile + Line>:

- <only profile>: Shows only the profile deviation
- <only line>: Shows only the flank line deviation
- <both>: Shows both deviations one underneath the other

If only profile or line is chosen, the graphic will be scaled so that it fills the entire area.

3.8.3 Display type: Tooth thickness

Not available in the *Wave Production* variant.

3.8.4 Display Format: Pitch

«Settings» / «Display» menu
–Display type– <pitch>

The pitch can be set as follows:

- <no pitch>, pitch is not shown. The screen is used to display the profile and flank line.
- <Line>

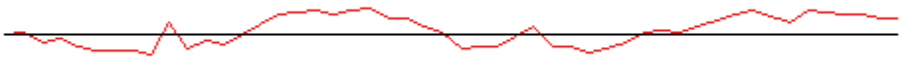

Fig. 4 Pitch as a line

- <Block empty>

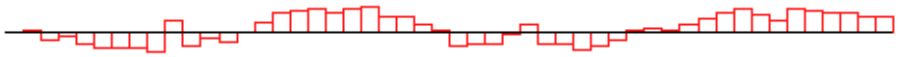

Fig. 5 Pitch as a diagram with empty blocks

- <Block filled>

Fig. 6 Pitch as a diagram with full blocks

This setting applies for the diagrams runout and cumulative pitch right and left.

3.8.5 Display Format: Profile + Lead

«Settings» / «Display» menu
–Display format– <Profile + Line>

Deviation curves can be set as follows:

- <Line>, the deviation is shown as a red line by default.

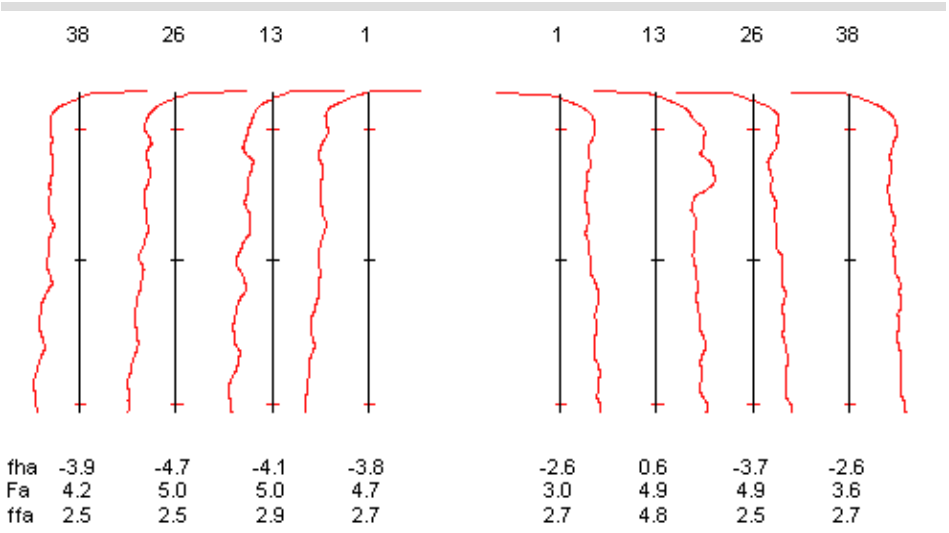

Fig. 7 Deviation shown as a line

- <Filling>, the area between the nominal curve and the deviation curve is filled out.

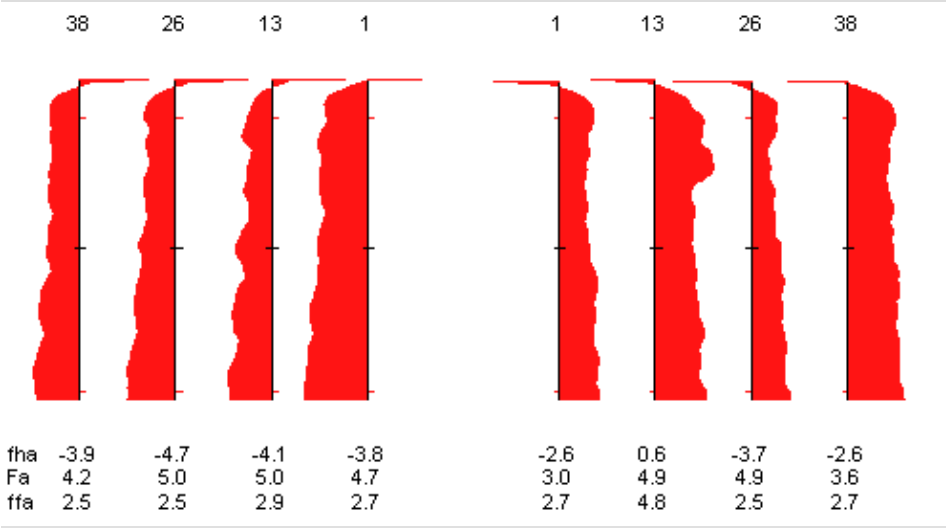

Fig. 8 Deviation filled display

- <Normal>, normals are drawn between the nominal curve and the deviation curve.

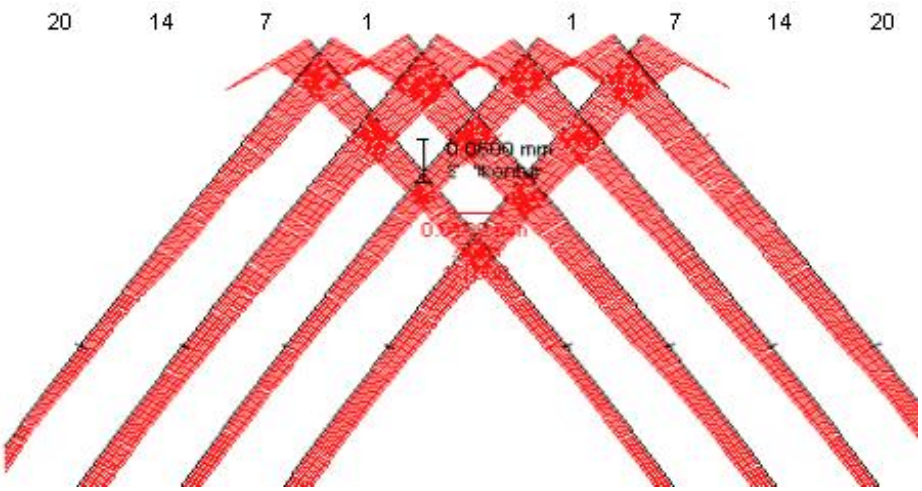

Fig. 9 Deviation with greatly magnified normals

3.8.6 Characteristic Values: Additional

With characteristic values, it is also possible to display average values, maximum values, and the range of the values.

Select «Settings» / «Display»
–Characteristic values– «Additional» menu

If <Average values> is selected, the system outputs the average values of the angular deviation between data blocks.

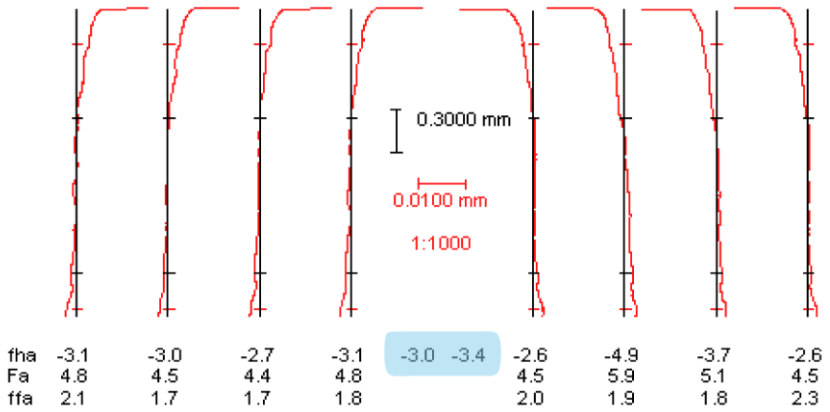

Fig. 1 Outputting average values

If <Maximum values> is selected, the maximum values among the data blocks will be output.

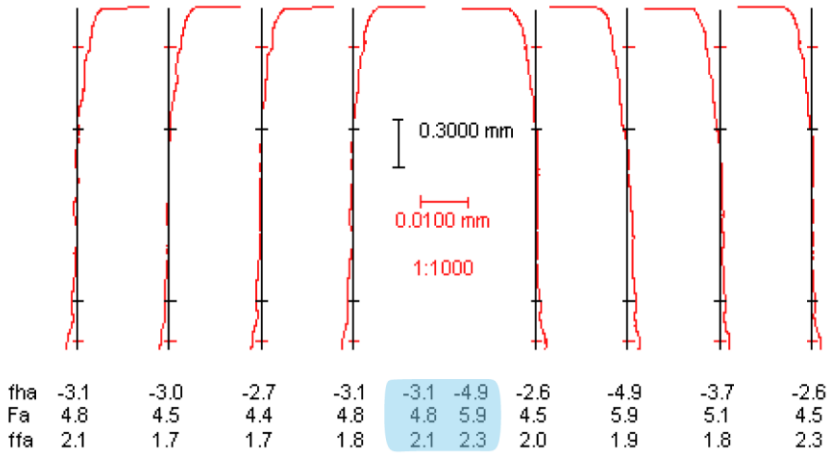

Fig. 2 Outputting maximum values

If <Range> is selected, the system outputs the absolute range between the values.

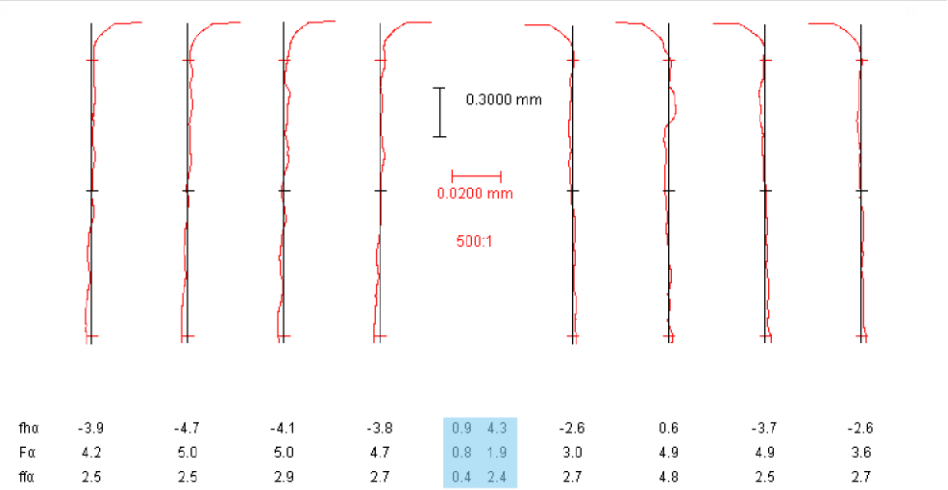

Fig. 3 Outputting range

3.8.7 Characteristic Values: Profile and Line

Instead of the standard characteristic values, it is possible to output the values with a 6σ distribution and total.

Select «Settings» / «Display»
–Characteristic values– «Profile + Line» menu

If you select <Statistical spread 6σ + Total>, the system displays the values with a 6σ distribution and an additional total instead of the standard values.

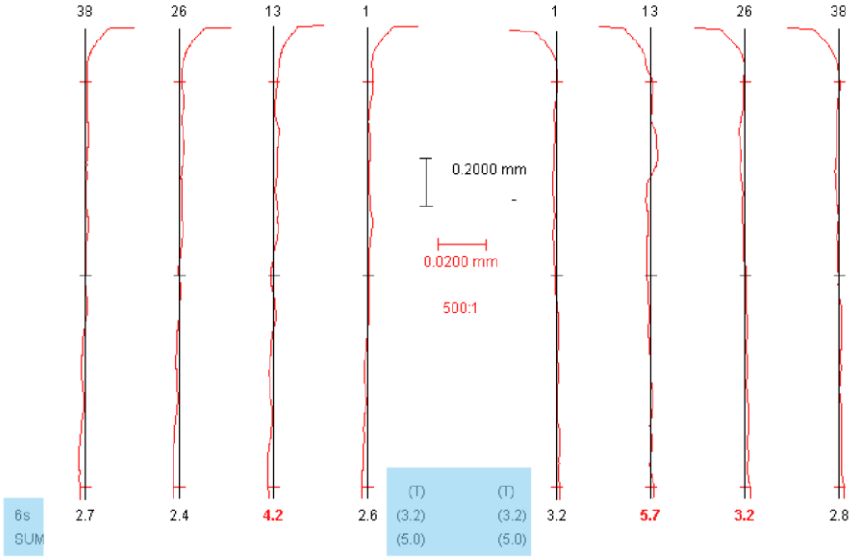

Fig. 4 6σ distribution and display of tolerances

If the <Tolerances> button is selected, the system additionally outputs the values of the tolerances (T) in parentheses. If no tolerances are defined, the display in parentheses is blank.

You enter the tolerances for 6σ and the total in «Settings» «Ripple» «Tolerances».

3.8.8 Drawing

Select «Settings» / «Display» menu
–Draw– Settings

In the –Draw– group, one or more of the following settings can be selected:

- <Combined curves>
- <Combined sections>
- <Files together>
- <Regression>
- <Crowning>
- <Setting>
- <Pitch sine>

An example of each of these settings can be found on the following pages.

3.8.8.1 Combined Curves Display

«Settings» / «Display» menu
–Draw– <Combined curves> selected

The deviation curves for all teeth are usually displayed one next to the other.

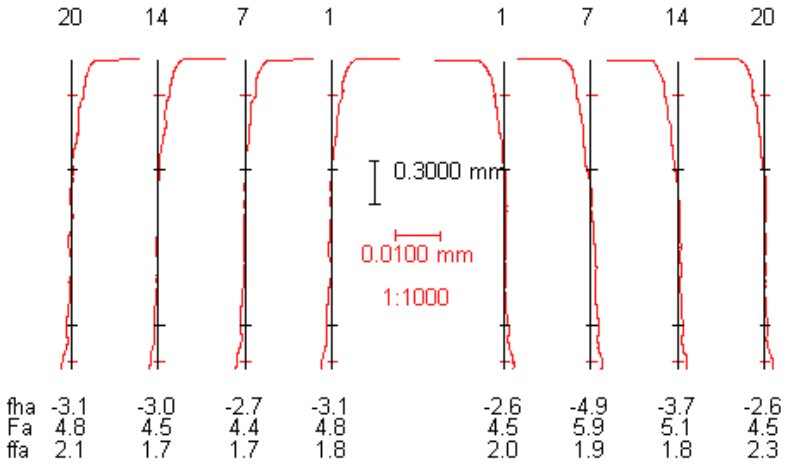

Fig. 5 Curves shown individually

If the <Combined curves> option is selected, the deviation curves for all teeth are displayed one on top of the other.

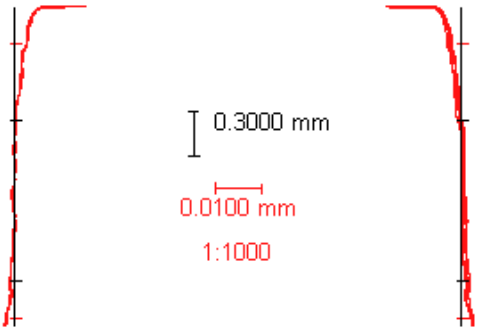

Fig. 6 Curves for all teeth, combined presentation

The results below the graphic are not output, since they are different for each tooth.

The <Combined curves> display can also be activated and deactivated via the toolbox using the [All Teeth] button.

3.8.8.2 Combined Display of Files

«Settings» / «Display» menu
–Draw– <Files together> selected

If several measured data files are loaded, each file is assigned a different color, which is specified in the key beneath the graphic.

By default, the curves for each tooth are drawn one on top of the other.

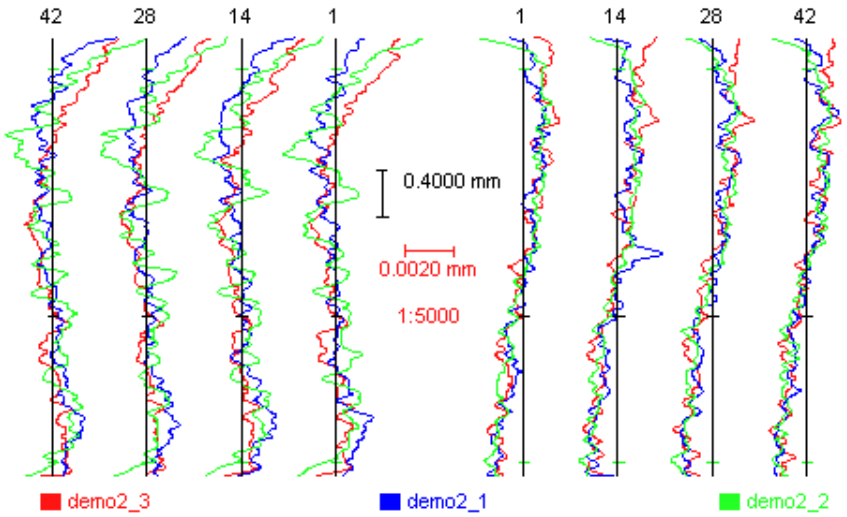

Fig. 7 Several files: displayed per tooth

If the <Combined curves> option is selected, the deviations for all teeth per file are displayed one on top of the other.

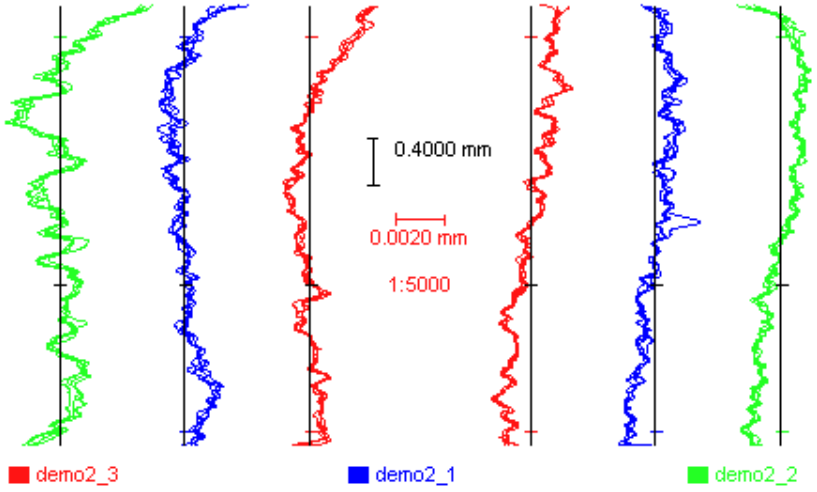

Fig. 8 Several files: <Combined curves> display

You can also choose the <Combined curves> display via the toolbox.

If the <Files together> setting is selected in addition, all curves for all teeth and all files are displayed one on top of the other.

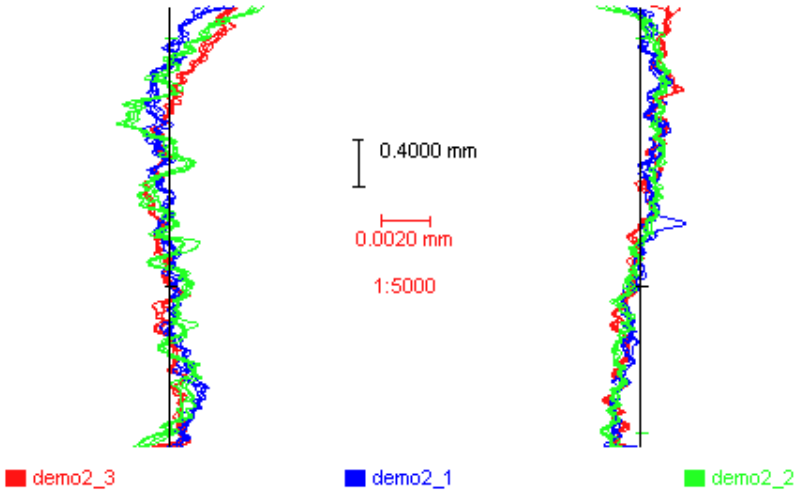

Fig. 9 Several files: <Files together> and <Combined curves>

3.8.8.3 Regression

«Settings» / «Display» menu
–Draw– <Regression> selected

A best-fit line is plotted in lilac.

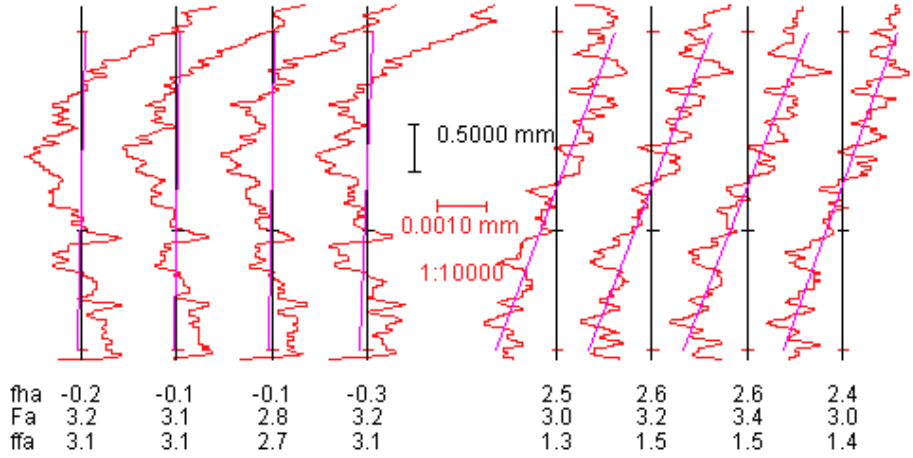

Fig. 10 Display with best-fit line

The colors in the display are assigned as follows:

- Black: Zero line
- Red: Measured curve
- Lilac: Best-fit line

3.8.8.4 Display of Crowning

«Settings» / «Display» menu
–Draw– <Crowning> selected

In profile and lead, the crowning is plotted as a best-fit curve in lilac.

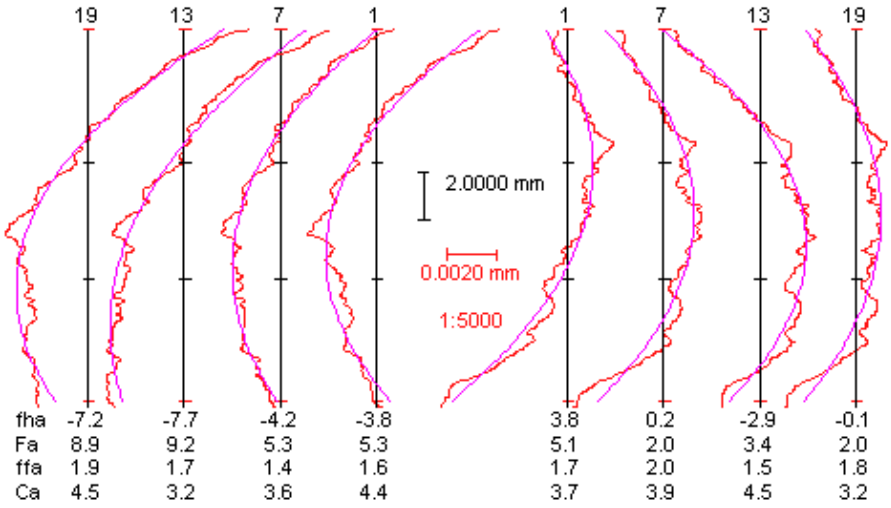

Fig. 11 Display of best-fit curve for crowning

3.8.8.5 <Torsion>

Prerequisites

The following must be fulfilled:

- The torsion or topography must have been measured.
- Torsion is measured in the *Cylindrical gear* program in three sections, called a, b and c.

Select «Settings» / «Display» menu
–Draw– <Torsion>

If <Torsion> is measured, but not selected, the center section (b) will automatically be displayed.

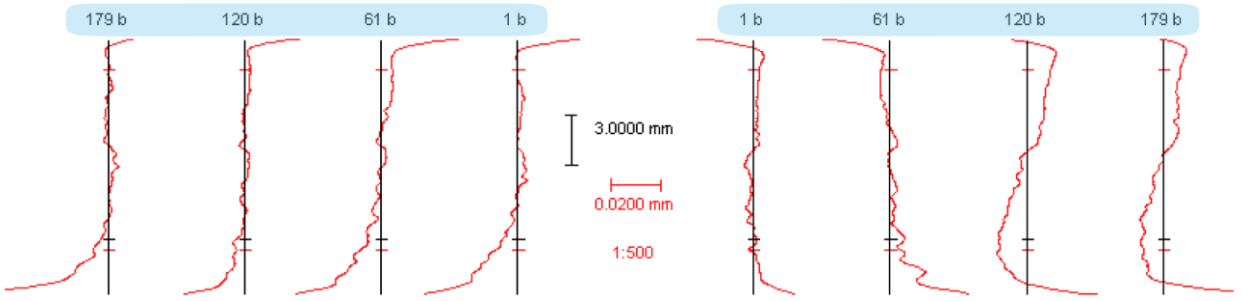

Fig. 12 Display of center section b

If <Torsion> is selected, the sections of tooth 1 will be displayed.

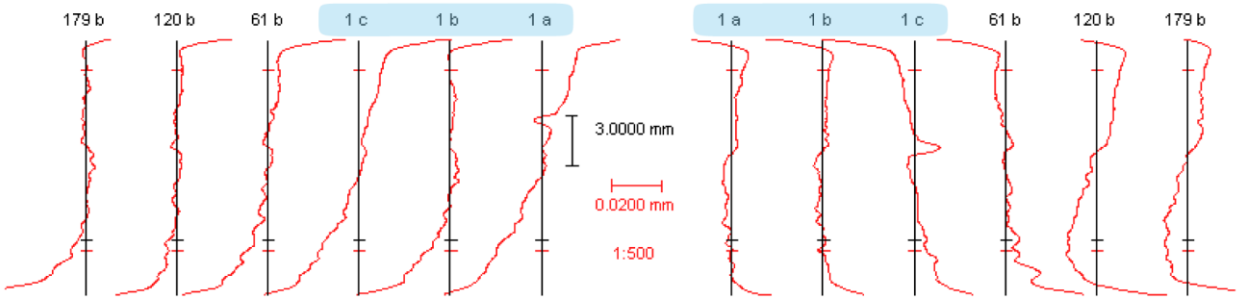

Fig. 13 Torsion on tooth 1

If <Torsion> and <Combined sections> are selected, the sections for the tooth for which torsion was measured will be placed one on top of the other.

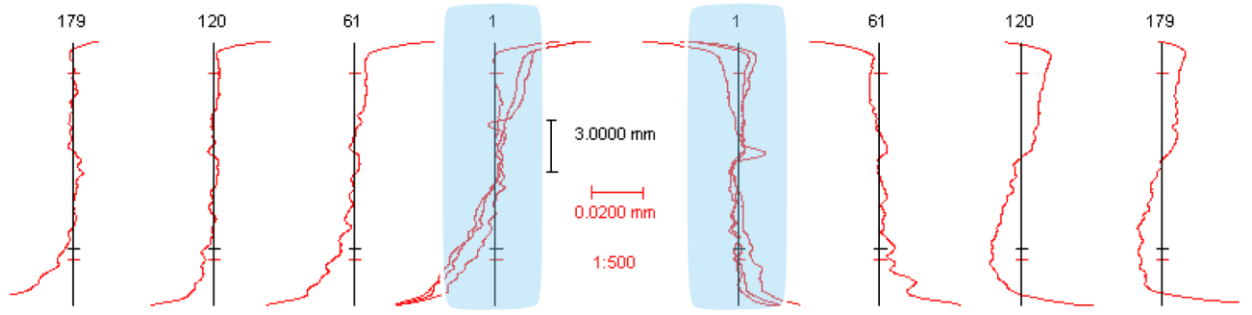

Fig. 14 <Torsion> and <Combined sections> selected

In this example, the torsion was measured on 1 tooth only.

3.8.8.6 Combined Display of Sections

The measuring curves for a given tooth are placed one on top of the other when several sections have been measured.

Prerequisite The following condition must be met:

- Topography or torsion must be measured.

Select «Settings» / «Display» menu
–Draw– <Combined sections>

If <Combined sections> is selected, the sections per tooth will be placed one on top of the other.

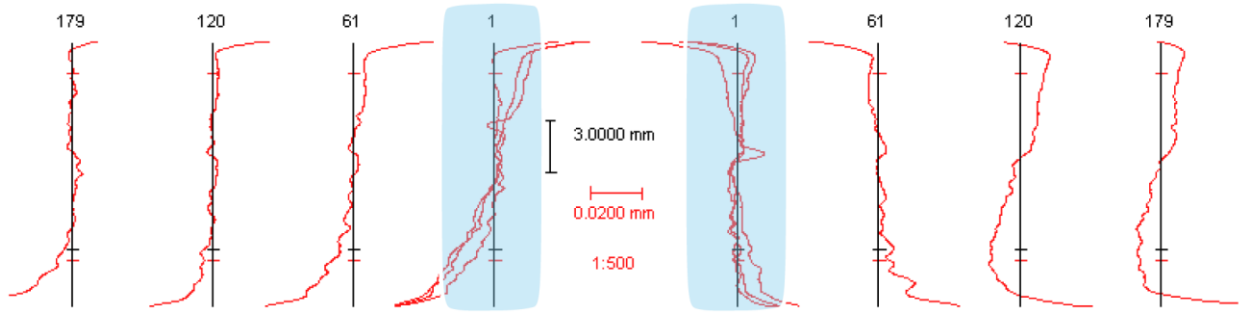

Fig. 15 Combined sections, 1 tooth

If the topography has been measured, this means there are sections for several teeth.

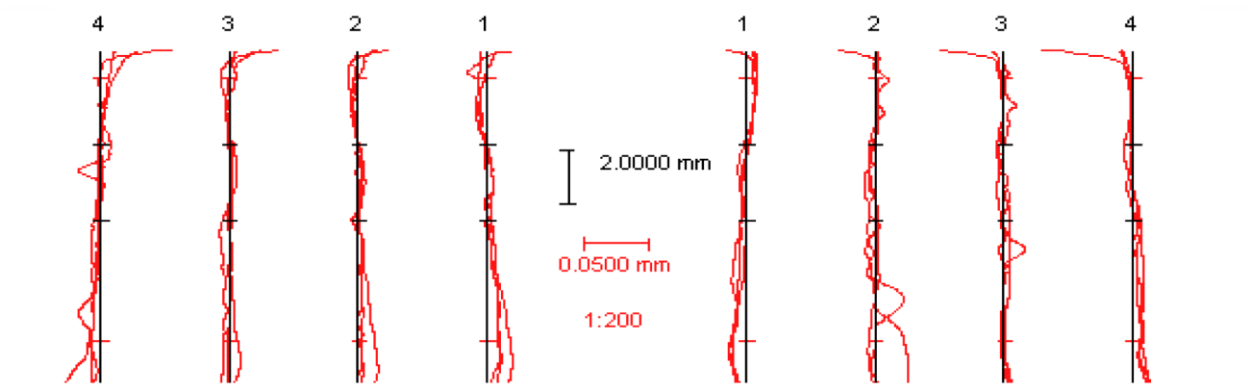

Fig. 16 Sections of several teeth shown in a combined view

3.8.8.7 <Pitch sine>

A sine curve is plotted on the diagram for runout, cumulative pitch right and cumulative pitch left.

«Settings» / «Display» menu
–Draw– <Pitch sine> selected

Fig. 17 Sine wave in the diagram

3.8.9 3D Color Gradient

In the 3D presentation, a color gradient can make the deviation easier to distinguish.

«Settings» / «Display» menu
–3D - color gradient–

Settings for the color gradient:

- <Plot target curve>, target curve is plotted as a black line
- <Plot deviations with emphasis>, makes the deviations larger
- <Profile in foreground>, plots the profile line over the color gradient
- <Color lilac> symbolizes the maximum deviation; this deviation is specified directly
- <Color yellow> symbolizes the lowest deviation

Examples of settings can be found in the chapter titled *Color Topography Display*.

3.8.10 3D Presentation

In the 3D deviations graphic, it is possible to display the numbering.

«Settings» / «Display» menu
–3D presentation– <Draw numbering>

Settings:

- <Draw numbering>: If the button is selected, the system displays the numbering of the flanks and sections in the 3D deviations graphic.

3.9 General settings

Language of the graphical user interface, units, and fonts are specified here.

«Settings» / «General» menu

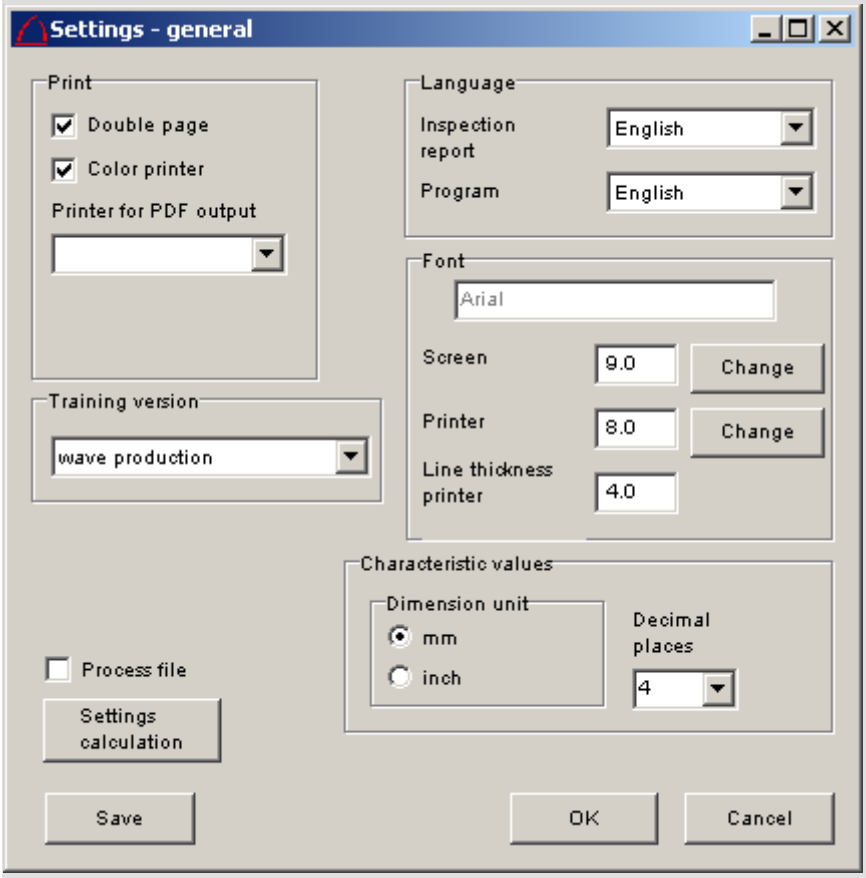

Fig. 1 «Settings – general» window

Fields and functions	Meaning
–Print–	
<Color printer>	Print in color Notice: With monochrome printers, exceeded tolerances are printed in bold type.
<Double page>	If selected, profile, lead, and pitch will be displayed on one sheet.
Printer PDF output	Used to select a pre-installed printer
–Language–	
<Inspection report>	Language used for diagrams and printouts

Fields and functions	Meaning
<Program>	Language of the graphical user interface. If the GUI language is changed, the language for the test report automatically changes to the same language. If a different language is required for the test report, the language must be changed again. The GUI language only becomes active following a restart.
–Font–	
<Font>	The font is the same for the screen and the printout.
<Screen>	Using the [Change] button, the font and font size can be set in a separate window.
<Printer>	Using the [Change] button, the font and font size can be set in a separate window.
<Line thickness printer>	Thickness of lines in points for printout.
<Process file>	Program steps are stored in the *verlauf.log* (process.log) file.
[Settings calculation]	Used to define the setting for calculating the characteristic values. See next section.
–Characteristic values–	
<Dimension unit>	Choices: <mm>, <Inch>
<Decimal places>	Number of decimal places for numbers
[Save]	Changes are permanently saved when the [Save] button is pressed.

Tab. 1 «Settings – General» input fields

If the selected font for the screen or printer produces illegible results, you can reset the settings under «File» «Reverse configuration changes» (this only works if you have not yet saved the changes).

The standard font is Arial. With other fonts, there is no guarantee that all the necessary special characters will be available for the selected language.

3.9.1 Calculating Characteristic Values

Setting for calculating the characteristic values.

Select «Settings» / «General» menu
[Settings calculation] button

Fields and functions	Meaning
<Take account of positive deviations outside the analysis range>	Positive deviations are taken into account for the calculation.
<fHβ preceding sign according to VDI>	When selected, the sign of the angular error is defined to VDI rather than DIN.
<Extrapolate Fhβ and Cβ to face width>	The angular error and crowning are calculated automatically for the evaluation range. If this field is selected, the evaluation takes place for the entire face width.
–Reference to pitch deviation–	By default, pitch parameters and curves relate to the arc of the measuring circuit on which the measuring ball contacts the workpiece. To compare results with other programs, the following reference diameters are available.
<V-Circle>	The pitch deviation relates to the arc with the corresponding diameter.
<Reference circle>	
<Measuring circuit>	
<Base circle>	

Tab. 2 «Settings - calculation» input fields

3.9.2 Log Book / Process File

If an unexplained error occurs while the program is in use, the process file should be activated.

Select «Settings» / «General» menu
<Process file>

All selected steps are stored in a log book. The *verlauf.log* (process.log) file is placed in the program's main directory.

If necessary, the *verlauf.log* (process.log) file, the *configuration file,* and the measurement file in which the error occurred must be submitted to Klingelnberg Service for troubleshooting.

3.10 Settings – Sequence

Determines how the automatic sequence of evaluation after the measurement should take place.

«Settings» / «Sequence» menu

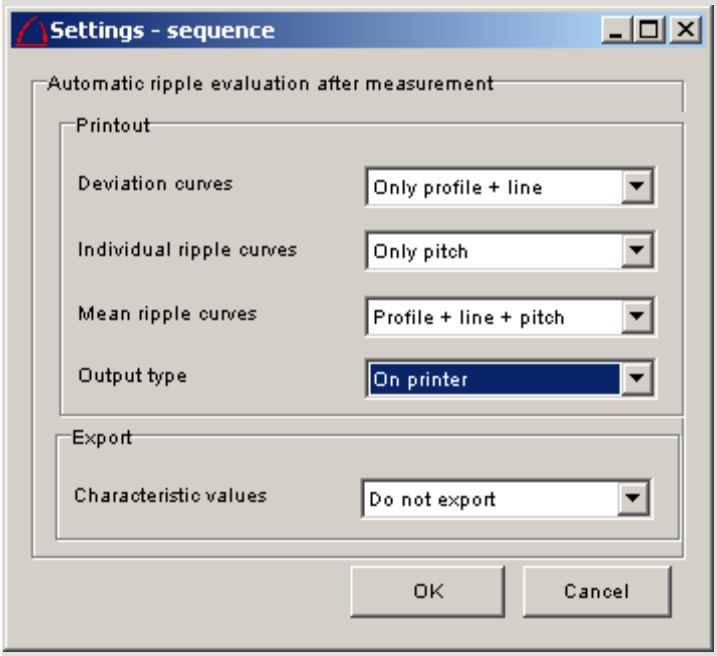

Fig. 1 «Settings – Sequence» window

Fields and functions	Meaning
--Print output--	
<Deviation curve> <Individual wave curves> <Average wave curve>	Defines the printout for the curves. The following settings are possible: – no printout – only profile and line – only pitch – profile + line + pitch
<Output type>	Determines whether the printout should be in a PDF file only, to the printer only, or both.
--Export--	
<Characteristic values>	Enables export of the wave analysis parameters

Tab. 1 «Settings – Sequence» input fields

3.11 Ripple Analysis

3.11.1 Settings – Ripple

The ripple can be evaluated in profile and lead as well as in the pitch. Specification of tolerance values is also possible.

The <Normal user> setting is provided to make it easier for inexperienced users to carry out evaluation. The table further on shows a comparison of the functions and parameters used between a <Normal user> and an <Experienced user>.

The evaluation is customized as follows for the job at hand:

«Settings» / «Ripple» «General» menu

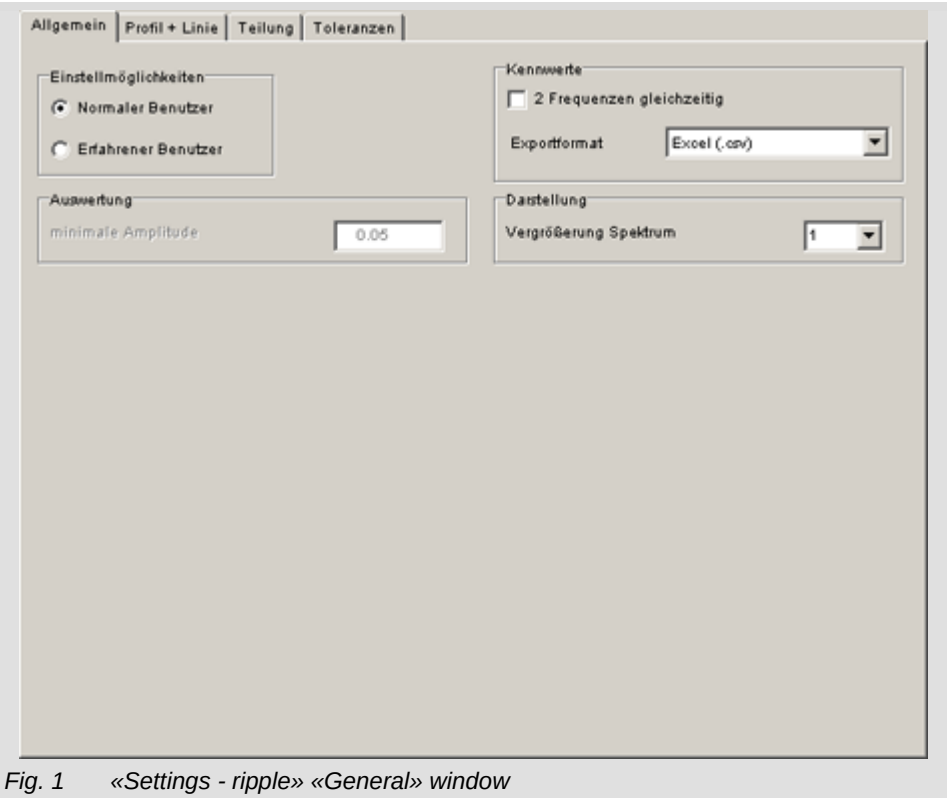

Fig. 1 «Settings - ripple» «General» window

Fields and functions	Meaning
–Setting options–	
<Normal user>	A limited choice of functions and parameters. This mode is sensible for users that have not had a lot of experience in handling the program.

Fields and functions	Meaning
<Experienced user>	A wider selection of functions and parameters (only sensible for experienced users)
–Evaluation–	
<Minimum amplitude>	The minimum amplitude specifies the minimum value used to calculate a maximum. All amplitudes below this value are ignored.
–Characteristic values–	
<2 frequencies simultaneously>	If selected, 2 frequencies are always calculated and displayed. The displayed spectrum relates to the second calculated frequency.
<Export format>	Selection of the export format for the characteristic values (Excel or QS-Stat) Export characteristic values in menu: *File / Export characteristic values of ripple*
–Display–	
<Spectrum enlargement>	Selection of the zoom factor If you enter a value > 1, the spectrum is scaled by the scaling factor compared to the deviation curve. A scale for the spectrum is also plotted.

Tab. 1 Input fields and functions in the «Settings - ripple» «General» window

Function	Normal	Experienced
General		
–Evaluation– <Minimum amplitude>	–	+
–Characteristic values– <2 frequencies simultaneously>	+	+
–Characteristic values– <Export format>	+	+
–Display– <Spectrum enlargement>	+	+
Profile + Line		
–Evaluation– <All teeth together>	+	+
–Evaluation– <Evaluation method>	–	+
–Common evaluation–	+	+
–Individual evaluation– «Calculation» <Correction>	–	+
–Individual evaluation– «Calculation» <Data source>	+	+
–Individual evaluation– «Calculation» <Resolution>	–	+
–Individual evaluation– «Output» <Spectrum>	–	+
–Individual evaluation– «Output» <Frequency parameter>	+	+
–Frequencies–	+	+
–Evaluation ranges–	–	+
–Display–	+	+

Function	Normal	Experi-enced
–Characteristic values–	–	+
Pitch		
–Evaluation– <Evaluate pitch curves>	+	+
–Evaluation– <Evaluation method>	–	+
–Frequencies– <max. calculation frequency>	–	+
–Frequencies– <Use evaluation frequencies>	+	+
–Display–	+	+
Tolerances	+	+

Tab. 2 Overview of functions for normal and experienced users

«Settings» / «Wave»
«Profile + Line» menu

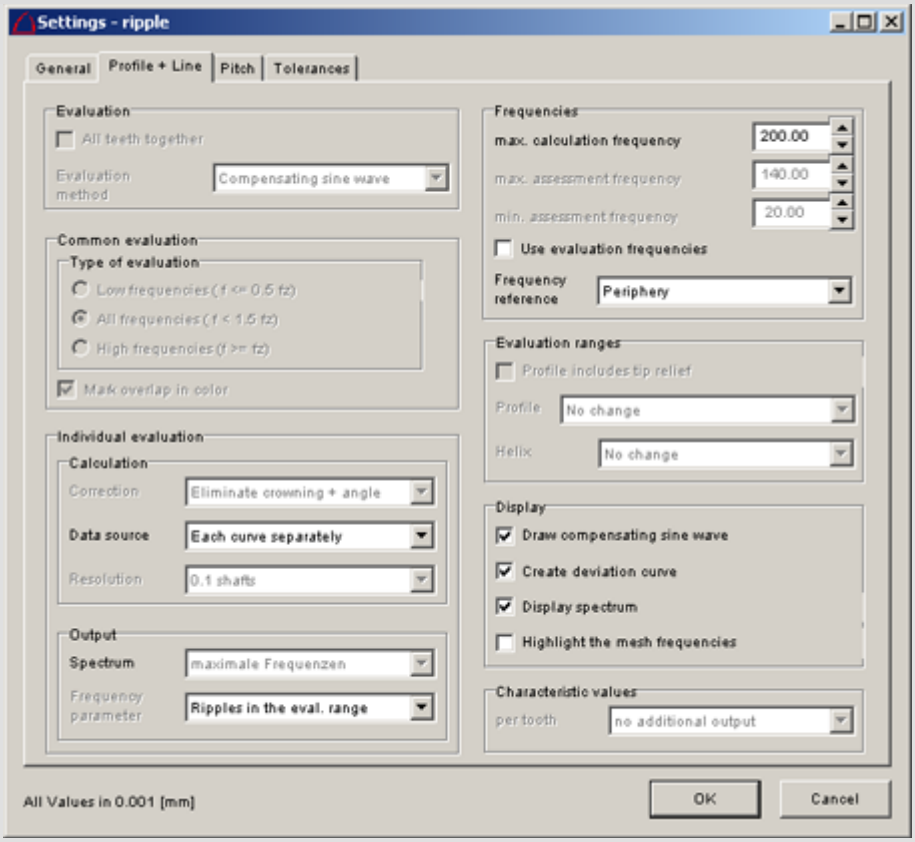

Fig. 1 «Settings - wave» «Profile + Line» window

Fields and functions	Meaning
–Evaluation–	
<Evaluation method>	– <Compensating sine wave>: The compensating sine wave is the preferred (standard) calculation method, which is also the most precise. – <FFT1 (window: rectangle)> or <FFT 2 (window: Hamming)>: Fourier transformation as an alternative method (option)
–Individual evaluation – Calculation–	
<Correction>	Crowning + angular deviation can be calculated in the wave calculation of the individual curves. Since crowning is considered to be wave, crowning and the angular deviation should be corrected at standard evaluation.
<Data source>	Selection of whether you want to calculate each measuring curve separately or whether an average curve or the average spectrum should be used for calculation.
<Resolution>	Selection of the resolution that you want to use at frequency calculation.
–Individual evaluation – Output–	
<Spectrum>	
<Frequency parameter>:	By default, the compensating sine frequency is the number of <Waves in the eval. range>. With <Waves per mm>, the system outputs a standardized frequency regardless of the size of the evaluation range. With <Waves per revolution>, the system projects the wave on one tooth to a full revolution.
–Frequencies–	
<max. calculation frequency>	The maximum frequency that is calculated and displayed in the spectrum.
<Use evaluation frequencies>	Selects the fields for the maximum and minimum evaluation frequency. If NOT enabled, only the maximum calculation frequency is effective. This button is used to switch between the general evaluation (waves present on the curve) to a specific evaluation (size of amplitude in a frequency band).
<max. assessment frequency> <min. assessment frequency>	Within the range of minimum to maximum assessment frequency, the maximum is determined and output as a characteristic value in the form of amplitude, frequency and phase position (optional feature). All maxima outside this range are not taken into account, even if they are below the maximum calculation frequency. Maxima not taken into account are shown in gray in the spectrum. The analysis is limited to 10 maxima (default). If max-

Fields and functions	Meaning
	ima are removed from the spectrum, the number of maxima that can be detected is decreased. The symbol "???" is output when the maximum number has been exceeded.
<Frequency reference>	Selection of what you want the evaluation frequency to be referred to (the evaluation range and the calculation frequency, the circumference of a multiple of the number of teeth).
–Evaluation ranges–	
<Profile includes tip relief>	At loading of the measured data, activates tip relief in the evaluation range of the profile. **Changes to the settings do not come into effect until the measured data has been reloaded.**
<Profile>	When measured data is loaded, the evaluation range for the profile is reduced such that the symmetrical contact ratio or the contact ratio at the tooth tip is ≤ 1. **Changes to the settings do not come into effect until the measured data has been reloaded.**
<Helix>	When measured data is loaded, the evaluation range for the lead is reduced to contact ratio ≤ 1. **Changes to the settings do not come into effect until the measured data has been reloaded.**
–Display–	
<Draw compensating sine wave>	If selected, the wave analysis result is plotted as a superimposed sine wave.
<Create deviation curve>	If selected, the deviation curves are shown.
<Display spectrum>	If selected, the frequency spectrum is drawn in next to the deviation curves.
<Highlight the mesh frequencies>	In the spectrum, highlight the mesh frequency and multiples thereof.
–Characteristic values–	
<per tooth>	Additional inputs per tooth (phase position or 6σ distribution) The phase position is defined as the distance of the positive amplitude to the middle of the tooth or the rolling path.

Tab. 1 Input fields and functions in the «Settings - wave» «Profile + Line» window

«Settings» / «Ripple» «Pitch» menu

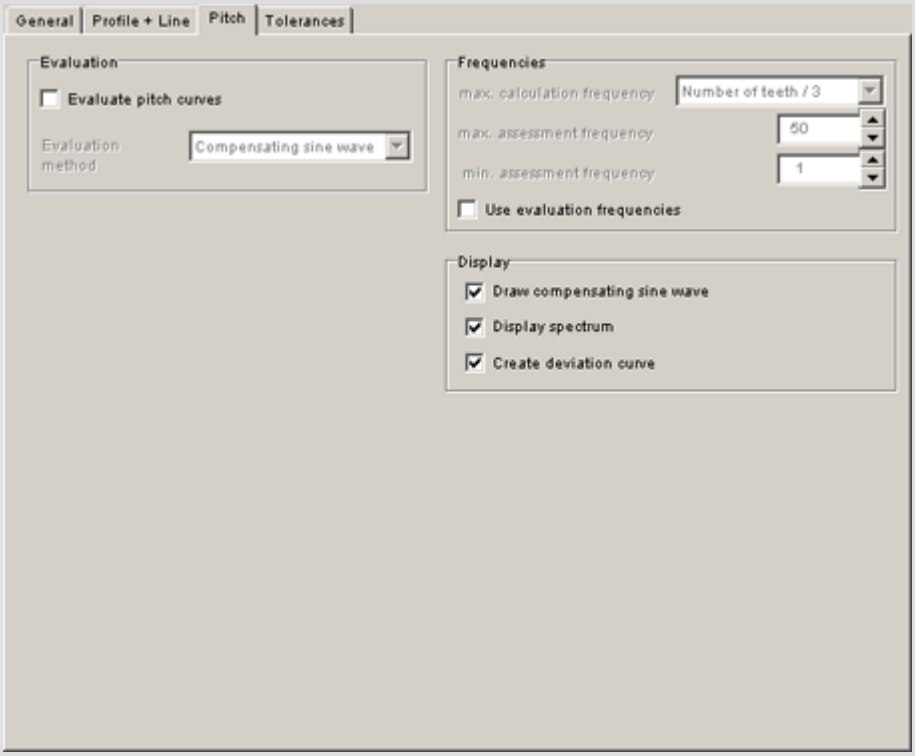

Fig. 2 «Settings - ripple» «Pitch» window

Fields and functions	Meaning
–Evaluation–	
<Evaluate pitch curves>	Activates ripple analysis for pitch curves
<Evaluation method>	<Compensating sine wave> = The standard calculation of the frequency spectrum <FFT> = Alternative calculation (Fast Fourier Transformation)
–Frequencies–	
<max. calculation frequency>	<Number of teeth / 3> <Number of teeth / 2> The maximum frequency that is calculated and displayed in the spectrum.
<max. assessment frequency> <min. assessment frequency>	Limitation of the frequency range for the calculation. Excluded frequencies are shown in gray in the graphic.
<Use evaluation frequencies>	Activates the previously specified evaluation ranges

Fields and functions	Meaning
–Display–	
<Draw compensating sine wave>	In the graphic, plots a compensating sine wave as a pink curve to the deviation curve. <Create deviation curve> must be activated.
<Display spectrum>	In the graphic, plots the spectrum as a blue bar.
<Create deviation curve>	Plots the deviation curves in the graphic.

Tab. 2 Input fields and functions in the «Settings - ripple» «Pitch» window

«Settings» / «Ripple» «Tolerances» menu

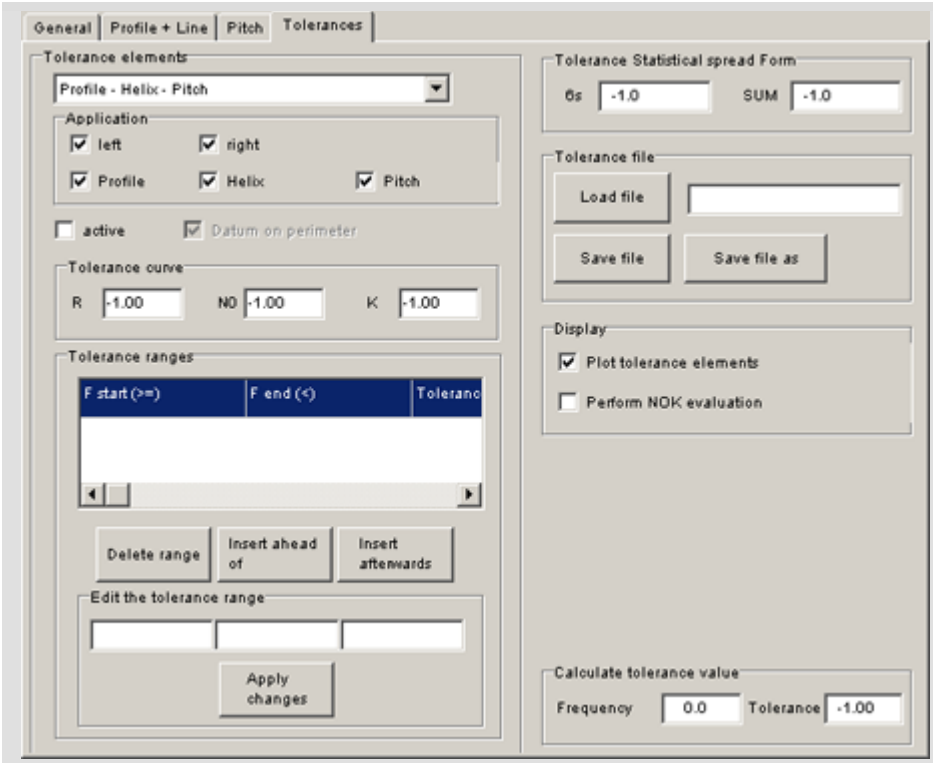

Fig. 1 «Settings - ripple» «Tolerances» window

Fields and functions	Meaning
–Tolerance elements–	
<Profile> <Helix> <Pitch>	Choosing the tolerance element from the file list
<Profile – Helix – Pitch>	Selecting more than two tolerance elements leads to all of them being grouped.
<left>	Activates application of the tolerance specifications to the left-hand tooth flanks.
<right>	Activates application of the tolerance specifications to the right-hand tooth flanks.
<active>	Activates the tolerance specifications to the ripple application. If the button is NOT selected, the tolerance specifications are not applied to the ripple evaluation.
<Datum on perimeter>	Activates application of the tolerance specifications to one rotation of the workpiece.

Fields and functions	Meaning
	As standard, the frequency specifications are relative to the evaluation range of the deviation curve.
–Tolerance curve–	
<R> <N0> <K>	The tolerance curve describes a continuous tolerance range as a limit curve. It is specified by three parameters: <R> = Permissible ripple depth (at R<0 no tolerance curve) <N0> = Constant for describing the tolerance curve <K> = >Correction value The formula is as follows: S(w) = R / (W-1)N where N = No + K / W (W = frequency)
–Tolerance ranges–	
<F start> <F end> <Tolerance>	Specifies deviating ranges within the tolerance curve. These ranges have priority over the tolerance curve. <F start> = Start of the frequency range <F end> = End of the frequency range <Tolerance> = The tolerance value that is to apply in the previously specified range. Make all the inputs for the values in the –Edit the tolerance range– section.
[Delete range]	Delete a previously specified tolerance range. You must have highlighted the range first using the mouse.
[Insert ahead of] [Insert afterwards]	Inserts a new tolerance range AHEAD OF or AFTER one that you highlighted using the mouse.
–Edit the tolerance range–	
<F start> <F end> <Tolerance>	Input fields for specifying tolerance ranges
[Apply changes]	Apply the new values of a tolerance range or the changed ones.
–Tolerance file–	
[Load file]	Opens a file window to load a saved tolerance file.
[Save file] [Save file as]	Opens a file window to save the current tolerance file. The name of the tolerance file is saved with the configuration and the system loads it automatically at starting.
–Display–	
<Plot tolerance elements>	In the representation of the spectrum, plots the tolerance curve including the deviating tolerance ranges.
<Perform NOK evaluation>	Evaluate the parameters versus the current tolerances. If the tolerances are exceeded, the system displays "NOK" (not OK).
–Calculate tolerance value–	

Fields and functions	Meaning
<Frequency> <Tolerance>	Calculation of tolerance as a test. When you enter a frequency, the system calculates the associated tolerance.

Tab. 1 Input fields and functions in the «Settings - ripple» «Tolerances» window

3.11.2 Evaluation Type

The type of evaluation affects the results of the ripple analysis:

- Standard:
  If there is no previous knowledge of the frequency of the ripple to be analyzed, the standard setting <Middle frequency> results in an analysis without corrections.
- Crowning and angular deviation:
  If the measured curves for each tooth show crowning or angular deviation, this results in ripples with the frequency of the number of teeth, fz, and their multiples in the common evaluation. Due to the high amplitudes of these ripples, actual ripples in the spectrum are attenuated or suppressed altogether.
- <Maximum contact ratio>
  If a toothed gear has actual ripples from 0.5 – 1.5 fz and also has crowning or angular deviation, the actual ripple is eliminated with the corrections above. In this case, the selected evaluation length, i.e. the maximum frequency, must be large enough for the curves to have a contact ratio significantly greater than 1.

3.12 Import/Export Settings

These settings apply to GDE-format imports of measured data captured with the «Cylindrical gear 7.x» program. Different tooth thickness parameters are used in *«Cylindrical gear 7.x»*.

«Settings» / «Import / Export» menu

Fields	Meaning
–Import GDE–	Choice of tooth thickness parameters to be used and the order in which the tooth thickness parameters will be imported. Sample selection: – 1. <Addenium modification coeff.> – 2. <Normal tooth thickness> – 3. <2-ball dimension> – 4. <Base tangent length> Use the next parameter only if the first parameter <Addendum modification coeff.> is not available, etc.
<Compare the selected tooth thickness values and report any deviations>	Select to perform a plausibility check on the values.
<Path to the measured data>	By default, the measured data is in the path of the configuration file. If the measured data is stored at another location, the corresponding path must be entered here.
[Change]	A change in the path specification is only applied when you click this button.
<Path to the export data>	If the data is to be exported, the corresponding path must be entered here. You specify the export format (QSTAT or Excel) in the «Settings» / «Ripple» «General» menu.
[Change]	A change in the path specification is only applied when you click this button.
<Paths apply only for the current configuration>	Select the button if you want the set paths to apply ONLY to currently loaded configuration. Otherwise, the path specifications apply on a global basis. This means that you can use this button to set individual paths for each configuration file.

Tab. 2 «Settings – Import» window

4 Error messages

4.1 Messages by Subject

4.1.1 Messages On Program Start-Up

Message	Cause / Corrective action
The data and configuration files are currently in use. The program cannot be used	Wait until the other user has closed the program.

Tab. 3 Messages on program start-up

4.1.2 Messages About Files

Message	Cause / Corrective action
The file cannot be created	The desired file cannot be generated. Check the data and make corrections. Check the access rights.
The file cannot be opened	The desired file is in use.
File access denied	The desired file is protected and cannot be opened.
File not found	The desired file is not available. Check the path and file name.
Too many files selected	Up to 12 files can be compared.
Only GDE nominal data can be loaded in this program version.	The program settings specify that with .xml files only the nominal data section can be opened. Contact the manufacturer.
GDE data cannot be opened in this program version.	The program does not include the option to open measurement files with an *.xlm extension. Contact the manufacturer.
Only multiple files with the same tooth count are being loaded.	Files to be compared must have the same geometric data.
The data differs by xxx. Not all data is represented correctly.	Files to be compared must have the same geometric data.

Tab. 4 File messages

4.1.3 Messages about Hardware

Message	Corrective action
Not enough memory	The PC does not have enough memory. The program cannot be executed.
Not enough disk space	There is not enough space on the hard disk. The program cannot be executed.
Please make the appropriate printer settings	The printer settings are not correct.

Tab. 5 File messages

4.2 Messages by Number

4.2.1 110000 – 119999

Number	Message	Cause / Corrective Action
110101	File xy not found	File xy is missing; the file name or path is incorrect. Enter the file correctly
110101	License.dat file not found	Restore the license file from the data backup or contact the manufacturer.
110301	Reference circle smaller than base circle	Workpiece geometry contains errors. Check the involute data.
110302	The new base circle is larger than the reference circle	Workpiece geometry contains errors. Check the involute data.
110302	Comparison possible for nominal involute only	The evaluation can only be performed for the nominal involute.
110303	Geometry iteration limit exceeded	The data for simulation contain errors. Enter the correct data.
110304	Position iteration limit exceeded	The data for simulation contain errors. Enter the correct data.

Tab. 6 Messages 110000 – 119999

4.2.2 130000 – 139999

Number	Message	Cause / Corrective action
130101	Error when importing measured data	Measured data is incomplete or the file contains errors.
130301	Maximum number of teeth exceeded	Data cannot be evaluated. Maximum number of teeth is 260.
130302	A conical gear cannot be processed.	Contact the manufacturer to provide information on the special features of this toothed gear.
130401	The value for pitch is at the edge of the profile value range	Modify parameters for the measurement. Repeat the measurement.
130402	Klingelnberg data have invalid version	Request a newer interface from the manufacturer.
130403	Unit not in millimeters in Klingelnberg data	Change the unit.

Number	Message	Cause / Corrective action
130404	The lead torsion was measured at the edge of the profile measuring range	Modify parameters for the measurement. Repeat the measurement.
130405	The profile torsion was measured at the edge of the lead measuring range	Modify parameters for the measurement. Repeat the measurement.
130406	File cannot be loaded with the demo version of the program	You can only run the demo version using the supplied data.
130407	Incorrect ball dimension: the center of the ball dimension is smaller than the base circle	Adjust the involute.
130408	File name must be passed with the extension (xx.yyy)	Correct the file extension.
130409	Profile curve contains no valid value at the pitch point	Measured data incomplete
130410	Lead curve contains no valid value at the pitch point	Measured data incomplete

Tab. 7 Messages 130000 – 139999

4.2.3 140000 – 149999

Number	Message	Cause / Corrective action
140101	Error when reading the file	File contains errors.
140102	Mode filename is empty	File invalid.
140103	Incorrect program file versions	The program file cannot be executed.
140104	Please use only configuration files supplied with the new program	The configuration file cannot be opened.
140401	Lizenz.dat file contains faulty data	Lizenz.dat contains errors or does not belong to the current program version. Contact the manufacturer.
140402	Invalid license file cannot be deleted	Lizenz.dat contains errors or does not belong to the current program version. Contact the manufacturer.
140403	Current license file was deleted during operation	You must not delete *lizenz.dat.* Restore *lizenz.dat* from the data backup.
140501	Regression cannot be calculated; no measuring points within the evaluation range	Choose an appropriate evaluation range.

Tab. 8 Messages 140000 – 149999

4.2.4 170000 – 179999

Number	Message	Cause / Corrective Action
170101	The number you entered was not a whole number. Please enter another number.	Invalid entry; enter only whole-number values.
170101	The number you entered was not a real number. Please enter another number.	Invalid entry.

Tab. 9 Messages 170000 – 179999

4.2.5 190000 – 199999

Number	Message	Cause / Corrective Action
190101	Alpha_kt negative despite ball correction	Check involute data; measuring data may be incomplete.
190102	Reference ball for Mdk calculation not defined	Check involute data; measuring data may be incomplete.
190103	Number of teeth for base tangent length calculation not defined	Invalid number of teeth
190301	Entries in color file greater than maximum color	Check "lilac" color entry; otherwise contact the manufacturer.
190401	Graphics error	Check involute data; measuring data may be incomplete.

Tab. 10 Messages 190000 – 199999

5 Parameters

The pages that follow contain definitions of relevant terms for the presentation of deviation parameters.

This guide covers standard evaluations only and does not take account of customer-specific factory standards.

5.1 Cylindrical Gears

Cylindrical gears are gears with cylindrical pitch surfaces.

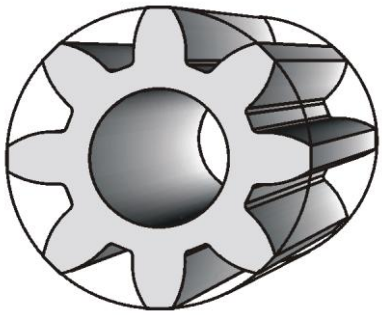

Fig. 2 Cylindrical gear with cylindrical pitch surfaces

Characteristics:

- Teeth can be located on the inside or outside of the cylinder. These are called:
  - External gearing
  - Internal gearing
- Teeth can be straight or helical
  - Straight-tooth gear
  - Helical gear
- The gear action involves 2 toothed gears rolling off one another. There are three tooth forms: circular arc, cycloid, and involute. Only involutes are considered here.

5.1.1 Lead Identification

The right or left flank is the flank an observer sees to his right or left when looking in an established direction at a tooth pointed upward.

This definition applies to both external and internal gears. With a cylindrical gear pair, the right flank works with the right flank and the left flank with the left, assuming the same viewing direction

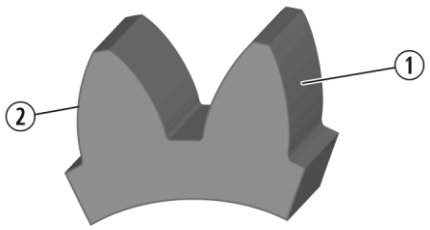

Fig. 3 External gearing

① *Right flank*

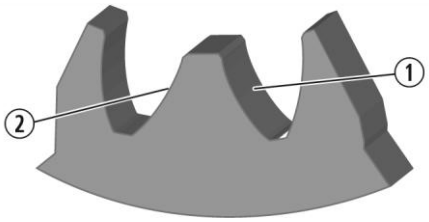

Fig. 4 Internal gearing

② *Left flank*

5.1.2 Parameters

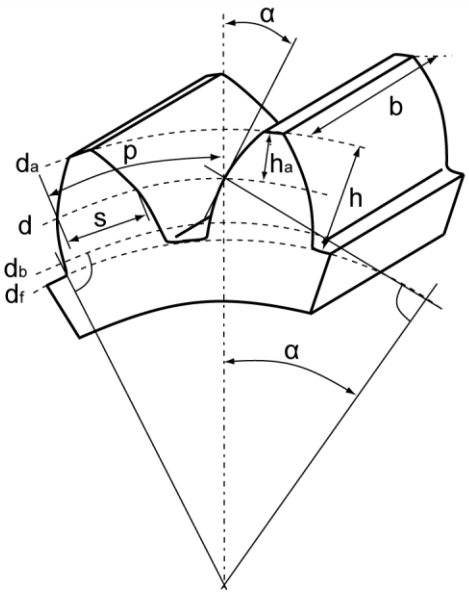

Fig. 5 Cylindrical gear parameters

Size	Description
d_a	Tip diameter
d	Reference diameter
d_f	Root diameter
d_b	Base diameter
h	Tooth depth
h_a	Addendum
p	Pitch on the reference cylinder
s	Tooth thickness on the reference cylinder
b	Gear face width
α	Pressure angle

Tab. 11 Cylindrical gear parameters

Pitch (p) is proportional to module (m) of the gear: $P = \pi * m$

The reference diameter is obtained by multiplying the module by the number of teeth: $d = m * z$

5.1.3 Helix Angle

For straight-toothed cylindrical gears, the helix angle is ß = 0.

For helical cylindrical gears, the helix angle determines the lead:

- ß > 0 for right-hand teeth
- ß < 0 for left-hand teeth

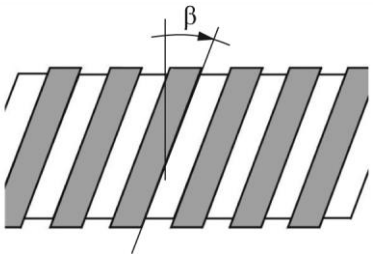

Fig. 6 Right-hand ß > 0

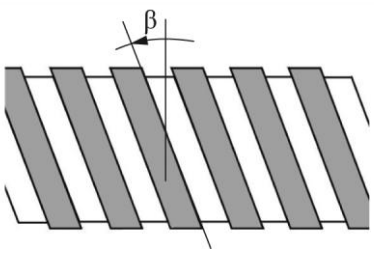

Fig. 7 Left-hand ß > 0

For gears with internal gearing, the direction and the sign reverse.

5.1.4 Sign of Angle Error in acc. with DIN and VDI

The sign of angle error can be defined in acc. with DIN, VDI, or <+-+>. The sign of angle error for DIN and VDI is the same for right-handed leads, but opposite for left-handed leads.

For straight gear, the angle is handled mathematically in acc. with DIN but in terms of absolute value in acc. with VDI.

DIN

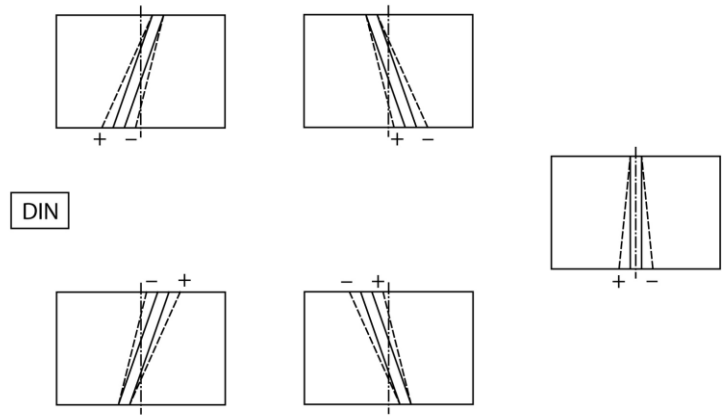

Fig. 8 Sign of angle error in acc. with DIN

Right-handed	Left-handed	Line

VDI

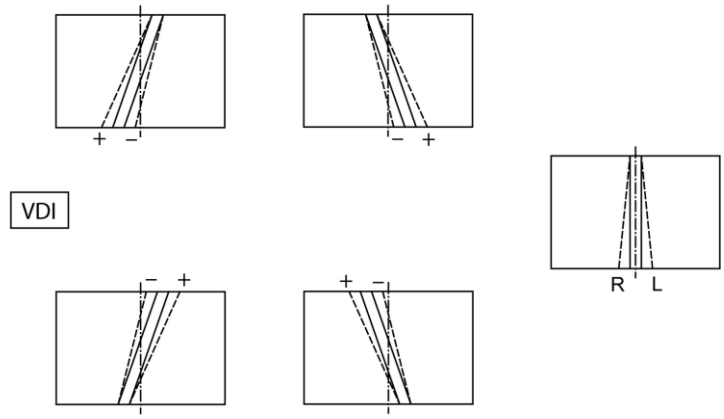

Fig. 9 Sign of angle error in acc. with VDI

Right-handed	Left-handed	Line

<+-+>

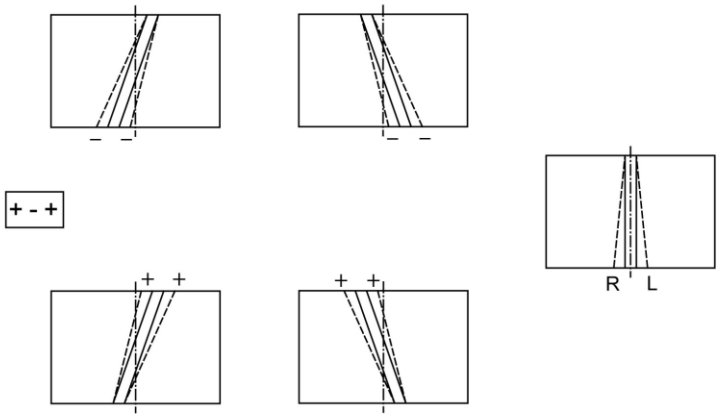

Fig. 10 Sign rule in acc. with <+-+>

Right-handed	Left-handed	Line

5.1.5 Ball Dimension

The ball dimension is an indirect measure of tooth thickness. A measurement ball with diameter D_M is positioned in a tooth space such that it is in contact with both tooth flanks. This ball is adjusted mathematically with the measuring center.

2-ball dimension

2 balls are positioned on the flanks of the two tooth spaces located the furthest apart from each other.

The 2-ball dimension is also called diametric 2 ball dimension. On a gear with external gearing, it is the largest external dimension over the two balls; on a gear with internal gearing, it is the smallest internal dimension between the two balls.

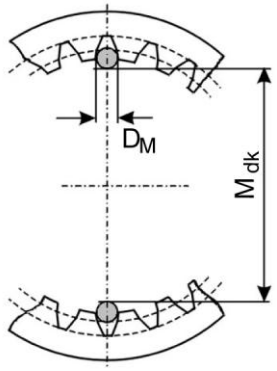

Fig. 11 Internal gearing

D_M Ball diameter

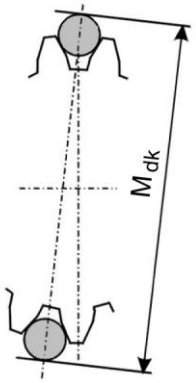

Fig. 12 External gearing

M_{dk} Diametric 2-ball dimension

5.2 Overview of Parameters

fHa = fHα	Profile angle deviation
Fα	Total profile deviation
Ffa = ffα	Profile form deviation
α	Pressure angle
Ca = Cα	Depth crowning
F_{Ko}	Tip relief
F_{Fu}	Root relief
β	Helix angle
fHβ	Tooth trace angle deviation
Fβ	Total tooth trace deviation
fo, fu	End relief
Cβ	Helix crowning
Ffβ	Tooth trace angle deviation
Mdk	2-ball dimension
f_p	Individual pitch deviation
R_p	Range of pitch error
F_{pk}	Cumulative pitch-span variation
f_u	Pitch jump
F_r	Runout deviation
R_s	Variation of tooth thickness

Tab. 12 Parameter overview

5.3 Profile Deviations

Involute gears have involutes only in the transverse section. For this reason, tooth profile deviations are only measured in the transverse section.

5.3.1 Total Profile Deviation

Total profile deviation Fα (or Fa) of a tooth flank is the distance between the two nominal profiles AA and A“A“ that touch and enclose the tooth flank inside the profile evaluation range.

The desired deviations in the form of an involute are allowed for by corresponding deviations of the lines AA and A’ A’ from straight lines.

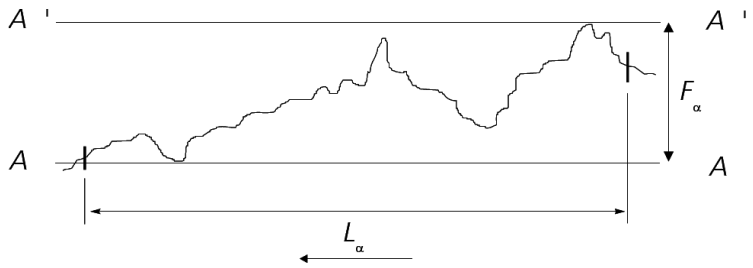

Fig. 13 Total profile deviation

Fα	Total profile deviation
Lα	Profile evaluation range
AA, A”A”	Nominal profiles enclosing the actual flank

Tab. 13 Parameters for total profile deviation

5.3.2 Profile Form Deviation

Profile form deviation ffα of a tooth flank is the distance between the two involutes of the actual base circle that touch and enclose the actual profile inside the profile evaluation range. Desired deviations from the form of the involutes are allowed for by deviations from the straight lines.

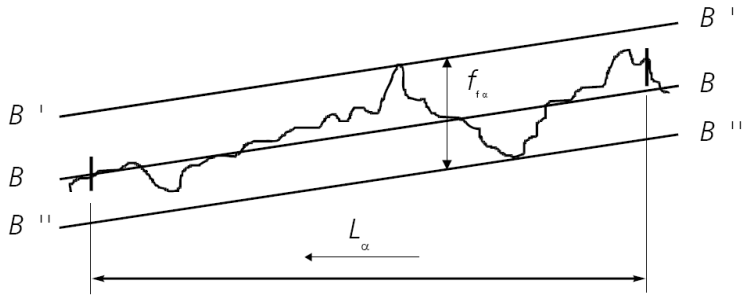

Fig. 14 Profile form deviation

ffα	Profile form deviation
Lα	Profile evaluation range
BB	Centering line for actual involute
B'B', B''B''	Parallel lines enveloping centering line for actual involute

Tab. 14 Parameters for profile form deviation

The profile form deviation also includes the wave depth of the profile ripple. The profile ripple is a deviation that recurs periodically with the rolling angle.

5.3.3 Profile Angle Deviation

Profile angle deviation fHα is the distance between the two nominal profiles C'C' and C''C'' that intersect the centering profile – that is, the nominal profile modified by a helical component – at the starting point and end point, respectively, of the profile evaluation range. Profile angle deviation fHα is generally given in µm as the linear measure associated with profile test range Lα.

Profile angle deviation fHα is positive when the involute of the actual base circle rises toward the material-free side compared with the nominal profile in the direction of increasing working lengths.

Profile angle deviation fHα is negative when the involute of the actual base circle slopes down toward the material side in the direction of increasing working lengths.

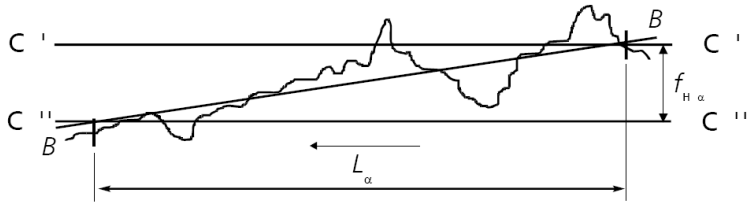

Fig. 15 Profile angle deviation

fHα	Profile angle deviation
Lα	Profile evaluation range
BB	Centering line for actual involute
C'C', C''C''	Nominal profiles intersecting the profiles at the test range starting point and end point, respectively.

Tab. 15 Parameters for profile angle deviation

5.3.4 Depth Crowning

Depth crowning C_α modifies the shape of the profile.

This figure shows how the values for F_α, $f_{H\alpha}$, and $f_{f\alpha}$ are determined from the profile test diagram while taking account of the specified crowning $C_{\alpha Soll}$ (Cα setpoint).

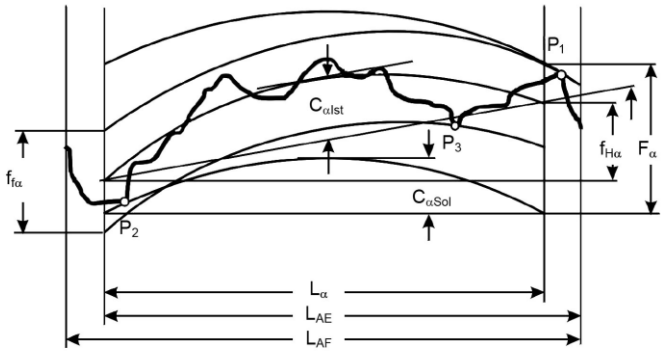

Fig. 16 Depth crowning

L_α	Profile evaluation range
L_{AE}	Profile evaluation range, including tip area
L_{AF}	Profile measuring range (range of the tooth profile in which the measured values were recorded)
P_1, P_2	Highest and lowest point, respectively, at which the enveloping setpoint parabola is placed from both sides (a determining factor for the value of total deviation F_α)
P_1, P_3	Highest and lowest point, respectively, at which the enveloping actual parabola is placed from both sides (a determining factor for the value of form deviation $f_{f\alpha}$)

Tab. 16 Parameters for depth crowning

For the evaluation, a regression parabola is calculated in the evaluation range. The two intersection points on the parabola are connected to the boundary lines of the evaluation range, thereby producing a chord.

The distance between a parallel line and the chord gives depth crowning C_α.

5.4 Tooth Trace Deviations

The tooth trace is the intersection between the tooth flank and the reference cylinder. Deviations of the tooth trace from its nominal form are measured tangentially to the base cylinder in sequential transverse sections.

5.4.1 Total Tooth Trace Deviation

Total tooth trace deviation Fβ of a tooth flank is the distance between the two nominal profiles that touch and enclose the tooth flank inside the tooth trace evaluation range.

Desired deviations from the ideal helix are allowed for by corresponding deviations of the lines AA and A“A“ from straight lines.

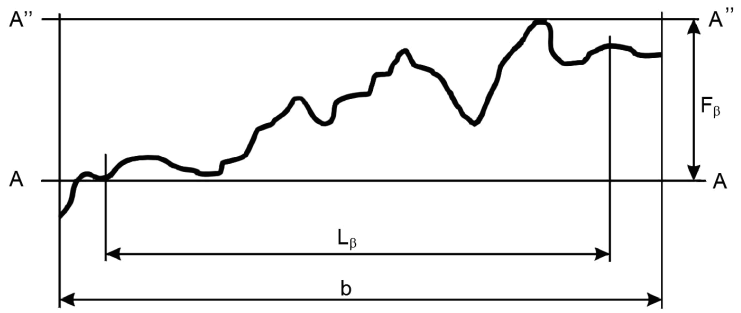

Fig. 17 Total tooth trace deviation

Fβ	Total tooth trace deviation
Lβ	Tooth trace evaluation range
b	Face width
AA, A”A”	Nominal tooth traces enclosing the actual flank

Tab. 17 Parameters for total tooth trace deviation

5.4.2 Tooth Trace Angle Deviation

Tooth trace angle deviation fHβ is the distance in a transverse section plane between the two nominal tooth traces that intersect the helix with the actual lead at the starting point and end point of the evaluation range.

It is generally given in µm as the linear measure associated with tooth trace test range Lβ.

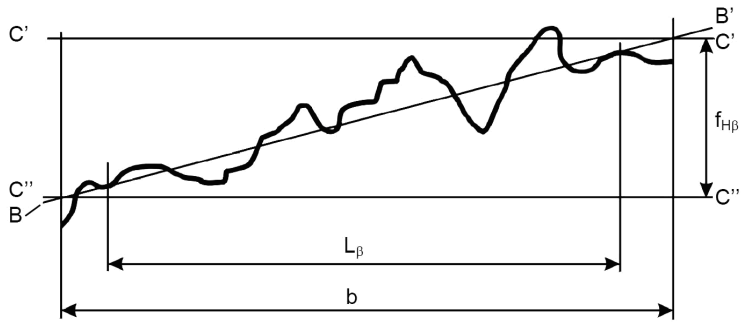

Fig. 18 Tooth trace angle deviation

fHβ	Tooth trace angle deviation
Lβ	Tooth trace evaluation range
b	Face width
BB	Centering line for actual tooth trace
C'C', C''C''	Nominal tooth traces intersecting the tooth traces at the test range starting point and end point

Tab. 18 Parameters for tooth trace angle deviation

5.4.3 Tooth trace angle deviation

Tooth trace angle deviation fHβ is the distance between the two helices and the actual lead, which touch and enclose the actual flank within the tooth trace test range, taking into account the desired deviation from the helix form.

5.4.4 Helix Crowning

Helix crowning modifies the tooth profile in its face width.

This figure shows how the values for F_{β}, $f_{H\beta}$, and $f_{f\beta}$ are determined from the tooth trace test diagram while taking account of the specified crowning $C_{\alpha Soll}$ (Cα set-point).

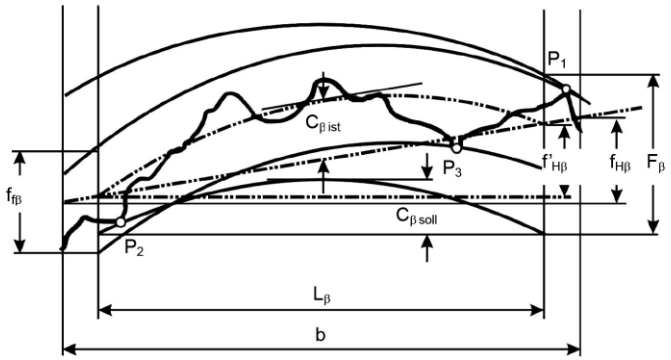

Fig. 19 Helix crowning

b	Face width
L_{β}	Tooth trace evaluation range
P1, P2	Highest and lowest point, respectively, at which the enveloping setpoint parabola is placed from both sides (a determining factor for the value of total tooth trace deviation F_{β})
P1, P3	Highest and lowest point, respectively, at which the enveloping actual parabola is placed from both sides (a determining factor for the value of tooth trace form deviation $f_{f\beta}$)

Tab. 19 Parameters for helix crowning

Note that crowning C_{β} must be referenced to evaluation range L_{β}. The highest point is determined by placing a parallel line on the regression curve.

To determine $f_{H\beta}$ the chord of the regression parabola should be used; $f_{f\beta}$, the regression parabola is used.

Tooth trace deviation angle $f_{H\beta}$ is calculated from the value $f'_{H\beta}$ measured inside evaluation range L_{β} by extrapolating to face width b.

5.5 Circular Pitch Variation

Circular pitch variations are measured on the reference circle or a measurement circle centered with respect to the gear axis and located as close to the reference circle as possible. The difference between measurement circle diameter d_M and reference circle diameter d affects the deviation measurements by a factor d_M/d and is generally negligible.

5.5.1 Individual Pitch Variation f_p

Individual pitch variation f_p is the difference between the actual dimension of an individual transverse pitch and the nominal dimension p_t.

On a gear with <z> teeth, there are <z> individual pitch variations of the right flanks and just as many variations of the left flanks. The f_p variations are calculated as the difference between the individual measured values and the average of all <z> measured values.

5.5.2 Total Pitch Variation F_p

The greatest cumulative pitch-span variation on a toothed gear is designated total pitch variation F_p. It is unsigned and is calculated as the difference between the largest and the smallest pitch-span variation values.

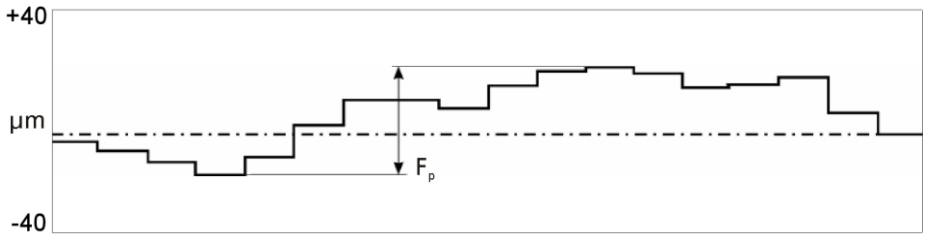

Fig. 20 Total pitch variation

5.5.3 Pitch Line Runout F_r

The pitch line runout (concentricity variation) is determined by means of a measuring element (sphere, cylinder, or V head) introduced into the tooth spaces. The measuring element contacts the tooth flanks near the X-circle. The radial position difference of the measuring element is measured for each tooth space.

F_r denotes the greatest difference among the measured values.

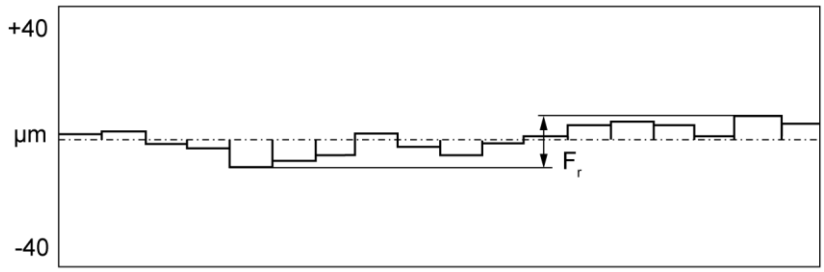

Fig. 21 Pitch line runout (concentricity variation)

Concentricity variation is caused primarily by the following:

- Eccentricity of the gear teeth in the plane of measurement perpendicular to the gear axis
- Uneven space widths due to pitch variations in the right flanks and left flanks

6 Information

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