rexroth
A Bosch Company

Virtual Machine Builder

Application Description
R911396688

Edition 02

Title	Virtual Machine Builder
Type of Documentation	Application Description
Document Typecode	DOK-GENERL-VMB********-AP02-EN-P
Internal File Reference	RS-df49a37b55a1a9130a347e860d655ec6-2-en-US-3

Change Record Edition 02, 2020-04

Refer to tab. 1-1 "Change record" on page 1

Editorial Department Engineering Automation Systems - Solution Integration HMI, NC Controls and Support, BeZe, JüAr (TaDo/MePe)

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1 About this documentation

Editions of this documentation

Edition	Release date	Note
01	2019-02	First edition
02	2020-04	Complete revision chapter 12 "Appendix 1: Application example on how to design a machine kinematics" on page 51 supplemented

Tab. 1-1: Change record

2 Overview

Use the Virtual Machine Builder to quickly and easily create a kinematic machine model for machine tools. The machine definition supports machine tools and other movable systems with an unlimited number of rotary and translatory axes.

The machine to be modeled has to have a conventional serial kinematic structure. The Virtual Machine Builder is not suitable for machines with a parallel kinematics.

License

The Virtual Machine Builder can be purchased as stand-alone installation. It does not depend on IndraWorks and can thus be installed on the local PC of a machine designer.

To purchase the "Virtual Machine Builder" license :

SWS-MTX***-ENG-01VRS-D0-VMB-DGL, R911394064

A dongle is required to operate the application. Use the dongle to activate the license key provided by Bosch Rexroth. The dialog to activate the license is shown immediately after starting the Virtual Machine Builder.

3 Menu bar

The menu bar includes toolbars with multiple tabs at the upper edge of the application window. Use the menu bar to access the main program functions.

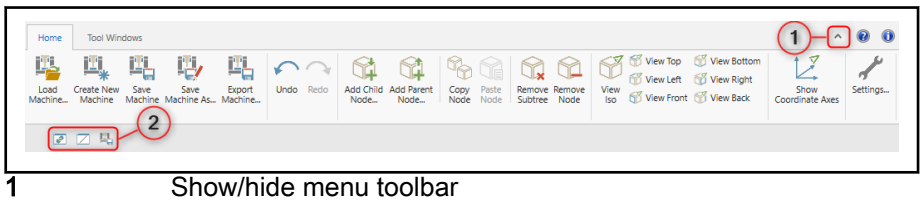
A miniature toolbar known as the quick access toolbar is located below or above the menu bar. The user can add functions to the quick access toolbar. To edit the quick access toolbar, right-click on the menu bar or on an icon on the quick menu bar.

This chapter describes the menu bar functions on the following two tabs:

- "Home"
- "Tool Windows"

3.1 “Home”

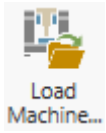
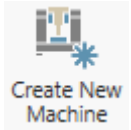
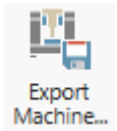
"Home" tab on the menu toolbar item:

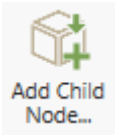
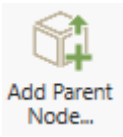
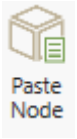
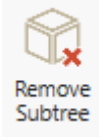
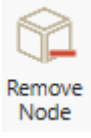
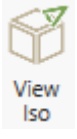
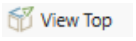
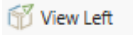
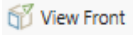
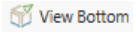


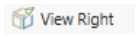
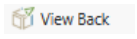
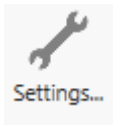
1 Show/hide menu toolbar
? Show help (also use <F1>)
i Show information on the product
2 Quick access toolbar

Fig. 3-1: "Home" menu toolbar

Functions of the toolbar buttons:

	Load Machine…	Loads an existing machine model. A file browser window is displayed. The user can select the machine model file (.xml) in this file browser window
	Create New Machine	Creates the machine definition node (i.e. the "root" node) for the kinematic machine model
	Save Machine	Saves the current file. Also refer to "User rights to save the machine model" on page 7
	Save Machine As…	A file browser window is displayed and the user can save the current machine model to a different machine model file (.xml). Also refer to "User rights to save the machine model" on page 7
	Export Machine…	The complete machine including the model and all machine geometry in the kinematic tree is exported to a folder Also refer to "User rights to save the machine model" on page 7

	Undo	Undoes the last change at the machine model
	Redo	Redoes the last change at the machine model
	Add Child Node…	Inserts the child node below the selected node A menu is displayed including all available node types
	Add Parent Node…	Adds a parent node above the selected node. A menu is displayed including all available node types
	Copy Node(s)	Copies the selected node(s)
	Paste Node(s)	Inserts the node(s) below the selected node
	Remove Subtree(s)	Removes the subtree(s) from the selected node(s)
	Remove Node(s)	Removes the selected node(s)
	View Iso	Displays the machine model as isometric view
	View Top	Top view of the machine model (towards the negative z-axis)
	View Left	View on the left side of the machine model (towards the positive x-axis)
	View Front	Front view of the machine model (towards the positive y-axis)
	View Bottom	View on the bottom side of the machine model (towards the positive z-axis)

	View Right	View on the right of the machine model (towards the negative x-axis)
	View Back	Rear view of the machine model (towards the negative y-axis)
	Show Coordinate Axes	Enables/disables the representation of the axis scales of the world coordinate system
	Settings	“Settings” menu is displayed

User rights to save the machine model

Write access to the target folder is required for the functions "Save Machine", "Save Machine as" and "Export Machine". If the machine model is directly modified in an IndraWorks installation, the user has neither admin rights nor write permissions. Users without write access should use the function "Export Machine" and back up the model in a shared folder, e.g. "My Documents".

Save machine as

"Save Machine as" saves only the XML file of the machine model to a different folder or to a folder with another name. The resources (e.g. STL files) are not saved. If the XML file is saved to a different folder, absolute paths are entered instead of relative path specifications for the resource files. Thus, maybe no machine geometry data is displayed if the original resource files are not available anymore later on. Thus, use the "Export Machine" function preferably.

Providing the machine model in the NC Simulation

The folder created via "Export Machine"" includes all files belonging to the simulation model and with the structure required to apply them to the NC Simulation. The provision of the machine model to the simulation depends on the version:

- 15V06 and older:

  The complete folder and the machine model are copied to the subfolder of the IndraWorks installation "IndraWorks/Simulation/MW Models".

  Enter the name of the machine model additionally into the options of the simulation, into the `MachineModel` tag.

- 15V08 and higher:

  The machine model is part of the IndraWorks project. Model data is represented by own nodes in the project tree of IndraWorks Engineering. There is an "Add..." function in the "Machines" node (right click). Use this function to select an XML file created with the Virtual Machine Builder from a file selection dialog. The complete folder is added to the IndraWorks project. A new node with the name of the XML file is created. This node is provided with the "Applying..." function.

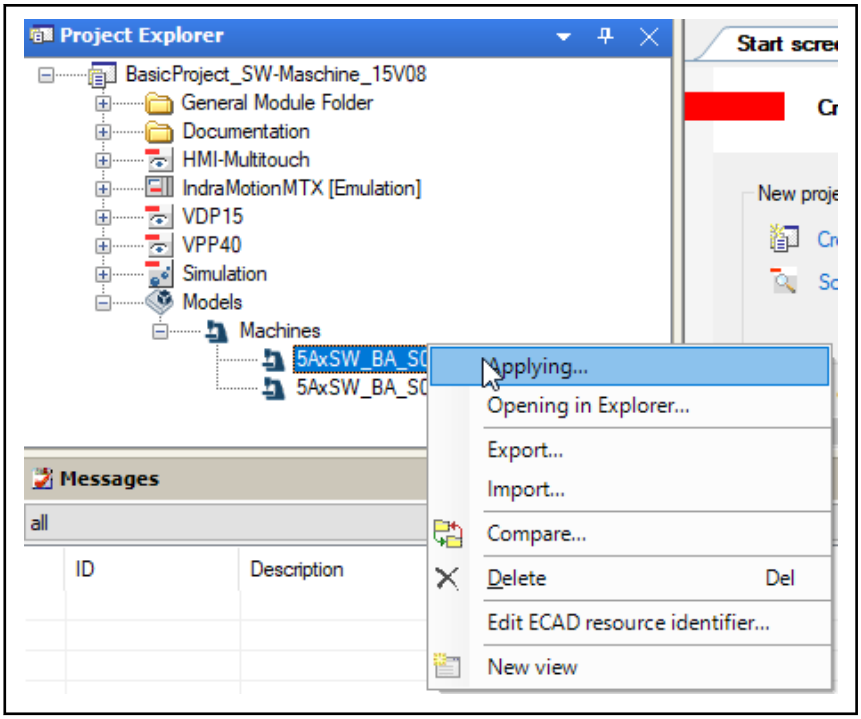


Fig. 3-2: Applying a machine model

The machine model can be applied either before starting IndraWorks Operation or while IndraWorks Operation is open. The prompt "A new machine model is available. Do you want to apply it to the simulation?" Confirm this prompt with **Yes** and the machine model is provided to the simulation. Confirm this prompt with **No** and the prompt "Do you want to delete the new machine model?" is shown. If you agree, the transfer is canceled. Otherwise, a prompt is shown again to apply the model when IndraWorks Operation is started again.

3.2 “Tool Windows”

"Tool Windows" tab on menu toolbar:

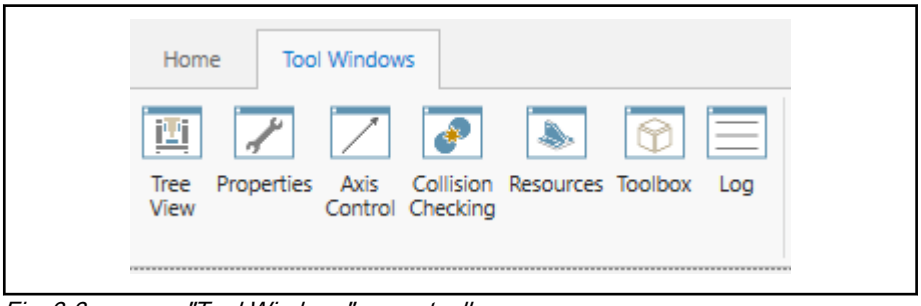
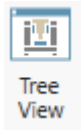
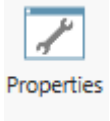
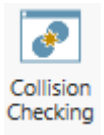
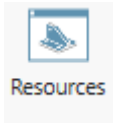
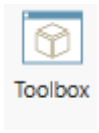
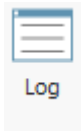


Fig. 3-3: "Tool Windows" menu toolbar

The toolbar buttons show the following functions:

	Tree View	Show/hide the “Tree View” window
	Properties	Show/hide the “Properties” window
	Axis Control	Show/hide the “Axis Control” window
	Collision Checking	Show/hide the “Collision Checking” window
	Resources	Show/hide the “Resources” window
	Toolbox	Show/hide the “Toolbox” window
	Log	Show/hide the “Log” window

4 “Tree View” window

This window displays the currently defined kinematic machine model as graphic "tree". This window consists of "nodes" or objects with specific properties. The tree view displays the nodes hierarchically. The total list of node types in the "tree" is described in the following chapters.

4.1 Node types

4.1.1 “Machine Definition” node

The "root" node in the kinematic tree represents a machine definition.

4.1.2 “Rotation Axis” node

A rotation axis node (rotary axis node) is a logical node in the kinematic tree. The node represents a rotary axis with limited axis values in a machine. Once the node type has been defined as rotation (rotary) type, it cannot be changed to a linear (translatory) axis anymore. Changing the rotary axis values also changes the position of the complete subtree, i.e. the tree rotates around the rotary axis.

4.1.3 “Translation Axis” node

A translation axis node (translatory axis node) is a logical node in the kinematic tree. The node represents a translatory axis with limited axis values in a machine. Once the node type has been defined as translatory axis type, it cannot be changed to a rotary axis anymore. Changing the translatory axis values results in a position change of the complete subtree, i.e. the tree moves along the translatory axis.

4.1.4 “Machine Geometry” node

A machine geometry node represents a physical machine component. In contrast to the stock, a machine geometry node cannot be chipped.

Instead, a collision is reported (provided the collision settings were set up accordingly).

4.1.5 “Stock” node

A stock node is a logical node in the kinematic tree. The node represents a stock in the machine. It is used as placeholder for additional stocks and clamping devices. It can be checked for collisions between the stock node and other tools and/or machine geometry nodes.

4.1.6 “Tool” node

A tool node is a logical node in the kinematic tree. The node represents a tool holder position in the machine. The tools can be inserted and removed as required.

4.1.7 “Transformation” node

A transformation node is a logical node in the kinematic tree. The node represents a transformation from one coordinate system to another. Each node is defined with regard to the coordinate system of this parent node. The transformation node can be used to easily define nodes in the kinematic tree, e.g. to stack several geometric objects upon each other.

4.1.8 "Chuck" node

The chuck node fixes the stock on the spindle. All chuck jaw nodes below the chuck are part of the chuck. They are used for clamping or unclamping (also refer to chapter 4.1.12 ""Chuck Jaw" node" on page 13).

While clamping, the chuck jaws of a chuck node move linearly towards the spindle until they touch the stock. There is a fixed connection between the chuck jaws of the chuck node and the stock. The stock is kinematically connected to the chuck.

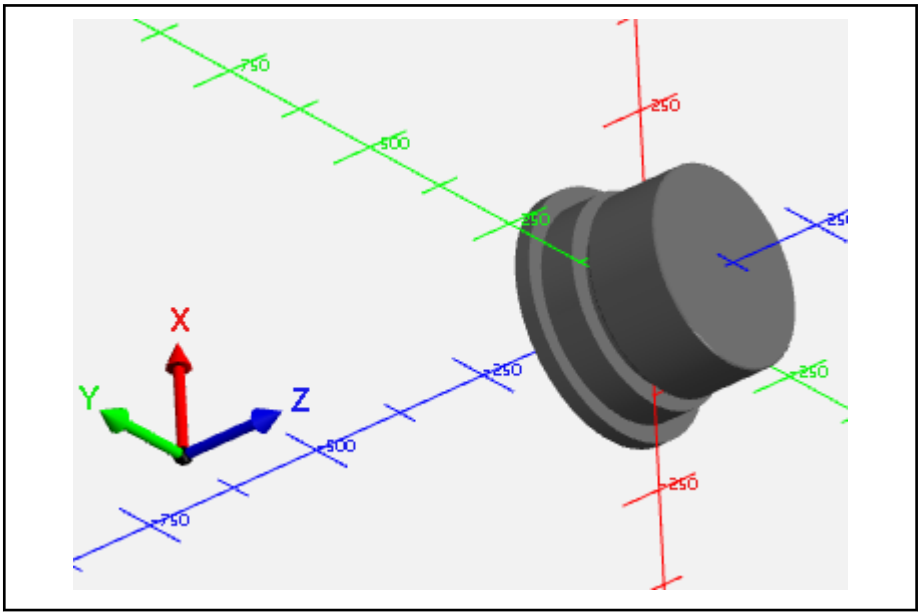


Fig. 4-1:

4.1.9 "Dummy Clamp" node

A dummy clamp node can be used in a simulation if no correct description is available for the real clamp. A dummy clamp node can optionally be used to fixedly place the stock on the milling table.

4.1.10 "Tail Stock" node

A tail stock node represents a tailstock or a tailstock center. It is used to centrically support and tension the stock in the machine. Analogously to the chuck jaw node, the node type clamps and positions until the stock is touched. This feature is not yet implemented.

4.1.11 "Steady Rest" node

The steady rest node represents a steady rest in a machine used to support a large stock along the rotary axis. There is no fixed connection between the clamped stocks and the chuck jaws of the steady rest node. Thus, the steady rest can move along the rotary axis and the stock can rotate around that axis. Therefore, a steady rest node is not mechanically connected to the stock.

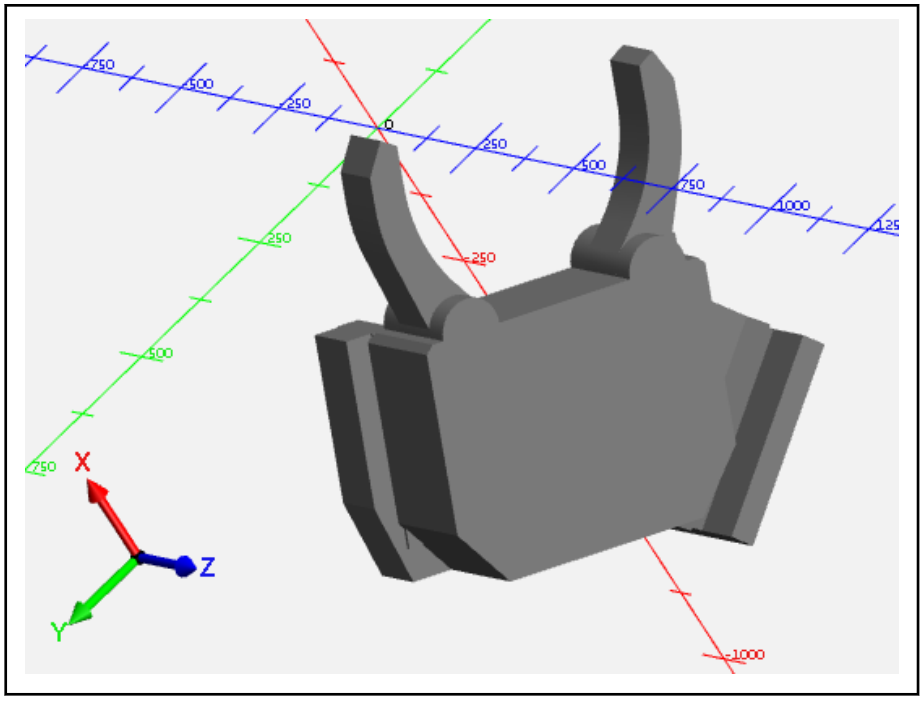


Fig. 4-2:

4.1.12 "Chuck Jaw" node

A chuck jaw node is a logical node in the kinematic tree responsible for the motion function of a chuck jaw during clamping and unclamping.

The following figure shows three chuck jaws that are children of a chuck jaw node.

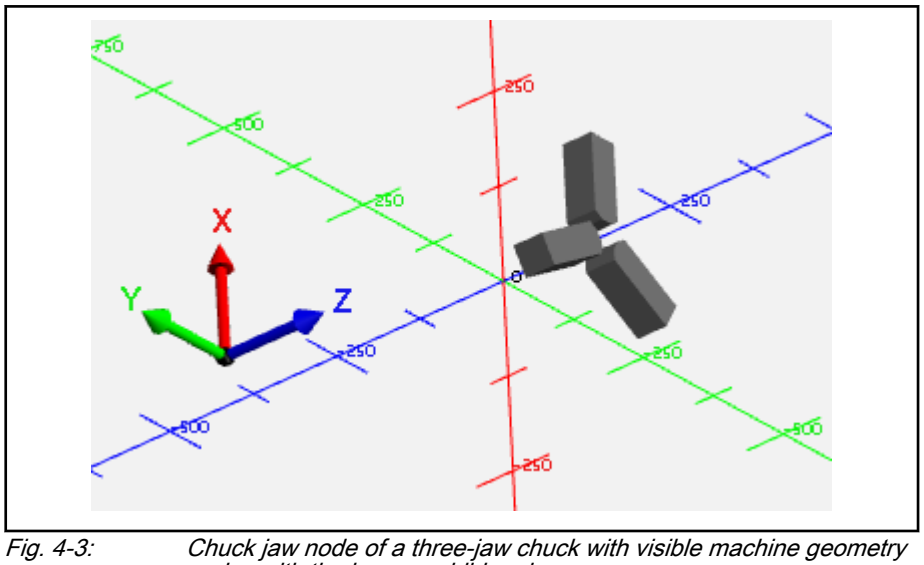


Fig. 4-3: Chuck jaw node of a three-jaw chuck with visible machine geometry nodes with the jaws as child nodes

4.1.13 "Steady Rest Jaw" node

A steady rest jaw node is a logical node in the kinematic tree representing a steady rest jaw.

4.1.14 "Tactile Tool Setting" node

A tactile tool setting node represents a physical object in the machine structure. In contrast to the machine geometry node, this node is always visible and does not collide with the cutting edge of the tool if the tool is moving in feed mode and not spinning.

4.1.15 "Wire Guide" node

This node is used for the machine technology "Wire eroding" and represents the wire routing.

4.1.16 "Wire Tool" node

This special tool node is used for the machine technology "Wire eroding" and represents the wire for the material removal.

4.1.17 "Additive Tool" node

This node represents a tool adding material (3D print).

4.1.18 "Virtual" node

A virtual node is a logical node in the kinematic tree. The virtual node represents a virtual object in the machine which refers to a physical object in the machine. A virtual node displays a physical node at another position with different visual properties.

4.2 Pop-up menu

Right-click into the "Tree View" window. If one or more nodes are selected, a context-sensitive menu is displayed. This menu contains different operating elements affecting the kinematic tree that represents the machine model.

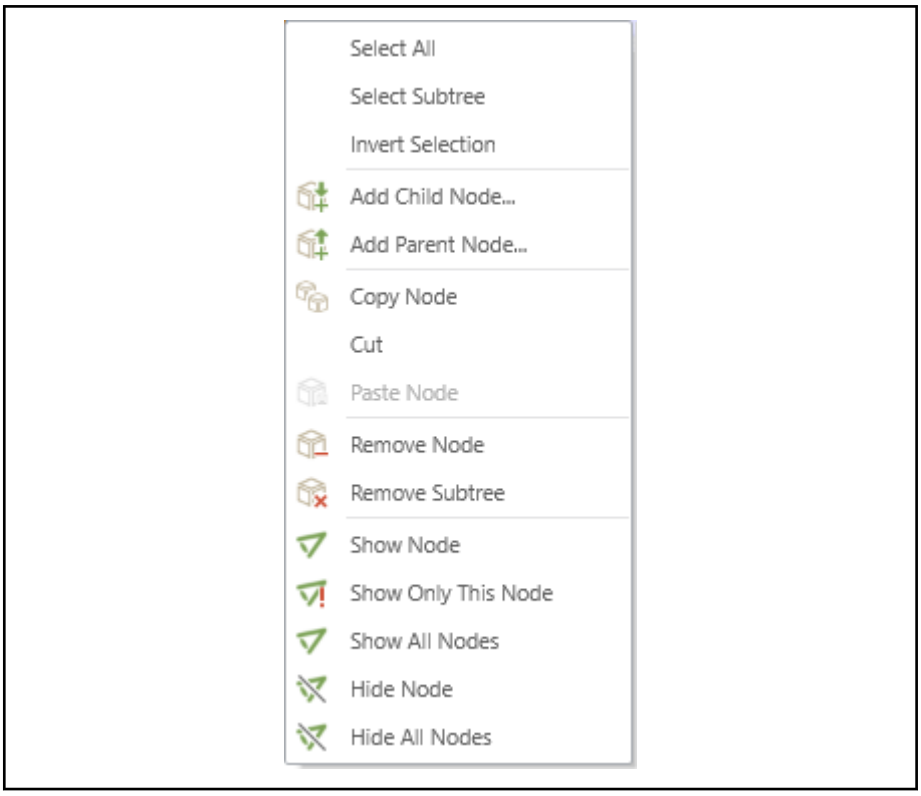


Fig. 4-4: Pop-up menu of the "Tree View" window

There are the following menu functions:

	Select All	Select all the nodes in the kinematic tree
	Select Subtree	Select this node and all the child nodes in the kinematic tree
	Invert Selection	Switches the current status "selected" for all nodes in the kinematic tree
	Add Child Node…	Adds a child node below the selected node in the kinematic tree
	Add Parent Node…	Adds a parent node below the selected node in the kinematic tree
	Copy Node(s)	Copies the selected node(s) into the clipboard
	Cut	Removes the selected node(s) from the kinematic tree and stores it/them into the clipboard
	Paste Node(s)	Duplicates the node(s) in the clipboard below the selected node in the kinematic tree
	Remove Node(s)	Removes the selected node(s) from the kinematic tree
	Remove Subtree(s)	Removes the subtree(s) below the selected node(s) from the kinematic tree
	Show Node(s)	Sets the visibility of the selected node(s) to TRUE
	Show Only This/ These Node(s)	Sets only the visibility of the selected node(s) to TRUE. The visibility of all other nodes is set to FALSE
	Show All Nodes	Sets the visibility of all nodes to TRUE
	Hide Node(s)	Sets the visibility of selected node(s) to FALSE
	Hide All Nodes	Sets the visibility of all nodes to FALSE

In the tree representation, click and press Ctrl or Shift to select multiple nodes or complete areas.

4.3 Menu to create nodes

If only one node is selected in the tree view and either the command "Add Child Node..." or "Add Parent Node" is executed, which are provided as tools in the toolbar of the start-up screen or in the pop-up menu, the following window is displayed. The user can select the node type in this window.

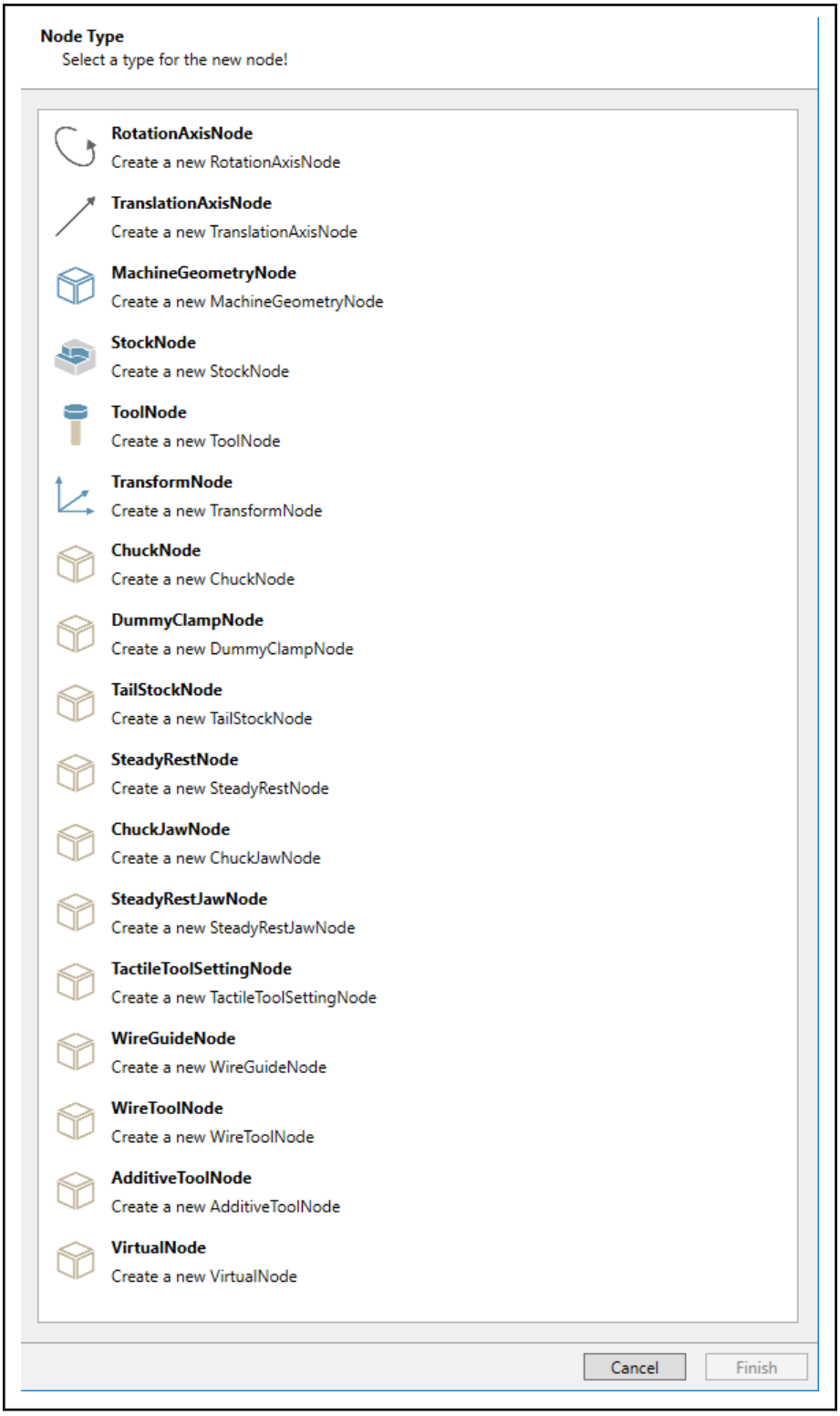


Fig. 4-5: Node creation menu

5 “Properties” window

When selecting a node in the tree view, the properties of that node are displayed in the "Properties window". This section describes the properties for each of the node types and provides information on an optimum machine model.

5.1 “Machine Definition” node

The machine definition node is the "root" node for the kinematic tree. It includes the properties "Machine name" and the currently used "unit" to describe the machine, i.e. “Metric” for millimeters, “Imperial” for inch or “Not set”.

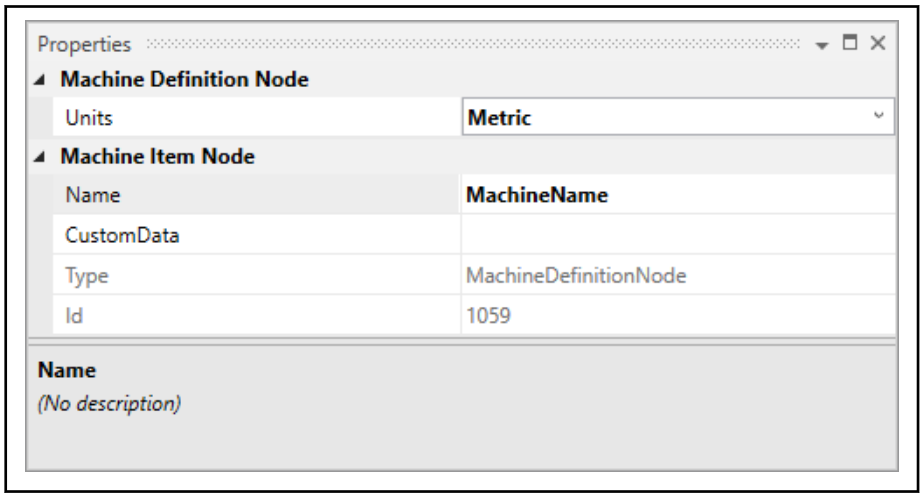


Fig. 5-1: Layout of the window "Properties" at the machine definition node

Properties of the machine definition node

Units	Shows the linear dimension unit used. • Metric: Millimeter • Imperial: Inch • Not set: Not specified
Name	Machine model name
CustomData	Currently not analyzed
Type	Node type
Id	Unique ident number specified by the system

5.2 “Rotation Axis” node

The rotation axis node is a rotary axis around the origin of rotation with a specific orientation and limited axis values.

Rotary axes can also simulate the spindle mode. The geometries in the subtree below the rotation axis node are shown as enveloping body.

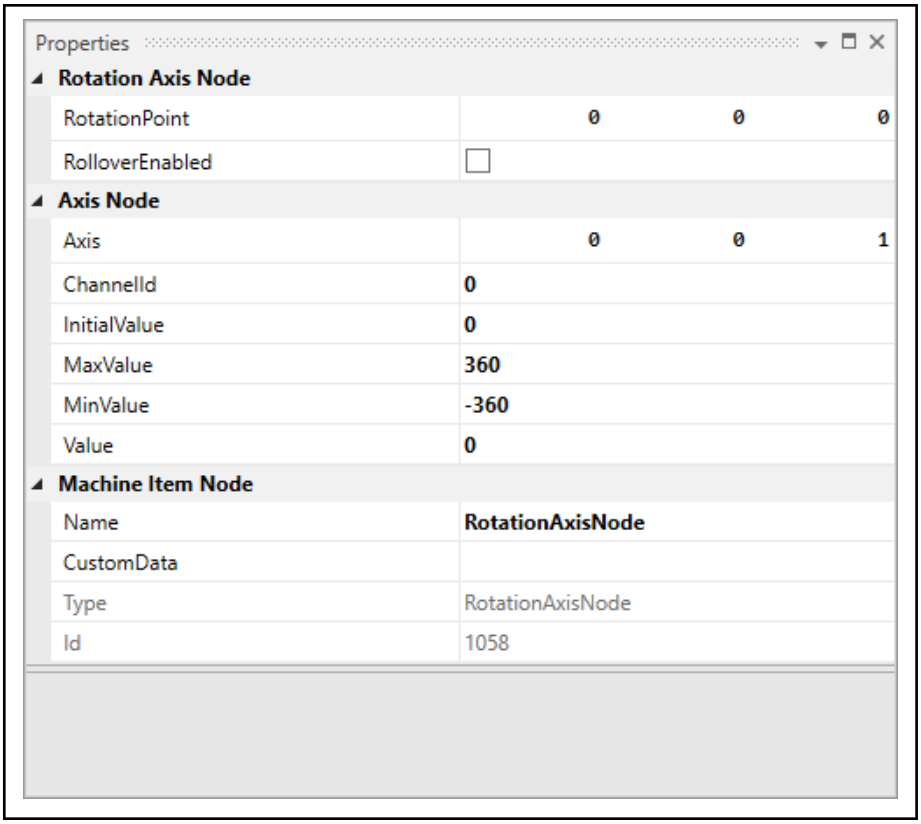


Fig. 5-2: Layout of the window "Properties" at the rotation axis node

Properties of the rotation axis node

RotationPoint	Position of the rotary axis in the local coordinate system. The three numerical values from left to right apply to x, y and z
RolloverEnabled	Select the endlessly rotating rotary axes ("Modulo" mode)
Axis	Orientation of the rotary axis. The three numerical values from left to right apply to the directions x, y and z
ChannelId	The simulation fills in the channel number to which the axis is assigned
InitialValue	Initial position when showing the model. Axis position of a closed hook to be opened manually. For more information on the hook, go to the end of the section.
MaxValue	Upper travel range limit
MinValue	Lower travel range limit
Value	Currently set axis position
Name	Node properties
CustomData	Can be analyzed in the statement part (variable CUSTOMDATA$) in the simulation

Type	Node type
Id	Unique ident number specified by the system

Please note when filling in the "Axis" property:

- 0 for the directions to which the rotary axis does not point
- 1 for the directions to which the rotary axis points (at least partially)
- If the rotary axis moves the stock, set -1 once instead of 1

Please note when filling in the "Name" property:

- If a drive moves the axis, set the physical axis name.
- If the axis moves a **hook to be manually opened**, compose the name from the character string "DOOR" (not case-sensitive)

5.3 “Translation Axis” node

The translation axis node (translatory axis node) is a translatory axis along a translation direction with limited axis values.

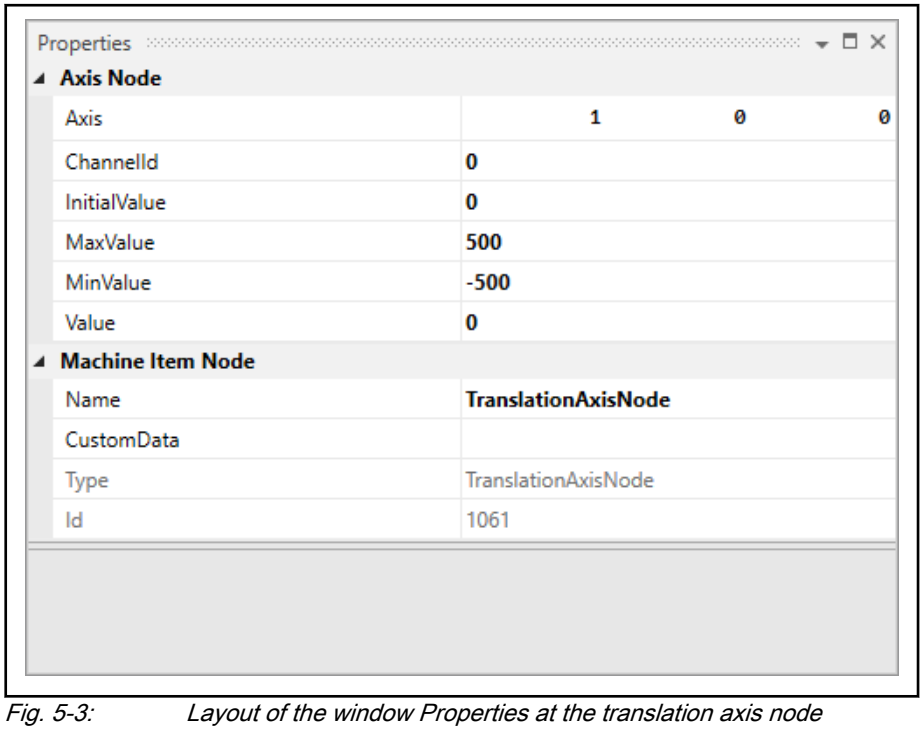


Fig. 5-3: Layout of the window Properties at the translation axis node

Properties of the translatory axis node

Axis	Orientation of the linear axis. The three numerical values from left to right apply to the directions x, y and z
ChannelId	The simulation fills in the channel number to which the axis is assigned

InitialValue	Initial position when showing the model. Axis position of a closed hook to be opened manually. For more information on the hook, go to the end of the section
MaxValue	Upper travel range limit
MinValue	Lower travel range limit
Value	Currently set axis position
Name	Node properties
CustomData	Can be analyzed in the statement part (variable CUSTOMDATA$) in the simulation
Type	Node type
Id	Unique ident number specified by the system

☞ Please note when filling in the "Axis" property:

- 0 for the directions to which the linear axis does not point
- 1 for the direction to which the axis points if the tool is moved
- -1 for the direction to which the axis points if the stock is moved

Please note when filling in the "Name" property:

- If a drive moves the axis, set the physical axis name.
- Punching: If it is an axis driven by a punching plunger, preferably name the axis "z" or "PUNCHHEAD" for the upper part and "PUNCHDOWN" for the lower part.
- If the axis moves a **hook to be manually opened**, compose the name from the character string "DOOR" (not case-sensitive)

5.4 "Machine Geometry" node

The machine geometry node is one or multiple physical machine component(s). The node is defined by one or multiple mesh geometry file(s). A color can be specified for all node elements and the reflectivity response can be determined.

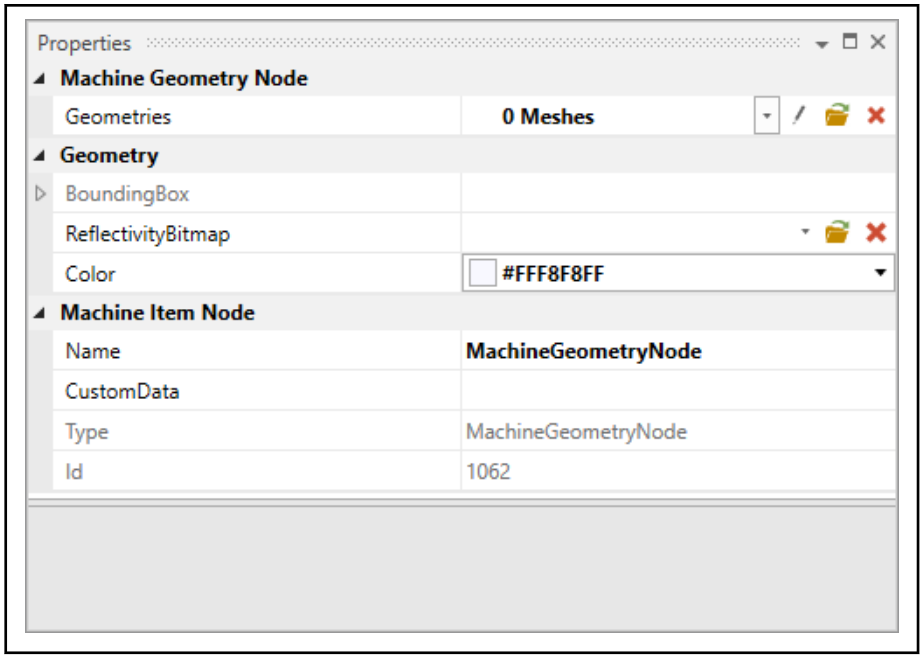


Fig. 5-4: Layout of the window "Properties" at the machine geometry node

Properties of the machine geometry node

Geometries	Shows the number of displayed meshes in the node and the assigned meshes for the collision analysis. Alternatively, the only assigned resource is displayed. Allow tools behind • : To select a single mesh from the resources • : To select the resources for the graphic display and the collision check in the "Machine Geometry Mesh Set Editor". Refer to "Machine geometry mesh set editor (mesh assignment editor for machine geometries)" on page 22 • : To add an STL file to the resources and to assign it simultaneously to the node as single mesh • : To delete all meshes from the node
BoundingBox	To show all dimensions of the bonding box, press

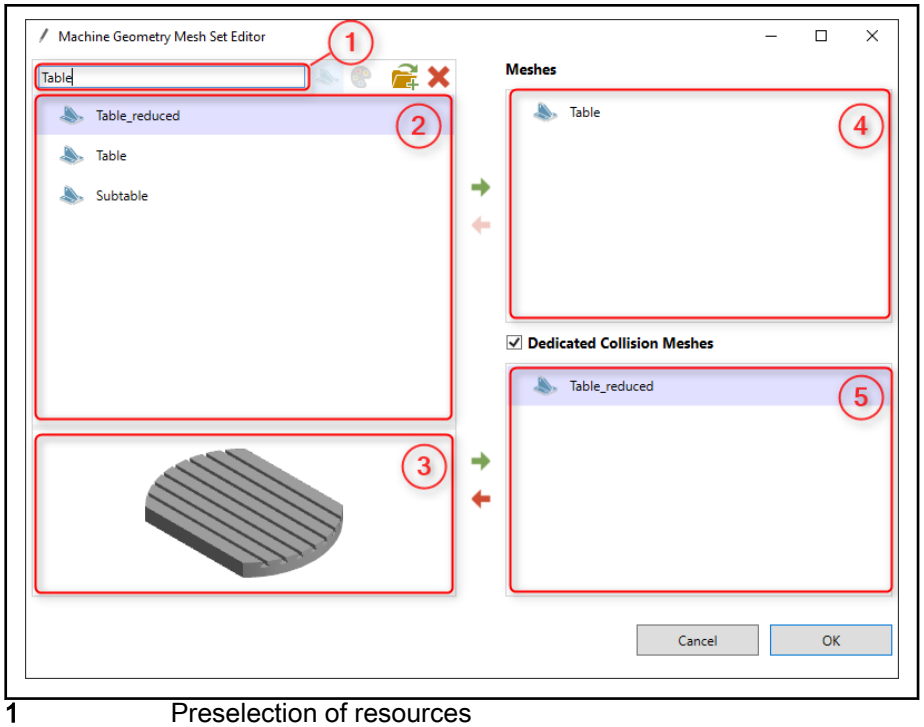
ReflectivityBitmap	Bitmap to simulate the reflection of the surrounding light with light and dark sections. Allow tools behind • : To select a bitmap from the resources • : To add a new bitmap to the node and resources • : To delete the bitmap from the node
Color	Shows the color and opens the color dialog
Name	Node properties
CustomData	Currently not analyzed
Type	Node type
Id	Unique ident number specified by the system

☞ Please note when filling in the "Name" property:

- If the name is composed of the character string "ALWAYSVISIBLE", the object is always visible (not case-sensitive)
- If the name is composed of the character string "INVISIBLE", the object is only visible after a collision (not case-sensitive)
- If the name is composed of the character string "ACTIVE", the object is visible (not case-sensitive) if the switch position  is "Hide - inactive elements", even if it is not moved by a drive. Useful for example for machine tables fixedly attached to the housing (not case-sensitive)

Machine geometry mesh set editor (mesh assignment editor for machine geometries)

The mesh assignment editor is used to add or remove meshes to or from a machine geometry node as geometry to be displayed or as geometry for the collision check. The mesh resources can also be managed in this dialog.



1	Preselection of resources
2	Resource list (meshes)
3	Mesh display
4	List of meshes to be shown
5	List of meshes for the collision check

Fig. 5-5: Mesh assignment editor for machine geometries

How to manage the resources displayed in the “Resources” list (2):

- To import new resources (meshes as STL files), press .
- To delete a resource, select it in the “Resources” list (2) and press . Alternatively, press <Del>.
- To reduce the number of displayed resources, enter a character string that is part of the name of the resources to be listed into the input field for the preselection (1).
- The context-sensitive menu of the resources list allows to:
  - delete
  - select all
  - reduce a mesh. After the execution, the reduced mesh is shown with the name extension "_reduced" in the list.

Assignment of meshes to the machine geometry node for the graphic display:

1. Select the mesh(es) from the “Resources” list.

   The mesh(es) is/are highlighted and a preview is shown on the display area (3).

2. Press on the left of the list for the meshes to be displayed.

   The mesh(es) is/are now also displayed under "Meshes" (4).

3. To exclude a mesh from the representation, select this mesh in the list "Meshes" and press or <Del>.

The meshes to be graphically displayed are identical to those for the collision check if no meshes were defined for the collision check.

Assignment of meshes for the collision check:

1. Select **Dedicated Collision Meshes**.
   The list of meshes is shown for the collision check (5).
2. Select the mesh(es) from the "Resources" list.
   The mesh(es) is/are highlighted and a preview is shown on the display area (3).
3. Press on the left of the list of the meshes for the collision check (5).
   The mesh(es) is/are now shown in the list of collision meshes (5).
4. To exclude a mesh from the collision check, select this mesh in the list "Dedicated Collision Meshes" and press or <Del>.

The collision check is started after the nodes have been assigned to the collision groups. Refer to chapter 7 ""Collision Checking" window" on page 41.

5.5 "Stock" node

The stock node represents a stock in the machine and also represents the insertion position for more stocks as well as clamping devices and drawings. A raw part geometry can be assigned to the node as mesh.

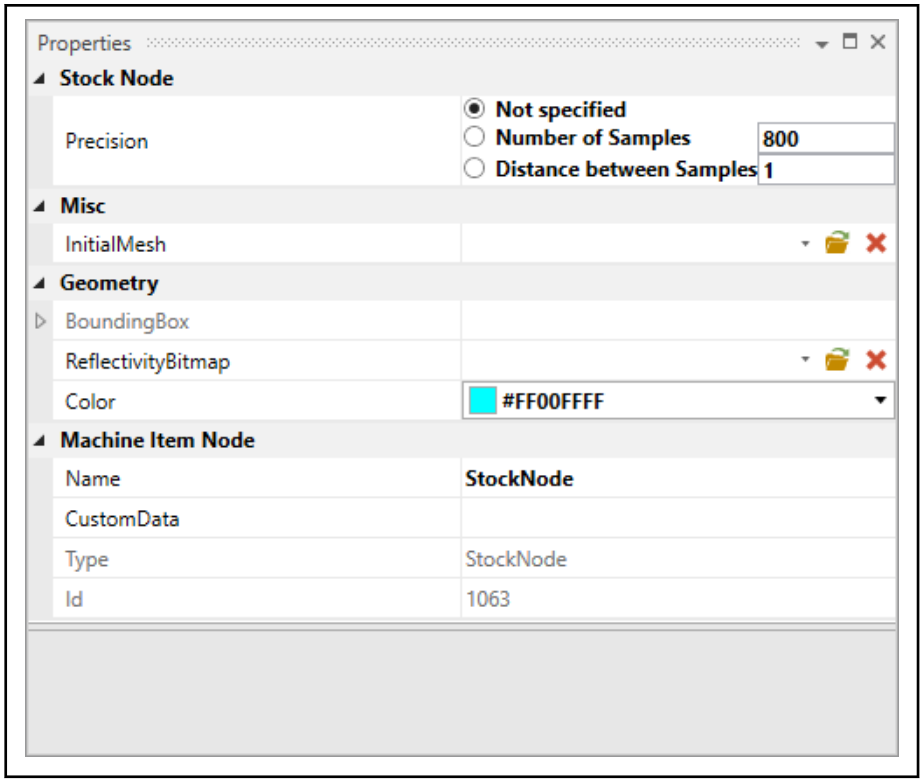


Fig. 5-6: Layout of the window "Properties" at the stock node

Properties of the stock node

Precision	Determines the precision of the stock model similarly to the resolution of samples. • Not specfied: Not specified • Number of Samples: Number of samples per diagonal • Distance between Samples: Distance of the samples in the linear dimension unit The specified precision refers only to the initial stock. The setting in the options of the simulation applies to all others
InitialMesh	Name of the resource for a raw part, the initial stock. Allow tools behind • : To select a mesh from the resources • : To add an STL file to the resources and to simultaneously assign it to the node • : To delete the mesh from the node

BoundingBox	To show all dimensions of the bounding box of the initial stock, press 
ReflectivityBitmap	Bitmap to simulate the reflection of the surrounding light with light-dark transitions. Allow tools behind •  : To select a bitmap from the resources •  : To add a new bitmap to the node and resources •  : To delete the bitmap from the node
Color	Shows the color of the unmachined stock and opens the color dialog. The raw part color from the "Options" is used in the simulation
Name	Node properties
CustomData	Currently not analyzed
Type	Node type
Id	Unique ident number specified by the system

Please note when filling in the "InitialMesh" property:

It is only reasonable to define an initial stock if it is a stock for demonstration or removal purposes or if the machine is primarily used to machine only one stock. In the "Reset raw part" menu function of the simulation, the function "Renew raw part according to machine model" is available additionally.

Please note when filling in the "Name" property:

- If possible, do not use the characters /, \, ?, %, *, :, ", <, > and #
- The name must not exceed 32 characters. If multi-clampings are used with up to 9 additional stocks, the length is limited to 30 characters. For 99 stocks, it is limited to 29, and to 28 for 999
- If there are multiple stock nodes in the machine model, ensure that the selection of one or multiple stock nodes can be programmed effectively with the cycle STOCKSEL when specifying the names. If required, use placeholders

5.6 "Tool" node

The tool node represents a tool holding position in the machine.

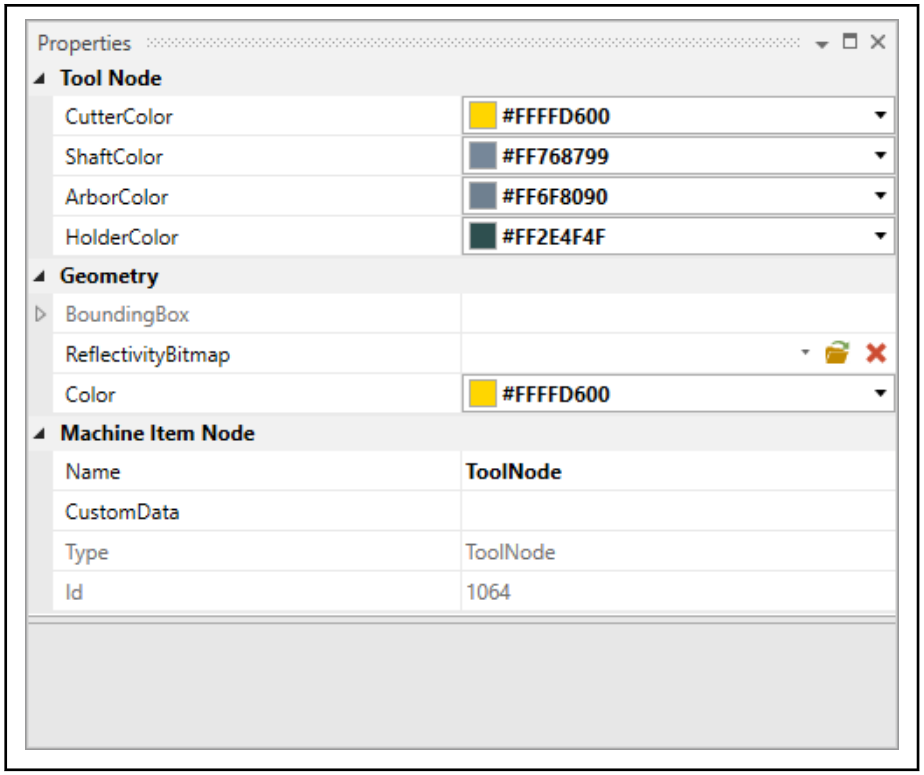


Fig. 5-7: Layout of the window "Properties" at the tool node

Properties of the tool node

CutterColor	Shows the cutter color of the tool and opens the color dialog. The color of the simulation options can be determined in the simulation
ShaftColor	Shows the tool shank color and opens the color dialog. The color of the simulation options can be determined in the simulation
ArborColor	Shows the chuck color or the color for a similar clamping device and opens the color dialog. The color of the simulation options can be determined in the simulation
HolderColor	Shows the tool holder color and opens the color dialog. The color of the simulation options can be determined in the simulation
BoundingBox	To show all dimensions of the bonding box, press ▷

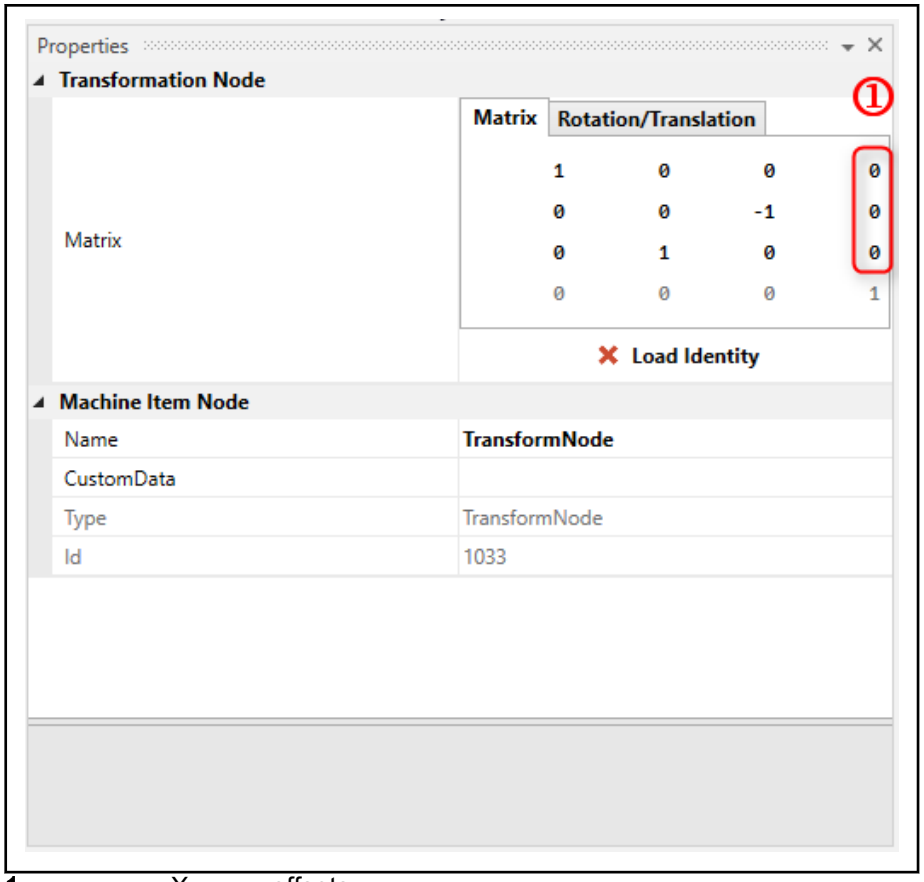
ReflectivityBitmap	Bitmap to simulate the reflection of the surrounding light with light and dark sections. Allow tools behind • : To select a bitmap from the resources • : To add a new bitmap to the node and resources • : To delete the bitmap from the node
Color	Shows the color and opens the color dialog. Irrelevant
Name	Node properties
CustomData	Currently not analyzed
Type	Node type
Id	Unique ident number specified by the system

☞ Please note when filling in the "Name" property:

If there are multiple tool holders in the machine model, ensure that the name to be specified provides information to easily obtain the place number in a turret, the channel number and further information. This facilitates the applicative adaptation using an executable code in the tool connection in the options of the simulation and allows to use this code multiple times.

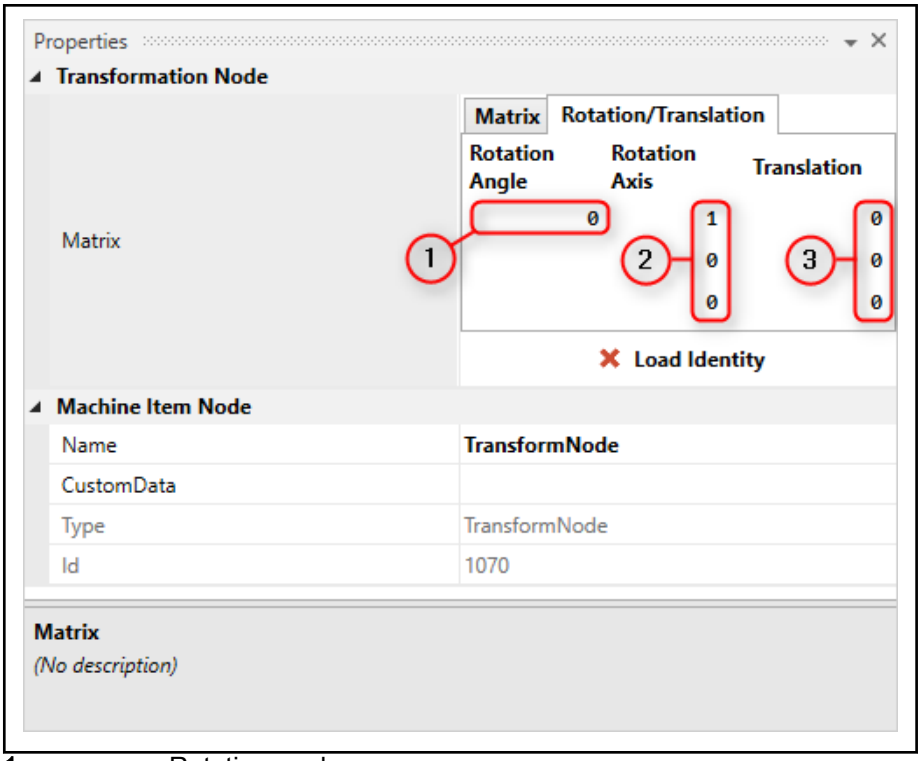
5.7 "Transformation" node

A transformation node represents the transformation from one coordinate system to another. The transformation is either defined by a translation and/or rotation together with the angle of rotation around the axis or directly using matrix elements.



1 X-, y-, z-offsets

Fig. 5-8: Transformation definition directly via the matrix



1 Rotation angle
2 Assignment of the rotation to x, y and z
3 X-, y-, z-offset

Fig. 5-9: Defines the transformation using the rotation angle and offset

Properties of the transformation node

Matrix, "Matrix" tab (Transformation as matrix)	Shows the elements of a 4x4 matrix. "Load Identity" enables the unit matrix
Matrix, Reiter Rotation/Translation	Defines the matrix via rotation angle, rotation axis and/or offsets: • Enter the angle under "Rotation Angle" (1). • Under "Rotation Axis", there are three input fields (2) below each other for the axes x, y and z. Enter 1 or -1 at the axis to rotate around. For the others, enter 0 • Under "Translation Axis", there are three input fields (3) below each other for the offset in x, y and z
Name	Node properties
CustomData	Currently not analyzed
Type	Node type
Id	Unique ident number specified by the system

1. When designing your machine model, ensure that the coordinate origin of the model matches the zero point of the machine. The directions of the linear axes should match the axis directions in the model.
2. If rule 1 causes a machine arrangement in world coordinates that does not correspond to the natural arrangement (e.g. machine in overhead), insert a transformation node directly below the machine definition node. The transformation node establishes the required position of the complete model.
3. The meshes for machine models are often provided with zero points and coordinate system orientations not matching rule 1. Add the transformation node to compensate these insuffiencies exclusively as parent node of the machine geometries. Avoid the transformation node in the kinematic chain between the stock node and the tool node.

5.8 “Chuck” node

A chuck node is a logical node in the kinematic tree representing a chuck.

For a detailed description of the node structure in the kinematic tree for a three-jaw chuck, refer to the appendix chapter 13 "Appendix 2: Node structure for a three-jaw chuck" on page 65.

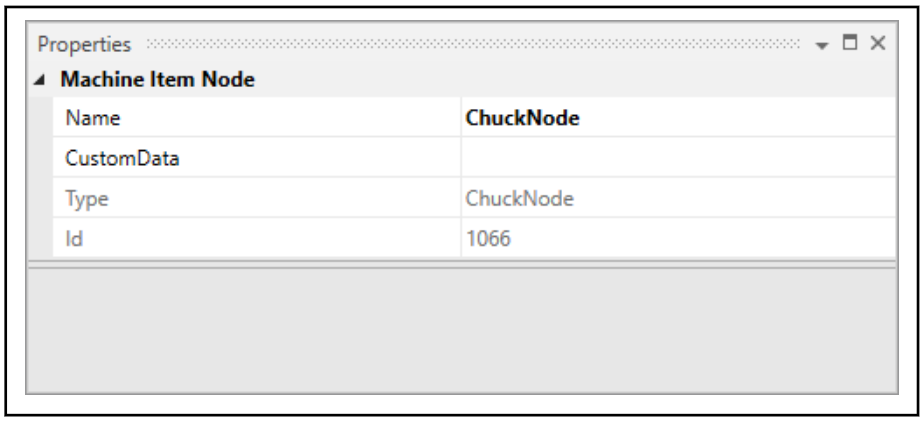


Fig. 5-10: Layout of the window "Properties" at the chuck node

5.9 “Dummy Clamp” node

A dummy clamp node is a logical node in the kinematic tree used to fix a stock without further description of the clamping device.

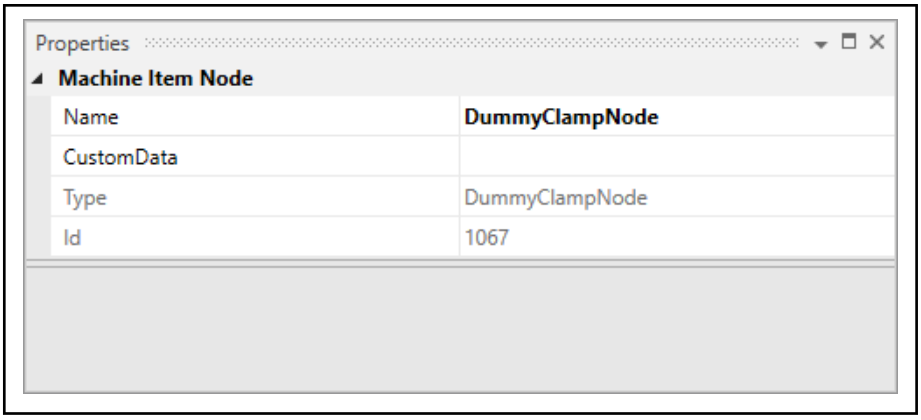


Fig. 5-11: Layout of the window "Properties" at the dummy clamp node

Generally, the simulation does not require an explicitly defined dummy clamp node. If required, the simulation inserts the node type automatically.

5.10 "Tail Stock" node

The tail stock node represents a tailstock center in the kinematic tree.

The tail stock node is not yet implemented.

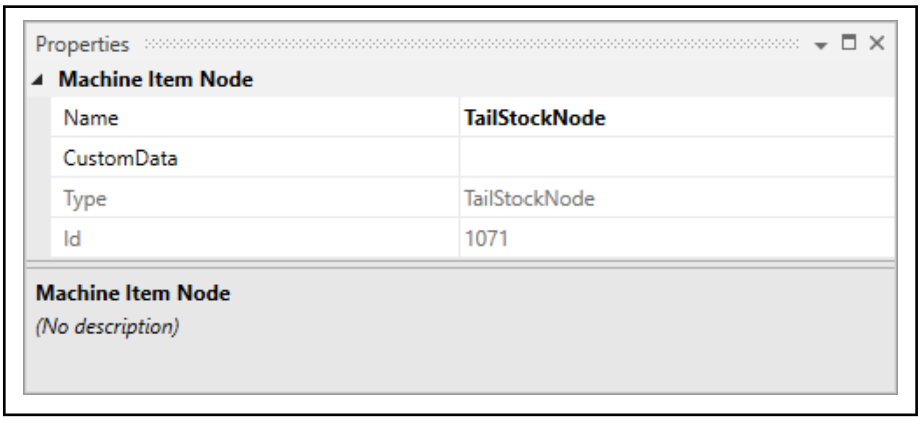


Fig. 5-12: Layout of the window "Properties" at the tailstock node

5.11 "Steady Rest" node

The steady rest node represents a steady rest to radially support thin turned parts. A node in the kinematic tree representing a steady rest.

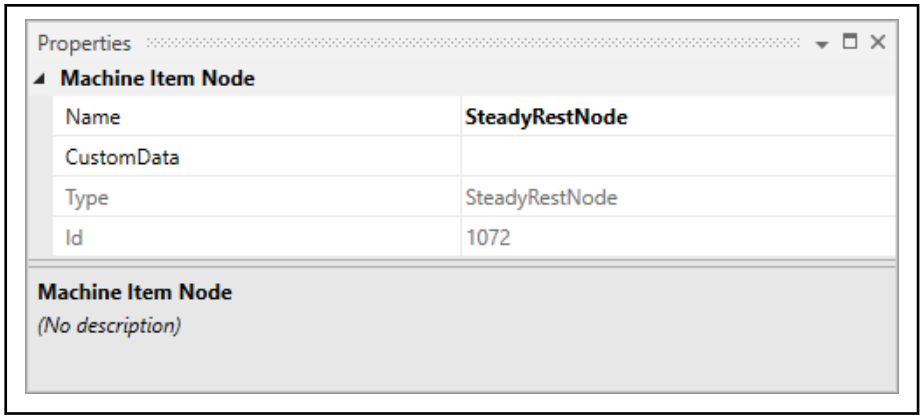


Fig. 5-13: Layout of the window "Properties" at the steady rest node

5.12 "Chuck Jaw" node

The chuck jaw node represents a chuck jaw in the kinematic tree.

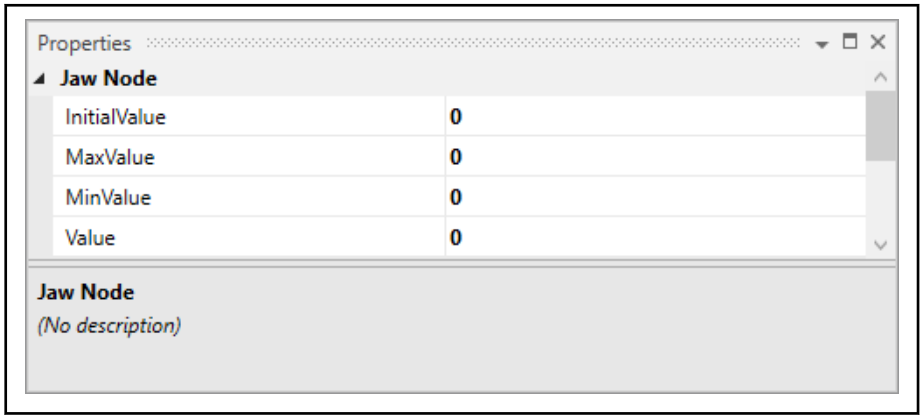


Fig. 5-14: Layout of the window "Properties" at the chuck jaw node

5.13 "Steady Rest Jaw" node

The steady rest jaw node represents a steady rest jaw in the kinematic tree.

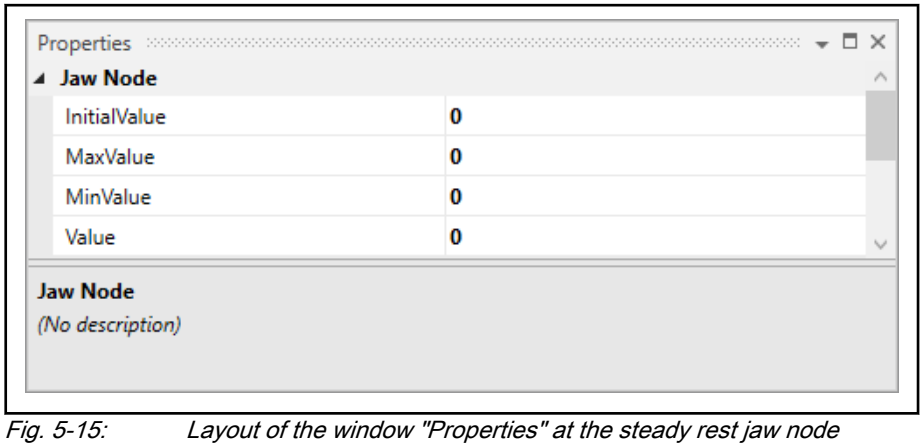


Fig. 5-15: Layout of the window "Properties" at the steady rest jaw node

5.14 "Tactile Tool Setting" node

The tactile tool setting node represents a physical machine component. The simulation does not register a collision with a tool edge as collision. The node

is defined by a mesh geometry file and always visible. It is also possible to define a specific mesh color and to determine the reflectivity response.

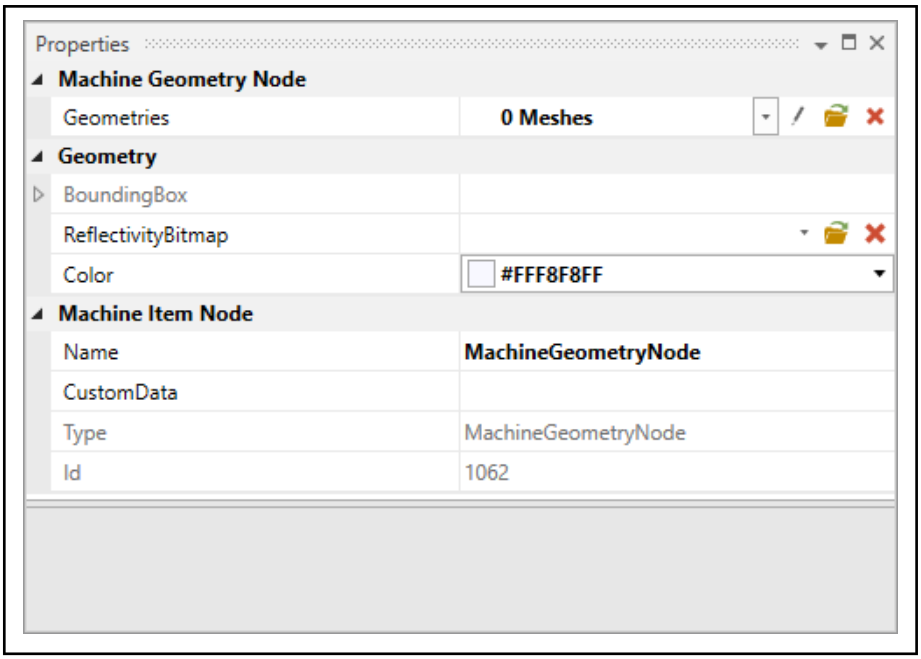


Fig. 5-16: Layout of the window "Properties" at the tactile tool setting node

5.15 "Wire Guide" node

The wire guide node represents a physical machine component for wire eroding. The node is defined by a mesh geometry file. It is also possible to define a specific mesh color and to determine the reflectivity response.

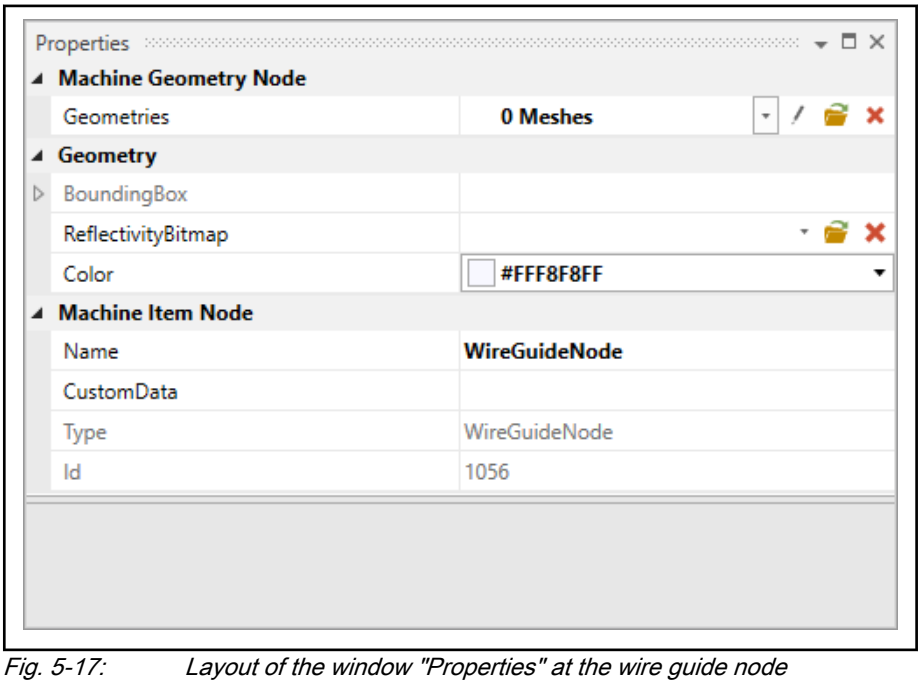


Fig. 5-17: Layout of the window "Properties" at the wire guide node

5.16 "Wire Tool" node

The wire tool node represents a tool holding position in the machine for wire eroding.

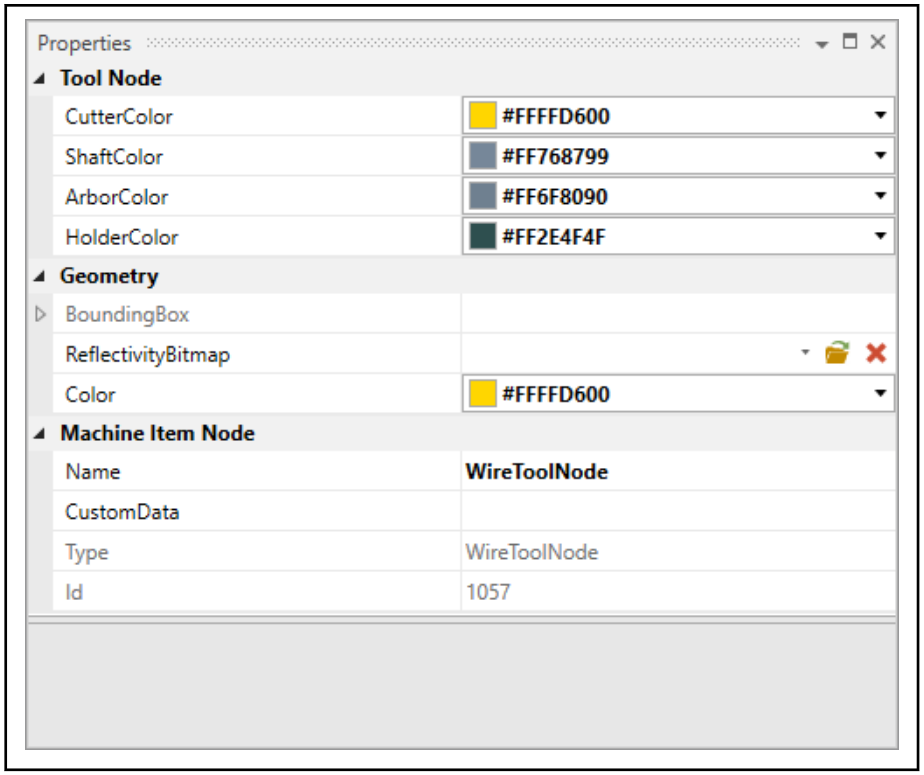


Fig. 5-18: Layout of the window "Properties" at the wire tool node

Properties of the wire tool node

CutterColor	Shows the cutter color of the tool and opens the color dialog. The color of the simulation options can be determined in the simulation
ShaftColor	Shows the tool shank color and opens the color dialog. The color of the simulation options can be determined in the simulation
ArborColor	Shows the chuck color or the color for a similar clamping device and opens the color dialog. The color of the simulation options can be determined in the simulation
HolderColor	Shows the tool holder color and opens the color dialog. The color of the simulation options can be determined in the simulation
BoundingBox	To show all dimensions of the bonding box, press ▷

ReflectivityBitmap	Bitmap to simulate the reflection of the surrounding light with light and dark sections. Allow tools behind • : To select a bitmap from the resources • : To add a new bitmap to the node and resources • : To delete the bitmap from the node
Color	Shows the color and opens the color dialog. Irrelevant
Name	Node properties
CustomData	Currently not analyzed
Type	Node type
Id	Unique ident number specified by the system

5.17 "Additive Tool" node

The additive tool node is a holding position in the machine for the material application (3D-printing, built-up welding).

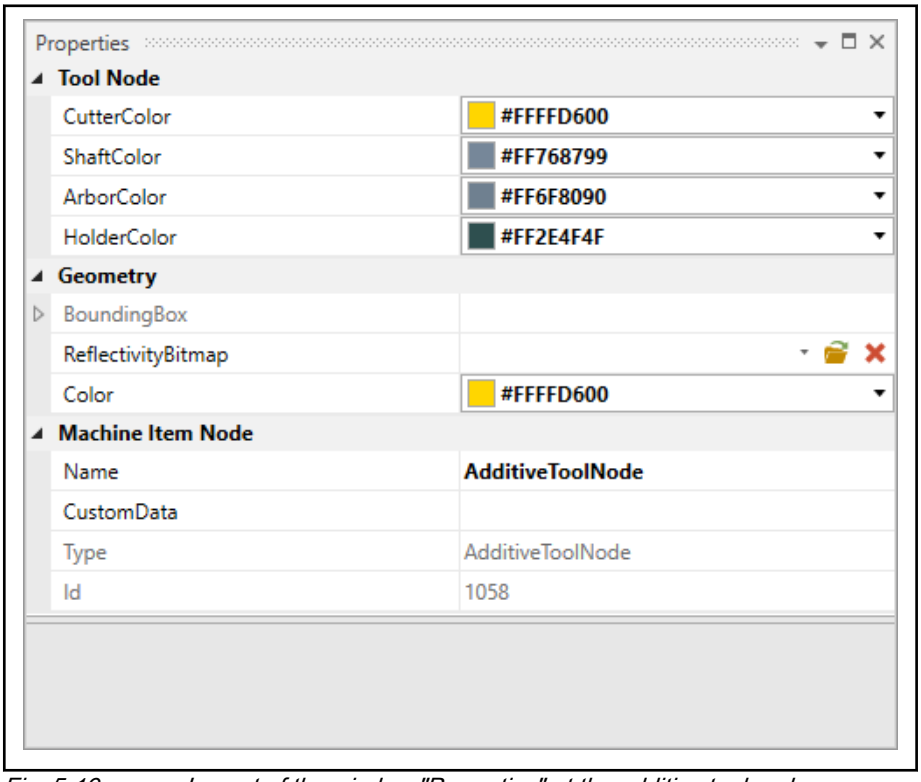


Fig. 5-19: Layout of the window "Properties" at the additive tool node

Properties of the additive tool node

CutterColor	Shows the cutter color of the tool and opens the color dialog. The color of the simulation options can be determined in the simulation
ShaftColor	Shows the tool shank color and opens the color dialog. The color of the simulation options can be determined in the simulation
ArborColor	Shows the chuck color or the color for a similar clamping device and opens the color dialog. The color of the simulation options can be determined in the simulation
HolderColor	Shows the tool holder color and opens the color dialog. The color of the simulation options can be determined in the simulation
BoundingBox	To show all dimensions of the bonding box, press 
ReflectivityBitmap	Bitmap to simulate the reflection of the surrounding light with light and dark sections. Allow tools behind •  : To select a bitmap from the resources •  : To add a new bitmap to the node and resources •  : To delete the bitmap from the node
Color	Shows the color and opens the color dialog. Irrelevant
Name	Node properties
CustomData	Currently not analyzed
Type	Node type
Id	Unique ident number specified by the system

 Whether it is a tool or an additive tool in the simulation depends on the tool type in the tool management of the MTX. It is shown at the tool node. Thus, additive tool nodes do not have to be declared in the machine model. Tool nodes and additive tool nodes are handled equally.

5.18 "Virtual" node

The virtual node represents a virtual object in the machine which refers to a physical object in the machine. The virtual node is determined by a color and/or a reflection bitmap.

6 “Axis Control” window

The “Axis Control” window includes all translatory and rotary axes defined in the current machine model. The window shows the limit values for each axis. To modify the current value within the limits, use a slide control or type directly into the value field.

To limit the number of displayed axes, enter characters into the "Filter for axis names" field. Thus, only the axes with the characters of the filter in their names are included.

Adjusting the axis value in the control window automatically refreshes the machine model and the updated value is displayed. This allows to check the kinematic machine model before executing the simulations.

The  button

opens a submenu with the following functions affecting **all displayed axes**:

- Reset all to initial value:

  The axes are moved to the initial value set in the “Properties” window of the axis node.

- Reset all to zero:

  The axes are moved to the coordinate zero.

Is spinning can be selected for a rotary axis. The rotary axis goes into the spindle mode. In this case, the child objects of the rotary axis are shown as enveloping body.

The following example shows x, y and z as linear axes and b and c as rotary axes in the machine model.

1 Filter for axis names
2 Reset axis positions
3 Reset to axis position initial Value
4 Apply axis position initial Value
5 Spindle mode

Fig. 6-1: “Axis Control” window

7 “Collision Checking” window

The "Collision Checking" window can be used to define all machine model components to be checked for collisions.

The nodes to be checked are selected within one collision group. The user can create any number of groups containing the nodes to be checked.

The following example shows a single collision group. In this group, the movement of the "Stock", the "Table" and the "Subtable" around the rotary axes b and c are checked for collision against the tool and machine geometry displacement along the z-axis. Each object selected on the left can be a collision partner of one of the objects selected on the right.

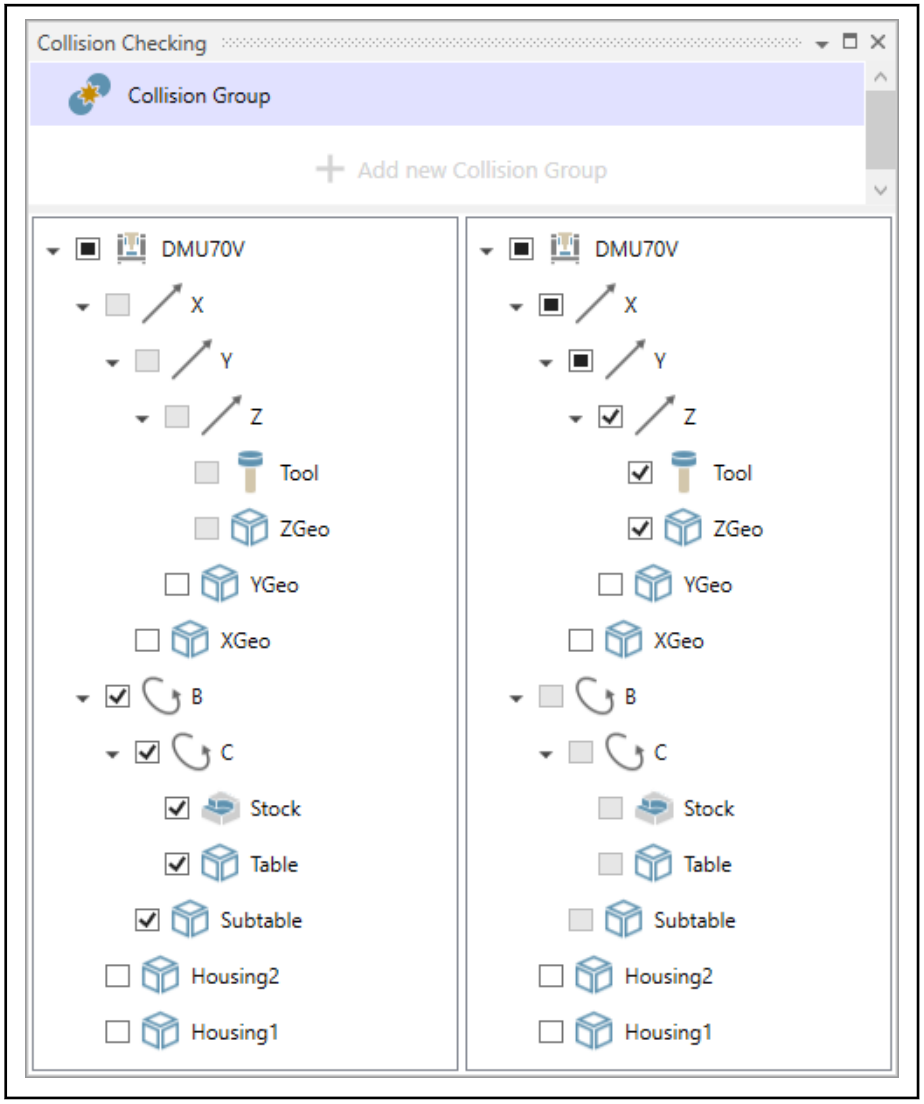


Fig. 7-1: “Collision Checking” window

For a performant collision check, select only objects in the collision groups which actually collide. Use can use the simplified "Dedicated Collision Meshes" for machine geometry nodes.

8 “Resources” window

Use the "Resources" window to check all machine geometry components in the machine model.

The machine geometry of the individual components is displayed in the lower section of the window. Use the mouse to change the view.

Additionally, the number of triangles used to represent the machine geometry can be used to reduce the respective machine component. This is very important when checking the collision of geometry nodes in the kinematic machine model (simplified "Collision Mesh").

Mesh geometry reduction

1. Right-click to select the component in the ""Resources” window".
2. Select the **Reduce Mesh** function from the context menu
   The “Mesh” representation is optimized.

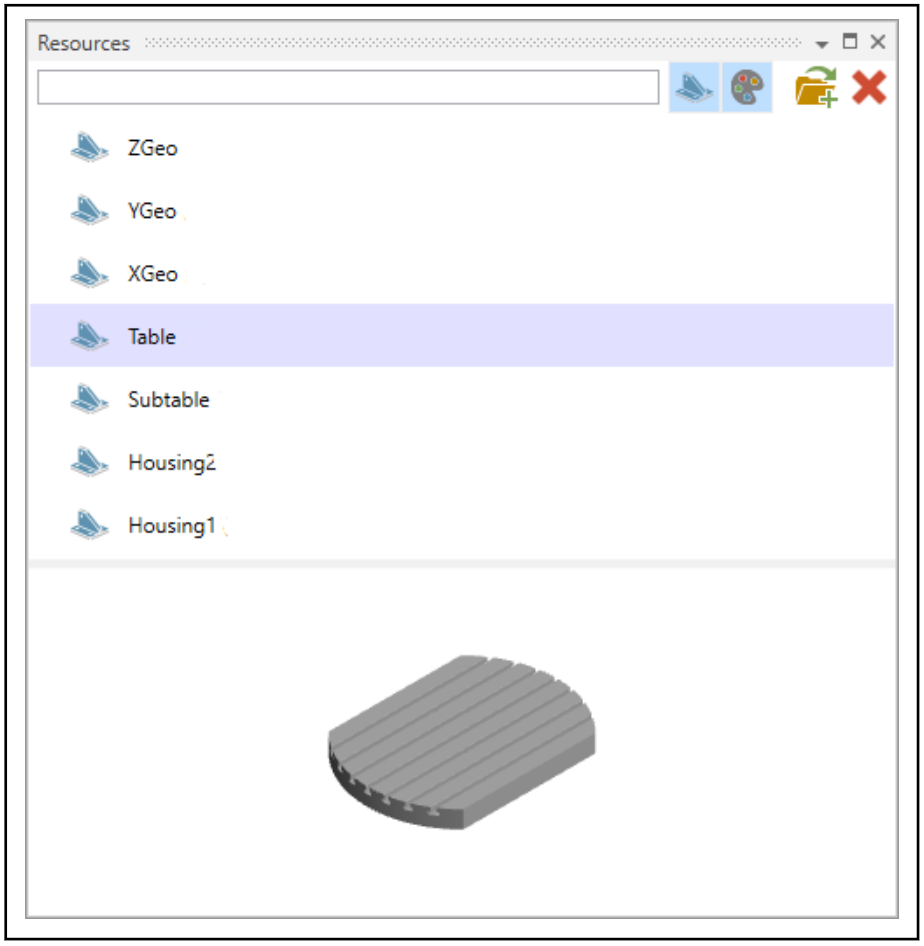


Fig. 8-1: “Resources” window

9 “Toolbox” window

The “Toolbox” window ("Toolbox window") contains a complete list of node types with descriptions.

To create nodes, select a node type from the “Toolbox” window. Use "drag&drop" to drag the node to an already existing node in the tree view. A child node is created at this position in the kinematic tree.

Alternatively, select a node in the tree view. Double-click on the node type in the “Toolbox” window to create the new child node below the selected node in the tree view.

Refer to the section chapter 4.3 "Menu to create nodes" on page 15 for the complete list of node types.

10 “Log” window

The “Log” window provides a complete history of all actions during a session using the Virtual Machine Builder.

☞ Each warning message of the kinematic machine model is displayed in the “Log” window.

11 Settings

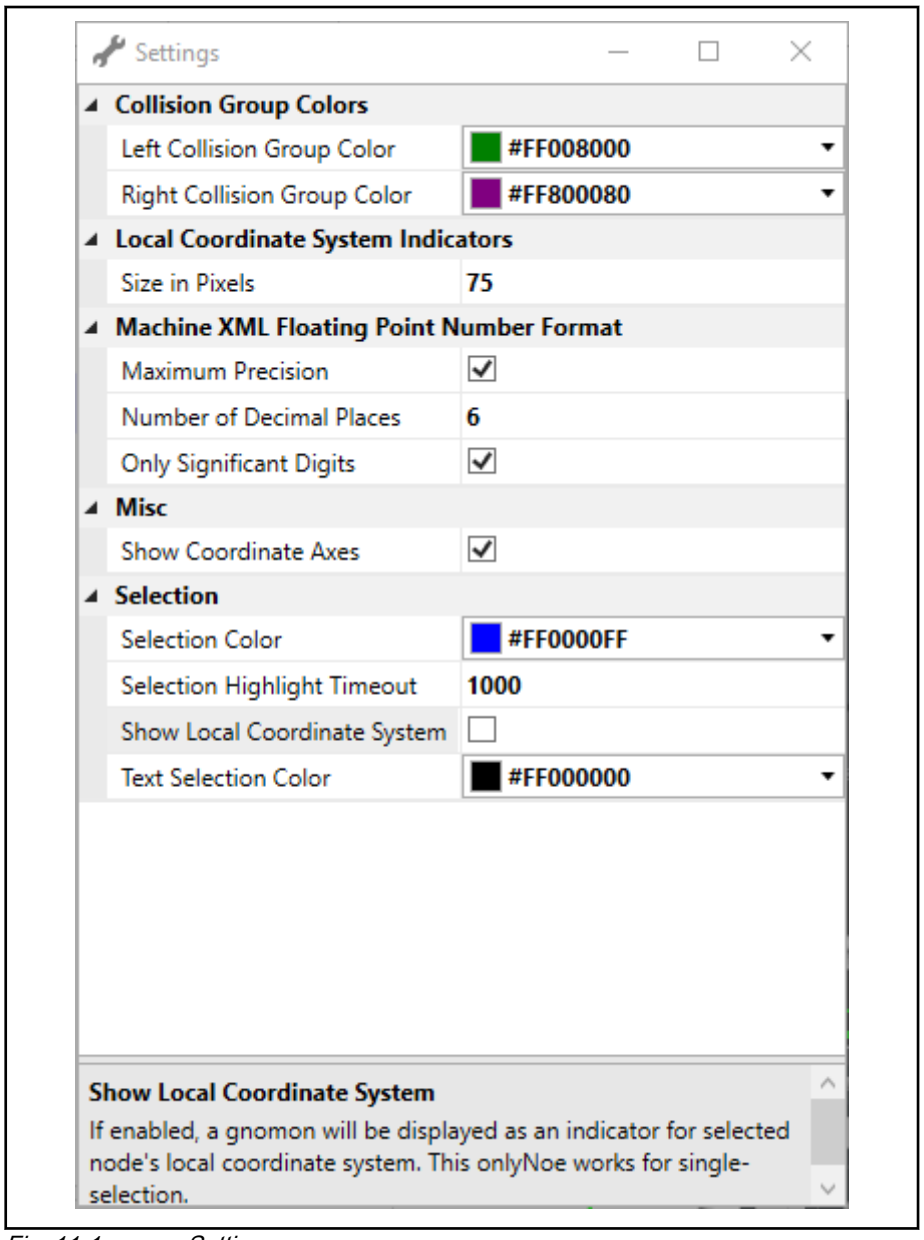


Fig. 11-1: Settings

Select the user settings for the Virtual Machine Builder in the "Settings" dialog.

- Left/Right Collision Group Color:

  Colors for the elements of a collision group on the left or right section in the “Collision Checking” window (see chapter 7 ""Collision Checking" window" on page 41)

- Size in Pixels:

  Length of an axis of the coordinate tripod for the local coordinate system

- Maximum Precision:

- If selected, the maximum possible number of decimals is written to the machine model file and the settings "Number of Decimal Places" and "Only Significant Digits" are ignored.

- Number of Decimal Places:

  Specifies the maximum number of decimals in the machine model file.
- Only Significant Digits:

  If selected, only the right zeroes in the decimals are not written to the machine model.
- Show Coordinate Axes: Adds or removes the representation of the axis scales
- Selection Color:

  Color of the machine geometry node(s) selected in the "Tree View"
- Selection Highlight Timeout:

  Interval in milliseconds between the highlighting of two different, selected nodes.
- Show Local Coordinate System:

  If selected, the current, local coordinate system is shown with a coordinate tripod at the selected node. It origin matches the zero point. The local coordinate system is invisible after the selection of multiple nodes.
- Text Selection Color:

  Text color of the name of the selected node(s) in "Tree View".

12 Appendix 1: Application example on how to design a machine kinematics

12.1 Task

Targets

While installing the Virtual Machine Builder, data is provided for an exercise on how to design a simulation model of a simplified machine tool with 4-axis kinematics (fig. 12-1 "Simulation model of the 4-axis kinematics for exercising purposes" on page 51).

Exercise the following:

- Design a kinematic structure with the required elements
- Link 3D geometry of the machine to the kinematics
- Check and set the kinematics with regard to the axis properties
- Define the collision relations of the geometries

Example data

The complete exercise is stored in the "Demo" subfolder. Open the File Explorer, then the installation folder Virtual Machine Builders and click on the shortcut "_LinkToCommonAppData". Either use the CAD data to create a new machine model (as described in the following sections) or use the ready machine model Demo.xml as basis and make your modifications.

Machine layout

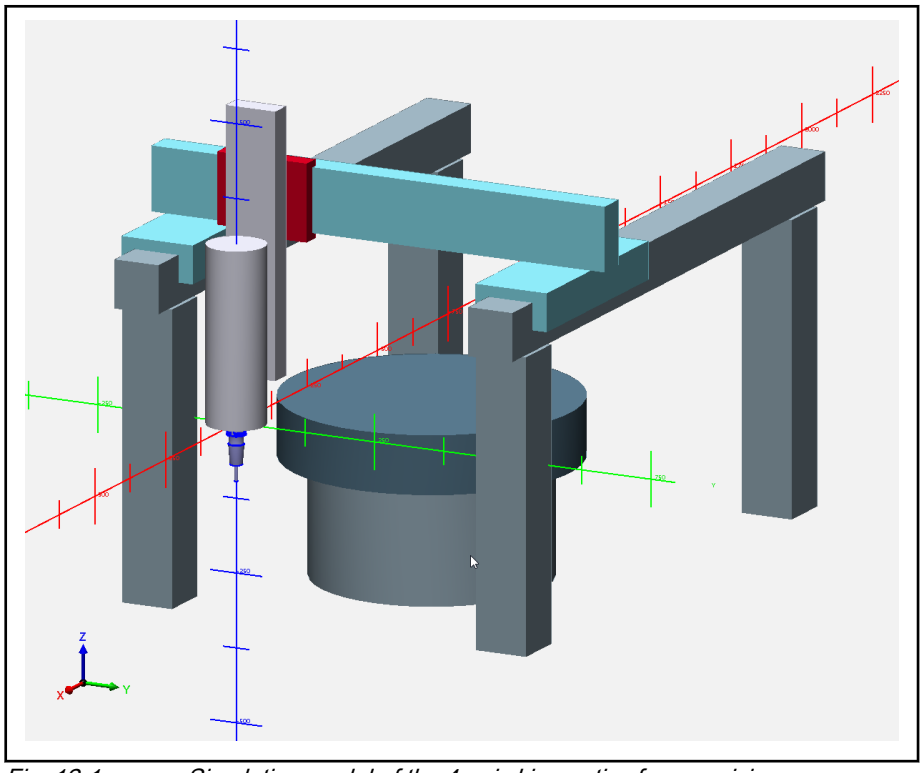


Fig. 12-1: Simulation model of the 4-axis kinematics for exercising purposes

12.2 Design of the kinematic structure

This step is used to map the kinematic relations of the machine in a tree structure.

Creating a machine definition

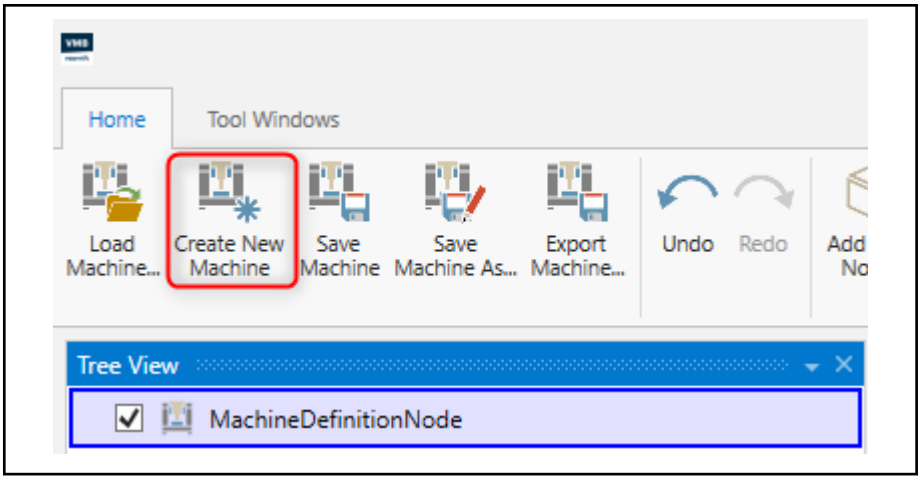


Fig. 12-2: Creating a root node of the kinematics

Select the root node and specify a new name (fig. 12-3 "Renaming the root node" on page 52) in the "Properties" window.

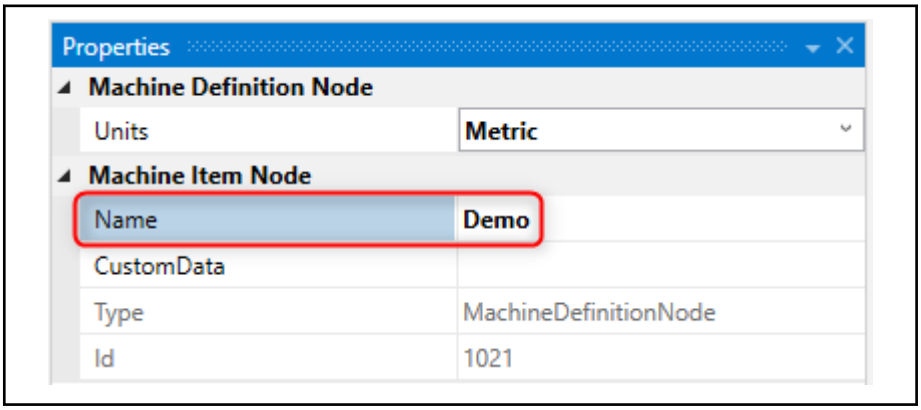


Fig. 12-3: Renaming the root node

Defining a kinematic structure

Use the node types for linear and rotary axes described in the chapters chapter 4 ""Tree View" window" on page 11 and chapter 5 ""Properties" window" on page 17 to set up a basic kinematics as shown in fig. 12-4 "Kinematic structure for exercising purposes" on page 52. Right-click on the node with the future child node and select "Add Child Node".

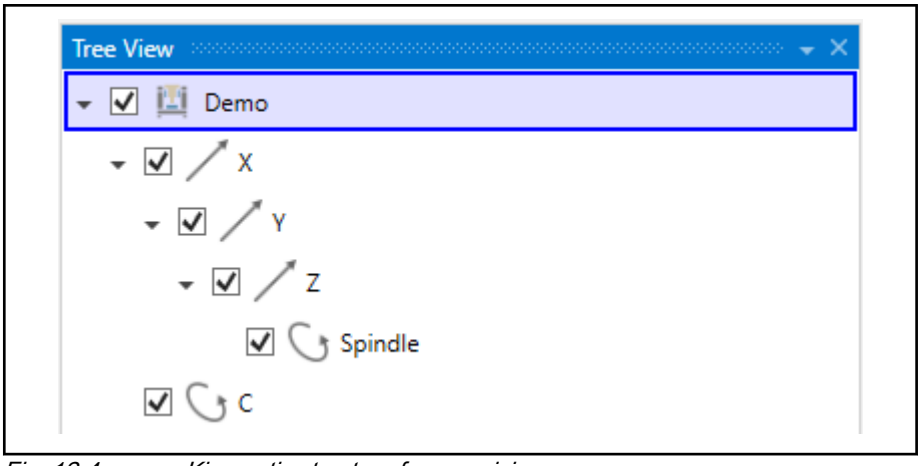


Fig. 12-4: Kinematic structure for exercising purposes

The node types "TranslationAxisNode""RotationAxisNode" are provided for linear and rotary axes. Create a node and then specify a name corresponding

to an axis name (X, Y, Z, C, Spindle) in the "Properties" window. Define the direction of motion of the axes in the "Axis" fields.

Please refer to the notes in the chapters chapter 5.2 ""Rotation Axis" node" on page 17 and chapter 5.3 ""Translation Axis" node" on page 19. The correctly defined axis directions and traversing distances can be checked visually after linking the geometry objects to the kinematics.

Fig. 12-5: Setting the direction of motion and names of an axis

Adding machine geometry node

To add geometry data to the kinematic structure, use "MachineGeometryNodes". Position and orientation of this geometry data corresponds to its original generation position during the CAD export. To subsequently position them, so-called "TransformNodes" have to be integrated into the kinematic structure (sequence: Parent node → TransformNode → MachineGeometryNode). Supplement the kinematic tree of the exercise following the structure given in fig. 12-6 "Kinematic structure with transformation and geometry node" on page 54.

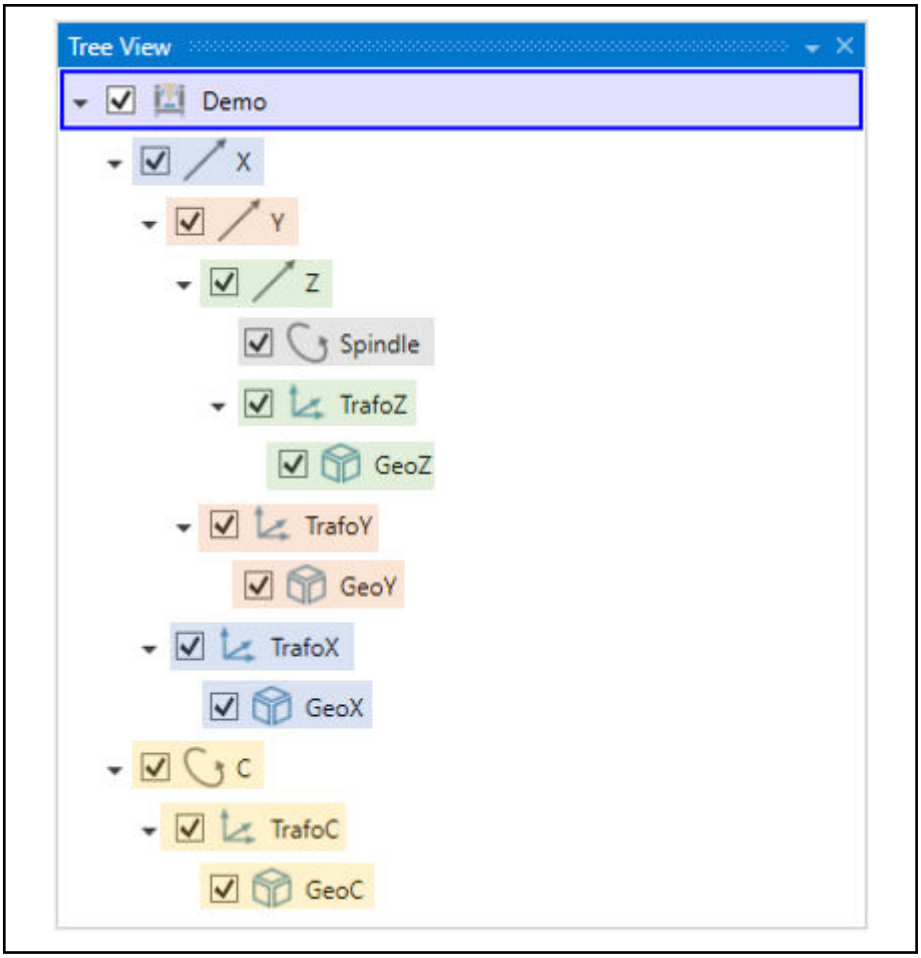


Fig. 12-6: Kinematic structure with transformation and geometry node

To implement geometries fixed in place (i.e. geometries that do not move together with the axes) into the kinematics, transformation and geometry nodes are required. These are directly linked to the root node. Create your exercise as shown in fig. 12-7 "Structural elements for geometries fixed in place" on page 54.

Fig. 12-7: Structural elements for geometries fixed in place

Tool and stock nodes

As a real machine tool, a machine simulation also requires structural elements to accept tools and stocks. To ensure that the model operates correctly with regard to material application, collision detection and path representation, there has to be a continuous connection between the tool and the stock holder via the kinematic tree. "ToolNode" and "StockNode" are provided as

structural elements. Complete the exercise with these elements as described in fig. 12-8 "Kinematic structure with tool node and stock node" on page 55.

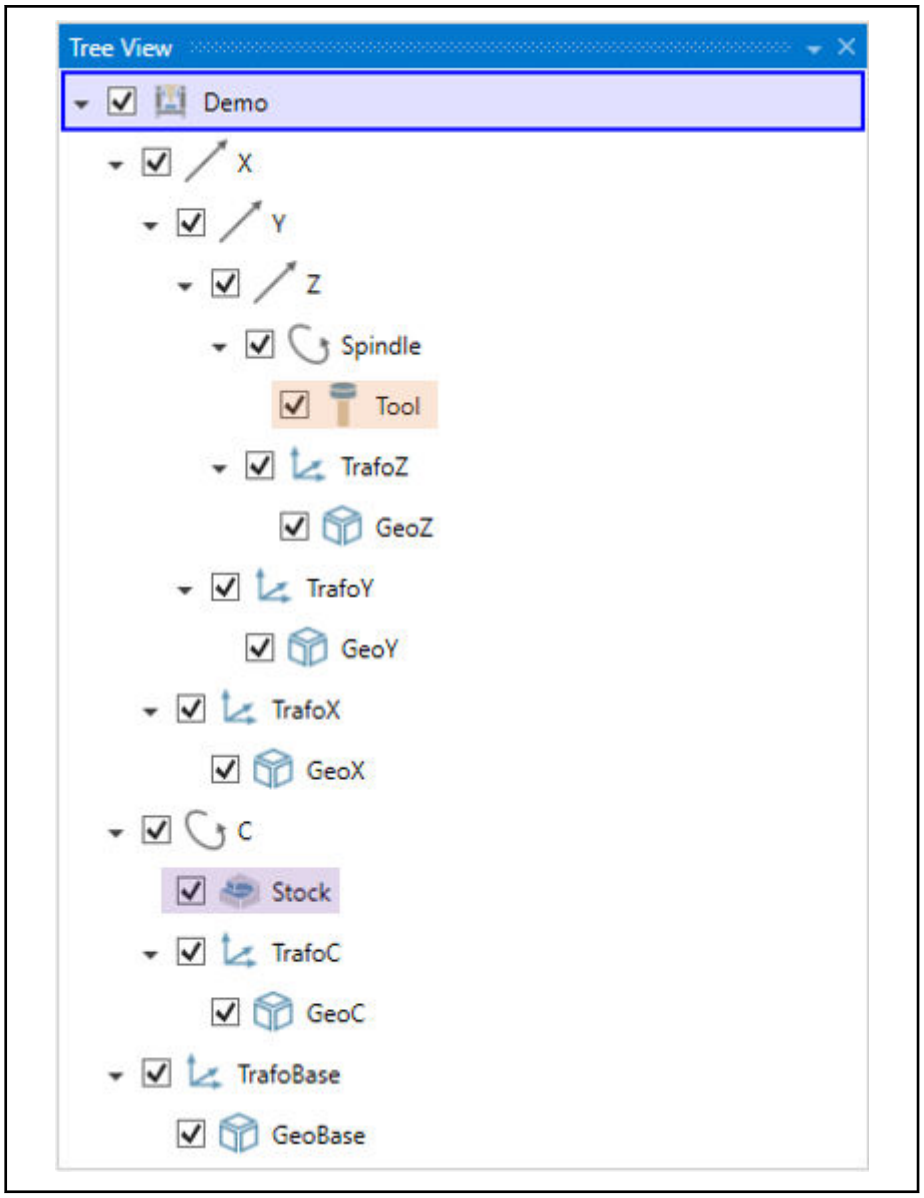


Fig. 12-8: Kinematic structure with tool node and stock node

Save The required kinematic structure for the example is now complete. To save this structure, go to "Save Machine As" (fig. 12-9 "Saving the kinematic model" on page 56).

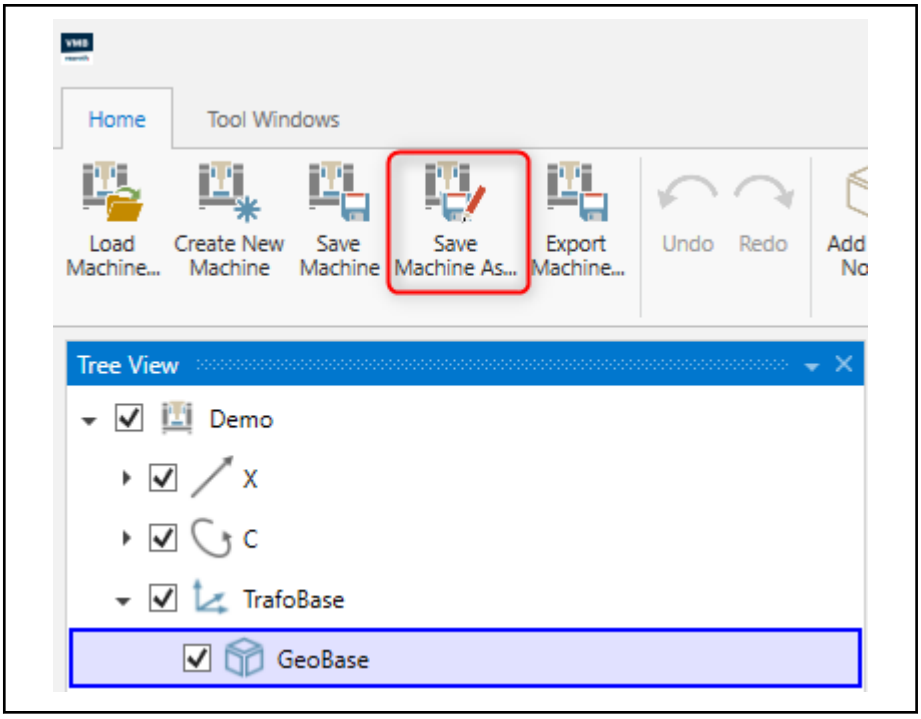


Fig. 12-9: Saving the kinematic model

12.3 Linking the kinematics to geometry data

To virtually represent a machine and to check the collision, 3D CAD data of the relevant physical components are required (workspace of the machine, clamping device, tools, stock). This chapter describes how to link CAD data to the kinematic structure and to modify their properties.

Data used in the exercise is stored in the "Demo" subfolder. Open the File Explorer, then the installation folder Virtual Machine Builders and click on the link "_LinkToCommonAppData". There are individual geometry data and the ready machine model file "Demo.xml".

Selecting geometry nodes

Load the geometries of the machine rack fixed in place and the clamping table. Select the "GeoBase" node of the type MachineGeometryNode in the kinematic tree (fig. 12-10 "Selecting the geometry node" on page 56)

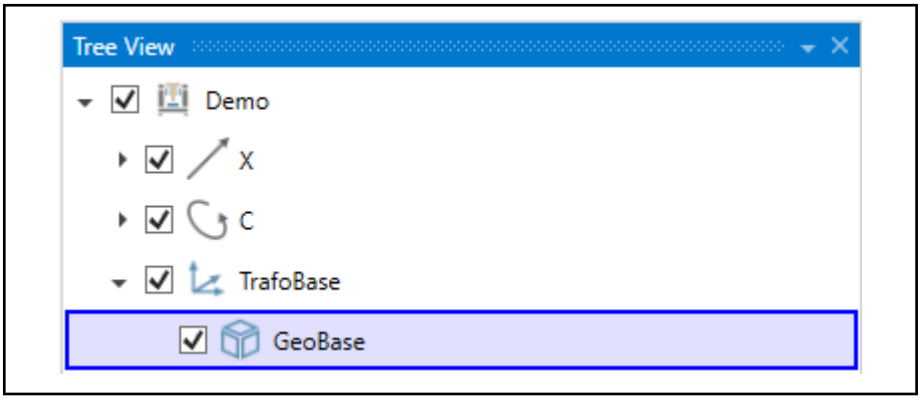


Fig. 12-10: Selecting the geometry node

Properties of the geometry node

One or multiple geometry object(s) can be linked to the geometry node and object properties can be specified in the "Properties" window. To modify color and visibility properties of the geometry objects, go to the "Color" entry. Declare the color definition using a color chart, the RGB value or a hexadecimal number. The transparency of the objects can also be set (fig. 12-11 "Selecting and coloring geometry data" on page 57)

Note that the color and visibility properties apply to all objects of the geometry node. Multiple geometry nodes have to be created before specifying different properties.

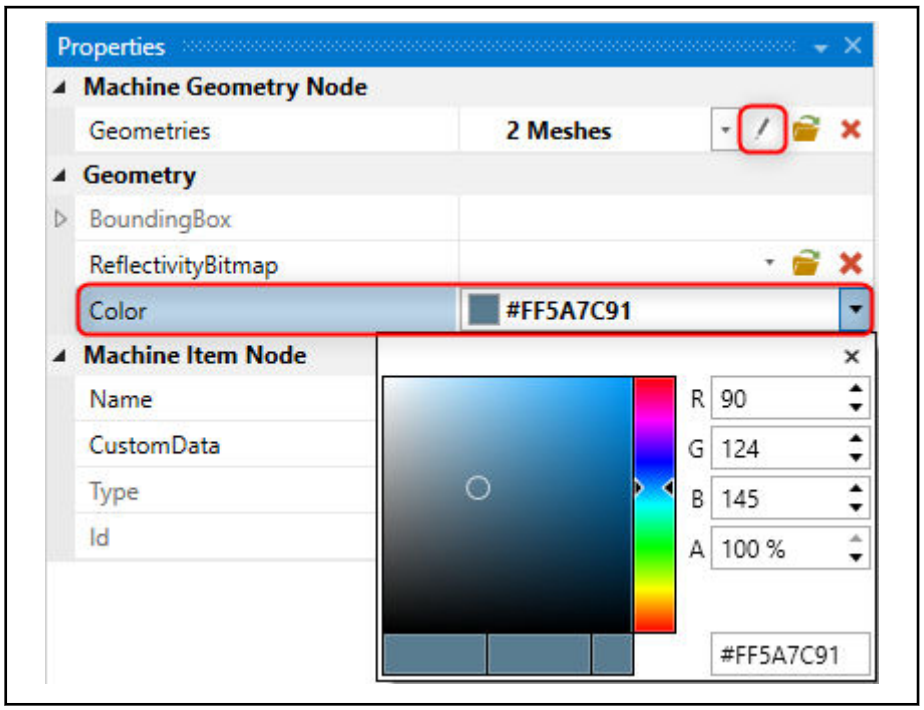


Fig. 12-11: Selecting and coloring geometry data

Assigning mesh(es)

To go to the "Machine Geometry Mesh Set Editor" (fig. 12-12 "Machine Geometry Mesh Set Editor to link geometry objects to geometry nodes" on page 58), press . Use this editor to create/manage a list of all geometry files and to link one or multiple objects from this list to the geometry node. A preview window facilitates the selection. Click on the arrows to add or remove the objects to or from the node.

The STL format is required as file format of the geometry objects. Most CAD systems can export this format. When creating an STL file, a faceted geometry is derived from the original geometry. Thus, the object geometry is used to approximate the area of the triangle. Note that a low export accuracy causes rough and inaccurate objects and thus affects the collision monitoring negatively. A very high export accuracy causes a high number of areas of a triangle and requires more performance of the simulation computer. Thus, find a suitable solution.

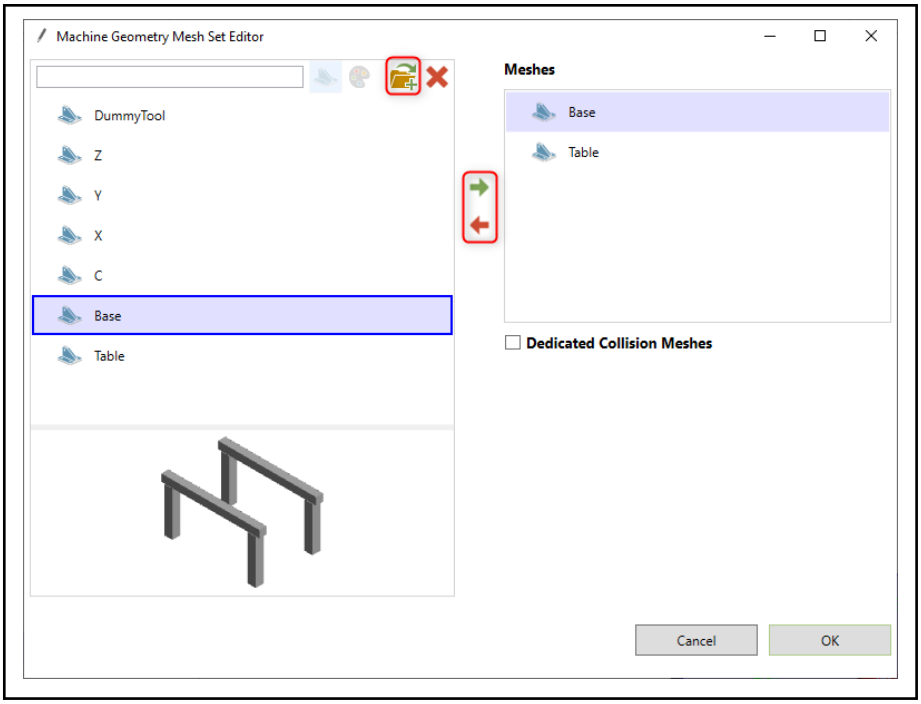


Fig. 12-12: Machine Geometry Mesh Set Editor to link geometry objects to geometry nodes

Add all geometry files to all other geometries and specify their properties.

- To select the file easier, the required geometries have file names in the example. These names correspond to the axis names of the kinematics.
- Optionally, load an "Initial Mesh" (here "InitialStock.stl)" into the stock node and add another MachineGeometryNode parallely to the tool node. Link the tool node to the geometry file "DummyTool.stl".

  The additional geometries at the stock and tool node show the position of the local coordinate systems and can help
  - to position the geometries as required with regard to the superordinate coordinate systems by adjusting the matrix of the directly superordinate transformation node.
  - to set the kinematic properties of the axes described in the following chapter.

  Delete the additional geometry node with the tool geometry at the latest when completing the machine model.

To show the local coordinate system, select an object in the "Tree View" window. Select **Show Local Coordinate System** in "Settings" (see chapter 11 "Settings" on page 49). The following figure visualizes the local coordinate system at the stock node using a coordinate tripod and a tool graphic. "InitialMesh" shows the position of the local coordinate system at the stock node.

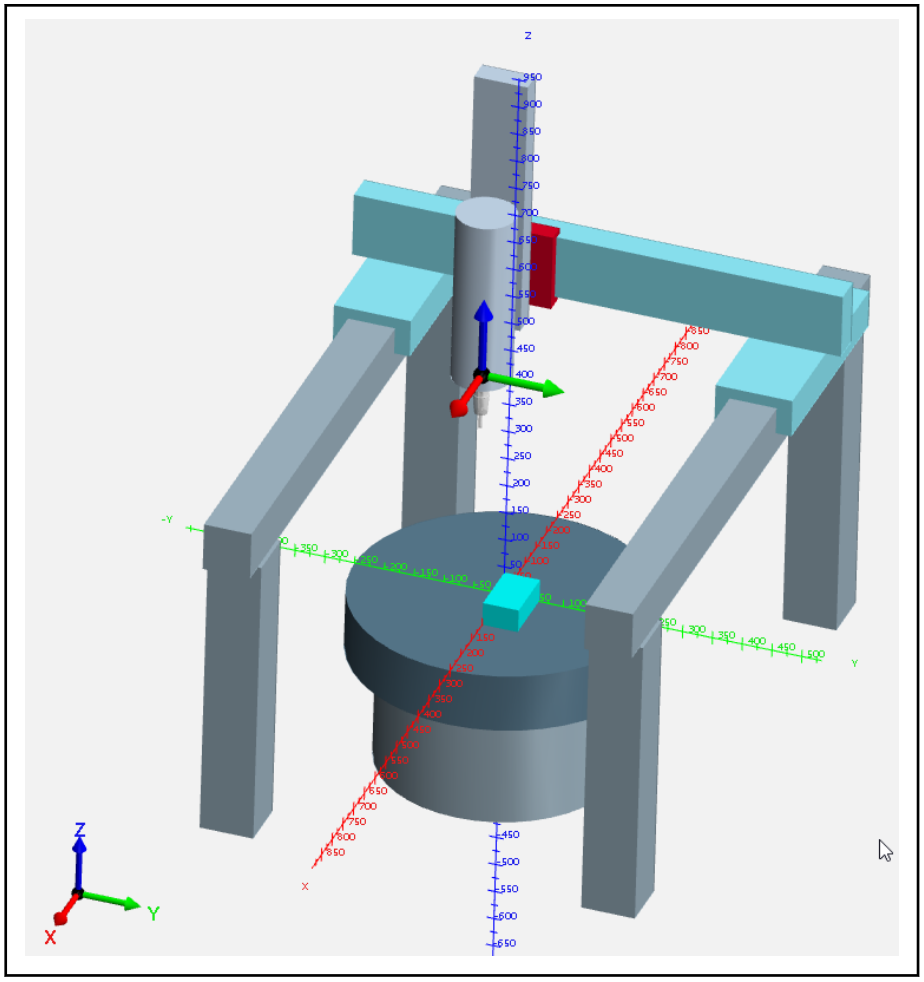


Fig. 12-13: Local coordinate system at the tool node and InitialMesh am Werkstückknoten

12.4 Check and set the axis properties of the kinematics

Axis Control window

After adding geometry objects to the kinematic structure, check the axes for a correct configuration and set them, as the axis motions can now immediately be checked visually. To move the kinematics, use the "Axis Control" window (see chapter 6 ""Axis Control" window" on page 39). Axes can be traversed using a slider or a switch or by entering values. Use **Is Spinning** to rotate a rotary axis.

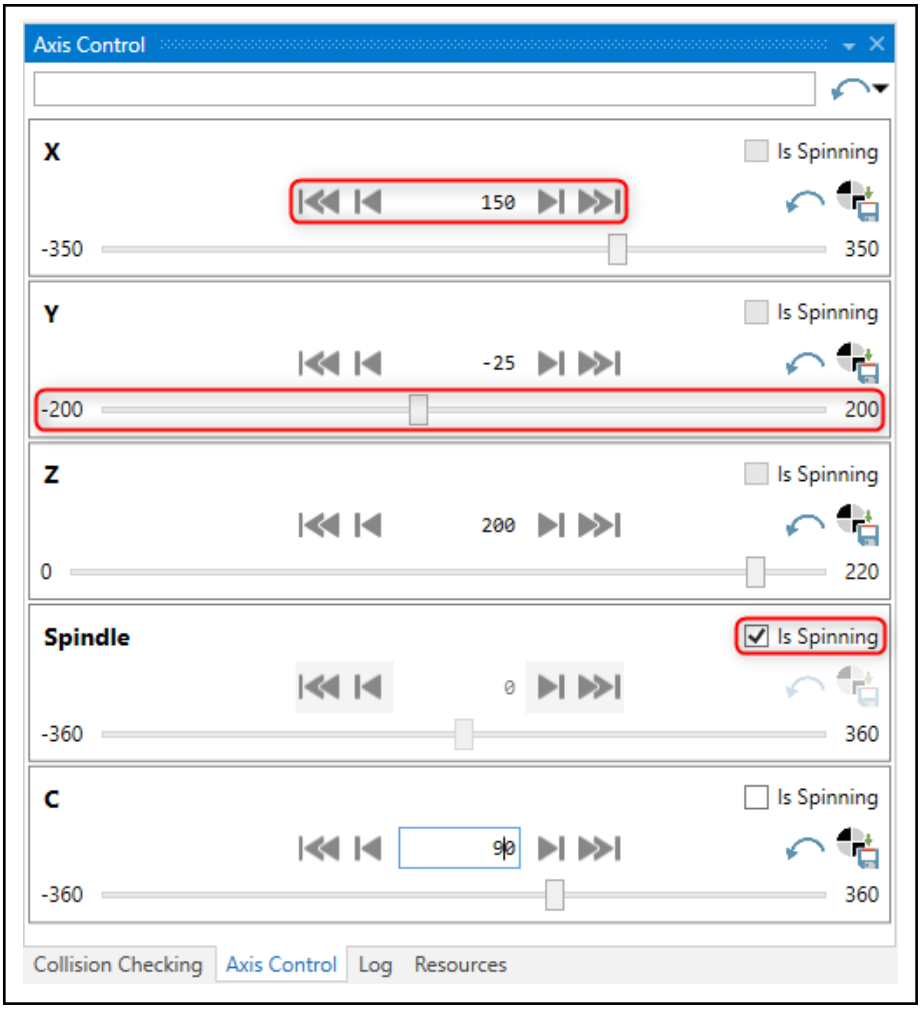


Fig. 12-14: Traversing kinematic axes

Properties window of the axes

To correct or set an axis, select an axis first in the kinematic tree via the "Properties" window. Select the "Axis" entry to specify the direction the axis points to. The setting 0 - 1 - 0 was selected in the example fig. 12-15 "Defining axis properties, example of a y-axis " on page 61, as the y-axis points towards the y-axis of the Cartesian world coordinate system.

To define the output position and the traversing limits of the axes, select the entries "InitialValue", "MaxValue" and "MinValue" (see chapter chapter 5 ""“Properties” window" on page 17 and chapter 5.3 ""“Translation Axis” node" on page 19).

The traversing distance definition is useful to visually check the kinematics in the Virtual Machine Builder. The values are not important during a later operation in the simulation mode, as the NC kernel monitors that the travel range is not violated.

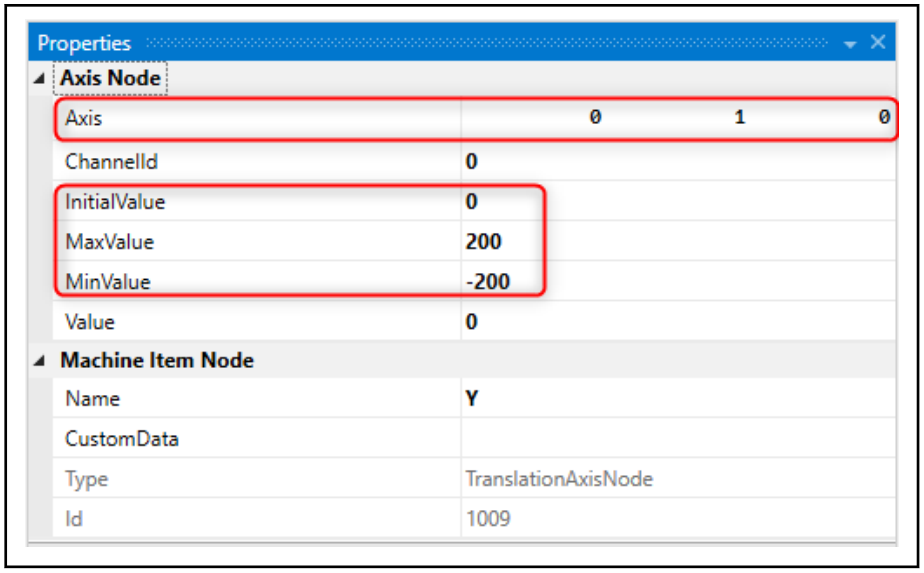


Fig. 12-15: Defining axis properties, example of a y-axis

For a rotary axis, specify the position of a point of the rotary axis in the local coordinate system (X, Y and Z in the input fields behind "RotationPoint"). Select **RolloverEnabled** for an endlessly rotating axis (as the c-axis moving the rotary table in this example). As the c-axis moves the stock and the axis is thus directed opposite the positive direction of rotation around z, "-1" is entered into the third field behind "Axis".

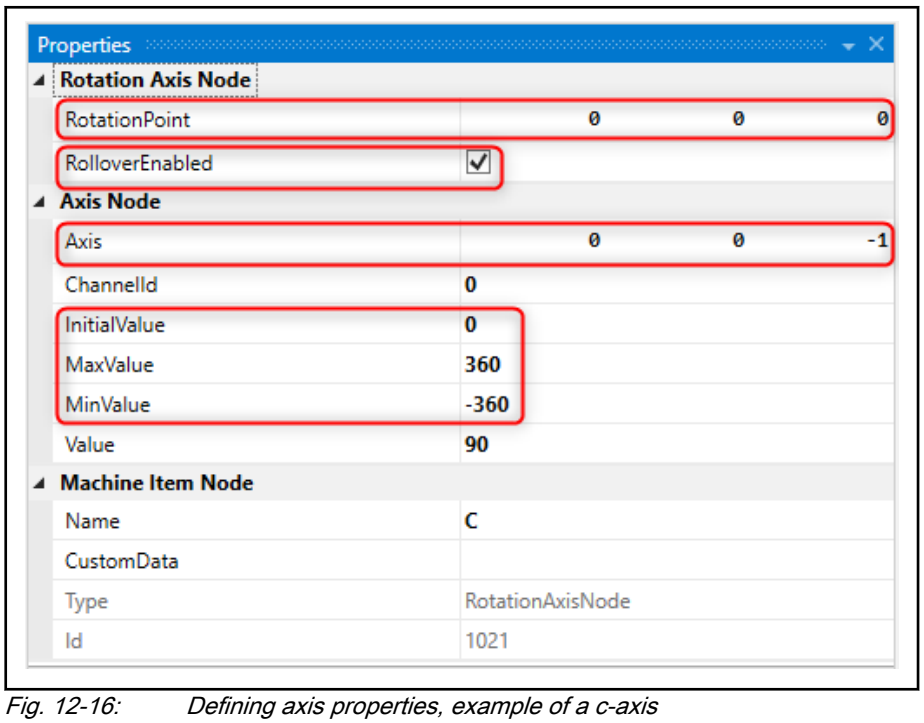


Fig. 12-16: Defining axis properties, example of a c-axis

12.5 Defining collision relations for a machine model

The collision monitoring is very important in the CNC simulation. To ensure a correct function, the geometry objects in the model have to be assigned to the correct collision groups. During the simulation, all objects on the left side of a collision groups are checked with all objects on the right side of the collision. To create collision groups and to assign the geometry objects to a colli-

sion group, go to the "Collision Checking" window (see chapter 7 ""Collision Checking" window" on page 41).

Defining a collision group

Define a collision group for your exercise and assign the respective geometry objects as shown in fig. 12-17 "Assigning the geometry objects of a collision group" on page 62. For a visual clarification in the 3D model, the geometries highlighted in the left field are colored in green and the geometries highlighted in the left field are colored in violet. Each object selected on the left can be a collision partner of one of the objects selected on the right.

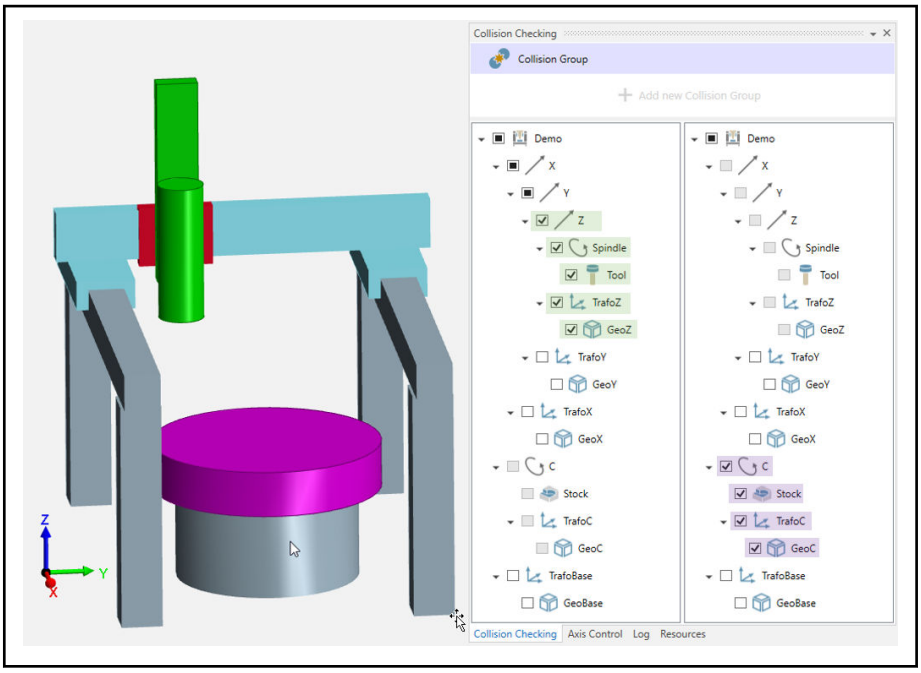


Fig. 12-17: Assigning the geometry objects of a collision group

Keep the number of collision partners (of the MachineGeometryNodes) as low as possible on both sides in order not to increase the computing effort more than required for the collision computation. Select only objects that can actually collide with each other within the travel range limits with the biggest tool and stock/fixture possible.

In the exercise, all objects below the z-axis can collide with the objects below the c-axis.

Exporting

Delete the auxiliary geometries additionally inserted to facilitate the calibration of the machine model (e.g. at the tool node).

The exercise is now complete. To subsequently use it, click on the "Export Machine" button to export the machine model to a separate folder (see fig. 12-18 "Exporting the machine model" on page 63). All geometry files used and the model file in xml format are stored in this folder (named after the name of the root node).

Only the model file is saved when saving the model using "Save Machine (As)". The geometry data remains at its original location. They are linked in the model file using absolute path specifications. With "Export Machine", copies of the geometry files are created in the target folder and these are linked in the model file (relative path specifications).

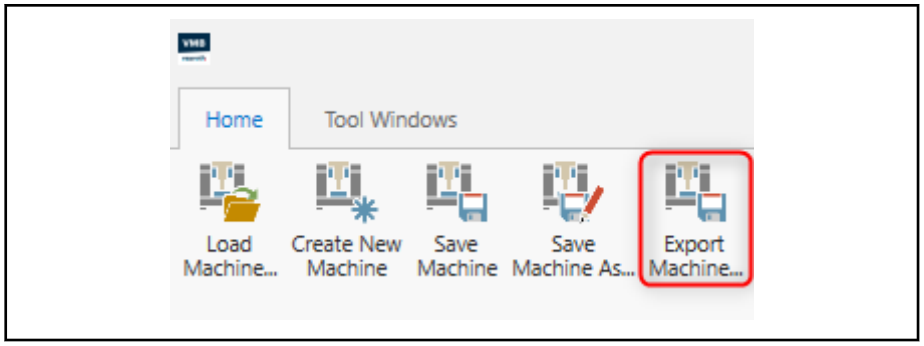


Fig. 12-18: Exporting the machine model

The folder created via "Export Machine"" includes all files belonging to the simulation model and with the structure required to apply them to the NC Simulation. The provision of the machine model to the simulation depends on the version. Also refer to "Providing the machine model in the NC Simulation" on page 7.

13 Appendix 2: Node structure for a three-jaw chuck

This chapter exemplarily describes the node structure for a three-jaw chuck. The structure is part of the kinematic tree.

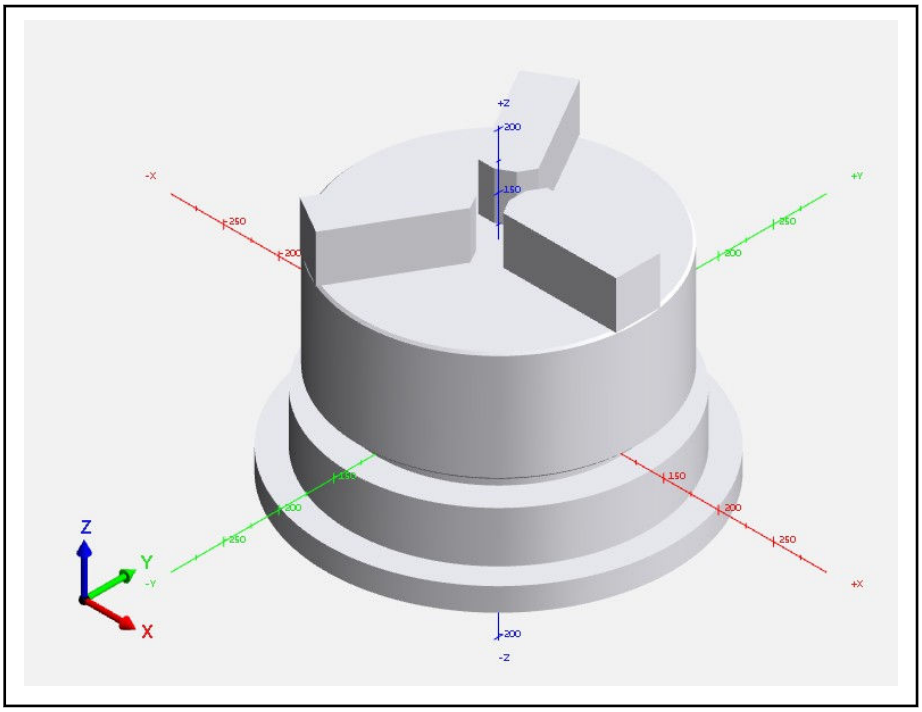


Fig. 13-1: Complete overview on a three-jaw chuck

Description of the node structure in the kinematic tree for a three-jaw chuck.

Select "Create New Machine" to create the kinematic tree for a three-jaw chuck. This creates the root node of the "Maschine" and allows to add all subordinate child nodes to fully represent the three-jaw chuck.

Select the machine definition node ("Machine Definition Node") and edit the name of the node as follows.

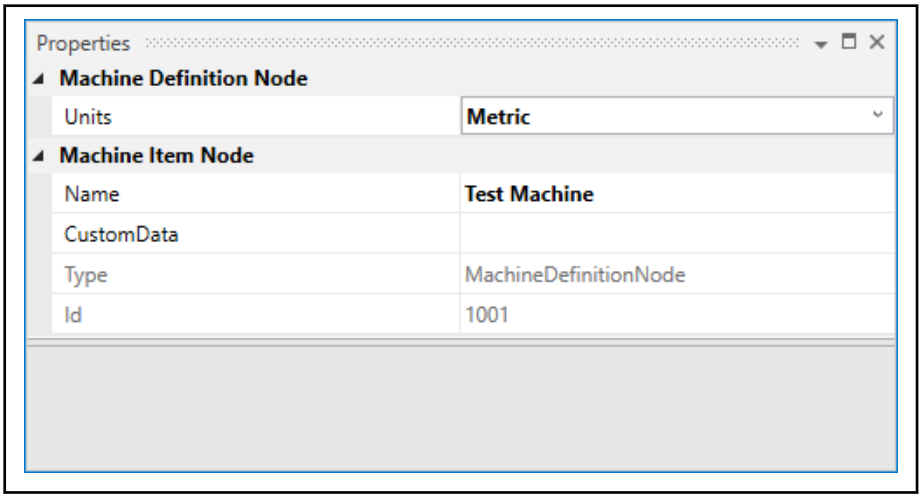


Fig. 13-2: "Properties" window of the machine definition node

To define the workpiece spindle, go to the menu item "Add Child Node" to create a rotary axis node called "C" with its rotary axis being the z-axis.

The minimum and maximum values of the rotary axis node are set to -1000 and +1000.

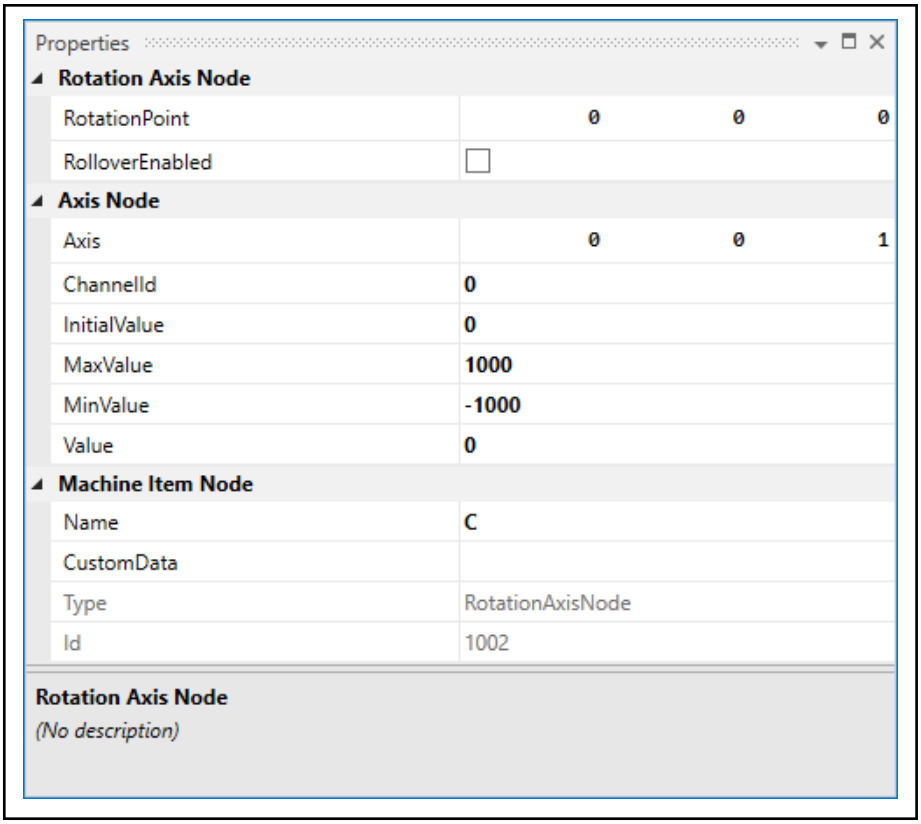


Fig. 13-3: "Properties" window of the rotary axis node for the stock spindle

To adjust the chuck position longitudinally along the spindle, a transformation node follows the rotary axis node. This node corresponds to the transformation of one coordinate system into another coordinate system. Each child node is defined with regard to the coordinate system of this parent node.

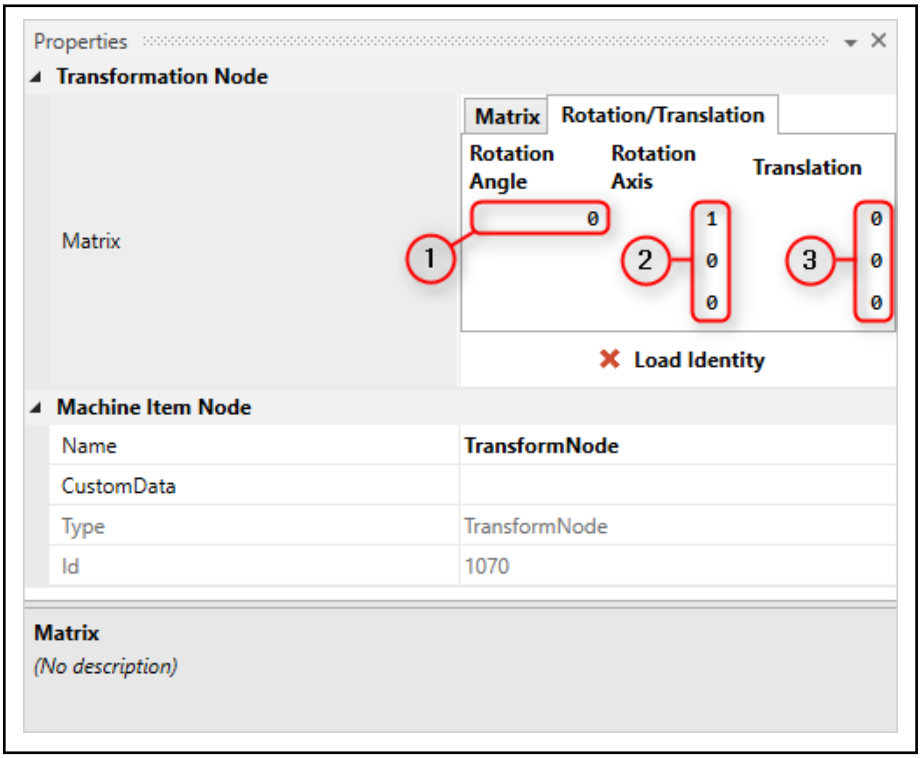


Fig. 13-4: "Properties" window for the transformation node above the chuck

The chuck node and the chuck geometry are created. First, add the chuck node to the rotary axis of the stock spindle as child node or to the subordinate transformation node.

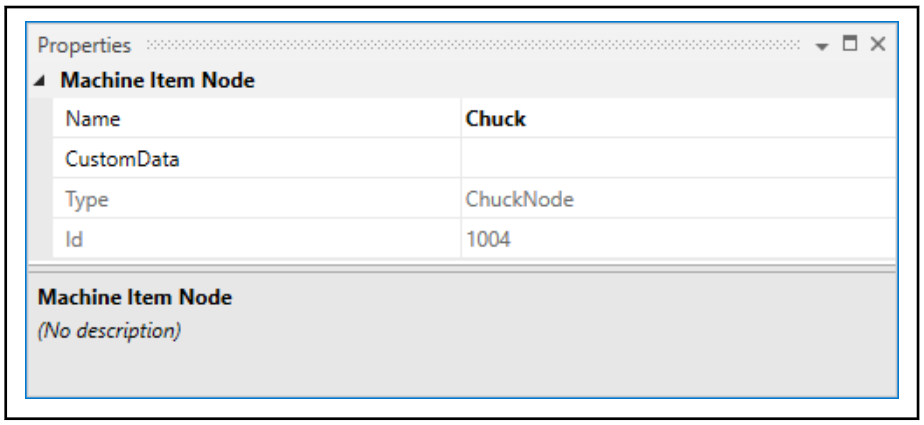


Fig. 13-5: "Properties" window of the chuck node

The chuck geometry ("Chuck Geo") is added as child node of the chuck node. Then, the geometry file "chuck.stl" is selected. It includes the mesh geometry of the chuck model.

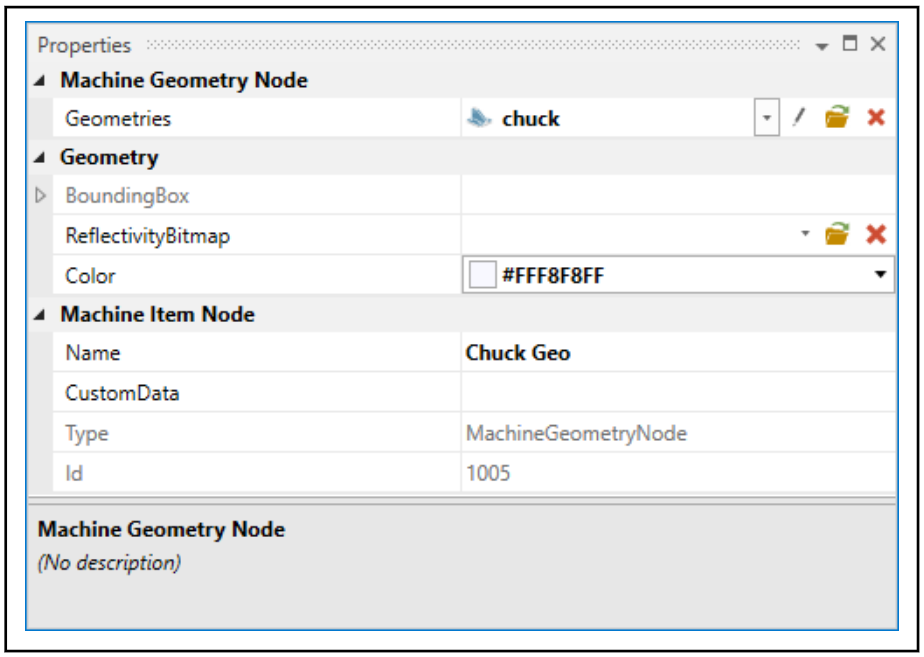


Fig. 13-6: "Properties" window of the machine geometry node with the chuck geometry

Subsequently, the user can create the chuck jaw node structure as subtree of the already defined chuck node. To create the three-jaw chuck, create the first chuck jaw as follows.

Create a transformation node for the chuck jaw 1 ("Chuck Jaw 1") to ensure that each child node is defined with regard to the coordinate system of this parent node.

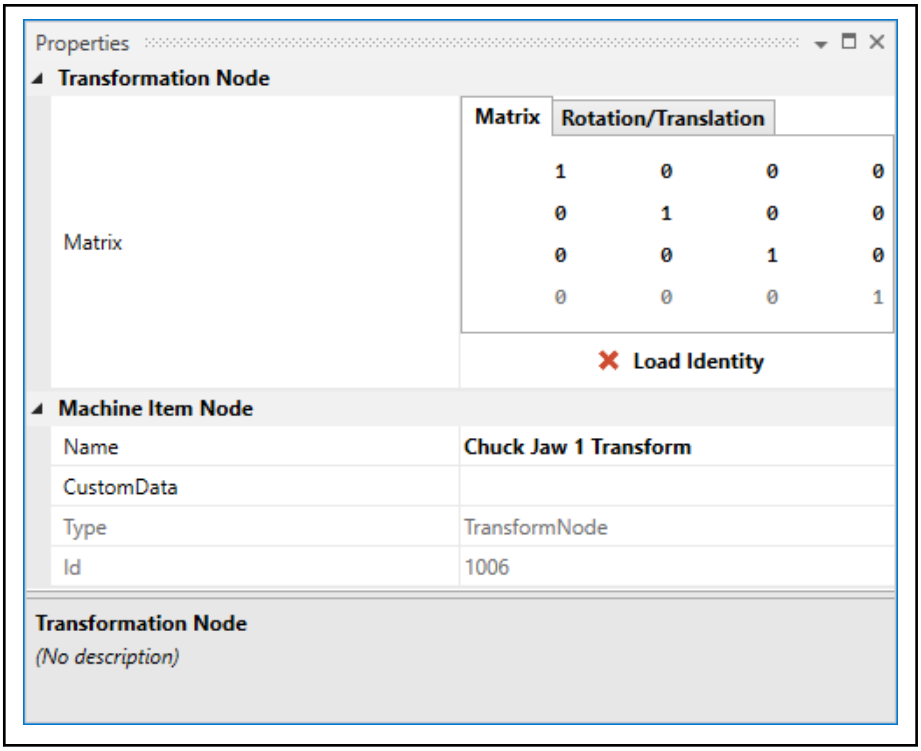


Fig. 13-7: "Properties" window for the transformation node on the first chuck jaw at 0°

Create the chuck jaw node ("Chuck Jaw Node","Chuck Jaw 1") as child node of the already defined transformation node ("Chuck Jaw 1 Transform").

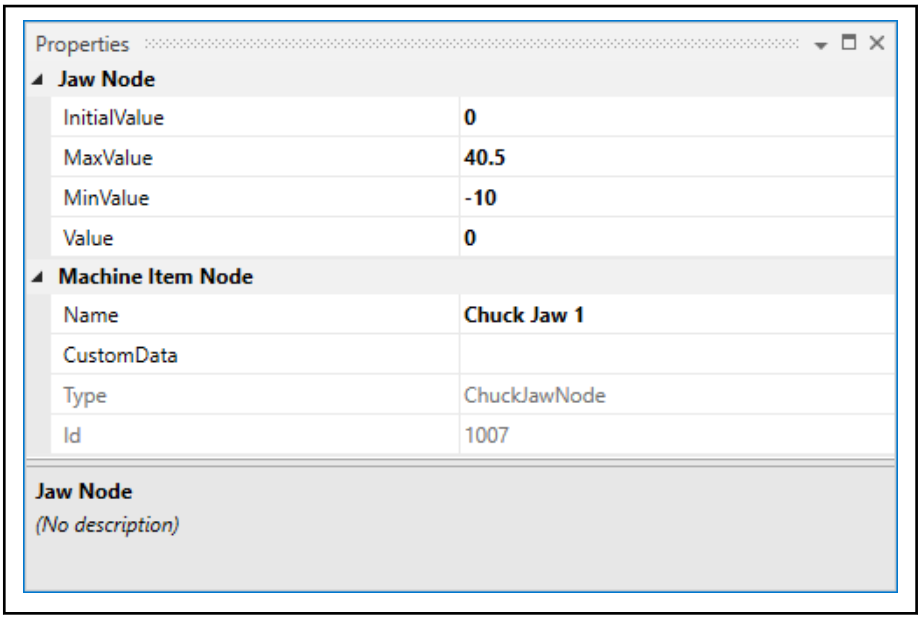


Fig. 13-8: "Properties" window for the chuck jaw node on the first jaw

The machine geometry "Chuck Jaw 1 Geo" is created as child node of "Chuck Jaw 1". "chuck_jaw.stl" includes the mesh geometry file.

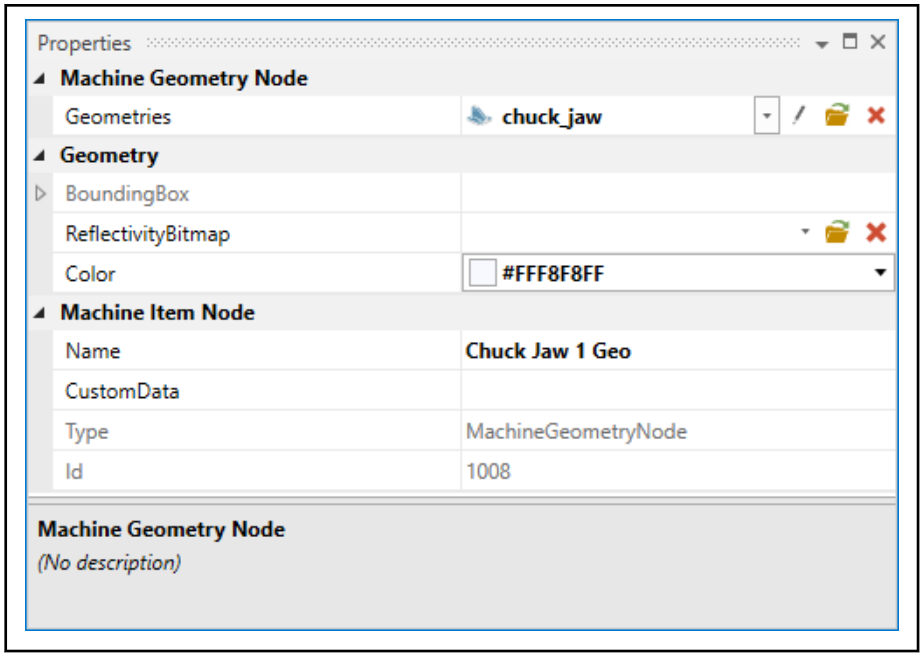


Fig. 13-9: "Properties" window of the machine geometry node for chuck jaw 1

The subtrees for "Chuck Jaw 2" are created analogously to the subtree for "Chuck Jaw 1 " using the same geometry file "chuck_jaw.stl" containing the mesh geometry.

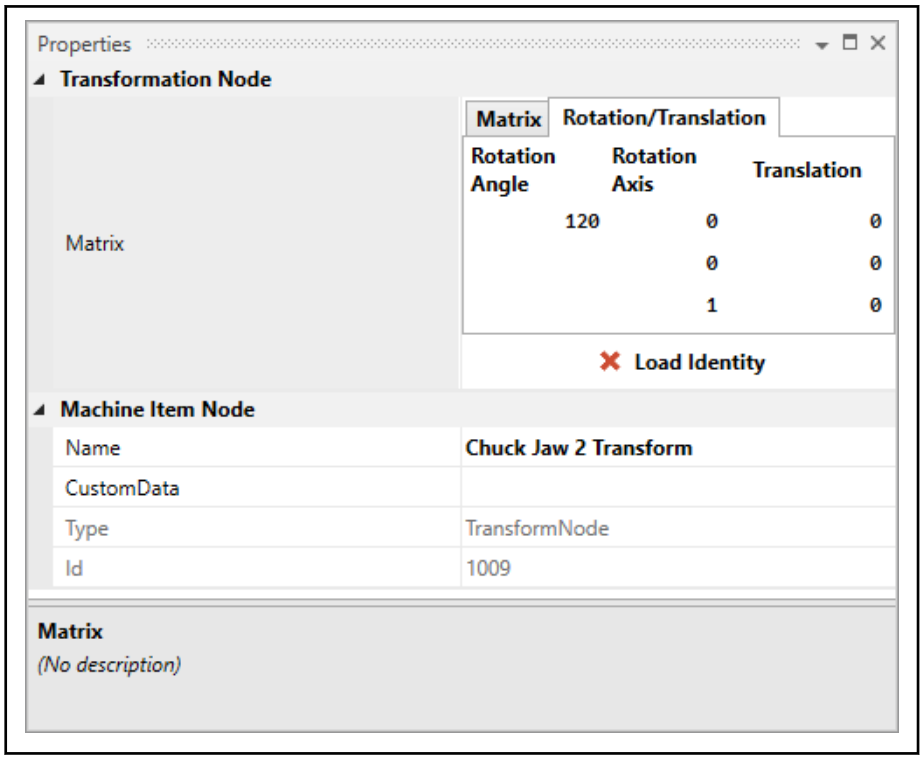


Fig. 13-10: "Properties" window for the transformation node on the second chuck jaw at 120°

The transformation node used is important, as the rotation of 120 degrees around the z-axis ensures that the translation values (in the limits "MinValue" and "MaxValue") are correct for jaw movement towards the unit vector (1,0,0) in the local coordinate system.

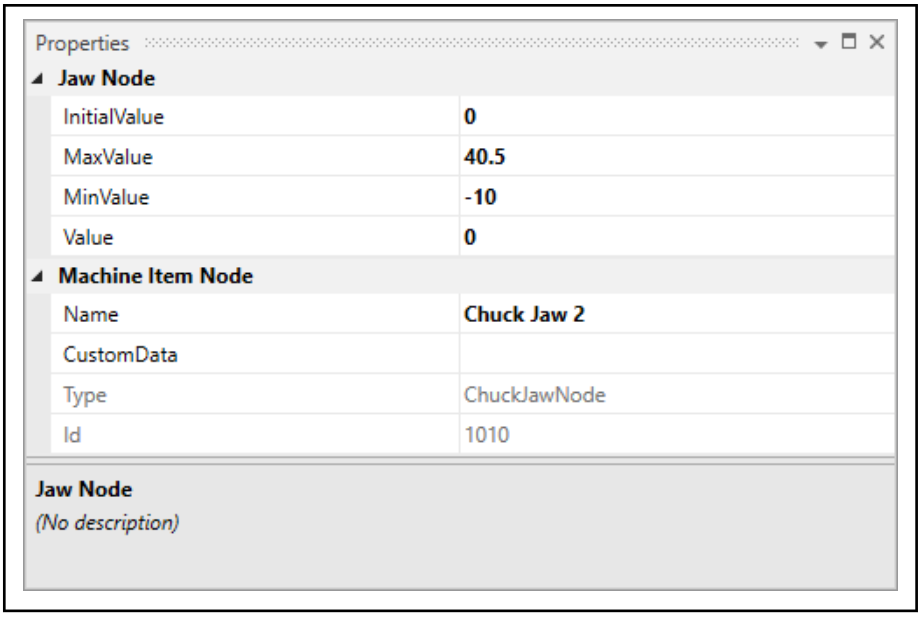


Fig. 13-11: "Properties" window for the chuck jaw node on the second chuck jaw

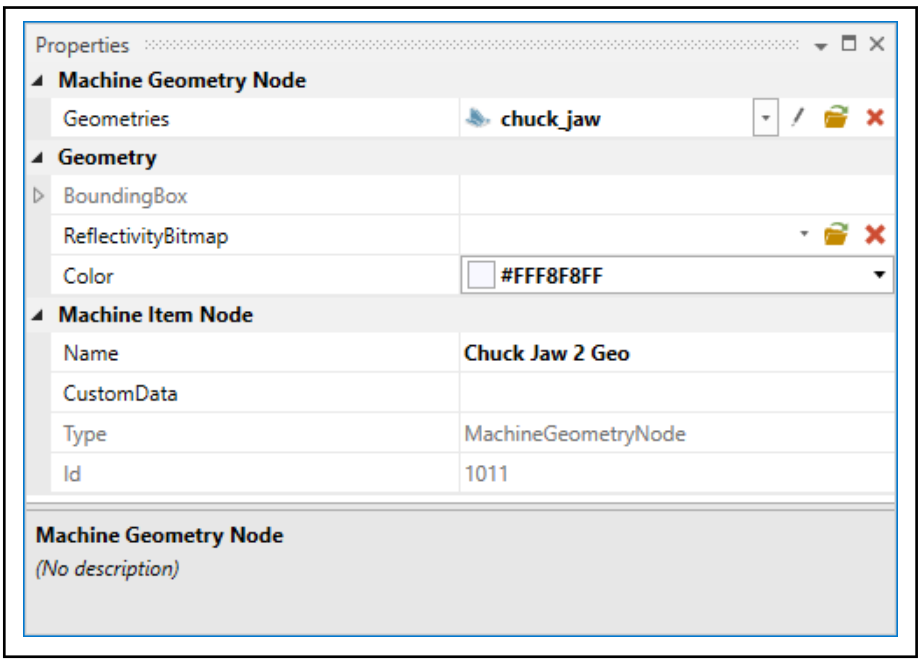


Fig. 13-12: "Properties" window of the machine geometry node for chuck jaw 2

The subtree for "Chuck Jaw 3" is created with the same geometry file "chuck_jaw.stl" that contains the mesh geometry.

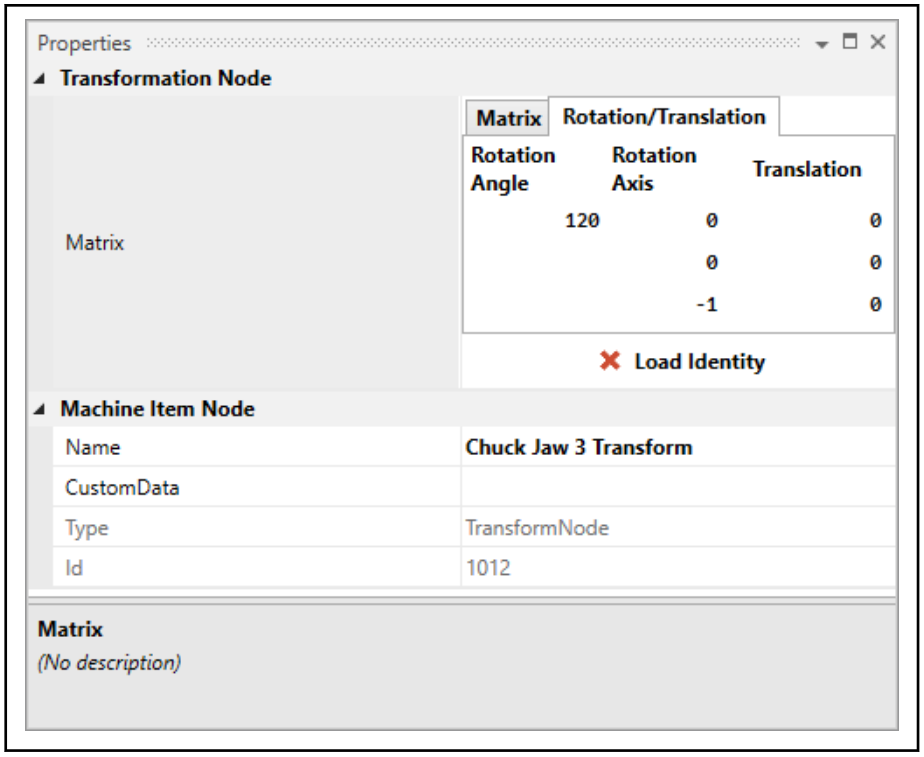


Fig. 13-13: "Properties" window for the transformation node on the third chuck jaw at -120°

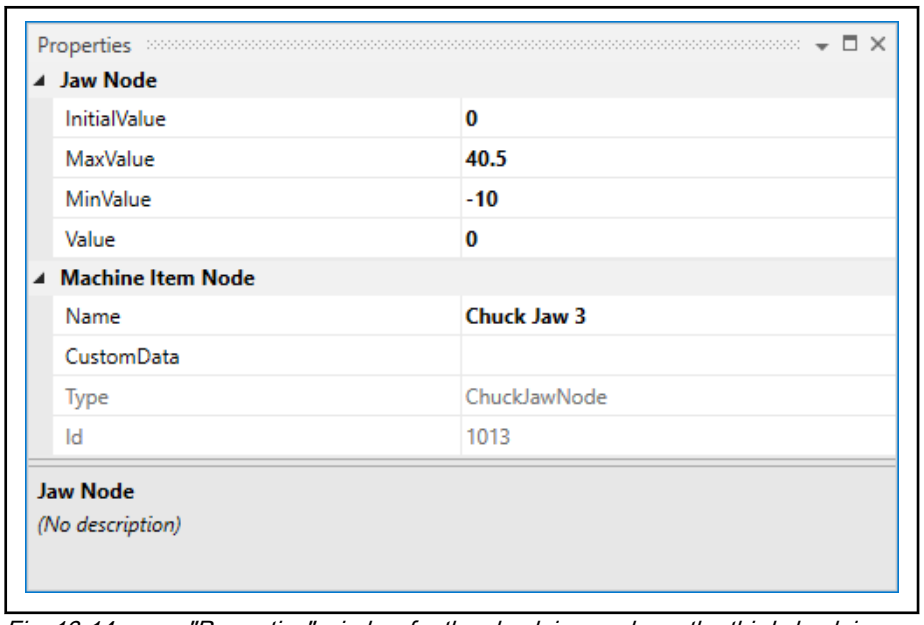


Fig. 13-14: "Properties" window for the chuck jaw node on the third chuck jaw

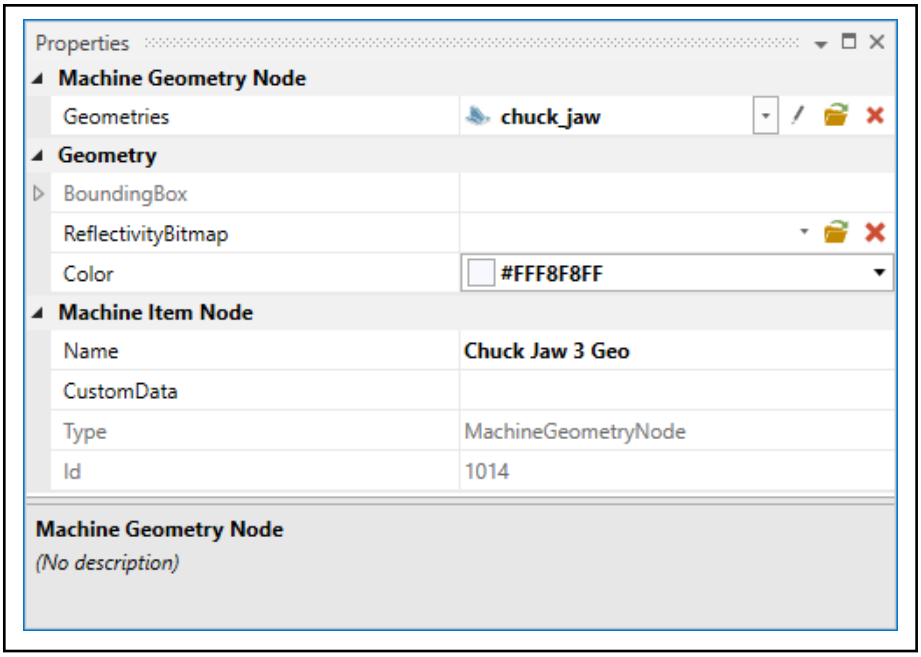


Fig. 13-15: "Properties" window of the machine geometry node for chuck jaw 3

This completes the kinematic subtree for the three-jaw chuck as shown below.

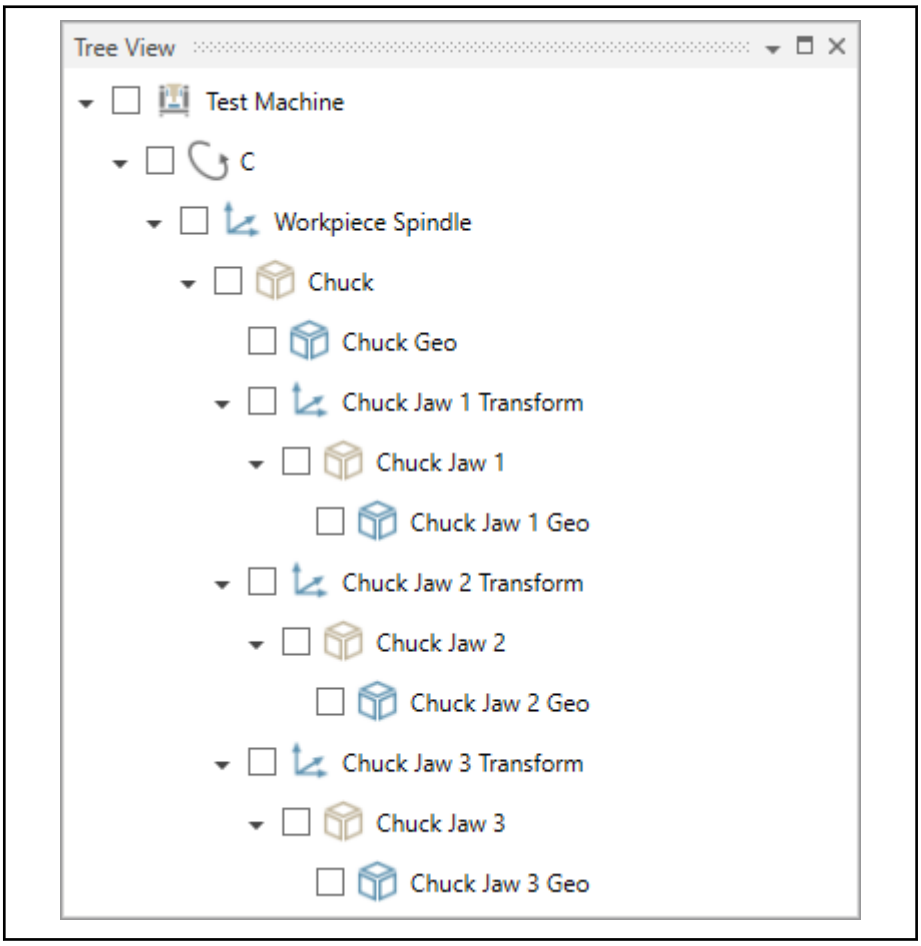


Fig. 13-16: Kinematic tree of a three-jaw chuck

The "Value" specified in each of the three chuck jaw nodes can be adjusted separately. The position of the relevant jaw is updated accordingly. The following figure shows an example of all three chuck jaws in end position.

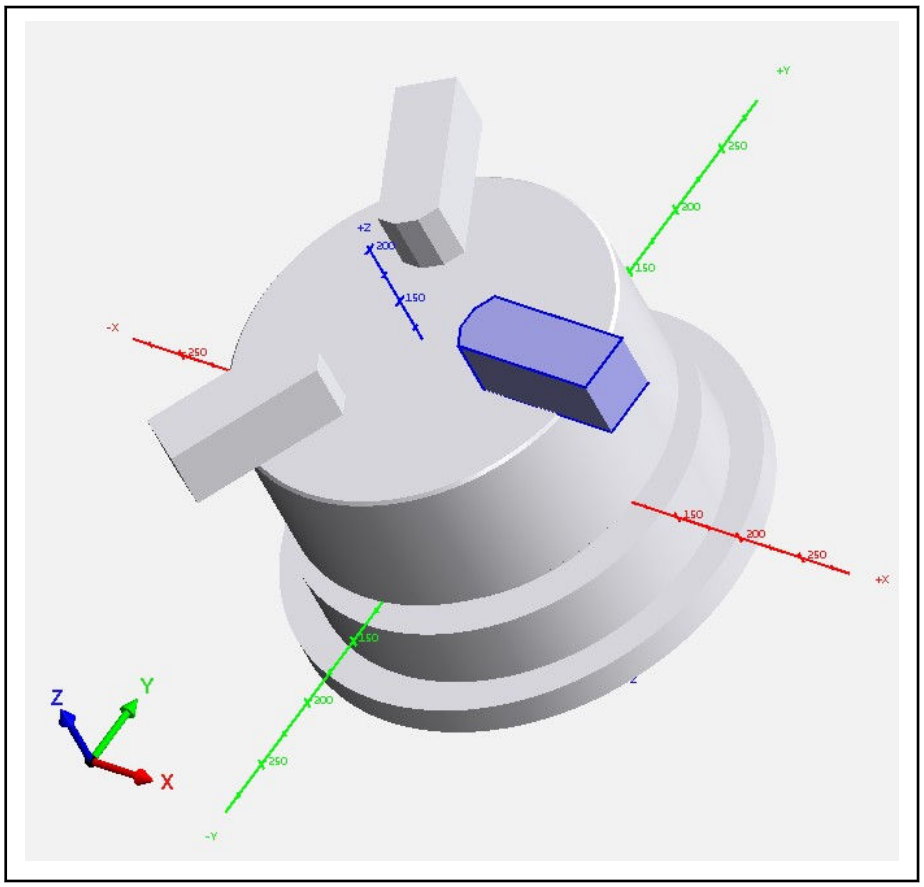


Fig. 13-17: Axis control of the c-axis with selected jaw 1 at 0°

Use the “Axis Control” window of the rotary axis "c" to rotate the chuck and jaw combination around the workpiece spindle (i.e. the z-axis).

Fig. 13-18: "Axis Control" window

14 Service and support

Our worldwide service network provides an optimized and efficient support. Our experts offer you advice and assistance should you have any queries. You can contact us **24/7**.

Service Germany

Our technology-oriented Competence Center in Lohr, Germany, is responsible for all your service-related queries for electric drive and controls.

Contact the **Service Hotline** and **Service Helpdesk** under:

Phone:	**+49 9352 40 5060**
Fax:	**+49 9352 18 4941**
E-mail:	service.svc@boschrexroth.de
Internet:	http://www.boschrexroth.com

Additional information on service, repair (e.g. delivery addresses) and training can be found on our internet sites.

Service worldwide

Outside Germany, please contact your local service office first. For hotline numbers, refer to the sales office addresses on the internet.

Preparing information

To be able to help you more quickly and efficiently, please have the following information ready:

- Detailed description of malfunction and circumstances
- Type plate specifications of the affected products, in particular type codes and serial numbers
- Your contact data (phone and fax number as well as your e-mail address)

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