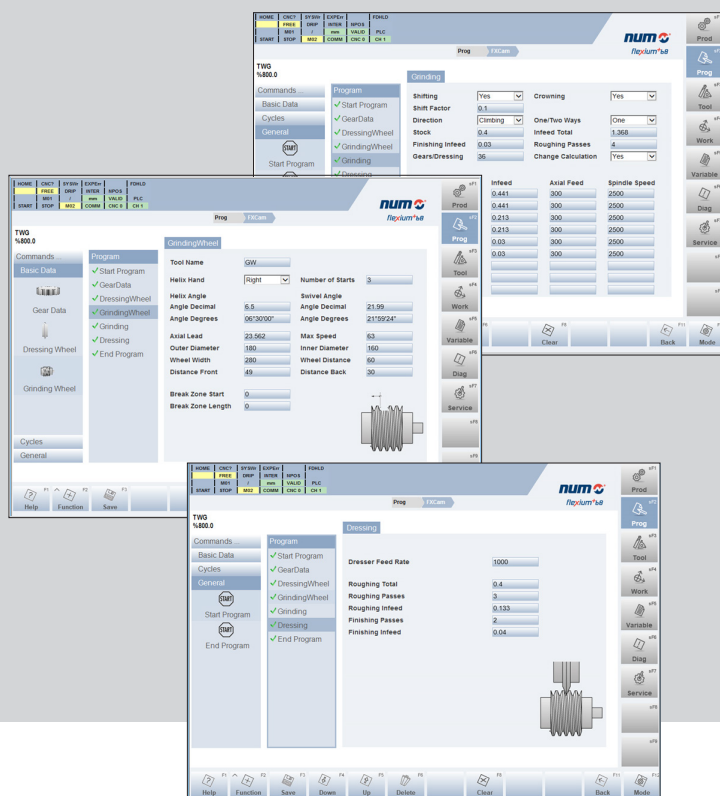


Flexium⁺ NUMgear TWG

Instruction manual

M00058EN-00

Edition 05.2018



flexium⁺

www.num.com

NUM
CNC HighEnd Applications

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1 Foreword

1.1 Introduction

This software runs on NUM Flexium⁺.

NUMgear TWG allows the operator to create and run programs to dress a grinding wheel and to grind gears using that grinding wheel by entering data into the graphic user interface without programming CNC code.

NUMgear TWG (Threaded Wheel Gear Grinding) is fully integrated into the *Flexium⁺ HMI* making use of the *Flexium⁺ soft keys*.

It allows data entry while the machine is running. Switching between the *NUMgear* screens and the other *Flexium⁺* screens is possible without data loss.

All data necessary to define the gear, the grinding wheel, the dresser, as well as dressing and grinding cycles can be set using the entry masks.

Graphics illustrate content and meaning of entry fields.

The *Fast Gear Alignment (FGA)* feature is included. It records the position of a master gear and then automatically adjusts the position of all following gears.

No acoustic emission sensor is necessary but can be used in addition to the FGA.

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1.2 NUMgear TWG User Interface Features

All the data that pertains to one particular workpiece is called a project in NUMgear.

The project is stored in a file and can be edited with the NUMgear HMI.

You can create projects, delete or save, edit projects, copy projects and finally generate the CNC code that will let the machine grind the part defined.

A project remains in the project directories - only the CNC program generated from the project will be transferred to the NC.

Projects can be saved and reloaded for further editing.

Project files can also be created on a PC connected to a Flexium+ controller. In addition, project files can be copied and used between different machines of the same type.

Changes made to the NC program will not be reflected in the project.

1.2.1 Basic structure

The basic structure of a project to grind gears and redress the grinding wheel after a predefined number of gears is very simple:

- Start Program
- Gear Data
- Grinding Wheel Data
- Dresser Data
- Grinding Cycle
- Dressing Cycle
- End Program.

1.3 Use of the manual

This manual is for use by qualified personnel only.

To reduce the risk due to an improper use of the product, do not perform any servicing other than that contained in this manual unless you are qualified to do so.

To ensure proper use of these products, please always read this User's manual carefully and retain for future reference. Should the unit require maintenance, please contact a NUM authorized service center only.

1.4 How to read the manual

This manual provides information about the NUMgear HMI.

Chapter	Description
1	Foreword This chapter introduces: - NUMgear TWG Machining Features. - Basic structure. - Use of the manual.
2	Get Started with the NUMgear HMI This chapter introduces: - Create a Project. - How to get around in NUMgear: Input Devices, Mouse and touch panel, Keyboard, Error Messages Predefined Patterns, Calculations. - Put Together a Program: Options Column and commands. - Create a Program.
3	Pages Description This chapter introduces: - Gear Data Page. - Gear Data Crowning. - Gear Data Corrections. - Dressing Wheel. - Grinding Wheel. - Grinding. - Dressing.

1.5 Document revisions

Date	Index	Reason for revision	See chapter
05 - 2018	00	Document creation	-

1.6 NUM Agencies

The list of NUM agencies is given click here <http://www.num.com>

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Summary

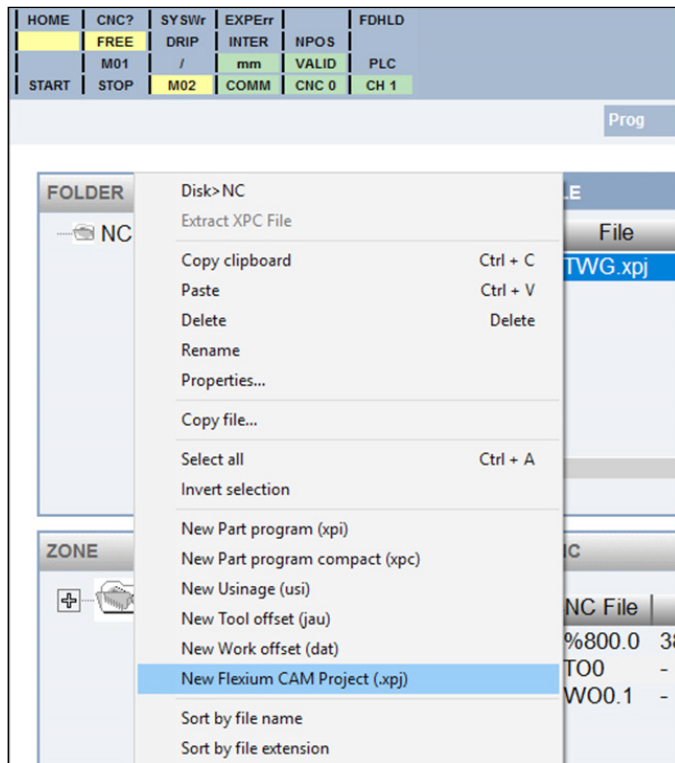
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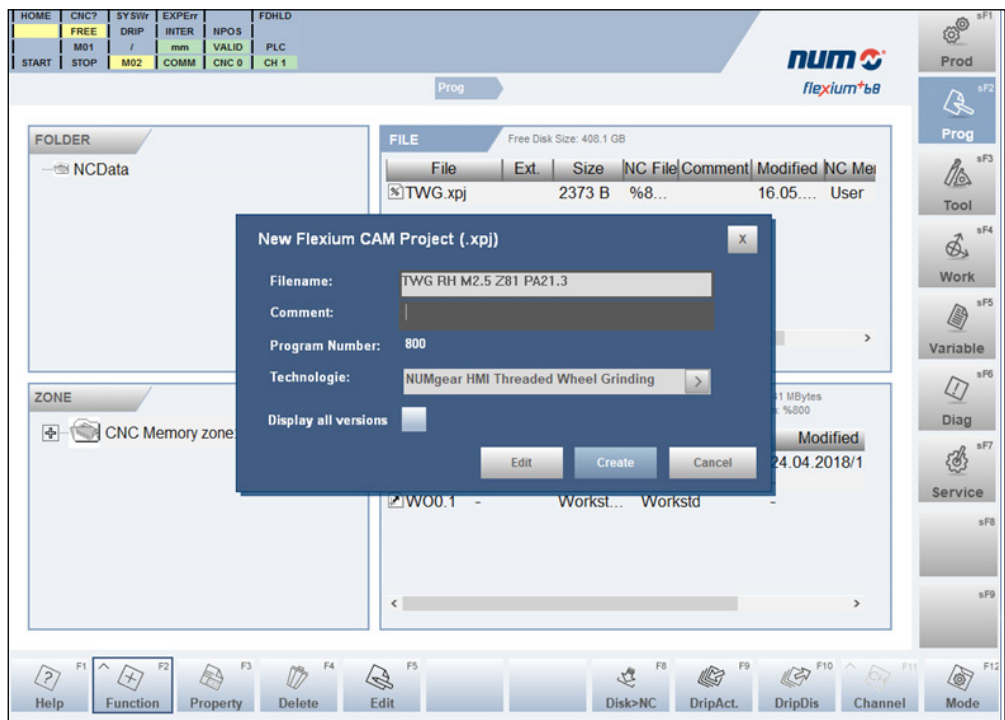
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2 Get Started with the NUMgear HMI

2.1 Create a Project

- Go to the programming page of the Flexium+ by using the *soft key* sF2 Prog.
- You create a new project by selecting the *soft key* F2 Function, create new *Flexium CAM project*.





- Enter the required data and save.
- Setting of the NC program number can be by default or set individually for each project depending on the setting in the *Flexium CAM Settings* on the service page.

A new project file will be generated into the NC Data folder selected.

To edit a project, select *the project file*.

2.2 How to get around in NUMgear

2.2.1 Input Devices

This program can be used with a variety of input devices such as keyboard, mouse, or touch panel as well as a combination of them.

2.2.2 Mouse and touch panel

- With mouse and touch panel, every item on the screen can be reached directly.
- A single tap or a single click will activate the corresponding page or entry control.
- To add items to the program flow, double tap or double click are necessary.

2.2.3 Keyboard

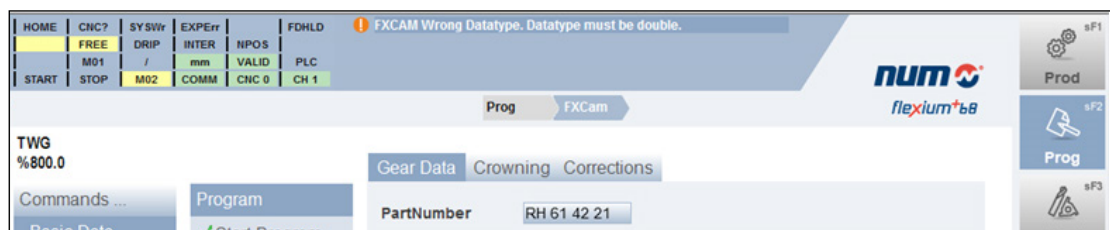
- With a keyboard, you use the tab key to switch between page areas.
- Use the arrow keys to move the focus between items in both left hand columns - the options and the program flow column.
- To get to the controls of a details page, activate that page using the tab keys, and use the arrow down once to set the focus to the first control on the page.
- Then move between the controls using the tab keys.

2.2.4 Error Messages

- Some entry fields have rules specified for them.
- The value for module e.g. cannot be 0 or negative. If you enter an invalid value, the system will display an error message.
- That error message will let you know that there are errors on the specific page as long as the focus is on an entry field with a correct value or without any rule defined.



- If the entry field that causes an error message gets the focus, the message displayed will change to the message defined for that entry field.



2.2.5 Predefined Patterns

- Some entry fields have predefined patterns that will not let you enter invalid keys, like characters for a numerical value.
- Some entry fields provide patterns that make data entry simpler.
- There are fields that require an angle as 00°00'00".
- The signs °, ' and " are given, so that entering 000000 will result in 00°00'00".
- Angle and degrees will be converted to each other respectively.

Helix Angle Hand	Right
Angle Decimal	21.5000
Angle Degrees	21°30'00"
Pressure Angle	
Angle Decimal	25.0000
Angle Degrees	25°00'00"

2.2.6 Calculations

- Also, entry fields have calculations included, that will change the values of other fields.
- Angles can be entered in decimal or with minutes and seconds.
- Only one form needs to be entered, the other will be calculated automatically as soon as the field loses the focus.

Direction	Climbing	One/Two Ways	One
Stock	0.4	Infeed Total	0.946
Finishing Infeed	0.03	Roughing Passes	2

In this case the infeed is calculated from the stock on the flanks.

2.3 Put together a Program

Here we will go over the process of putting together a program in a project file ready to be used to create the NC code.

For the description of each details page and its controls please see the next chapter. The details page will open automatically once an item is created or selected.

Please note that to add items to the program flow, double tap or double click are necessary.

The NUMgear HMI is made up of three elements.

From left to right they are:

- Options Column
- Program Column
- Details Pages.



2.3.1 Options Column

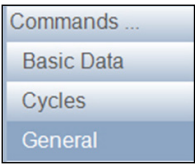
The Options Column is made up of three major categories:

- Commands
- Cycles
- General.

2.3.2 Commands

The Commands category contains the Basic Data:

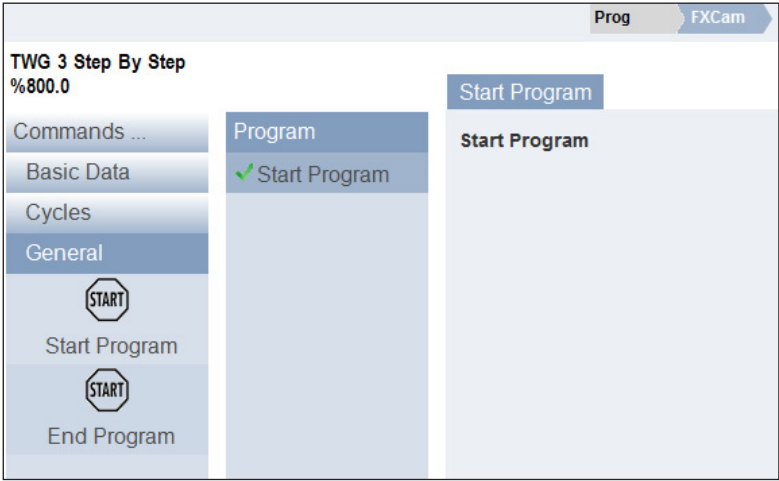
- Basic Data
- Cycles
- General.



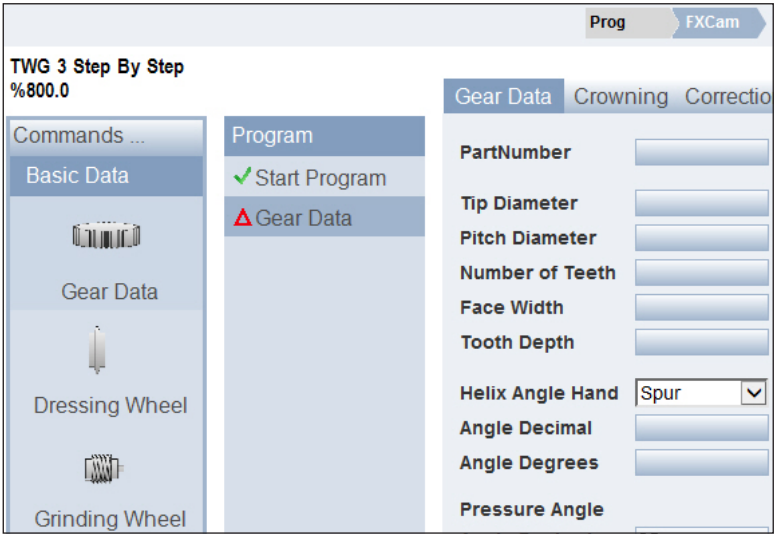
Basic Data	A screenshot of the "Basic Data" sub-menu. It contains three items: "Gear Data" with a gear icon, "Dressing Wheel" with a wheel icon, and "Grinding Wheel" with a grinding wheel icon. The "Basic Data" item from the parent menu is highlighted at the top. • Gear Data • Dressing Wheel • Grinding Wheel.
Cycles	A screenshot of the "Cycles" sub-menu. It contains two items: "Grinding" with a grinding wheel icon and "Dressing" with a dressing wheel icon. The "Cycles" item from the parent menu is highlighted at the top. • Grinding • Dressing
General	A screenshot of the "General" sub-menu. It contains two items: "Start Program" with a "START" button icon and "End Program" with a "START" button icon. The "General" item from the parent menu is highlighted at the top. • Start Program • End Program

2.4 Create a Program

- Open *General* and add *Start Program*. No data entry required.



- Select *Gear Data* and edit the details pages.



- Add data for the *Dresser Wheel* and the *Grinding Wheel*.

Prog		FXCam
TWG 3 Step By Step %800.0		
Commands ...	Program	DressingWheel
Basic Data	✓ Start Program	Tool Name
Cycles	⚠ Gear Data	Width of Dresser
General	⚠ Dressing Wheel	OuterDiameter da
		Reference z
Start Program		Profile Coordinate xp
		Tip Radius r
End Program		Distance btw. 2 O.D.

Prog		FXCam
TWG 3 Step By Step %800.0		
Commands ...	Program	GrindingWheel
Basic Data	✓ Start Program	Tool Name
Cycles	⚠ Gear Data	Helix Hand
General	⚠ Dressing Wheel	Helix Angle
	⚠ Grinding Wheel	Angle Decimal
Start Program		Angle Degrees
		Axial Lead
End Program		Outer Diameter
		Wheel Width
		Distance Front

- Open *Cycles* and add a *Grinding* and a *Dressing* cycle.

Prog FxCam

TWG 3 Step By Step
%800.0

Commands ...

Basic Data

Cycles

Grinding

Dressing

Program

- ✓ Start Program
- △ Gear Data
- △ Dressing Wheel
- △ Grinding Wheel
- △ Grinding

Grinding

Shifting Yes

Shift Factor 0.1

Direction Climbing

Stock 0

Finishing Infeed 0.03

Gears/Dressing

Pass	Infeed Total	Infeed
1		
2	0	
3	0	

Prog FxCam

TWG 3 Step By Step
%800.0

Commands ...

Basic Data

Cycles

Grinding

Dressing

Program

- ✓ Start Program
- △ Gear Data
- △ Dressing Wheel
- △ Grinding Wheel
- △ Grinding
- △ Dressing

Dressing

Dresser Feed Rate

Roughing Total

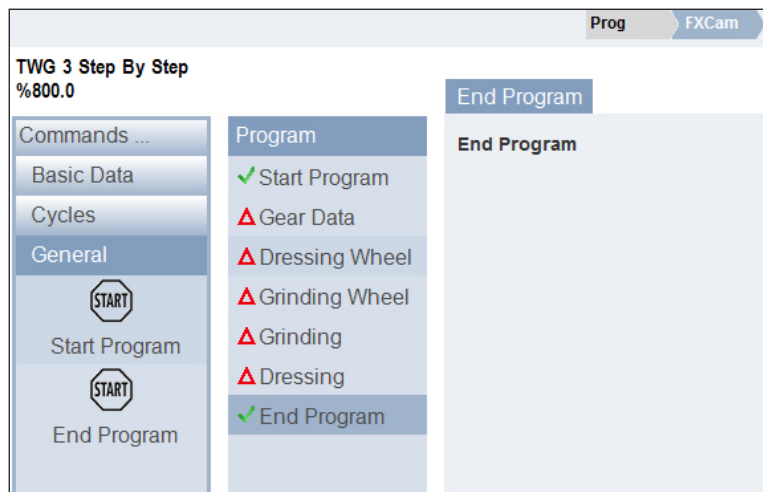
Roughing Passes

Roughing Infeed

Finishing Passes

Finishing Infeed

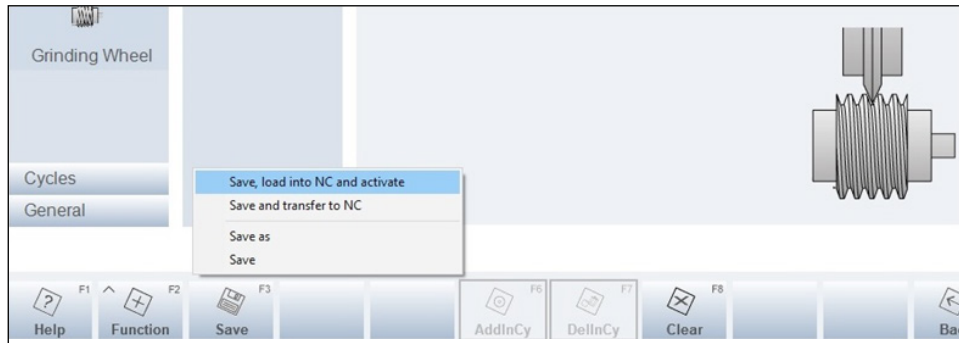
-
- To end the program flow, open *General* and select *End Program*. No data entry required.



You can always review the data you entered by selecting the entry in the program flow:

1. Start Program
2. Gear Data
3. Dresser
4. Grinding Wheel
5. Grinding Cycle
6. Dressing Cycle
7. End Program.

Entries in the program flow can be added and deleted, and the order of entries can be changed. The program flow reflects the CNC program that will be created and sent to the NC. And that is all that is required to create a program. Now select *Save, Load into NC* and activate.



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3 Pages Description

3.1 Gear Data Page

The *Gear Data Page* has three tabbed subpages.

The first is used to enter the common gear data.

In the second subpage, you can specify and modify crowning for the gear flanks.

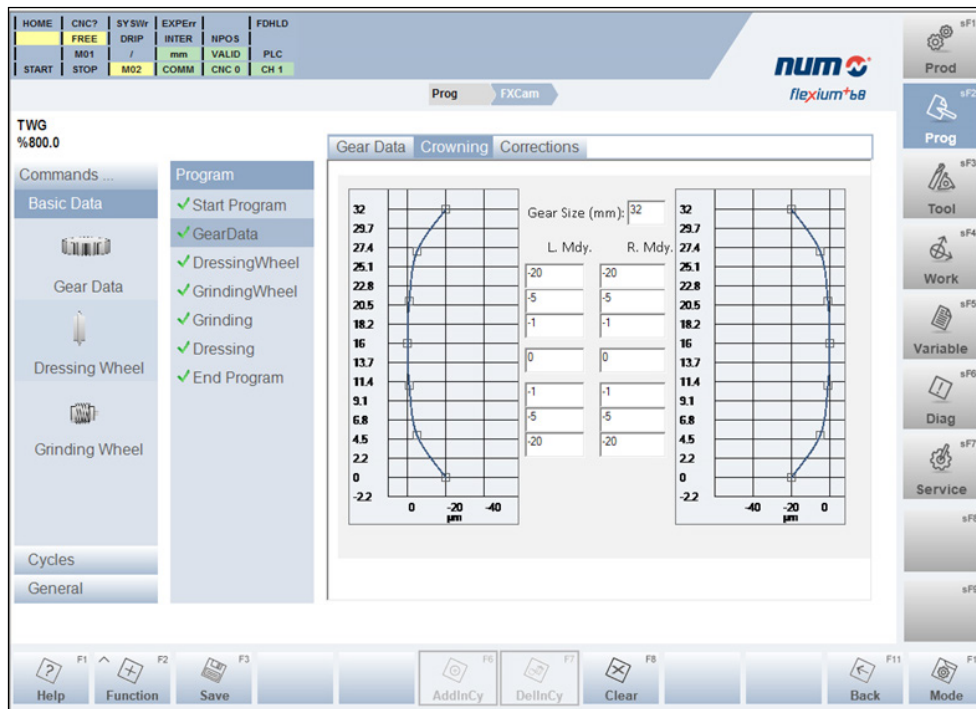
The third subpage allows for entry of correction values *fH Alpha* and *fH Beta*, once the gear has been measured.

3.1.1 Gear Data

Field Name	Description
Part Number	This is a string you can use to identify your gear.
Tip Diameter	This is the outer diameter of the gear.
Root Diameter	This is the inner diameter of the gear.
Pitch Diameter	Diameter of the gear where the pressure angle is measured.
Number of Teeth	Number of teeth to be cut on this gear blank. Minimum is three, maximum number is 9990.
Face Width	Refers to the length of the gear tooth. You must define exactly how long the teeth on the gear are. The value you enter here must be the face width of the gear blank. If you are cutting splines or end of shaft gears then enter the desired tooth length.
Module	Pitch diameter / Number of Teeth.

Tooth Depth	Distance between the tooth tip and the gap root of the gear. The tooth depth determines the travel of the grinding wheel in radial direction into the gear.
Z Distance	Distance from the homing position.
Helix Hand	You can select spur gear - no helix angle, right hand or left hand. If you think of the gear as a screw, a right hand gear when turned clockwise will screw in, and a left hand gear when turned clockwise will screw out.
Helix Angle	This field is displayed only for helical, not for spur gears. The angle can be entered in decimal degrees, or in degrees"minutes"seconds" and is always positive, as the sign is determined by the helix hand - right hand results in a positive and left hand results in a negative value.
Pressure Angle	This is used to enter the profile angle at the pitch circle.

3.1.2 Gear Data Crowning



Today's gearboxes are being built even smaller sporting even more gears.

Tear and wear as well as noise reduction are becoming more of an issue. One approach that shows good results is crowning of the teeth by changing their chordal thickness along the axis.

Crowned gears improve contact bearing in the center of the tooth, reducing pressure at top and bottom of the gear.

NUMgear TWG Crowning allows for modification of the flank line.

You can either use the input fields, or the mouse to drag the black rectangles to adjust the values.

3.1.3 Gear Data Corrections

The screenshot shows the NUMgear TWG software interface. At the top, a status bar displays machine status: HOME, CNC?, SYSW, EXPErr, NPOS, FDHLD, FREE, DRIP, INTER, mm, VALID, PLC, START, STOP, M01, M02, COMM, CNC 0, CH 1. The main interface is divided into several sections:

- Left Sidebar:** Contains icons for Basic Data, Gear Data, Dressing Wheel, and Grinding Wheel. Below these are buttons for Cycles and General.
- Central Menu:** A list of program steps with checkboxes: Start Program, GearData, DressingWheel, GrindingWheel, Grinding, Dressing, and End Program.
- Main Area:** Titled 'Gear Data Corrections', it contains two sections:
 - Flank Correction:** Fields for Top (0.021), Middle (16), Bottom (0.001), and tH Beta (0.02).
 - Profile Correction:** Fields for Tip (-0.2), Pitch (81.1), Root (0.2), and tH Alpha (0.03).
- Right Sidebar:** A vertical toolbar with icons for Prod, Prog, Tool, Work, Variable, Diag, Service, and others.
- Bottom Bar:** A row of function keys: F1 (Help), F2 (Function), F3 (Save), F6 (AddInCy), F7 (DelInCy), F8 (Clear), F11 (Back), and F12 (Mode).

Enter the values from the measurement protocol to correct grinding results on the flanks.

3.2 Dressing Wheel

num gear flexium+tb8

Prog FxCam

TWG %800.0

Commands ...

Basic Data

Gear Data

Dressing Wheel

Grinding Wheel

Cycles

General

DressingWheel

Tool Name DR 200 4 Tool Number 1

Width of Dresser 2.5 Width of Wheel 36

OuterDiameter da 210.5 Inner Diameter 182

Reference z 26 Pressure Angle pa 20

Profile Coordinate xp 124 Profile Coordinate zp 2.2

Tip Radius r 2 Profile Crowning HBR 2.6

Distance btw. 2 O.D. 14.25

Dresser Feed Rate 1000

Roughing Passes 4

Roughing Infeed 0.3

Finishing Passes 2

Finishing Infeed 0.012

Help F1 ^ F2 F3 AddInCy DefInCy Clear F8 F11 F12

Prod sF1

Prog sF2

Tool sF3

Work sF4

Variable sF5

Diag sF6

Service sF7

sF8

sF9

Field Name	Description
Tool Name	This is a string you can use to identify your dresser.
Tool Number	Identifies the dresser on the tools page.
Width of Dresser	Usable width of the dresser. Corresponds to the maximum gap width of the grinding wheel's thread.
Width of Wheel	Total width of dresser.
Outer Diameter	Outer diameter of the dresser.
Inner Diameter	Usable diameter of the dresser. Corresponds to the maximum gap depth of the grinding wheel's thread.
Reference z	Distance between the spindle face and the tip of the dresser.
Pressure Angle pa	Pressure angle of the dresser. Is transferred to the grinding wheel and to the gear at the pitch circle.
Profile Coordinate xp	Distance between the pitch circle of the dresser and its axis.
Tip Radius r	Tip radius of the dresser.
Profile Crowning	The profile crowning amount of the dresser. As it is a full form dresser, this corresponds to the crowning of the gear profile.
Distance between two OD	Difference between outer and inner diameter of the dresser.
Dresser Feed Rate	Maximum axial feed rate of the dresser into the grinding wheel.
Roughing Passes	Number of roughing passes done during one dressing cycle.
Roughing Infeed	Infeed per roughing dressing pass.
Finishing Passes	Number of finishing passes done during one dressing cycle.
Finishing Infeed	Infeed per finishing dressing pass.

3.3 Grinding Wheel

The screenshot displays the NUMgear TWG software interface for configuring a grinding wheel. The top status bar shows machine status: CNC7, FREE, DRIP, INTER, NPOS, VALID, PLC, CH 1. The left sidebar contains navigation options: Basic Data, Gear Data, Dressing Wheel, Grinding Wheel, Cycles, and General. The main area is titled 'GrindingWheel' and contains the following parameters:

- Tool Name:** GW
- Helix Hand:** Right
- Helix Angle:** 6.5
- Angle Decimal:** 06°30'00"
- Number of Starts:** 3
- Swivel Angle:** 21.99
- Angle Decimal:** 21°59'24"
- Axial Lead:** 23.562
- Max Speed:** 63
- Outer Diameter:** 180
- Inner Diameter:** 160
- Wheel Width:** 280
- Wheel Distance:** 60
- Distance Front:** 49
- Distance Back:** 30
- Break Zone Start:** 0
- Break Zone Length:** 0

A 3D model of a grinding wheel is shown on the right side of the main area. The bottom of the interface features a toolbar with icons for Help, Function, Save, AddInCy, DelInCy, Clear, Back, and Mode.

Field Name	Description
Tool Name	This is a string you can use to identify your grinding wheel.
Helix Hand	Right hand or left hand. If you think of the grinding wheel as a screw, a right hand grinding wheel when turned clockwise will screw in, and a left hand when turned clockwise will screw out.
Helix Angle	The angle can be entered in decimal degrees, or in degrees°minutes'seconds" and is always positive, as the sign is determined by the helix hand - right hand results in a positive and left hand results in a negative value.
Number of Starts	Number of threads of the grinding wheel.
Swivel Angle	The angle the grinding wheel is set to. Swivel angle corresponds to gear helix angle and grinding wheel helix angle.
Axial Lead	The axial distance between two rounds of the same thread. For a single threaded grinding wheel it is the distance between two threads. For a grinding wheel with five starts, it is the distance between every fifth start.
Max Speed	Maximum speed of the grinding wheel in meters per second. 63 m/s is the default value.
Outer Diameter	Diameter of the grinding wheel for start of the first grinding cycle.
Inner Diameter	Min. diameter of the grinding wheel once it has been dressed down. Dressing will stop once this value has been reached.
Wheel Width	Total width of the grinding wheel.
Wheel Distance	Distance between mounting and the grinding wheel.
Distance Front	Distance between spindle face and grinding wheel.
Distance Back	Distance between the rear of the grinding wheel and the enclosure.
Break Zones	Break zones can be specified to skip grinding along the given length of the grinding wheel.

3.4 Grinding

The screenshot shows the NUMgear TWG software interface for the Grinding screen. The top status bar indicates the machine is in 'FREE' mode, 'DRIP' is active, and 'M01' is selected. The 'Grinding' screen is active, showing various parameters for grinding a gear.

Parameters:

- Shifting: Yes
- Crowning: Yes
- Shift Factor: 0.1
- Direction: Climbing
- One/Two Ways: One
- Stock: 0.4
- Infeed Total: 1.368
- Finishing Infeed: 0.03
- Roughing Passes: 4
- Gears/Dressing: 36
- Change Calculation: Yes

Grinding Passes Table:

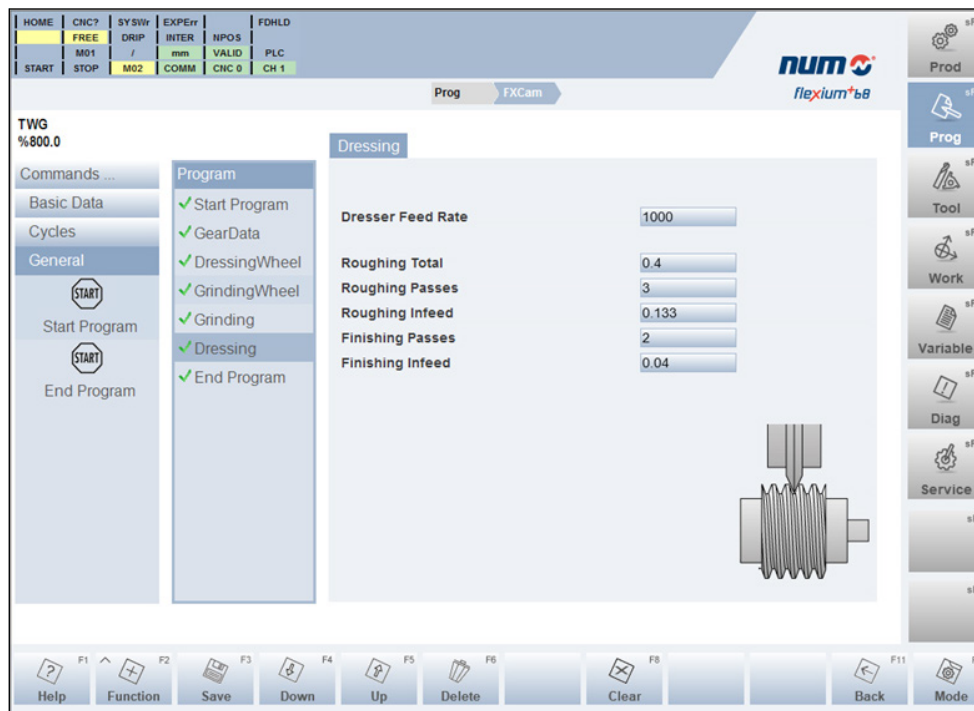
Pass	Infeed Total	Infeed	Axial Feed	Spindle Speed
1	0.441	0.441	300	2500
2	0.882	0.441	300	2500
3	1.095	0.213	300	2500
4	1.308	0.213	300	2500
5	1.338	0.03	300	2500
6	1.368	0.03	300	2500
7				
8				
9				

The interface also includes a sidebar with navigation options: Basic Data, Cycles, General, Start Program, End Program, and a bottom bar with function keys (F1-F12).

Field Name	Description
Shifting	Allows you to activate continuous segment shifting while grinding.
Crowning	Activate or deactivate crowning as defined with the gear data.
Shift Factor	Shifting of the grinding wheel relative to the gear is used to combine best grinding results with a long life time of the tool. Basically, an unused segment of the grinding wheel is used for finishing, and then the same segment is being used for roughing. The value of the shifting is module multiplied by number of threads of the grinding wheel. The shift factor allows you to modify that shifting value.
Direction	Define the direction combined by movement in Z and the rotation of the grinding wheel. Climbing - same direction - means that each particle of the grinding wheel reaches final grinding depth immediately. Grinding burn is less likely, as the area that is being heated by the grinding process is being removed completely by the process. Conventional – counter direction – means that each particle of the grinding wheel starts at a depth of zero and reaches its final grinding depth at the end of the process. That does produce a better surface quality. But it also raises the risk of grinding burn as the heat caused by grinding might extend to a depth not influenced by the grinding process.
One / Two Ways	The direction climbing / conventional defined before can be kept during the complete grinding process, or it can be set to alternate between climbing and conventional. The direction defined will be the first cutting strategy and will be the same during the process if you opt for one way. The direction defined will be the first cutting strategy but then the strategy will change for every grinding pass if you opt for two ways.
Stock	The amount of stock to remove at the pitch diameter.
Infeed Total	The way the grinding wheel has to move into the gear to completely remove the stock on both flanks. This value is being calculated if gear data has been input correctly.

Finishing Infeed	The amount of infeed to be used for the two finishing passes.
Roughing Passes	Number of passes required for roughing.
Gears/Dressing	How many gear can be ground with a dressed grinding wheel before it needs redressing.
Change Calculation	Gives you the option to change values calculated for roughing as well as finishing passes.
Grinding Passes	The values for all the grinding passes are being calculated. If you set the Change Calculation combo box to Yes, you can manually change those values. Please keep in mind that the total of all roughing and finishing passes will have to equal the Infeed Total value. If you change just one value and the amount is not what has been calculated previously, the value for Infeed Total will be displayed in red.

3.5 Dressing



Field Name	Description
Dresser Feed Rate	Axial feed rate dresser along grinding wheel.
Roughing Total	Amount of radial infeed for roughing.
Roughing Passes	Number of roughing passes.
Roughing Infeed	Calculated from Roughing Total and Roughing Passes.
Finishing Passes	Number of finishing passes.
Finishing Infeed	Total infeed for finishing.

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