Finding the Center of Rotation on a 5-Axis Head-Table Milling Machine with a 45-degree Nutating Head

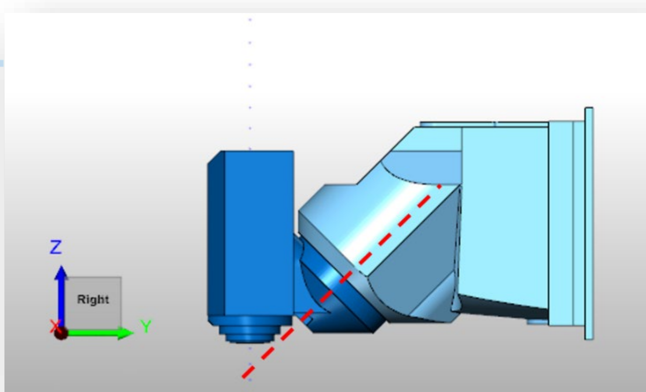
In the BobCAD-CAM system when using the multi-axis features your machine must be properly defined. The calculations that must be performed for proper G-Code creation depends on an accurate definition of your machine's kinematics. The location of the center of rotation on machines with nutating axis is usually measured by the machine tool manufacturer and available in machine's technical documents. However, the following is a simple step by step procedure that you can follow to find the center of rotation in case you don't have access to your machine's technical documents.

This document is prepared for a machine with 45-degree nutating axis located on one of the two main Cartesian planes (also known as plane of rotation for the nutating axis) : YZ or XZ. If the configuration of your machine doesn't quite match the above-mentioned criteria, contact the post-processor department and we will be more than happy to assist you with finding the center of rotation on your machine.

Finding the Vertical Component of the Center of Rotation

Step 1 – Find the Plane of Rotation (PoR)

On most 5-axis head-table machines with nutating axis, the PoR is either of the YZ plane or the XZ plane when both rotary angles are at zero degrees. The first step is to find the PoR as it is shown in the image below. If the nutating axis on your machine is not located on any of these two main planes, please contact the post-processor department for further assistance.



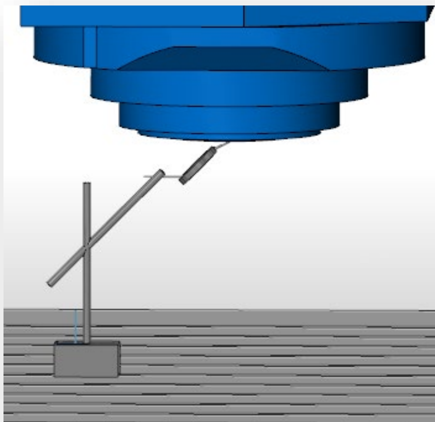
Example of a YZ plane of rotation

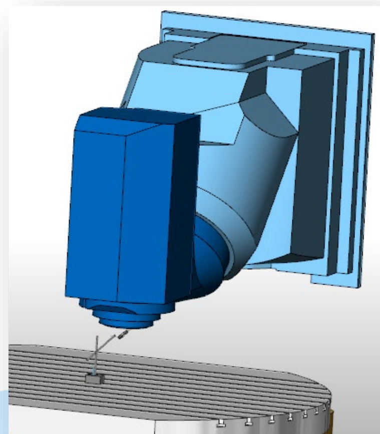
Note the plane of rotation and the vertical axis.

Plane of Rotation: ☐ YZ ☐ XZ

Step 2 – Measure the First Vertical Distance (Z_1)

As shown in the following image. Setup an indicator on your machine's table. Make sure the head is at its zero-degree position, lower the head down in the Z-axis direction and touch the end of the indicator with the face of the spindle, and then zero the reading on the indicator.





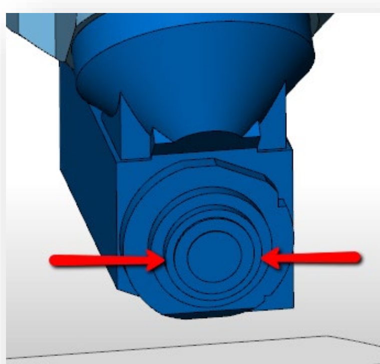
Note the Z axis position read on the machine controller for this location.

Z_1 = ______________________________

Important Note: Do not move the indicator setup as we need this exact position for later measurements.

Step 3 – Measure the Diameter of the Spindle Ring (SDM)

The spindle ring is the ground outer portion of the spindle that protrudes out of the spindle assembly. We need to know the accurate diameter of this as this value is used in the next step. The following image shows the spindle ring for this example machine.

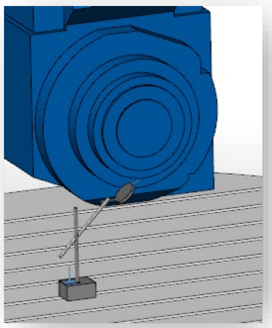


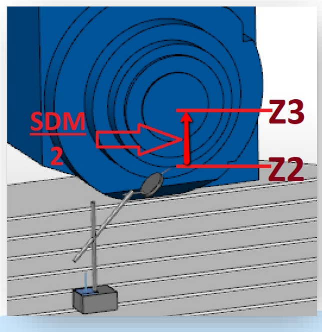
SDM = ______________________________

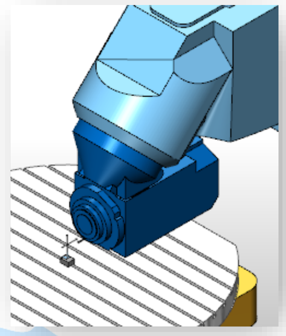
Note: We will be using the Radius instead of the diameter of the spindle in the next step

Step 4 – Measure the Second Vertical Distance (Z_2)

For this reading, the spindle axis should be rotated so that the spindle face is perpendicular to the orientation used to measure Z_1 (Head is at its 180-degree orientation) . Move up the head to clear the rotation area. Move the head until the lowest portion of the outside diameter of the spindle ring touches the indicator and takes the indicator back to zero as it is shown in images below.







Note the Z axis position read on the machine controller for this location.

Z_2 = ______________________________

Step 5 – Calculate the Adjusted Vertical Distance (Z_3)

Once you have Z_2 , subtract the radius of the spindle ring (SDM/2) from it to get the adjusted vertical distance (Z_3). The Z_3 value lets us know where the center of the spindle axis is located at this position.

$Z_3 = Z_2 - (SDM/2) =$ ______________________________

Step 6 – Calculate the Vertical Component of the Center of Rotation (Z_P)

To calculate Z_P, simply subtract Z_1 from Z_3. This tells us the vertical difference between Z_1 and Z_3 which is in fact the Z-axis component of the center of rotation.

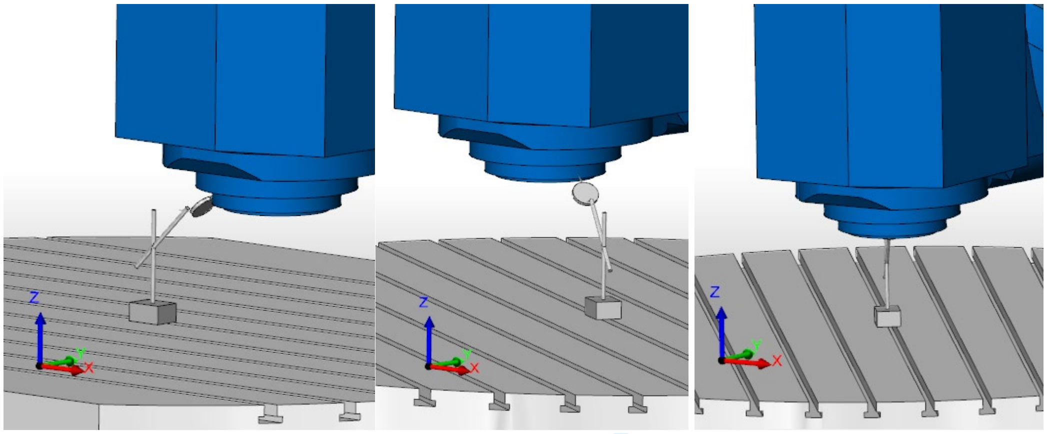
$Z_P = Z_3 - Z_1 =$ ______________________________

Finding the Horizontal Component of the Center of Rotation

Depending on whether PoR is YZ plane or XZ plane, you need to measure either the X-axis component or the Y-axis component of the center of rotation. Here, we assume the YZ is the PoR so we will show how you can measure the X-axis component (X_P) of the center of rotation. Please note the same logic applies when XZ is the PoR and you need to find the Y-axis component (Y_P) of the center of rotation.

Step 1 – Center the Machine Spindle and Measure the First Horizontal Distance (X_1 / Y_1)

For this reading, the spindle head should be at its 0-degree orientation . Move the head up to clear the rotation area. Make sure the indicator is installed on the table in a way that you can sweep it around the spindle ring's outside diameter by rotating the table. Move the head back down and in X-axis and Y-axis directions and start sweeping the indicator the spindle ring's outside diameter in order to center the spindle head on the rotary axis (see images below). Read the X-axis coordinate (Y-axis coordinate if PoR is XZ) of this point and zero the reading on the indicator.

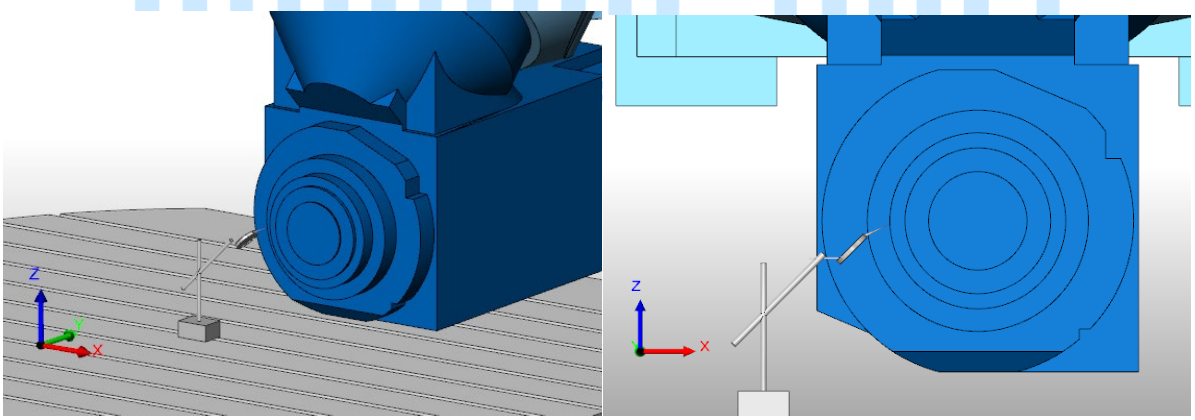


Note the value for this location with the axis identification letter (X or Y).

$_1$ = ________________________________

Step 2 –Measure the Second Horizontal Distance (X_2 / Y_2)

For this reading, the spindle head should be at its 180-degree orientation . While the indicator is still mounted on the table, move the head up to clear the rotation area. Then, rotate the head until it's oriented horizontally and then move the head back down and in X-axis and Y-axis directions until the indicator touches the left side of the spindle ring's outside diameter and it is taken back to zero as it is shown in the images below. Read the X-axis coordinate (Y-axis coordinate if PoR is XZ) of this point



Note the value for this location with the axis identification letter (X or Y).

$_2$ = ________________________________

Step 3 – Calculate the Horizontal Component of the Center of Rotation (X_p / Y_P)

To calculate X_p (Y_p if PoR is XZ), simply subtract the X_2 (Y_2 if PoR is XZ) from the X_1 (Y_1 if XZ PoR) and then divide the result by two. This gives us the horizontal component of the center of rotation. The X_p (Y_p if PoR is XZ) then will be entered in the machine definition file.

Note the axis identification letter (X or Y).

$_P = (\quad _1 - \quad _2) / 2 =$ ______________________________