Finding the Center of Rotation and the Direction of the Nutating Axis on a 5-Axis Head-Head Milling Machine with a 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. This document covers how to find the center of rotation and the direction of the nutating axis for a 5-axis nutating Head-Head machine so the BobCAD machine parameters can be correctly defined.

There is a simple test you can use to find the necessary values and we will walk you through this process here in this document.

Finding the Center of Rotation

Step 1 – Locate the Z Axis Position with the Spindle Vertical

As shown in the following image. Setup an indicator on your machine's table. Touch the end of the indicator with the face of the spindle, and then Zero the reading on the indicator.
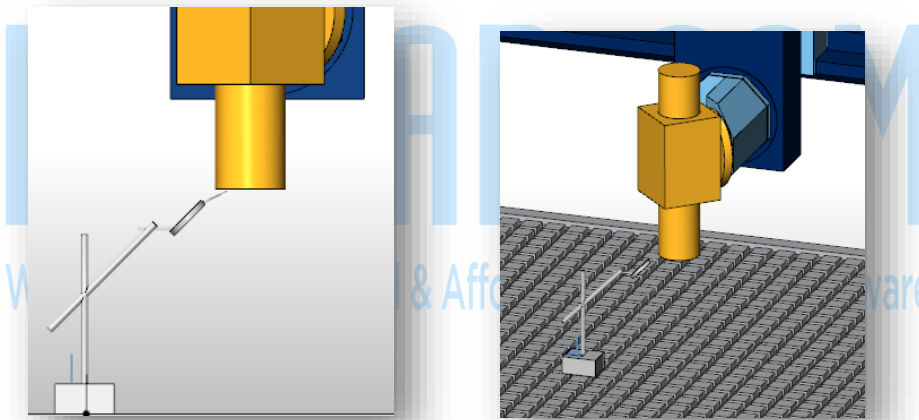

Note the Z axis position read on the machine controller for this location.

Z_1 = _____

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

Step 2 – Measure the Diameter of the Spindle Ring

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.
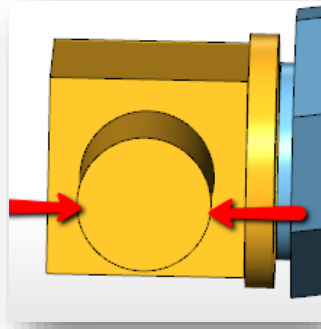

Spindle Diameter Measurement (SDM) = _____

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

Step 3 – Rotate the Primary Axis 90deg and Read the Z Axis Position

For the next reading the spindle axis should be rotated so that the spindle face is perpendicular to the orientation used to measure Z_1. Take a reading from the lowest portion of the outside diameter of the spindle ring. Once you have this value add/subtract the Radius of the spindle ring to get the Z value at the center of the spindle diameter.
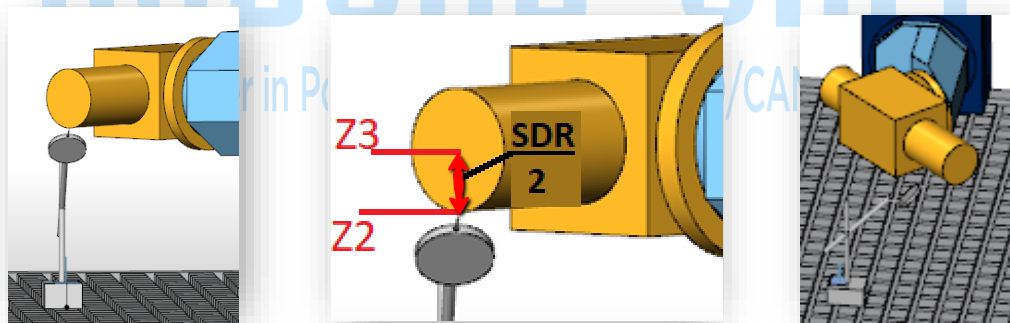
The Z_2 value is the reading from the machine's control to the location shown and takes your indicator back to zero. The Z_3 value is the adjusted Z value to let us know where the center of the spindle axis is located at this position. Subtract the Spindle Radius from Z_2 to get Z_3.

$Z_2 =$ _____

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

Step 5 – Calculate the Z-Component of the Center of Rotation (Z_P)

To calculate the Z_P, you simply subtract Z_3 from Z_1. This tells us the difference in Z for the two points. Z_P value will be used in your machine setup to determine the center of rotation for your spindle axis.

$$Z_P = Z_1 - Z_3 = \underline{\hspace{10cm}}$$

Step 6 – Return Z Axis Vertical and Rotate the Secondary Axis +90deg

For the next reading the primary axis should be rotated Back to the vertical position. Then rotate the Secondary Rotary axis so that the spindle is sitting perpendicular to its previous orientation. Take a reading from the lowest portion of the outside diameter of the spindle ring.
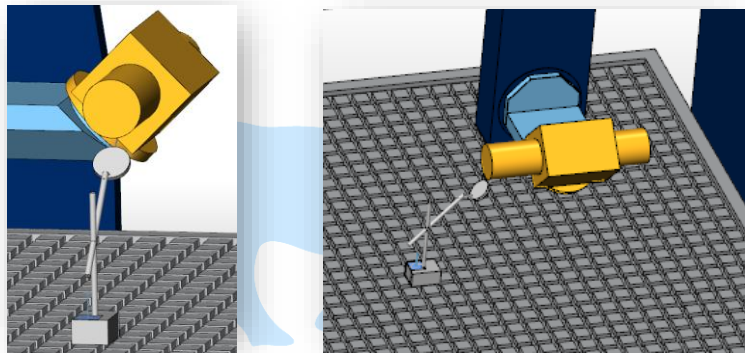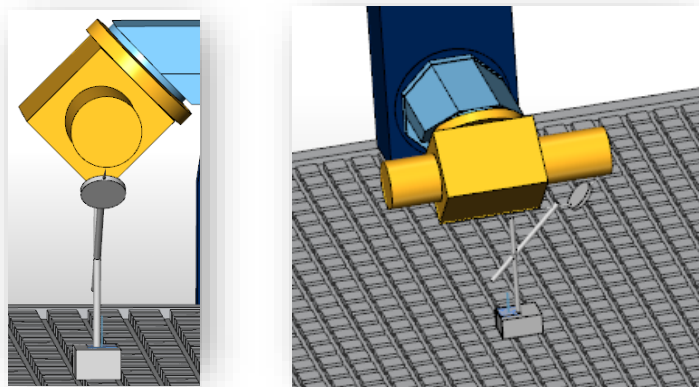

Note the Z axis position read on the machine controller for this location.

$$Z_4 = \underline{\hspace{10cm}}$$

Step 7 – Repeat with the Secondary Rotary Axis at -90deg

Now rotate the secondary axis to -90deg so that it is 180 degrees opposite its previous orientation. Take a reading from the lowest portion of the outside diameter of the spindle ring.

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

Z$_5$ = _____

Step 8 – Calculate the Offset of the Secondary Axis (Z$_O$)

To calculate the offset of the secondary axis, you simply find the difference between the Z4 and Z5 value, this will tell us the difference in Z caused by the offset. Dividing that number by 2 will give us the value of the offset itself. This offset value, along with Z$_P$ will be used in your machine setup to determine the center of rotation for your secondary axis.

Absolute difference between Z$_4$ and Z$_5$: $\Delta Z = [Z_4 - Z_5] = $ _____

Offset of the secondary axis: $Z_O = \dfrac{\Delta Z}{2} = $ _____

Finding the Direction of the Nutating Axis

### Step 1 – Find the Plane of Rotation for the Nutating Axis

On most machines, the nutating axis is a 2D vector located on one of the main XY, YZ, or ZX planes. Find that plane as it is shown in the image below. If the nutating axis is a 3D vector on your machine, please ignore this step and go to step 2.
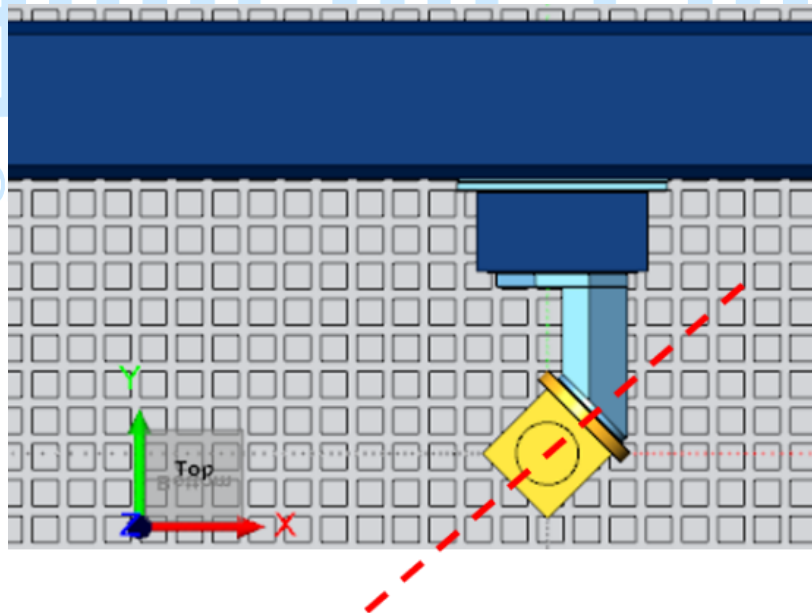
Note: The plane of rotation for this specific example XY.

Step 2 – Find the Angles that the Nutating Axis Makes with the X, Y, and Z

If the nutating axis is a 2D vector, find the angle that the nutating axis makes with one of the axes of the plane of rotation.
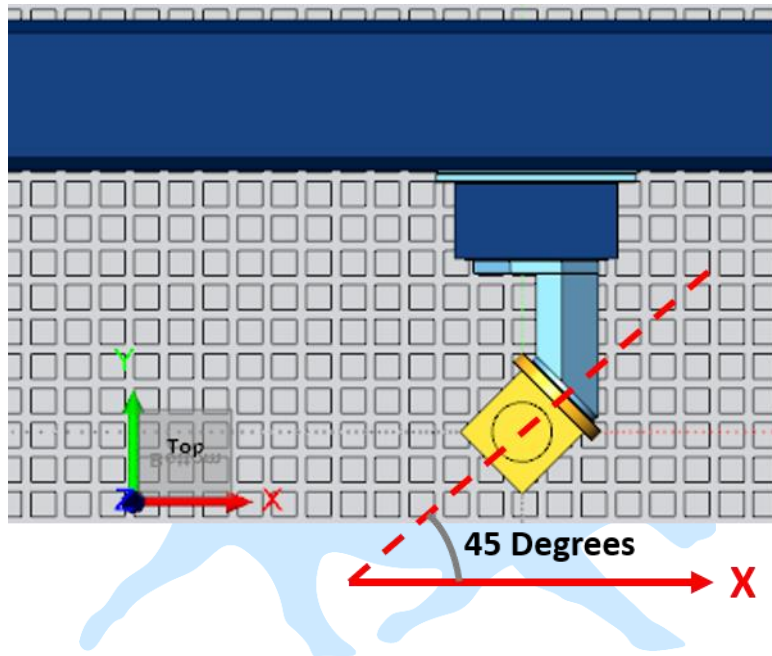
Note: In this specific example, the nutating axis makes 45 degrees with X and Y axes.

If the nutating axis is a 3D vector, ask the manufacturer to give you the information about the angles that the nutating axis makes with X, Y and Z.

Step 3 – Fill out the Nutating Axis Direction Table in the Post Request Form

Angle with X-Axis	Angle with Y-Axis	Angle with Z-Axis