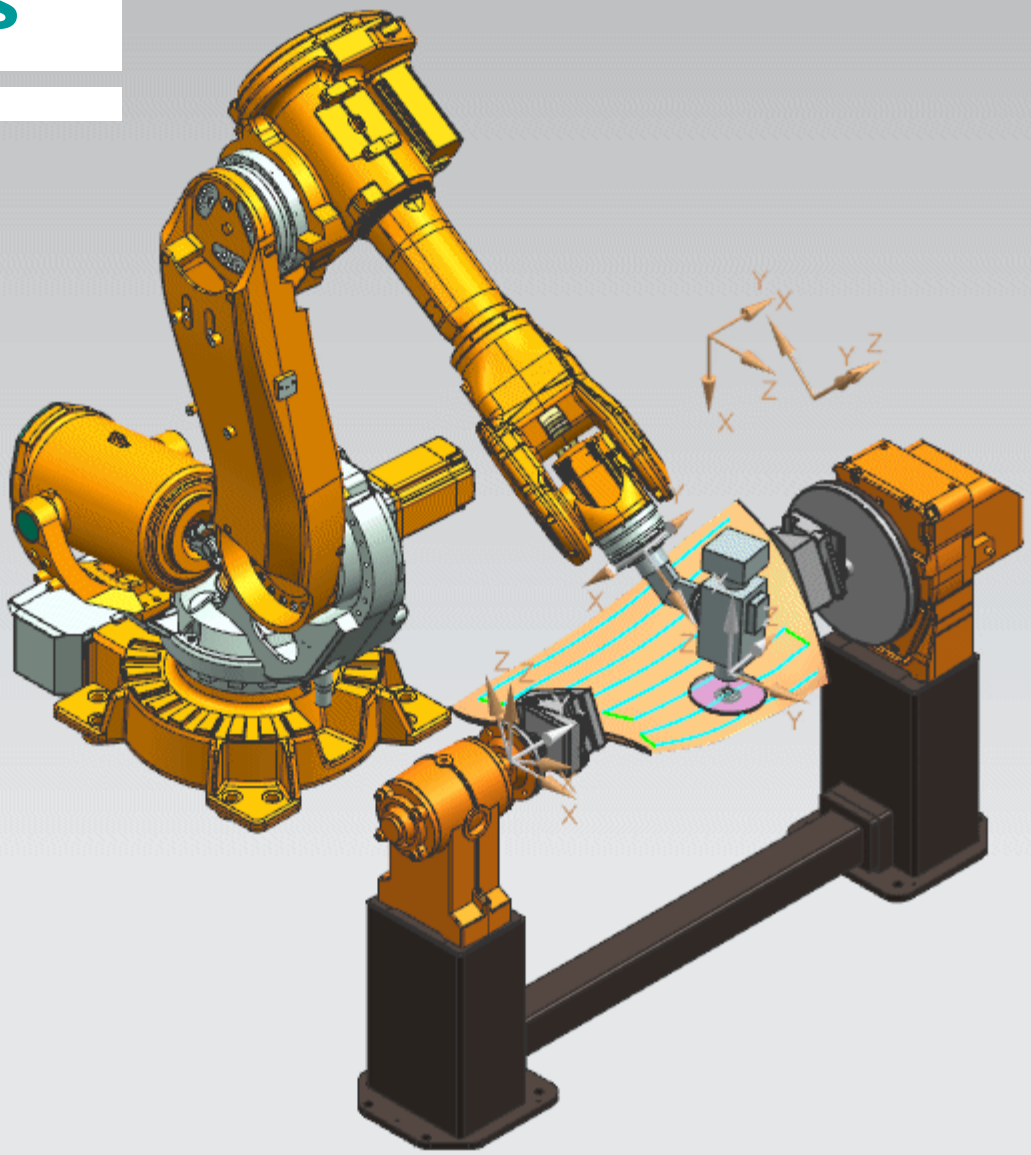
SIEMENS



Siemens PLM Software

NX CAM 11.0.1: Robotic Machining

Output NX milling tool paths to robotic machines.

Answers for industry.

About NX CAM

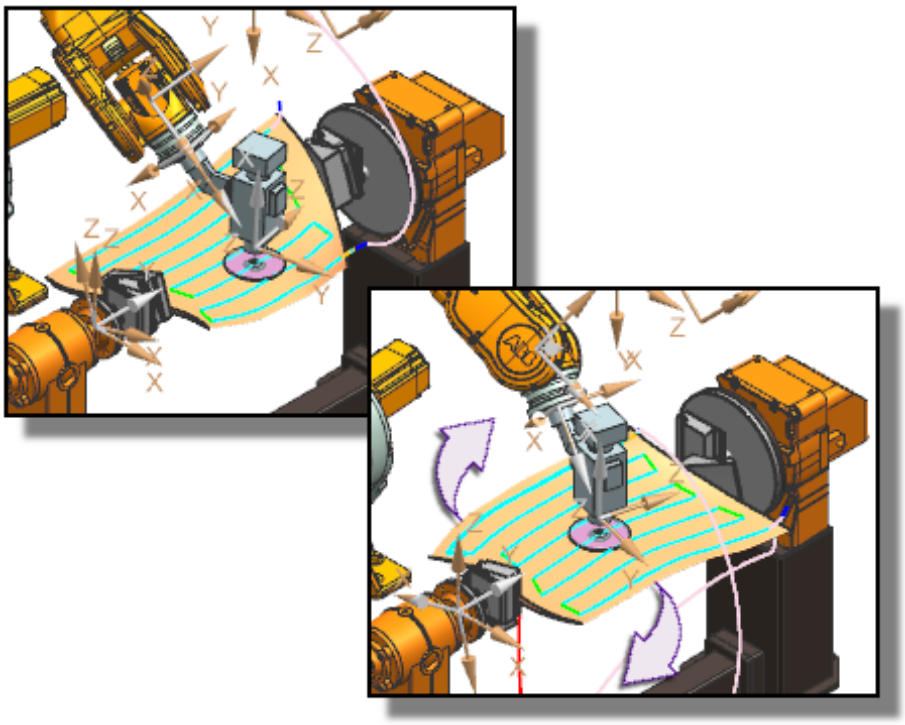
NX™ CAM software has helped many of the world's leading manufacturers and job shops produce better parts faster. You can also achieve similar benefits by making use of the unique advantages NX CAM offers.

This is one of many hands-on demonstrations designed to introduce you to the powerful capabilities in NX CAM 11.0.1. In order to run this demonstration, you will need access to NX CAM 11.0.1.

Visit the NX Manufacturing Forum to learn more, ask questions, and share comments about NX CAM.

Hands-on Demonstration: Robotic Machining

NX can simulate and output milling tool paths to robotic machines. Robotic machines are useful for milling, polishing, linishing, deburring, and laser, plasma, and water jet cutting. In this example, you will polish both sides of a turbine blade.



In this self-demo, you will:

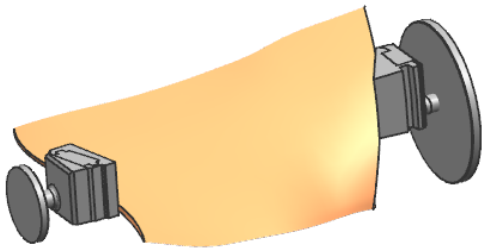
- Specify the robotic machine tool
- Simulate the robotic machine tool
- Examine the kinematics chain
- Define the part component in the setup configurator
- Check for collisions and make corrections
- Edit robotic machining rules
- Polish the opposite side of the blade
- View, edit, and add poses
- Postprocess

Prerequisites:

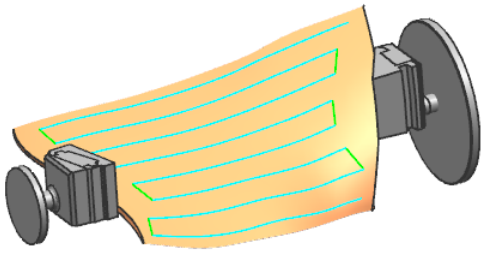
1. You will need access to **NX CAM 11.0.1** in order to run this demonstration.
2. You will need the appropriate licenses.
3. If you haven't done so already, download and unzip **robotic_machining.7z**.

Demo:

1. Open **Robotic_Polishing.prt** in NX.

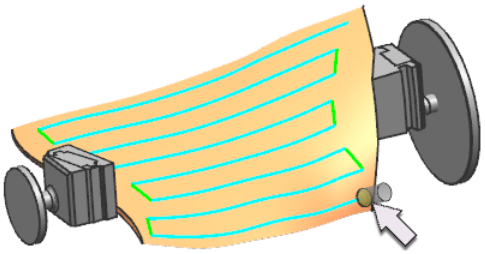


4. Select the **Operation Navigator** tab in the Resource Bar .
5. In the Program Order View, right-click **ROUGH1_SIDE1** and select **Replay**.



The tool path was created by a Variable Streamline milling operation.

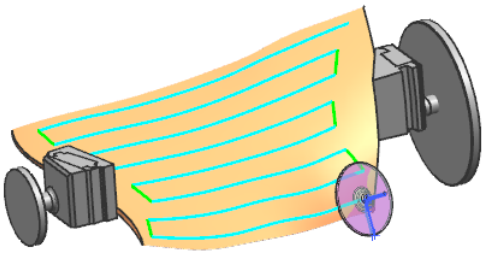
6. Click **Verify Tool Path** in the Ribbon Bar .
7. Select the **Replay** tab and select **Tool** from the **Tool** list.
   The milling tool used to create the tool path is displayed.



Display the polishing tool

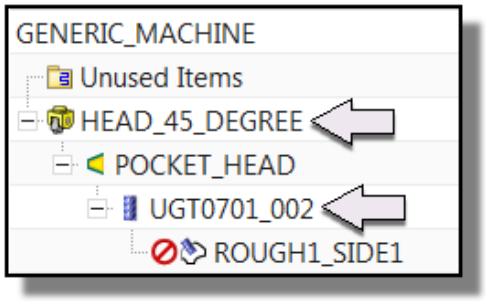
1. Select **Assembly** from the **Tool** list.

   The polishing disk that will be used by the robotic machine is displayed.



2. Slow down the Animation Speed and click **Play**  .
3. Click **OK** in the Tool Path Visualization dialog box.
4. Display the Machine Tool View of the Operation Navigator.

   The robotic machine will use the head and polishing tool defined in this view.

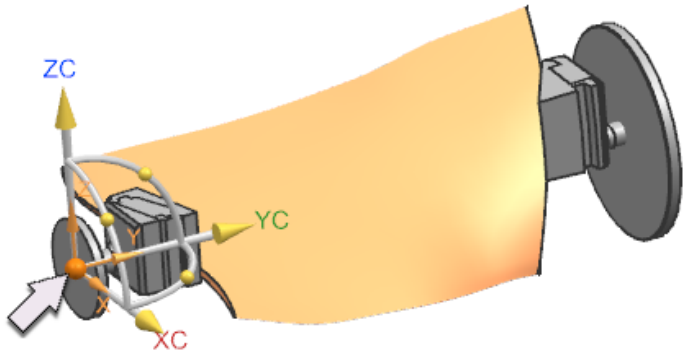


Specify the robotic machine tool

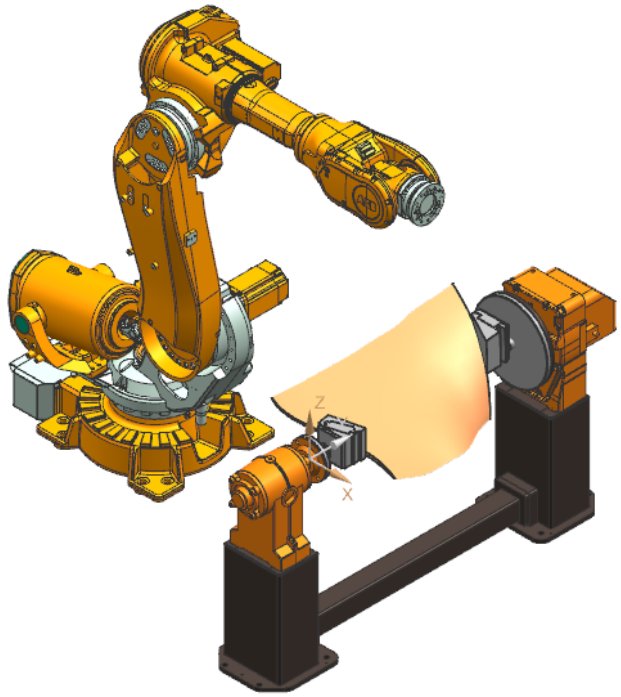
You will select a robotic machine tool from the library.

1. In the Operation Navigator, double-click **GENERIC_MACHINE**.
2. Click **Retrieve Machine from Library**  .
3. Select **ROBOT** from the **Class to Search** list.
4. Click **OK**.
5. Select **ABB_IRB_6640_235_255** from the **Matching Items** list.
6. Click **OK**.
7. Select **Use Part Mount Junction** from the **Positioning** list.
8. In the Border Bar, select **Entire Assembly** from the **Selection Scope** list.

9. Select the center point on the face of the mounting bracket.



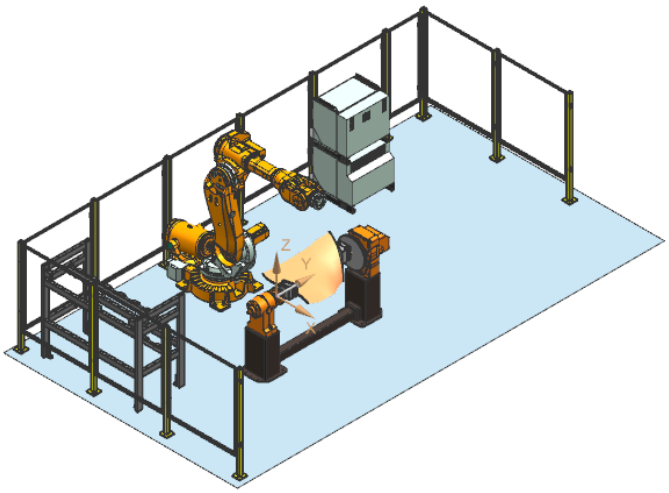
10. Click **OK** in the Part Mounting dialog box.
11. Click **OK** in the 6-Ax Robot With Positioner dialog box.
12. **Close** the Information window.
13. Display the machine tool in an isometric view.



You can also display the entire robotics work station.

14. Select the **Assembly Navigator** tab in the Resource Bar .

15. Select the **ABB_ex01_PolishingStation_noRobot** check box ☑ to display the station.

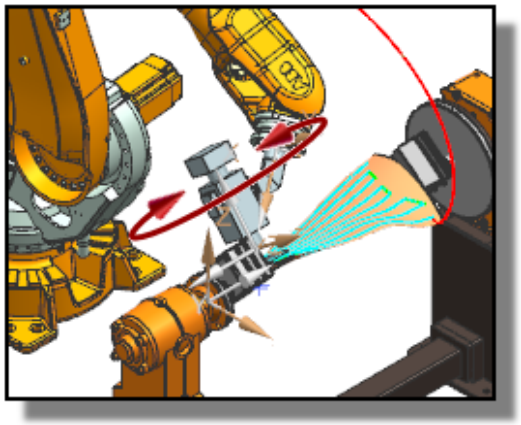


16. Select the **ABB_ex01_PolishingStation_noRobot** check box again to remove the station display.

Simulate the robotic machine tool

1. Select the **Operation Navigator** tab in the Resource Bar .
2. In the Machine Tool View, select **ROUGH1_SIDE1**.
3. Click **Simulate Machine** in the Ribbon Bar.
4. In the Simulation Settings section of the dialog box, select the **Show Tool Path** and **Show Tool Trace** check boxes ☑ if they are not already selected.
5. Click **Play** .

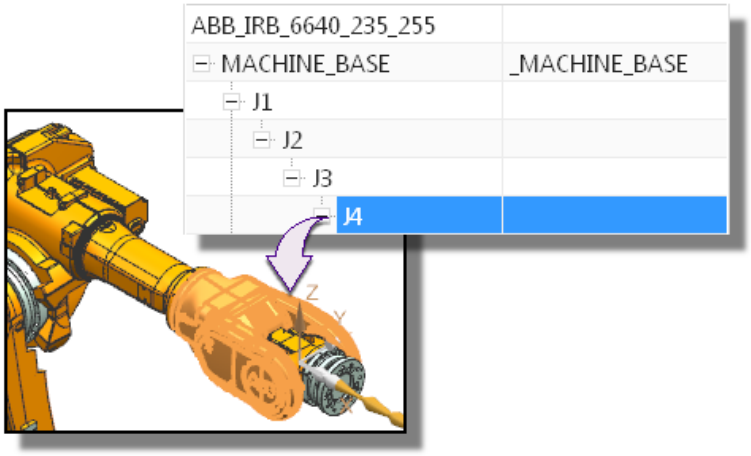
   Notice the excessive head rotation as the tool changes direction along the zig-zag tool path. You will eventually correct this J6 unwind by editing the robotic machining rules to control the head orientation.



6. Click **Continue until Reset**.
7. Click **OK** to complete the simulation.

Examine the kinematics chain

1. Select the **Machine Tool Navigator** tab in the Resource Bar .
2. On the background of the Machine Tool Navigator, right-click and select **Expand All** to see all of the objects.
3. Click each one of the objects (J1-J6) to highlight the various components of the machine tool.



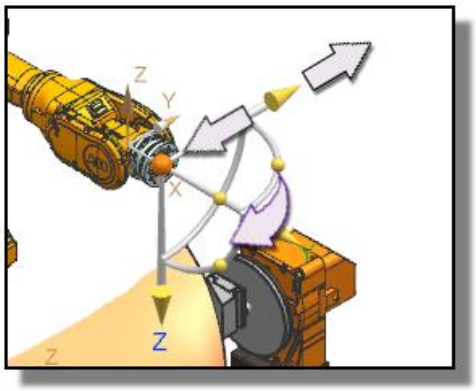
4. On the background of the Machine Tool Navigator, right-click and select **Preview Motion**.
5. Click **Show Machine Axis Positions** if the Machine Axis Positions dialog box is not currently displayed.

   You can use the sliders to manually control each joint of the robotic arm and observe the rotational limits. The blue dot for J5 indicates a singularity, or excessive joint rotation of J4 and J6 caused by J5 approaching its allowable 120 degree limit. You will correct this singularity by editing the robotic machining rules to control the joint rotation.

6. In the Preview Motion dialog box, select the **Move Spindle About Part** check box .

   This allows you to observe the robotic arm movement by dragging the graphic handles.

7. Drag the handles to see how you can move and rotate the arm.

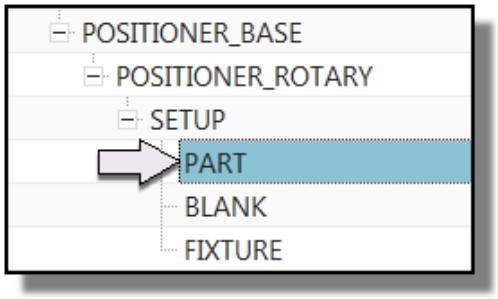


8. Click **Close** in the Preview Motion dialog box.

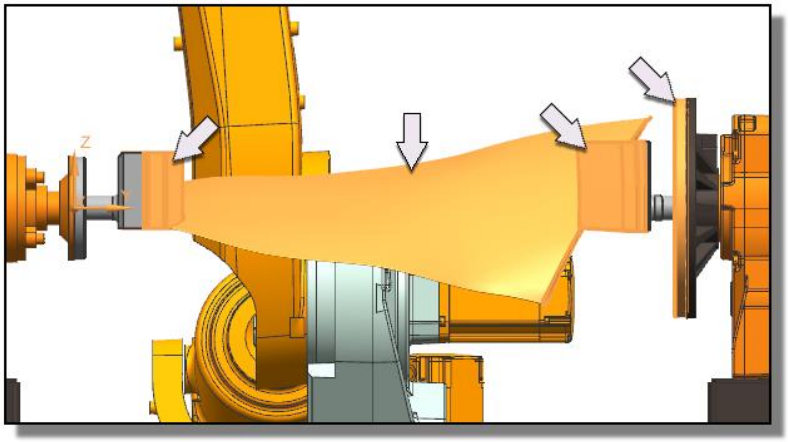
Define the part component in the setup configurator

You will specify the blade and clamps as the part component in the kinematics chain. This will allow you to check for collisions between the robotic arm and the part and fixture.

1. In the Machine Tool Navigator, double-click **PART** to edit the object.



2. Select the blade and the three fixture bodies indicated below to define the part component.



These three fixture bodies are the ones most likely to collide with the arm.

3. Click **OK**.

Check for collisions

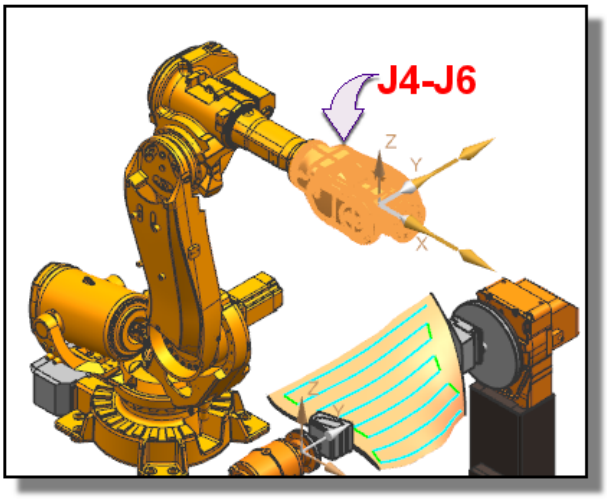
You will specify two objects with which to detect collisions. J4-J6 on the robotic arm will be the first object and the part component you just defined will be the second object. You will then perform a collision check using machine simulation.

1. Select the **Operation Navigator** tab in the Resource Bar .
2. In the Machine Tool View, select **ROUGH1_SIDE1**.
3. Click **Simulate Machine** in the Ribbon Bar.
4. Click **Simulation Settings** .
5. Select **On** from the **Collision Detection** list.

6. Click **Specify Collision Pairs**  .
7. In the First Object section of the dialog box, select **Component Parent** from the **Filter** list.

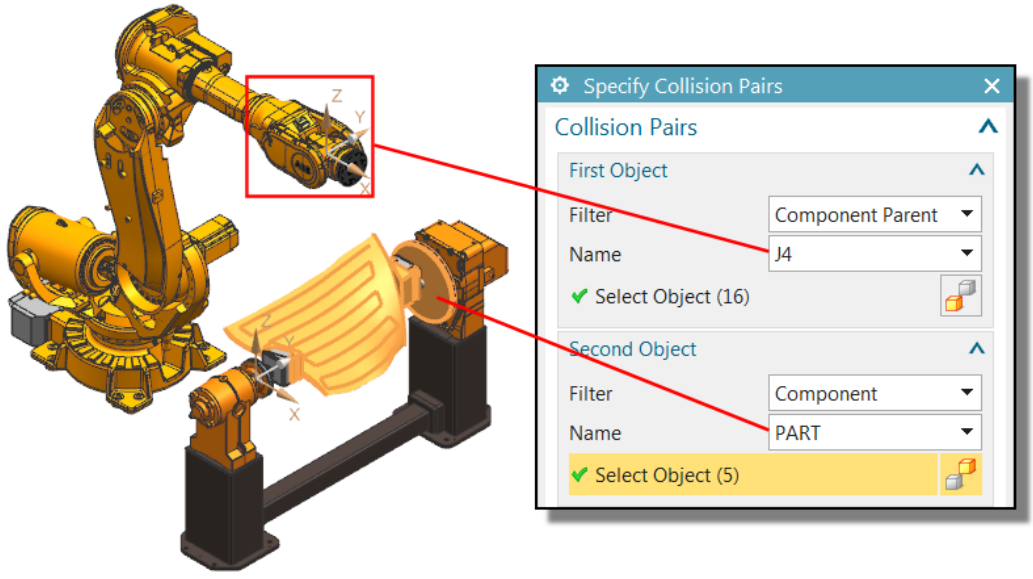
   Component Parent specifies that the selected object and all objects below it in the kinematics chain will be recognized as the first object in the collision pair.

8. Select **J4** from the **Name** list.



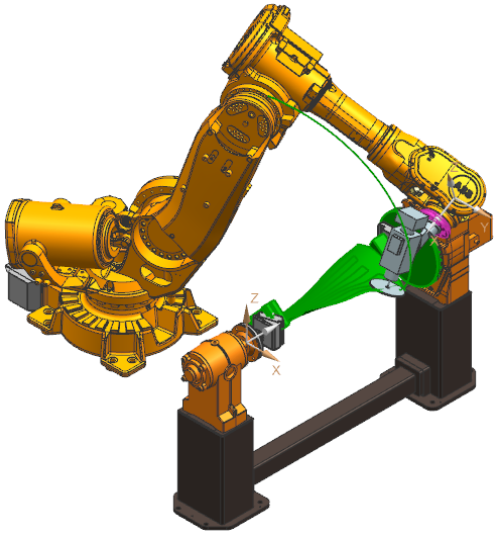
   Notice that there are 16 objects selected.

9. In the Second Object section of the dialog box, select **PART** from the **Name** list.



10. Type **5.000** in the **Collision Clearance** box.
11. Click **OK** in the Specify Collision Pairs dialog box.
12. Click **OK** in the Simulation Settings dialog box.
13. Click **Play**  .

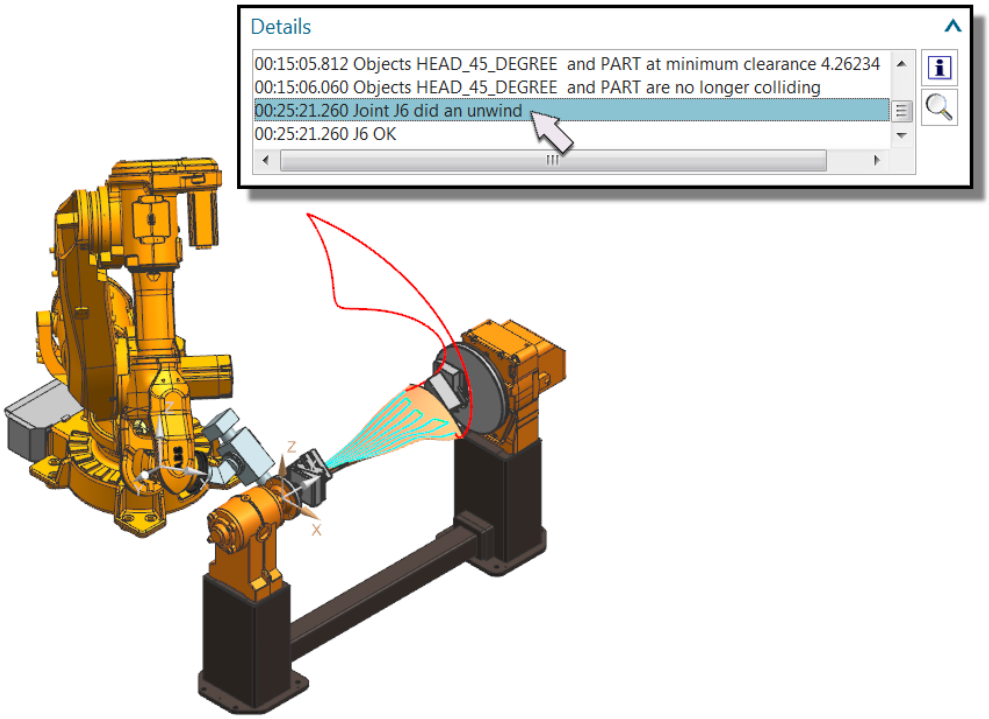
The J6 and PART objects violate the 5.000 mm collision clearance you specified due to the excessive 180 degree head rotation. You will edit the head orientation rules to prevent this collision.



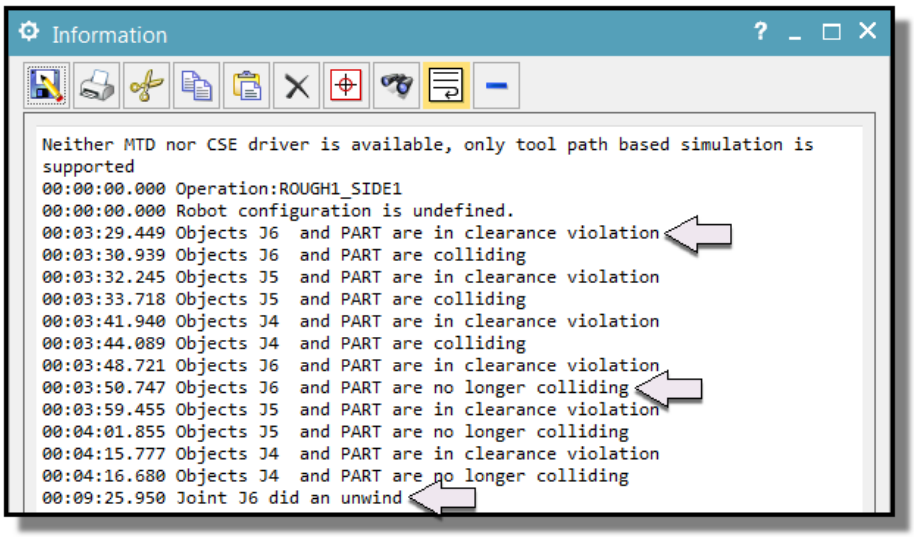
14. Click **Continue until Reset**.

    As before, joint J6 does an excessive rotation, or “unwind”.

15. Click **Continue until Reset**.
16. Expand Details section of the dialog box and click on various events in to see state of robot at that event.



17. Click **Write to Information Window**  to list all events (things that need to be corrected) in this operation.

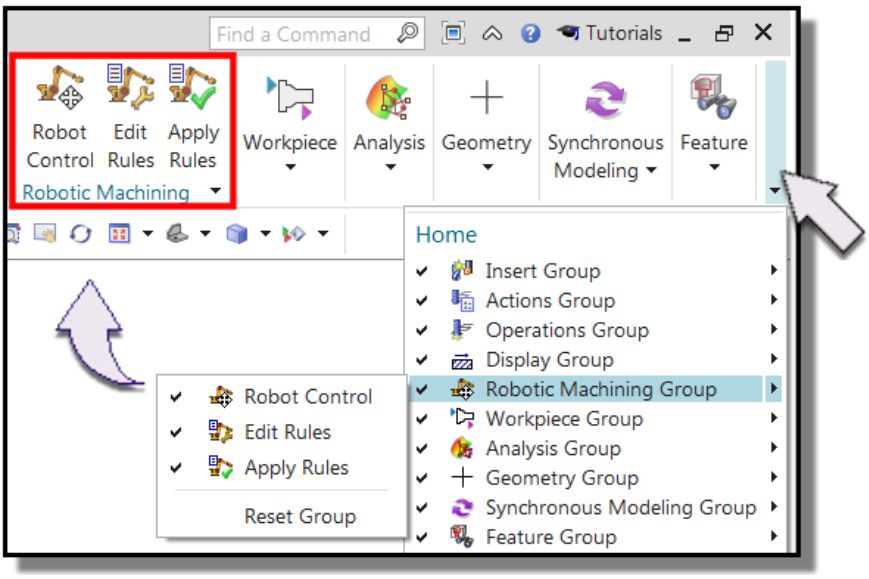


18. Click **OK** in the Simulation Control Panel dialog box.
19. Close  the Information window.

Specify Tool Orientation

You will eliminate the collisions by editing the robotic machining rule that controls the head orientation.

Note: If necessary, add the Robotic Machining Group to the Ribbon Bar.

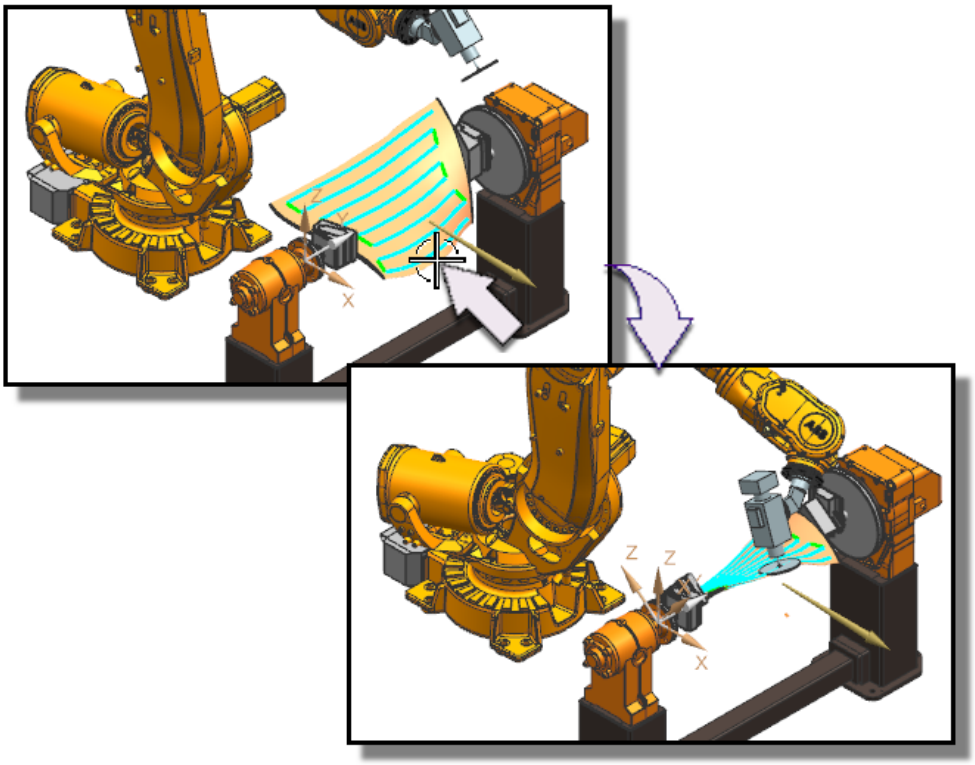


1. With **ROUGH1_SIDE1** still selected in the Operation Navigator, click **Robot Control** in the Ribbon Bar.

   The Robot Control dialog box allows you to graphically interact with the robot, set the robotic rules, apply them, and validate the results. The Robot Jog section of the dialog box determines how you wish to graphically maneuver the robot.

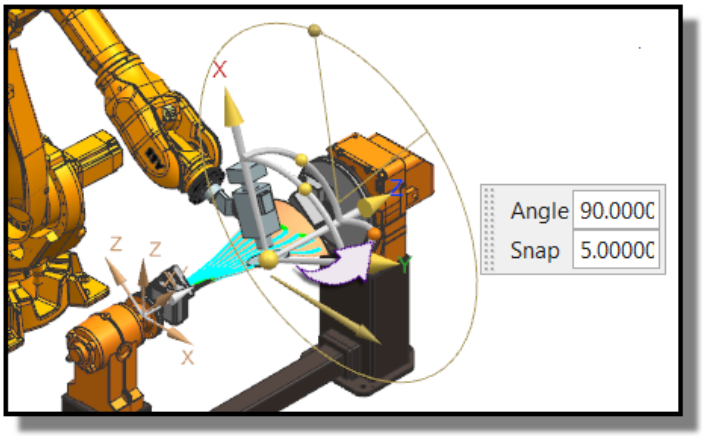
   - **Joint Jog** displays dynamic handles at the joint you specify. In this mode you directly jog any axis from the graphic screen.
   - **Tool Control Point Jog** displays dynamic handles at the tool control point.
   - **Path Position** positions the tool at any point you select on the tool path. For continuous path (G1) it is the same as simulation. For Joint moves (G0) that are part of the base operation, it does not follow the actual trace. It also does not show the move between poses.

2. Click **Path Position** .
3. Select a point on the tool path near the center of the last pass. (Any point on the tool path will actually work, but for this example this point is the easiest to see and work with.)

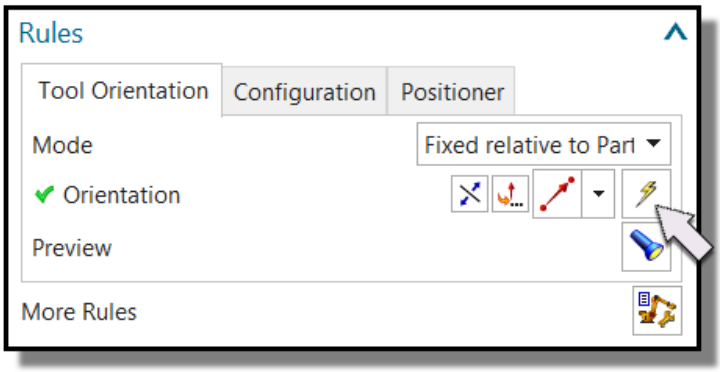


4. Click **Tool Control Point Jog** .

5. Use the graphic handle to rotate the head 90 degrees about the X axis.



6. In the Rules section of the dialog box, select the **Tool Orientation** tab.
7. Click **Use the current Y vector of the of the tool tip** .



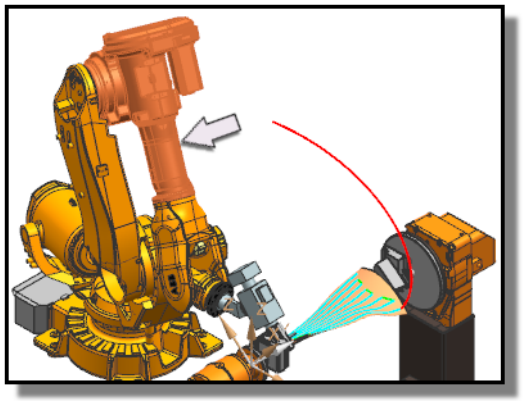
This captures the tool orientation you defined.

8. At the bottom of the dialog box, click **More** ▼ to see all of the dialog box options.
9. Select the **Execute Robotic Rules on OK and Apply** check box.

This applies the rules you define to the entire tool path each time you click **OK** or **Apply** in the Robot Control dialog box.

10. Click **OK**.
11. Click **Simulate Machine** in the Ribbon Bar.
12. Click **Play** .

J3 exceeds the limits of the robotic arm. Tilting the positioner can eliminate this problem.

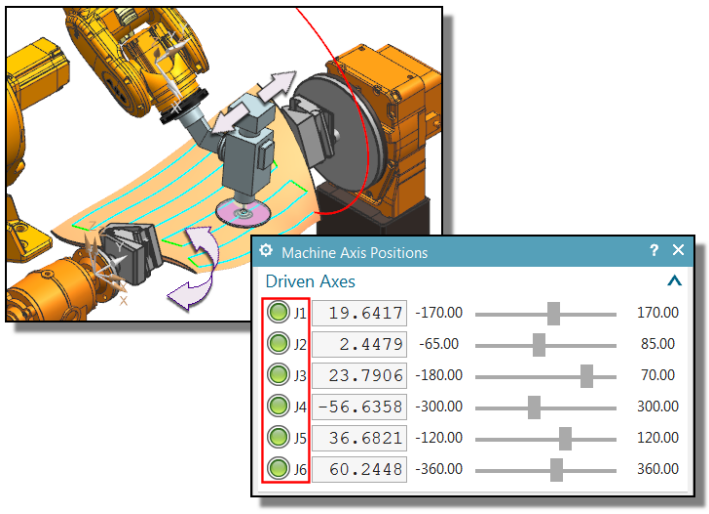


13. Click **Continue until Reset**.
14. Click **OK** to complete the simulation.

Specify Positioner Rules

1. Click **Robot Control** .
2. In the Rules section of the dialog box, select the **Positioner** tab.
3. Select **Constant Tool Axis** from the **Mode list**.
4. Select ZC from the **Target Axis Direction** list.
5. Click **OK**.
6. Click **Simulate Machine** in the Ribbon Bar.
7. Click **Play** .

   The positioner tilts the blade, allowing the head to remain vertical as it zig-zags. Collisions and singularities have been removed.



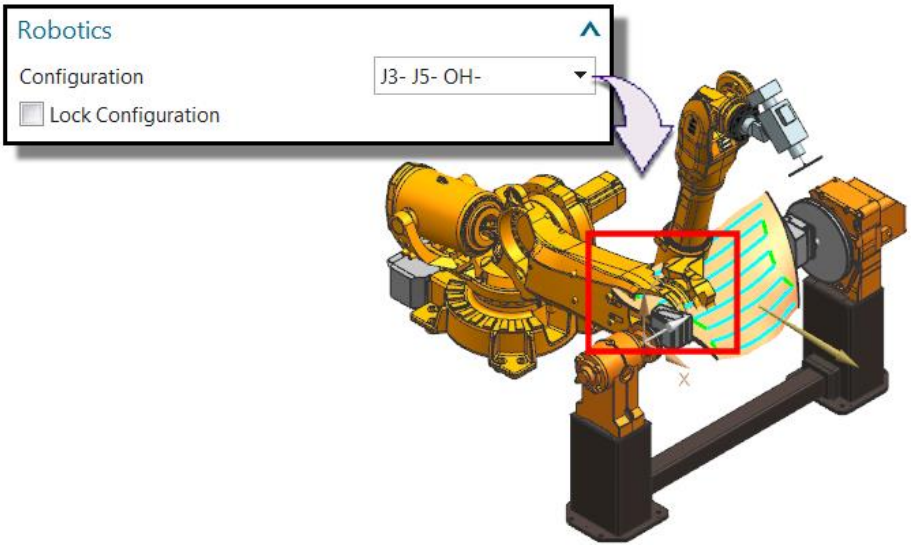
8. Click **OK** to complete the simulation.

Specify Robot Configuration

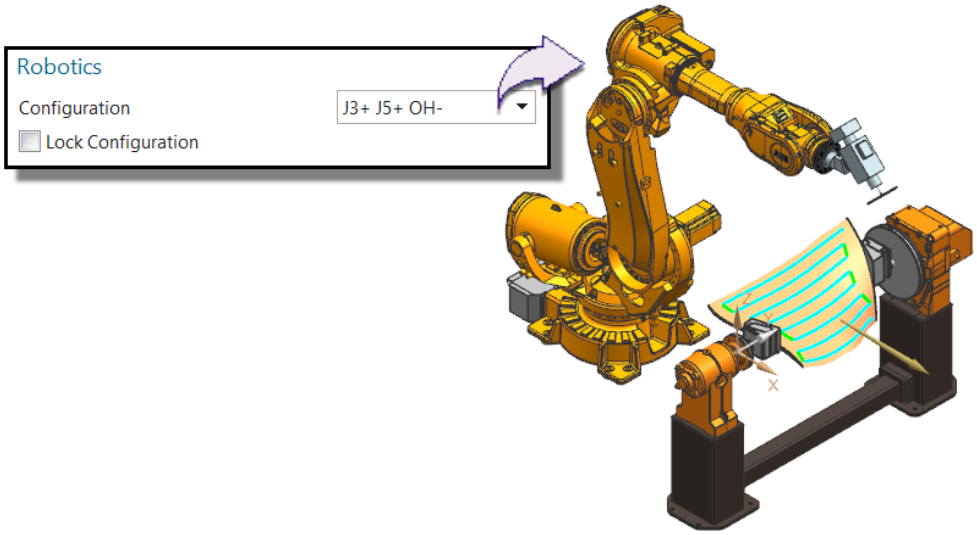
The robot configuration determines the best way for the robotic arm to reach the part.

1. Click **Robot Control**  .
2. In the Robotics section of the dialog box, select **J3- J5- OH-** from the **Configuration** list.

   This is configuration causes a collision between the robotic arm and the part and is not a desirable configuration to use for this operation.



3. Select **J3+ J5+ OH-** from the **Configuration** list.



4. In the Rules section of the dialog box, select the **Configuration** tab.
5. Select **Use the current configuration of the robot**  (J3+ J5+ OH-) from the **Configuration** list.
6. Click **OK**.

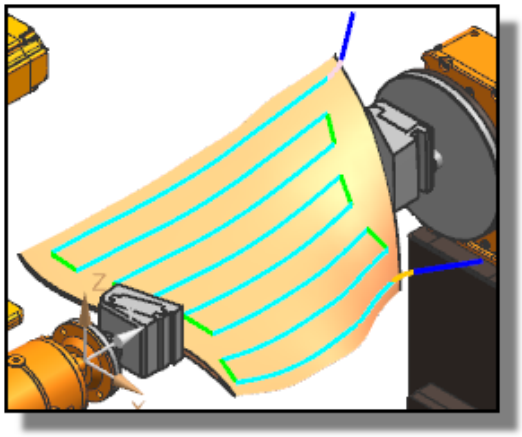
Specify Non-Cutting Moves and Motion Output Type

Next, you will specify non-cutting moves that will allow you to safely rotate the blade and polish the opposite side.

1. Double-click **ROUGH1_SIDE_1** to edit the operation.
2. Click **Non Cutting Moves**  .
3. Select the **Engage** tab.
4. In the Initial section of the dialog box, select **Arc-Normal to Part** from the **Engage Type** list.
5. Select the **Retract** tab.
6. In the Final section of the dialog box, select **Same as Initial Engage** from the **Retract Type** list.
7. Select the **Transfer/Rapid** tab.
8. In the Initial and Final section of the dialog box, select **Along Tool Axis** from the **Approach Method** list.
9. Type **200.000** in the **Distance** box and select **mm** from the list.
10. Select **Along Tool Ax**is from the **Departure Method** list.
11. Type **200.000** (**mm**) in the **Distance** box.
12. Click **OK**.
13. In the Machine Control section of the dialog box, select **Line** from the **Motion Output Type** list.

    Note: For robotics, it is essential that you specify a linear motion output type because circular moves, spline motions, and drill cycles are not currently handled.

14. Click **Generate**  .
15. Click **Overwrite Path**.



16. Click **OK** to complete the operation.
17. Click **Apply Rules**  .

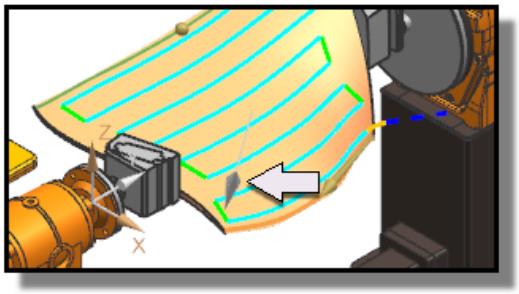
    Note: You must always Apply Rules after generating a tool path.

18. Click **OK** in the Tool Path Processing dialog box.

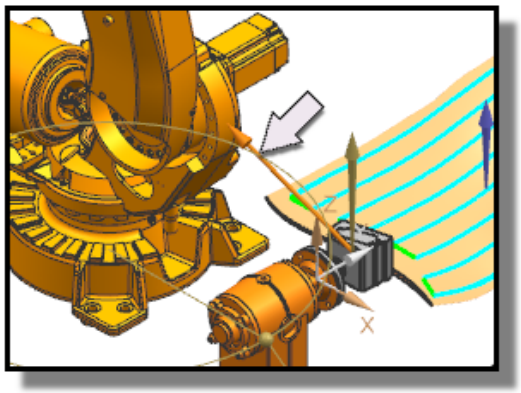
Polish the opposite side of the blade

You will copy and edit the existing operation to polish the opposite side of the blade. You will also edit the robotic machining rules to specify an appropriate tool orientation and configuration.

1. In the Program Order View of the Operation Navigator, right-click **ROUGH1_SIDE1** and select **Copy**.
2. Right-click **POLISH_BLADE_ROUGH_1** and select **Paste Inside**.
3. Right-click **ROUGH1_SIDE1_COPY** and select **Rename**.
4. Type **ROUGH1_SIDE2**.
5. Double-click **ROUGH1_SIDE2** to edit the operation.
6. In the Drive Method section of the dialog box, click **Edit**  .
7. In the Material Side section of the dialog box, click **Flip Material**  .



8. Click **OK**.
9. Click **Generate**  **.**
10. Click **OK** to finish editing the operation.
11. Click **Apply Rules**  .
12. Click **OK** in the Tool Path Processing dialog box.
13. With **ROUGH1_SIDE2** still selected, click **Robot Control**  .
14. In the Rules section of the dialog box, select the **Tool Orientation** tab.
15. Click **Reverse Direction**  .

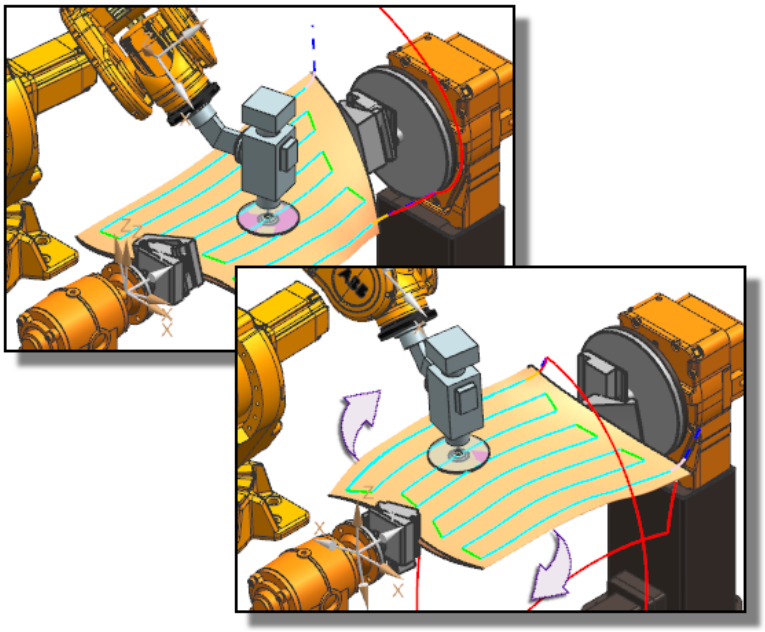


16. Select the **Configuration** tab.
17. Select **Use the current configuration of the robot**  (J3+ J5+ OH-).
18. Select the **Positioner** tab.
19. Notice that **Constant Tool Axis** is specified as the current **Mode**.
20. Click **OK**.

Simulate the machine tool

1. Select **POLISH_BLADE_ROUGH_1** and click **Simulate Machine**  .
2. Click **Play**  .

   Both sides of the blade are polished with no collisions or singularities occurring.



3. Click **Write to Information Window**  to verify there are no bad events.

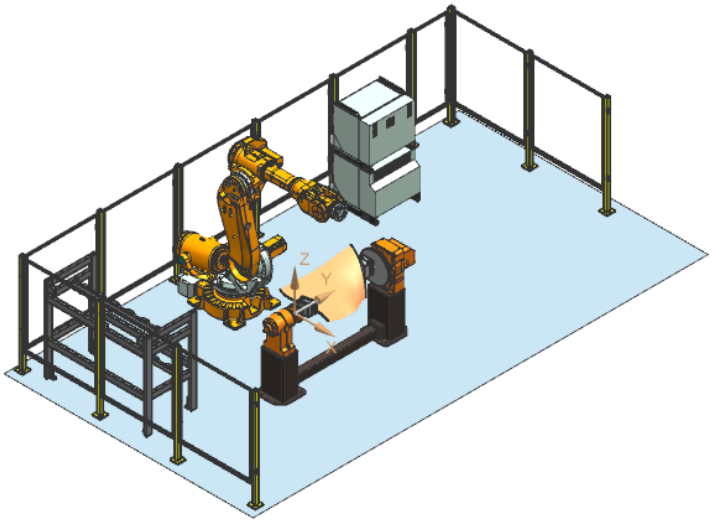
```
Neither MTD nor CSE driver is available, only tool path based simulation is supported
00:00:00.000 Operation:ROUGH1_SIDE1
00:26:30.239 Operation:ROUGH1_SIDE2
```

4. Click **OK**.
5. **Close**  the Information window.

Control Jog and Pose settings

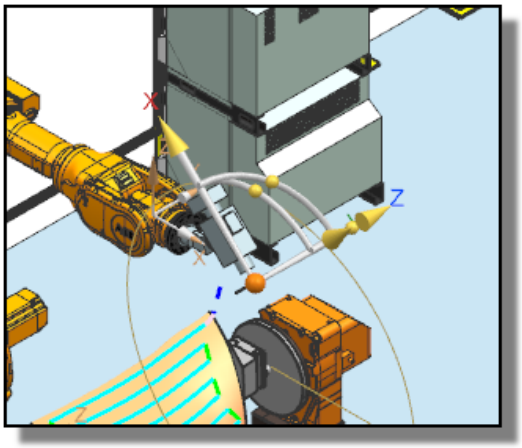
You can graphically jog the robotic arm to define machine poses. Once defined, poses can be used as start and end positions in operations. You will begin by viewing the existing poses.

1. Select the **Assembly Navigator** tab in the Resource Bar .
2. Select the **ABB_ex01_PolishingStation_noRobot** check box to display the station.

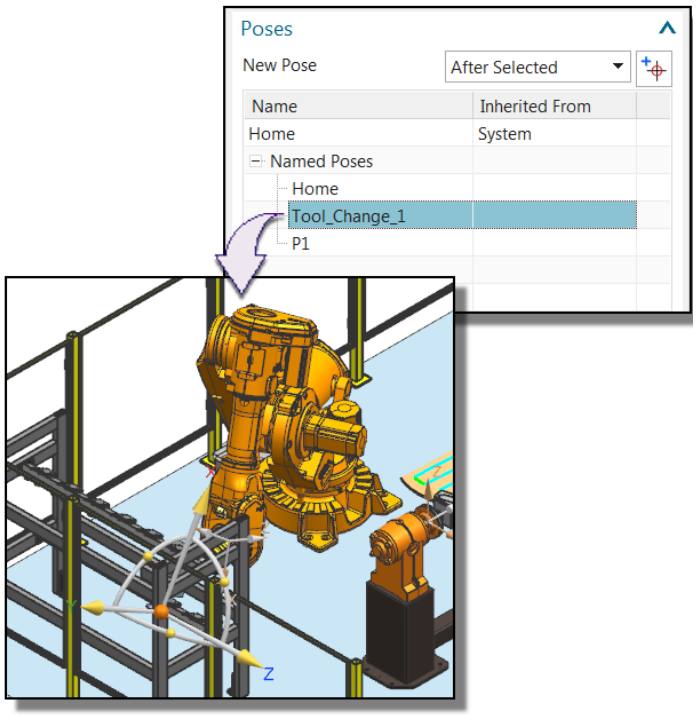


Displaying the station will allow you to see potential obstructions.

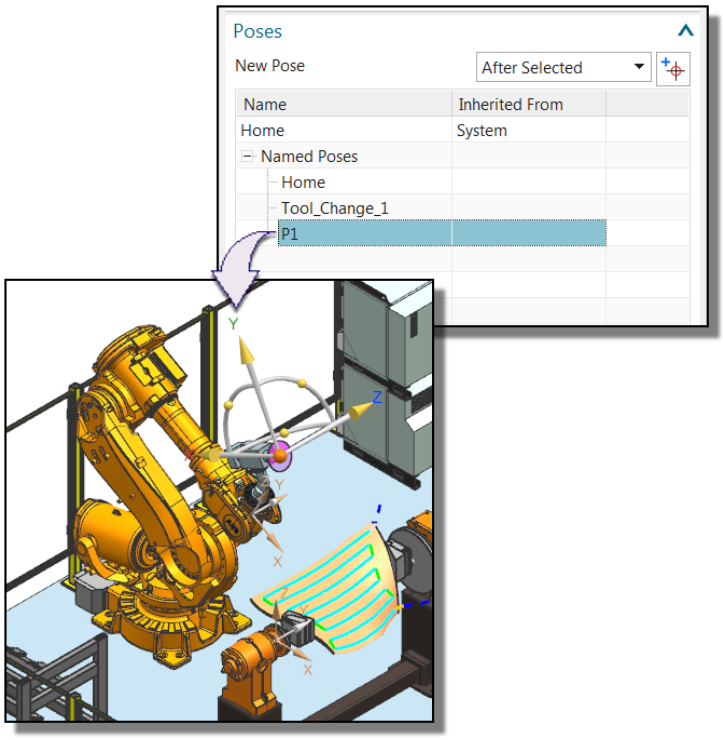
3. Select the **Operation Navigator** tab in the Resource Bar .
4. With the **POLISH_BLADE_ROUGH_1** program selected, click **Robot Control** in the Ribbon Bar.
5. Click **Tool Control Point Jog** to display the graphic handles at the tool control point.



6. Select **Tool_Change_1** in the **Poses** list to see the pose.
   Tool_Change_1 positions the head near the rack.



7. Select **P1** in the **Poses** list to see the pose.
   P1 positions the head above the part.



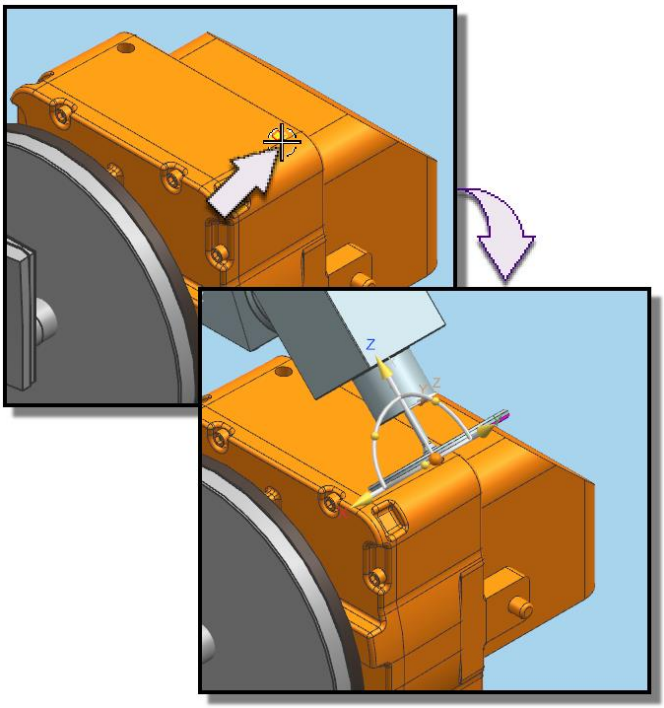
8. Click **Cancel** in the Robot Control dialog box.

Add a pose to an operation

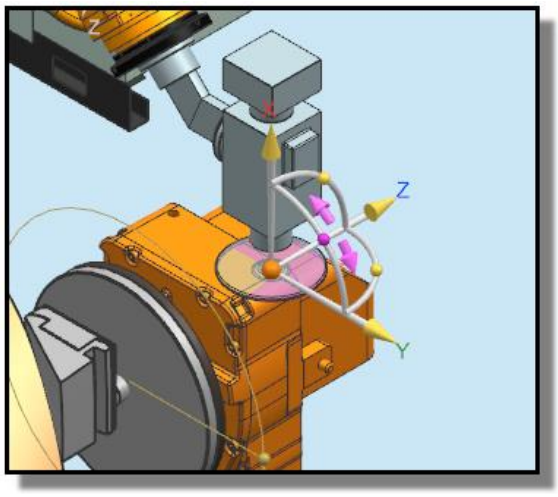
Poses can be added only if an object is selected in the Operation Navigator.

1. Select the **ROUGH1_SIDE2** operation.
2. Click **Robot Control**  in the Ribbon Bar.
3. With **Tool Control Point Jog**  still selected, select the center point of the hole on the top face of the positioner.

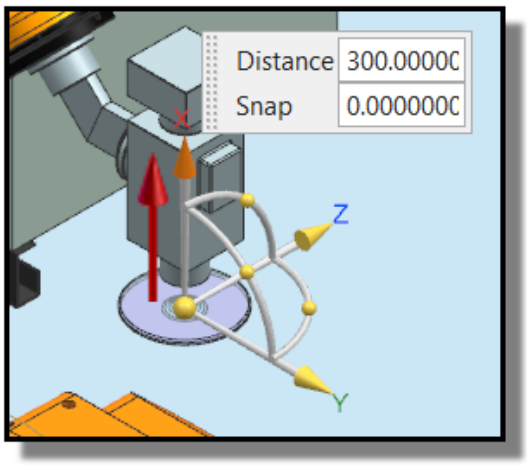
   The tool should position at the center point.



4. Use the graphic handle to rotate the head 45 degrees about the Z axis.

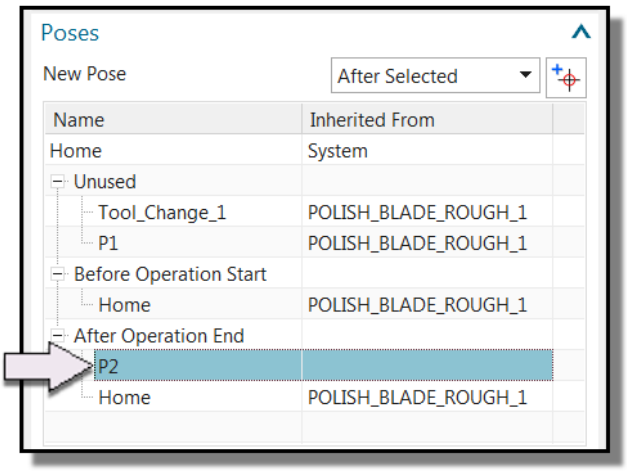


5. Drag the **X** arrowhead up an approximate distance of 300 mm.



6. Select **After Selected** from the **New Pose** list.
7. Select **After Operation End** in the **Name** list.
8. Click **Add**  .
9. Type **P2** in the **Name** column and press the Enter key.

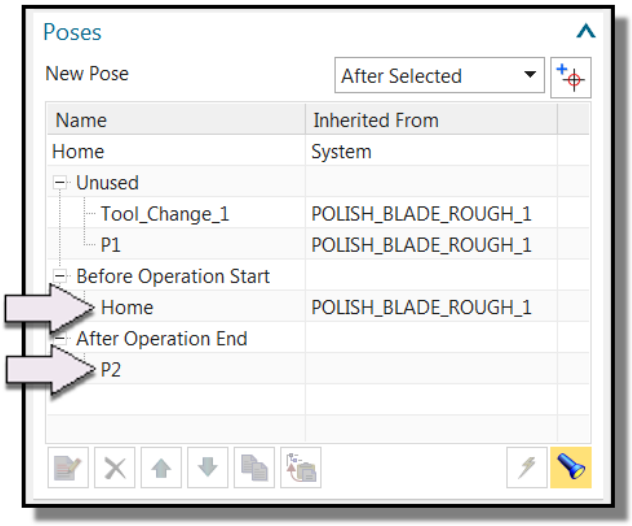
   A pose named P2 has been added following After Operation End.



   Notice that the **Home** pose is under After Operation End.

10. Select **Home** under After Operation End and click **Remove from the Branch**  .

The Home pose is now specified as Before Operation Start and the P2 pose is specified as After Operation.

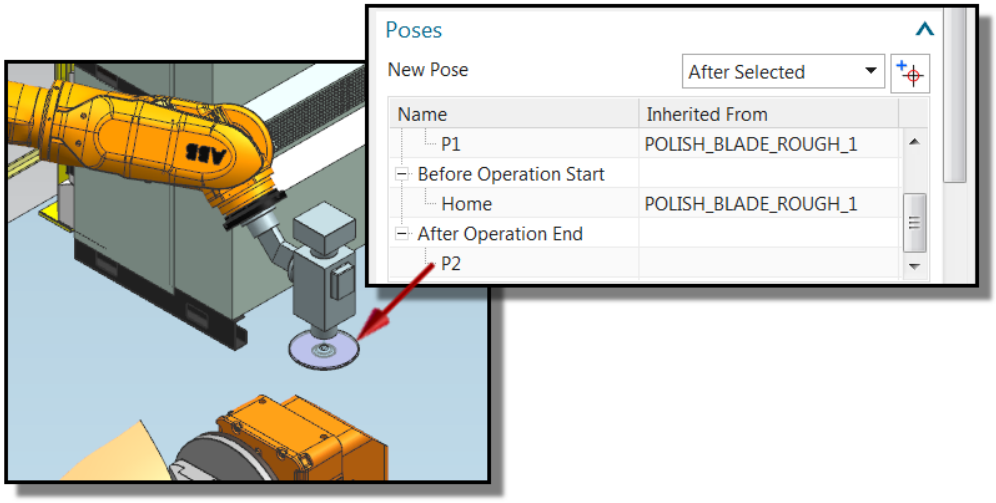


11. Click **OK** in the Robot Control dialog box.

Simulate the machine tool

1. With **ROUGH1_SIDE2** still selected, click **Simulate Machine**  .
2. Click **Play**  .

   The tool path ends at P2.



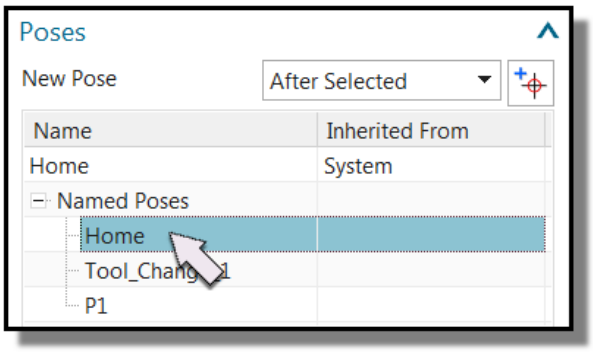
3. Click **OK**.

Edit a pose used by multiple operations

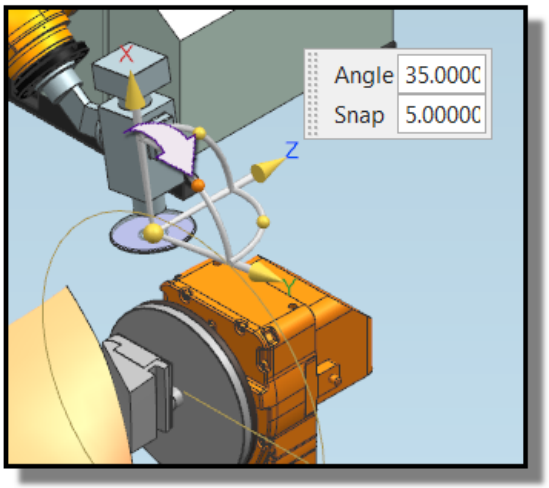
You may edit (Delete, Rename, or Update) poses when a single program or operation is selected. When a program is selected, all operations in that program that inherit the edited pose are affected. When an operation is selected, you may only edit poses that were defined locally and used by that operation alone. A pose used by multiple operations (inherited from a parent object) cannot be edited when an operation is selected.

In this example, you will select the program and edit the Home pose which is used by both operations in the program.

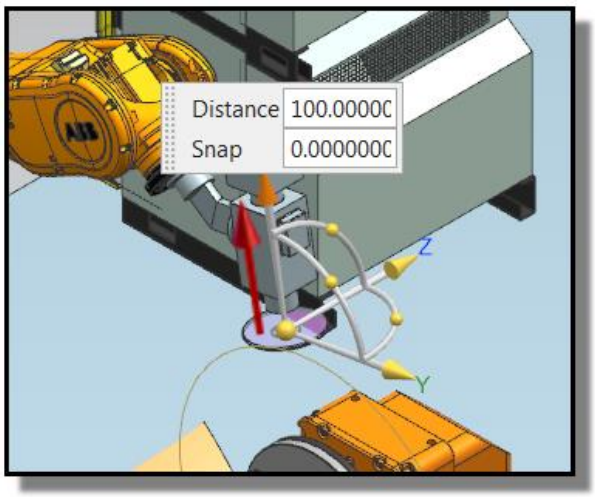
1. Select the **POLISH_BLADE_ROUGH_1** program.
2. Click **Robot Control**  .
3. Select **Home** in the **Poses** list.



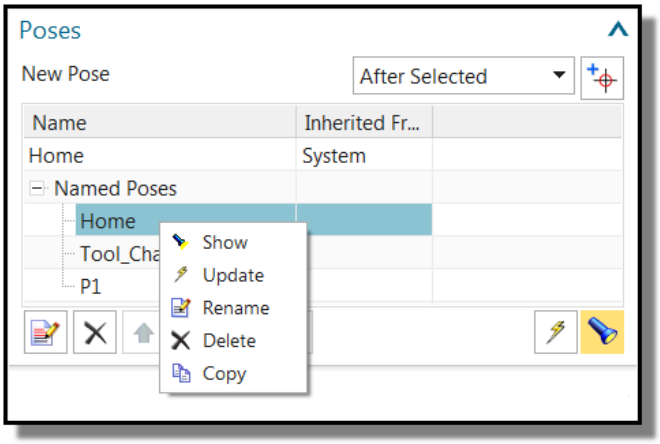
4. Rotate the head about the Z axis approximately 35 degrees.



5. Drag the **X** arrowhead in the positive direction a distance of approximately 100 mm.



6. Right-click **Home** and notice that you can **Update**, **Rename**, **Delete**, and **Copy** the pose.



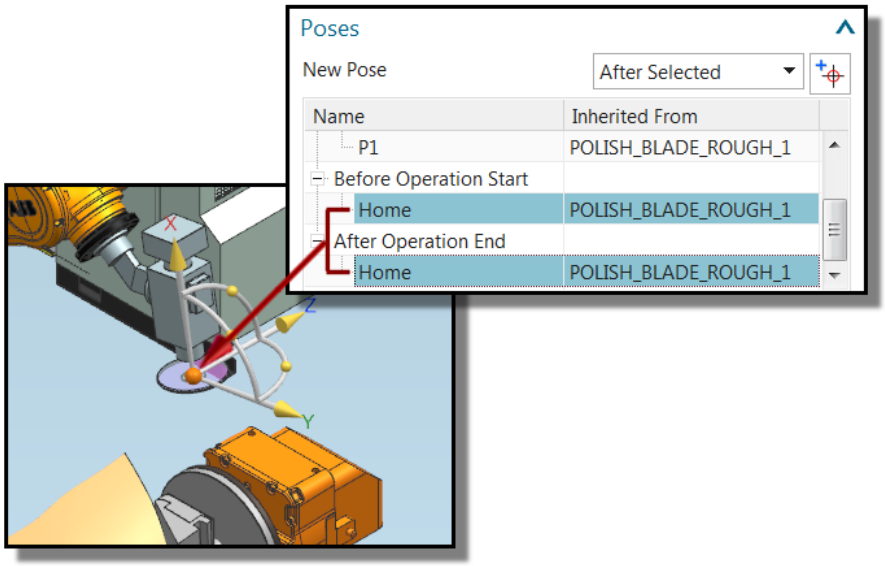
7. Select **Update**.
8. Click **OK** in the Robot Control dialog box.

View the edited Home pose in each operation

You will see how the Home pose has been edited for both operations while still being used as Start and End in the ROUGH1_SIDE1 operation and Start in the ROUGH1_SIDE2 operation.

1. Select the **ROUGH1_SIDE1** operation.
2. Click **Robot Control**  .
3. Select each of the two **Home** poses in the list.

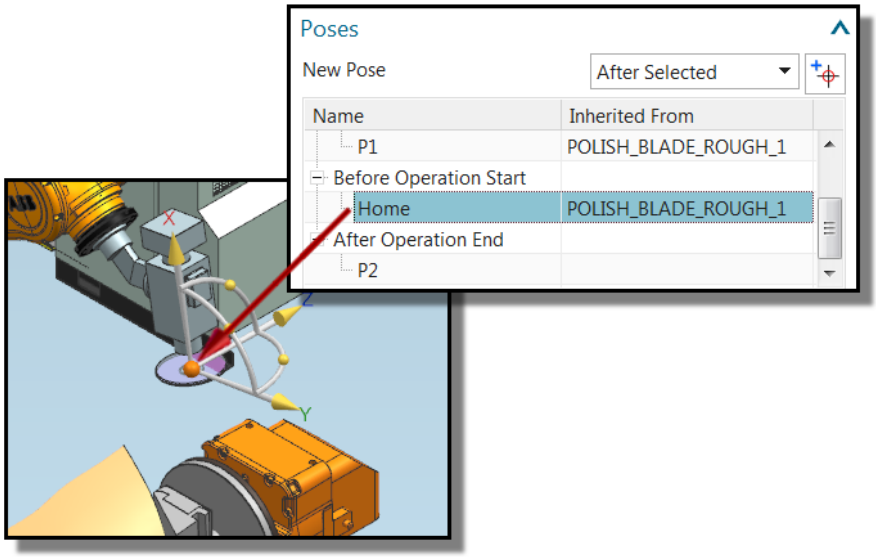
Notice that the Home pose is at the position and orientation you specified for the program and is being used as Start and End for this operation.



Also notice that P2 does not appear in the Poses list for this operation. This is because P2 was created inside the ROUGH1_SIDE2 operation.

4. Click **OK**.
5. Select the **ROUGH1_SIDE2** operation.
6. Click **Robot Control**  .
7. Select **Home** in the **Poses** list.

   Notice that the Home pose is at the position and orientation you specified for the program and is being used as Start for this operation.

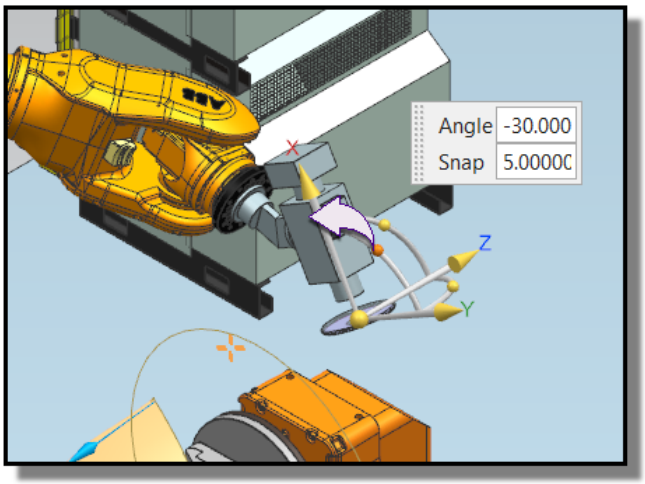


8. Click **OK**.

Edit a pose used by a single operation

When an operation is selected, you may only edit poses defined locally and used by that operation alone.

1. Select the **ROUGH1_SIDE2** operation.
2. Click **Robot Control**  .
3. Select **P2** in the **Poses** list.
4. Rotate the head about the Z axis approximately -30 degrees.



5. Right-click **P2** and select **Update**.
6. Right-click **P1** and notice that you cannot edit this pose (Delete, Rename, and Update options do not appear).

   This is because P1 was defined in the parent (POLISH_BLADE_ROUGH_1).

7. Right-click **Home** and notice that you cannot edit this pose (Rename, and Update options do not appear).

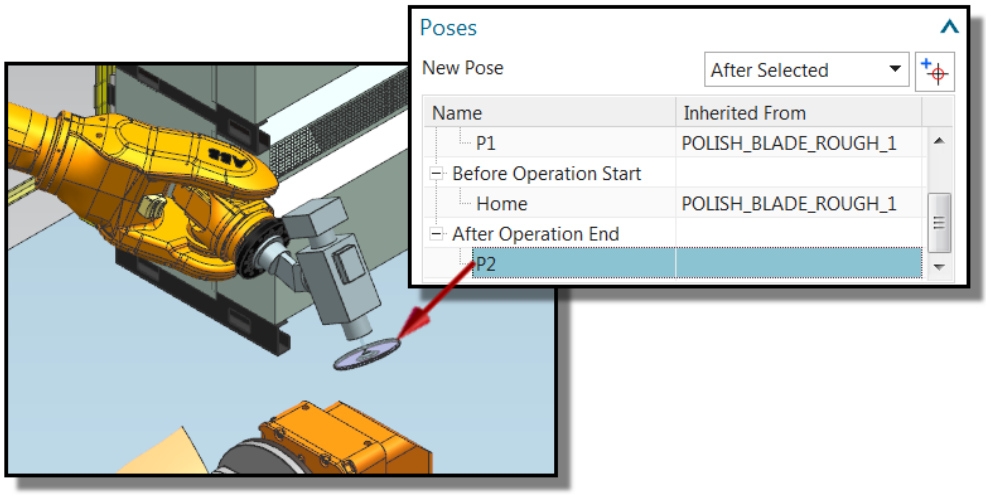
   Again, this is because Home was defined in the parent (POLISH_BLADE_ROUGH_1).

8. Click **OK** in the Robot Control dialog box.

Simulate the operation

1. Select the **ROUGH1_SIDE2** operation and click **Simulate Machine**  .
2. Click **Play**.

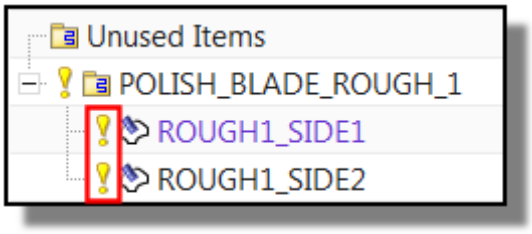
   The operation uses the edited P2 pose as the End.



3. Click **OK**.

Postprocess

1. Be sure tool paths have been generated and rules have been applied to the operations.



2. In the Program Order View, click **POLISH_BLADE_ROUGH_1**.
3. Click **Post Process**  in the Ribbon Bar.
4. In the Postprocess dialog box, select **ABB RAPID** from the **Postprocesor** list.
5. Click **Browse for an Output File** and specify a directory you can write to.
6. Click **OK** to postprocess.
7. **Close**  the Information window.
8. Close the part without saving.

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