

# **MODELA *Pro***

## **ZCL-650**

### **Rotary Axis Unit for MDX-650**

#### **USER'S MANUAL**

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Thank you very much for purchasing the ZCL-650.

- To ensure correct and safe usage with a full understanding of this product's performance, please be sure to read through this manual completely and store it in a safe location.
- Unauthorized copying or transferral, in whole or in part, of this manual is prohibited.
- The contents of this operation manual and the specifications of this product are subject to change without notice.
- The operation manual and the product have been prepared and tested as much as possible. If you find any misprint or error, please inform us.
- Roland DG Corp. assumes no responsibility for any direct or indirect loss or damage which may occur through use of this product, regardless of any failure to perform on the part of this product.
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# To Ensure Safe Use

## About ⚠️ WARNING and ⚠️ CAUTION Notices

 <b>WARNING</b>	Used for instructions intended to alert the user to the risk of death or severe injury should the unit be used improperly.
 <b>CAUTION</b>	Used for instructions intended to alert the user to the risk of injury or material damage should the unit be used improperly. * Material damage refers to damage or other adverse effects caused with respect to the home and all its furnishings, as well to domestic animals or pets.

## About the Symbols

	The ⚠️ symbol alerts the user to important instructions or warnings. The specific meaning of the symbol is determined by the design contained within the triangle. The symbol at left means "danger of electrocution."
	The ⚡ symbol alerts the user to items that must never be carried out (are forbidden). The specific thing that must not be done is indicated by the design contained within the circle. The symbol at left means the unit must never be disassembled.
	The ● symbol alerts the user to things that must be carried out. The specific thing that must be done is indicated by the design contained within the circle. The symbol at left means the power-cord plug must be unplugged from the outlet.

## ⚠️ WARNING



**Do not disassemble, repair, or modify.**

Doing so may lead to fire or abnormal operation resulting in injury.



**Do not use while in an abnormal state (i.e., emitting smoke, burning odor, unusual noise, or the like). Doing so may result in fire or electrical shock.**

Immediately switch off the power, unplug the power cord from the electrical outlet, and contact your authorized Roland DG Corp. dealer or service center.

## ⚠️ CAUTION



**Fasten the spindle, tool, and material securely in place.**

Otherwise they may come loose during cutting, resulting in injury.



**Do not insert the fingers between the rotary axis unit and the material.**

The fingers may be pinched, resulting in injury.



**Do not wear gloves, a necktie or wide-sleeved clothing.**

They may become caught in the tool, resulting in injury.



**Set the cutting area so that the tool does not contact the rotary axis unit or the like.**

Pieces of the tool or workpiece may fly off, resulting in injury.

## **CAUTION**

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**Do not allow liquids, metal objects or flammables inside the machine.**

Such materials can cause fire.

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In addition to the  **WARNING** and  **CAUTION** symbols, the symbols shown below are also used.

**NOTICE** : Indicates information to prevent machine breakdown or malfunction and ensure correct use.



: Indicates a handy tip or advice regarding use.

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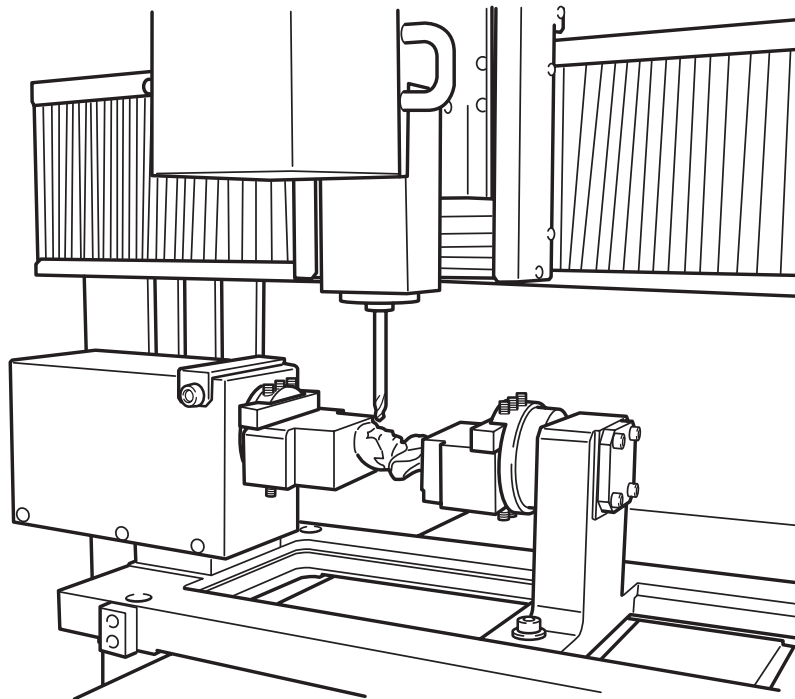
# Part 1 Features of the ZCL-650

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The ZCL-650 is a rotary axis unit exclusively for the MDX-650. By adding an axis of rotation (A axis) to the three X, Y, and Z axes of the MDX-650, it makes it simple to achieve multiple-surface cutting. Until now, double-sided cutting required precise positioning of the front and back surfaces, but using the ZCL-650 lets you carry out troublesome operations such as changing the front and back surfaces with ease.

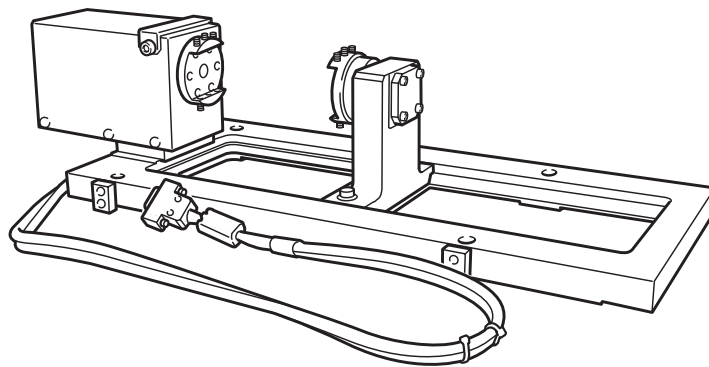
When the ZCL-650 is installed on the MDX-650, you can carry out simultaneous three-axis control for the X, Y, and Z axes or the X, Z, and A axes. (The A and Y axes do not operate simultaneously. Simultaneous four-axis operation of the X, Y, Z, and A axes is not possible.) You can easily switch between the A and Y axes using commands or the operation panel.

The A axis has a positioning range of 0 to 1,080 degrees (three full turns). It cannot be rotated continuously, like a lathe. The ZCL-650 is suited to cutting resins such as chemical wood and modeling wax. It is not suitable for cutting metal.

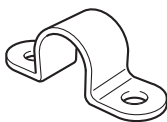


# Part 2 Setting Up

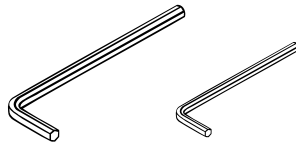
## 2-1. Included Items



Rotary axis unit



Cable clamp



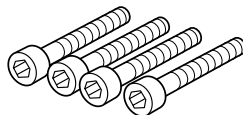
Hexagonal wrenches  
6 mm:1 3 mm:1



Y-center detection pin  
(diameter 6 mm)



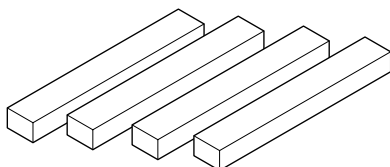
Screws: 4  
(for securing the cable clamp and  
for the slider retainer)



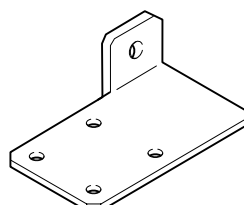
Cap screws: 4  
(for securing the rotary axis unit)



Washers: 4  
(for securing the rotary axis unit)

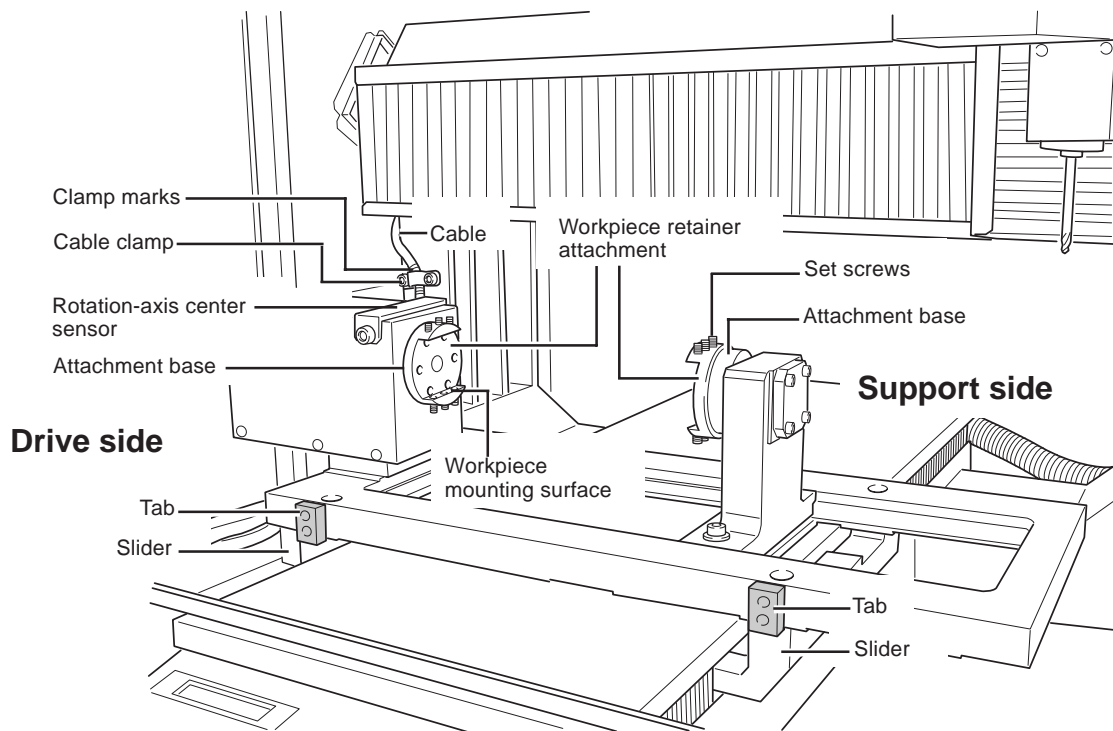


Spacers: 4



Slider retainer

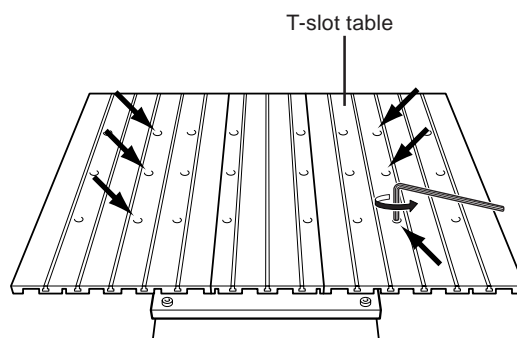
## 2-2. Names of Parts



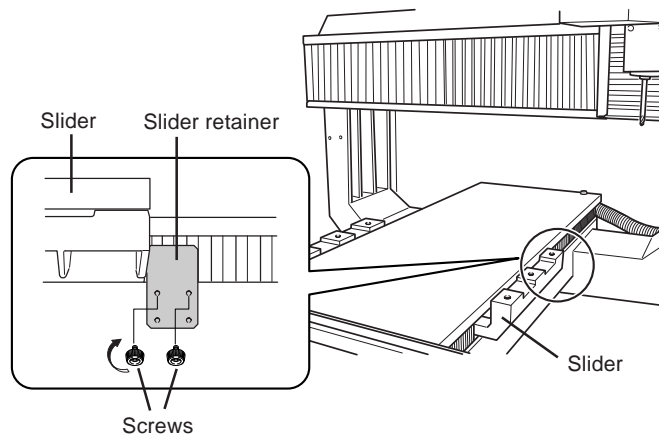
## 2-3. Installing the ZCL-650

**NOTICE** Before installing, be sure to switch off the MDX-650 and unplug the power cord. Attempting to connect or disconnect cables while the power is on may result in breakdown.

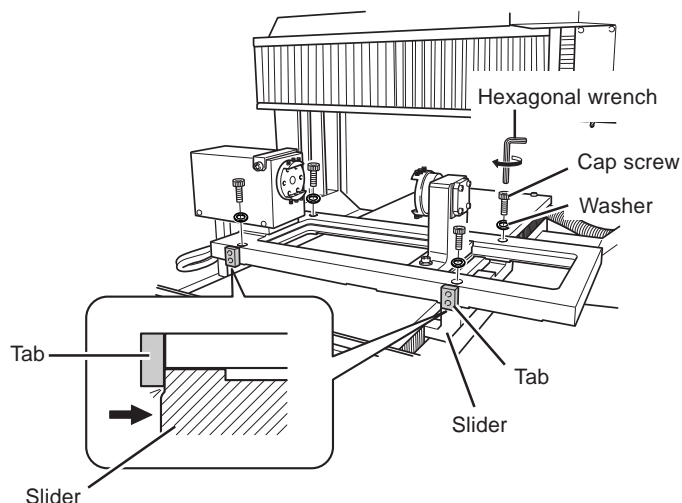
- 1 Turn on the power to the MDX-650. Press the [ ▼ ] key to move the T-slot table all the way to the front.
- 2 Turn off the MDX-650 and unplug the power cord.
- 3 Use the hexagonal wrench included with the MDX-650 to remove the six cap screws shown in the figure, then detach the T-slot table.



- 4 Use two screws to attach the slider retainer to the side and temporarily secure the slider in place.

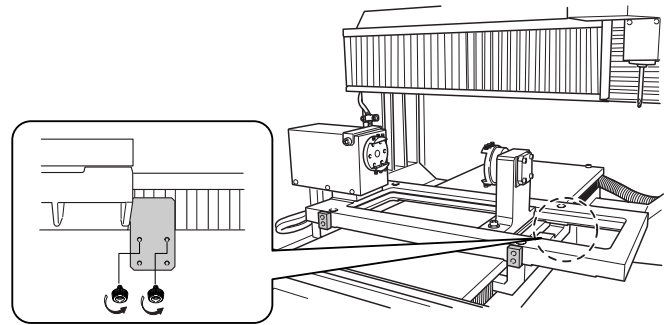


- 5 Clean away any build-up grime on the tabs and the sliders. Place the ZCL-650 rotary axis unit on the slider and secure in place using the four cap screws and washers while firmly pressing the tab against the slider. If insufficient pressure is applied or the installation is not straight, cutting accuracy cannot be assured.

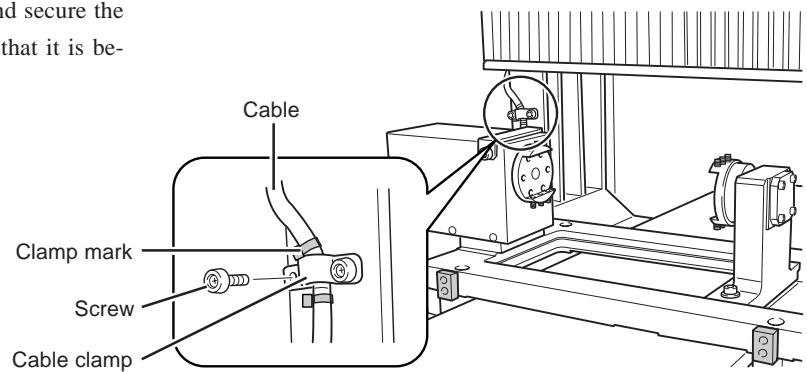




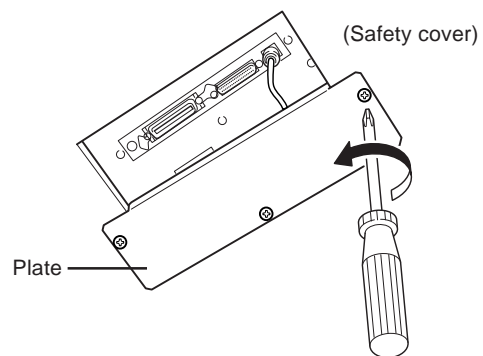
- 6** Detach the slider retainer you attached earlier.



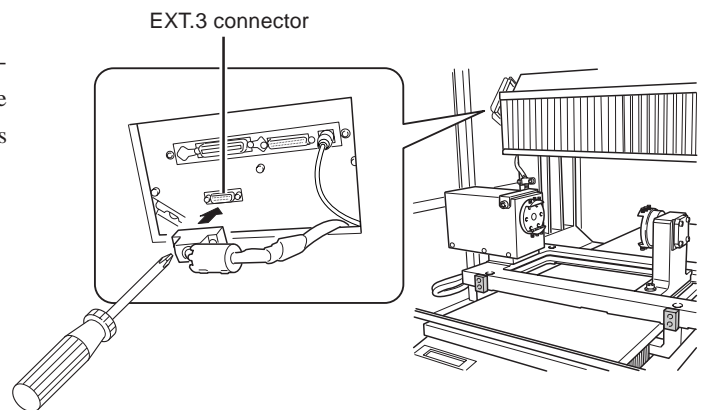
- 7** Use two screws to attach the cable clamp and secure the cable in place. Position the cable clamp so that it is between the white clamp marks.



- 8** If you're using the optional safety cover (ZBX-650), remove the plate on the left side of the ZBX-650.



- 9** Firmly insert the ZCL-650 cable into the "EXT.3" connector on the MDX-650. Use a screwdriver to tighten the connector screws. The ZCL-650 will not operate if this cable becomes disconnected or loose. Tighten securely.



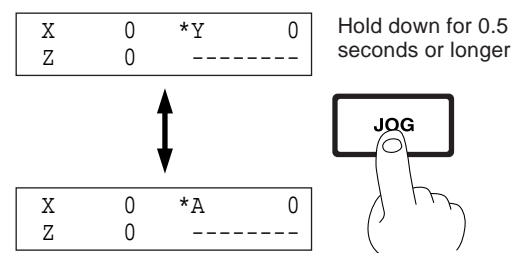
- 10** Store the center of rotation (Y axis) of the rotary axis unit in memory on the MDX-650. For information about how to do this, refer to "3-3. Setting the Y- and Z-axis Origin Point at the A-axis Center of Rotation" and see "Y-axis Center Alignment."

# Part 3 Using the Operation Panel

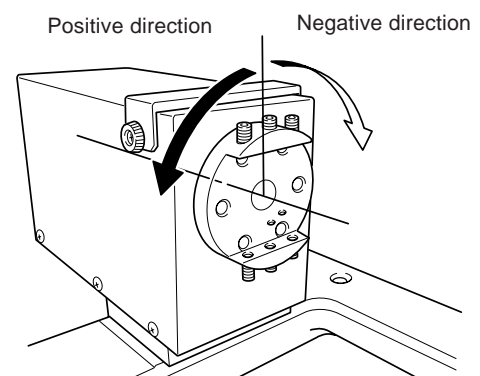
When you install the ZCL-650 on the MDX-650, the following keys operations and display menus are added. This section describes the added functions. For information about the basic operation of the operation panel, refer to the MDX-650 User's Manual.

## 3-1. Rotating the A Axis Using the Operation Panel

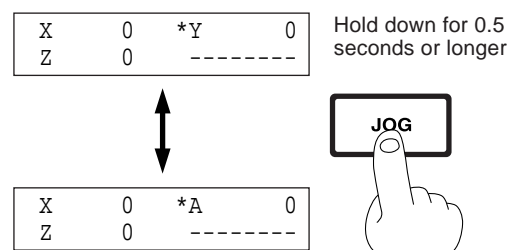
- 1 Hold down the [JOG] key for 0.5 seconds or longer. The display changes to show the coordinates of the A axis.  
When the power is switched on, the [▲] and [▼] keys on the operation panel are assigned to Y-axis operation, and the display also shows the Y-axis coordinates. Holding down the [JOG] key for 0.5 seconds or longer switches from the Y axis to the A axis.



- 2 Use the [▼] key to rotate in the positive direction (toward the front) and the [▲] key to rotate in the negative direction (toward the back). Also, when you press the [JOG] key to line up the [\*] with [A], you can also use the dial to perform these operations.



- 3 Holding down the [JOG] key again for 0.5 seconds or longer changes from the A axis to the Y axis.



## 3-2. Setting the A-axis Origin Point

The ZCL-650 has a coordinate range of three rotations from the origin point for machine coordinates. You can set the origin point for workpiece coordinates within this coordinate range.

- 1 Change the display to coordinate view.
- 2 Rotate the A axis to the angle where you want to set the origin point. (See "3-1. Rotating the A Axis Using the Operation Panel.")
- 3 Press the [XY/A] key.
- 4 Press the [ENTER] key. The screen flashes once and returns to the coordinate view. The A-axis origin point has now been set. The origin point is stored in memory until even after the power is turned off.

## 3-3. Setting the Y- and Z-axis Origin Point at the A-axis Center of Rotation

Aligning the Y- and Z-axis origin point for workpiece coordinates with the A-axis center of rotation makes it easy to determine coordinates at times such as when performing multiple-surface cutting. The ZCL-650 offers as feature that makes it simple to perform this setting. If you're using MODELA Player, be sure to carry out these operations.

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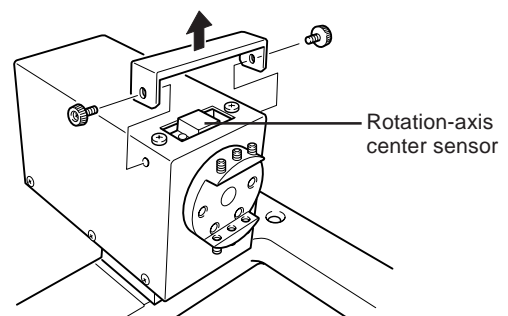
**NOTICE** Be sure to put back the sensor cover after use. Attempting cutting while the cover is left detached may result in cuttings building up on the sensor or getting inside the sensor, which may cause breakdown.

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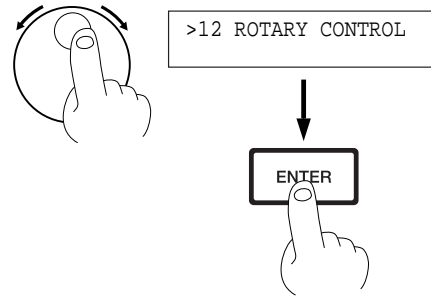
## Y-axis Center Alignment

Be sure to carry out this operation at least once after installing the ZCL-650. Also, do it after replacing the spindle unit.

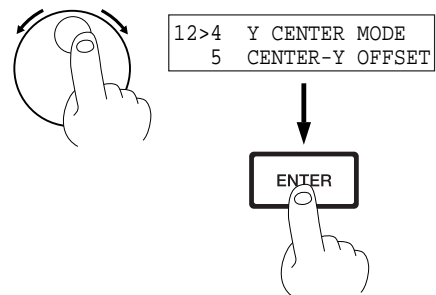
- 1 Remove the sensor cover.



- 2 Install the included Y-center detection pin on the spindle unit with an amount of extension of about 20 mm (about 1 in.).
- 3 Move the tip of the Y-center detection pin to a position about 2 to 3 mm (about 1/8 in.) above the rotation-axis center sensor.
- 4 Press the [EXIT] key to display the main menu.
- 5 Turn the dial to line up the arrow with [ROTARY CONTROL], then press the [ENTER] key.

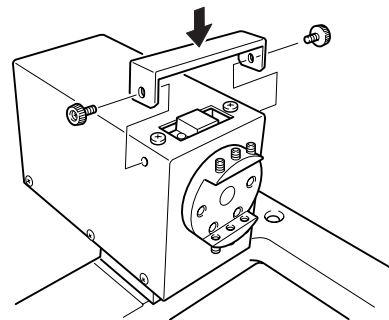


- 6 Turn the dial to line up the arrow with [Y CENTER MODE], then press the [ENTER] key.



- 7 A confirmation prompt appears. If everything is ready, press the [ENTER] key. The center of rotation of the A axis is detected automatically, and the Y-axis origin point is set at that point.  
The bell beeps when detection ends.

- 8 Put back the sensor cover.




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**NOTICE** Be sure to use the included Y-center detection pin to perform this operation. Using an end mill or the like may make accurate detection of the origin point impossible.

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If Y-axis center alignment of greater accuracy is required, use the [CENTER-Y OFFSET] function. This makes it possible to correct for sensor error. For detailed information, see "**Part 5 Offset Adjustment for the Y-axis and Z-axis Origin Points.**"

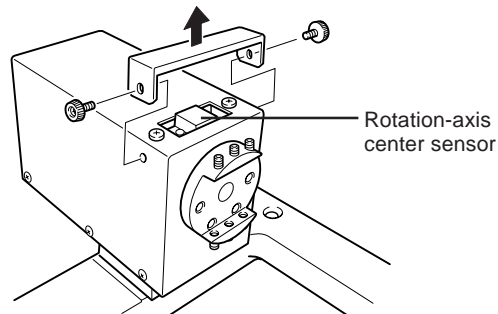
This Y-axis center position is stored in memory, and does not disappear even if you set the X- and Y-axis origin point at a different position. You can restore the Y-axis origin point to the center location at any time by executing [RESET Y POS]. For detailed information, see "**3-4. Added Display Menus.**"

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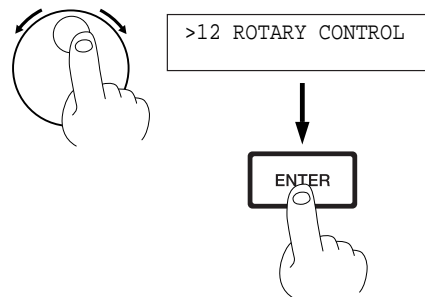
# Z-axis Center Alignment

Be sure to carry out this operation every time you change the tool.

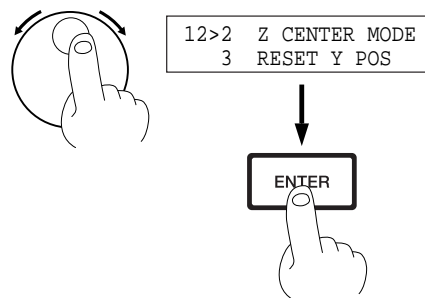
- 1 Remove the sensor cover.
- 2 Install the tool to use for actual cutting on the spindle.
- 3 Move the tip of the tool to a position about 2 to 3 mm (about 1/8 in.) above the rotation-axis center sensor.
- 4 Press the [EXIT] key to display the main menu.



- 5 Turn the dial to line up the arrow with [ROTARY CONTROL], then press the [ENTER] key.

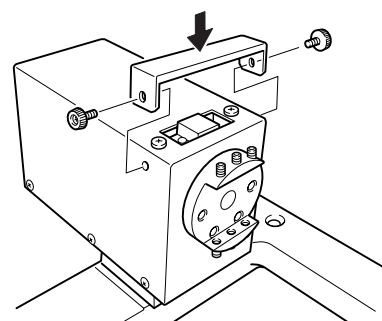


- 6 Turn the dial to line up the arrow with [Z CENTER MODE], then press the [ENTER] key.



- 7 Press the [-Z] key to lower the tool until it touches the rotation-axis center sensor. As soon as the tool touches the sensor, operation stops and the tool rises. The center of rotation of the A axis is detected automatically, and the Z-axis origin point is set at that point. The bell beeps when detection ends.

- 8 Put back the sensor cover.



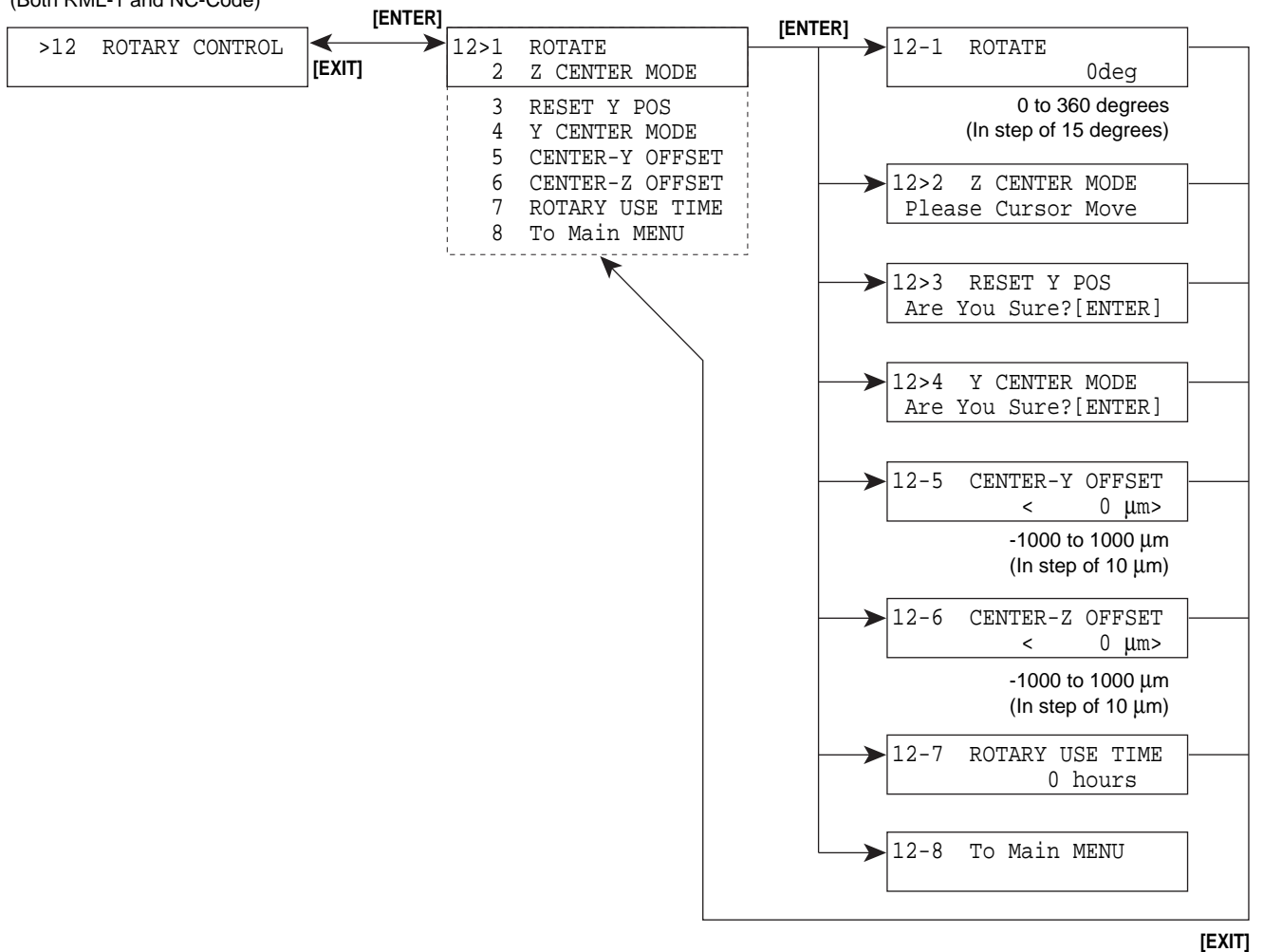
## 3-4. Added Display Menus

This section describes the display menus that are added when the ZCL-650 is installed on the MDX-650.

### Display Menu Flowchart

#### Main Menu

(Both RML-1 and NC-Code)



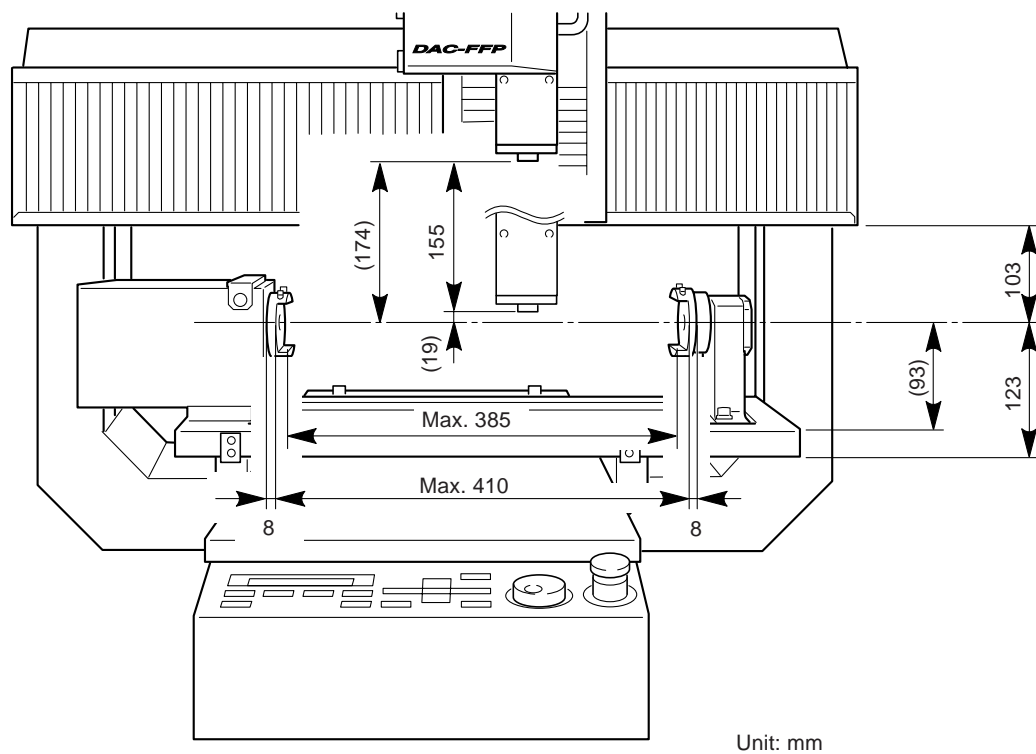
## Descriptions of the Display Menus

<b>12-1 ROTATE</b>	<p><b>Stored in memory :</b> No  <b>Setting range :</b> 0 to 360 degrees  <b>Steps :</b> 15</p> <hr/> <p>This references the user origin point (workpiece origin point) and rotates the A axis by the selected angle.</p>
<b>12-2 Z CENTER MODE</b>	<p>This uses the rotation-axis center sensor to set the Z-axis origin point at a location where the tool tip coincides with the height of the A-axis center.</p>
<b>12-3 RESET Y POS</b>	<p>This resets the Y-axis origin point at the location set previously with [Y CENTER MODE]. Even after the Y-axis origin point has been set at another location, you can reset it to the A-axis center by running this item.</p> <p>Running this item when [Y CENTER MODE] has never been run once sets the Y-axis origin point at the center of the maximum cutting range (for the MDX-650, this is 22,500).</p>
<b>12-4 Y CENTER MODE</b>	<p>This uses the rotational-center sensor to set the Y-axis origin point at a location where the tool center coincides with the A-axis center.</p> <p>Running this item initializes the [CENTER-Y OFFSET] value to zero.</p>
<b>12-5 CENTER-Y OFFSET</b>	<p><b>Stored in memory :</b> Yes  <b>Factory default :</b> 0  <b>Setting range :</b> -1,000 to 1,000 <math>\mu\text{m}</math>  <b>Steps :</b> 10</p> <hr/> <p>This corrects coordinate misalignment of the Y-axis origin point that [Y CENTER MODE] sets. Entering a positive value applies correction toward the back, and entering a negative value applies correction toward the front.</p> <p>Running [Y CENTER MODE] initializes this value to zero.</p>
<b>12-6 CENTER-Z OFFSET</b>	<p><b>Stored in memory :</b> Yes  <b>Factory default :</b> 0  <b>Setting range :</b> -1,000 to 1,000 <math>\mu\text{m}</math>  <b>Steps :</b> 10</p> <hr/> <p>This corrects coordinate misalignment of the Z-axis origin point that [Z CENTER MODE] sets. Entering a positive value applies correction upward, and entering a negative value applies correction downward.</p>
<b>12-7 ROTARY USE TIME</b>	<p>This displays the total usage time of the rotary axis unit. The value cannot be reset to zero. It keeps count of spindle rotation time when the ZCL-650 is connected to the MDX-650.</p>

# Part 4 Loading Material

## 4-1. The Cutting Area

### Maximum Cutting Area (When ZS-650T Is Installed)



### Important Points About the Cutting Area

The range that can actually be cut is limited by the following factors, which make it narrower than the range described above.

- Amount of tool extension
- Interference between the rotary axis unit or workpiece retainer attachment and the tool or spindle unit
- Interference between the loaded workpiece and the tool or spindle unit

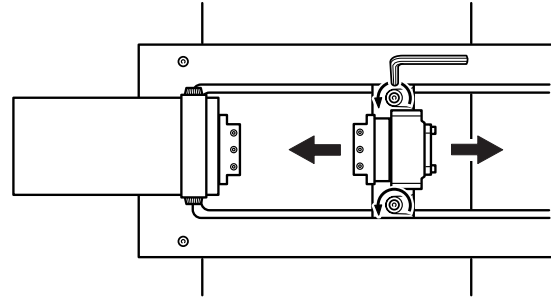
Special care is needed when you attach square material as the workpiece, because the corners may easily strike the tool when rotating the A axis.



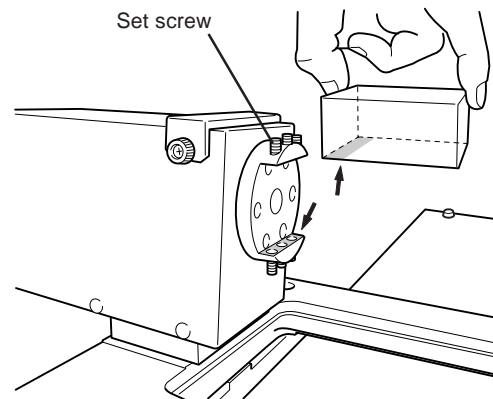
## 4-2. Loading Material

**1** Use the included hexagonal wrench (6 mm) to loosen the support-side retaining screws, then move the support side to match the size of the workpiece.

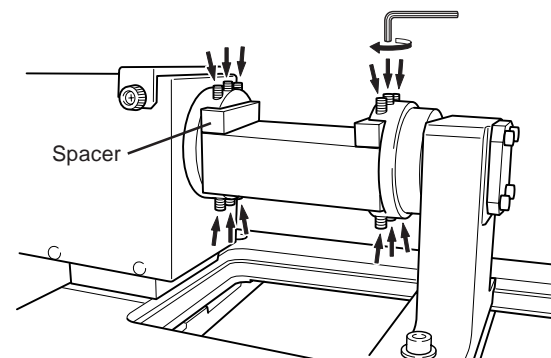
**2** Securely tighten the support-side retaining screws.



**3** Use the included hexagonal wrench (3 mm) to loosen the set screws for the workpiece retainer attachment on the drive and support sides, then insert the workpiece. If the workpiece is flat, press the flat surface of the workpiece against the workpiece brace surface of the workpiece retainer attachment.



**4** Tighten the set screws securely, using even force. If the workpiece is thin and the set screws do not reach, insert the included spacer or the like and secure in place.



Take care not to apply excessive force when securing the workpiece in place. Doing so may cause the workpiece to warp or deform during cutting. When you are using a soft workpiece made of foamed material or the like, precision may be affected by slipping of the workpiece during cutting or twisting during rotation.

When you are using the included workpiece retainer attachment, we recommend using a workpiece with a flat bottom surface.

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# Part 5 Offset Adjustment for the Y-axis and Z-axis Origin Points

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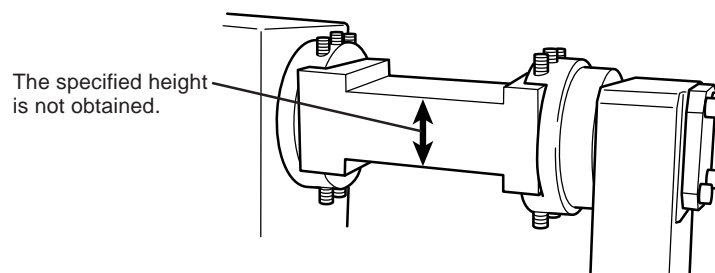
## 5-1. When Offset Adjustment Is Required

The Y-axis and Z-axis origin points of the MDX-650 are generally set at the center of rotation for the rotary axis unit. The ZCL-650 is provided with a rotation-axis center sensor for setting these origin points. Slight errors may occur in the origin-point settings made with this, but it's possible to correct them by adjusting the offset.

Misalignment of the position of the origin point may affect cutting as follows.

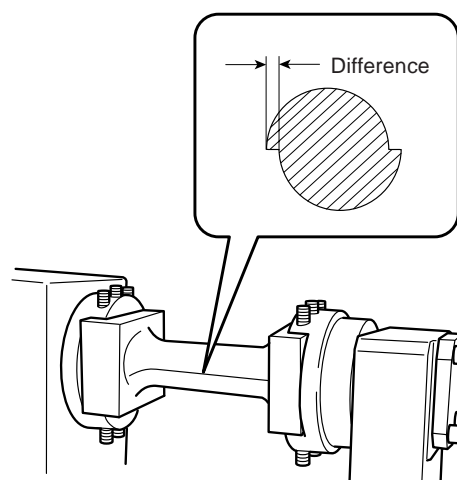
### Inaccuracy in the Z-axis Direction

There is an error in the thickness of the object when cutting the front or back surface. This is due to misalignment of the Z-axis origin point. Make correction as described in "5-2. How to Adjust the Center-Z Offset."



### Differences in Height at the Seam Between the Front and Back Surfaces

There is an error in the depth of the object. This results in differences the upper and lower height at the seam when you perform two-surface cutting for the front and back surfaces. This is due to misalignment of the Y-axis origin point. Make correction as described in "5-3. How to Adjust the Center-Y Offset."



# 5-2. How to Adjust the Center-Z Offset

To adjust the offset, you perform actual cutting of material and evaluate the amount of misalignment. There are no special rules about the particular cutting you should use. This section explains a simple method that lets you perform cutting without using any software. We recommend using modeling wax or chemical wood as the workpiece with this method.

- 1 Install a square end mill about 6 mm in diameter, then run [Z CENTER MODE]. For more information, see "3-3. Setting the Y- and Z- axis Origin Point at the A-axis Center of Rotation."
- 2 Load a box-shaped workpiece, then set the A-axis origin point at a place where the surface is level. Hold down the [JOG] key for 0.5 seconds or longer to return the [▲] and [▼] keys to Y-axis operation. For more information, refer to "3-1. Rotating the A Axis Using the Operation Panel" and "3-2. Setting the A-axis Origin Point."
- 3 Hold down the [SPINDLE] key for 0.5 seconds or longer to rotate the spindle. Press the [JOG] key to line up the [\*] with the spindle speed, then use the dial to make the setting for about 8,000 to 10,000 rpm.



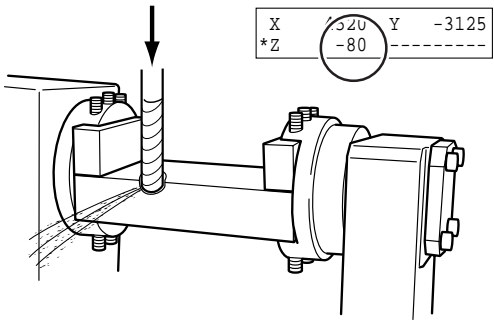
(RML-1)

X	0	Y	0
Z	0	*8000	RPM

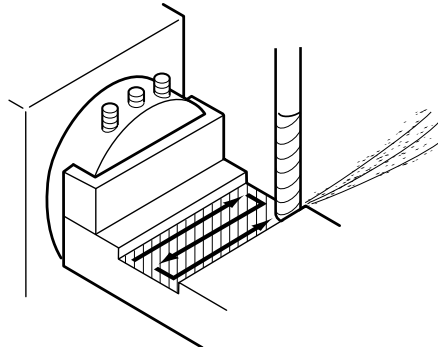
(NC-CODE)

X	0	Y	0
Z	0	*S80	OFS

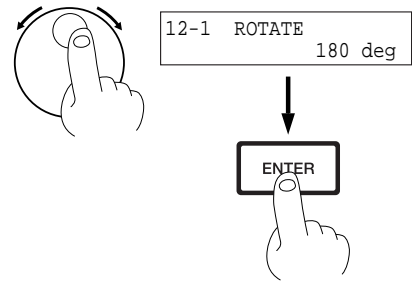
- 4 Move the tool to the edge of the workpiece. Use the [-Z] key and the dial to gradually lower the tool and cut in by about 0.2 to 0.5 mm. Make a note of the Z-axis coordinate value that appears on the display at this time. (Label this "coordinate a.")



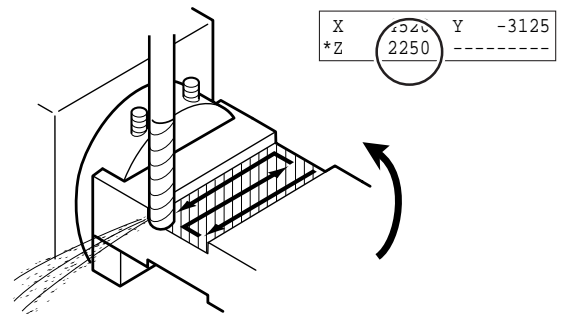
- 5 Use the [▲], [▼], [◀], and [▶] keys to move the tool, then cut the workpiece. Cut a sufficient range to allow use of Vernier calipers or the like.



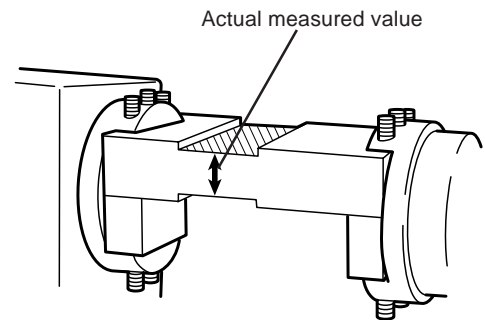
- 6** Press the [EXIT] key. Use the dial to select [12 ROTARY CONTROL], then press the [ENTER] key. In the same way, go to the [12-1 ROTATE] menu, then use the dial to make the setting for [180 deg]. Press the [ENTER] key. The tool rises and the workpiece is flipped.
- Use the [EXIT] key to go back to the coordinate-value screen.



- 7** Follow steps 3 to 5 to cut the back surface of the workpiece in the same way. Make a note of the Z-axis coordinate value at this time. (Label this "coordinate b.")
- When you have finished, use the [+Z] key to raise the tool, then press the [SPINDLE] key to stop the spindle.



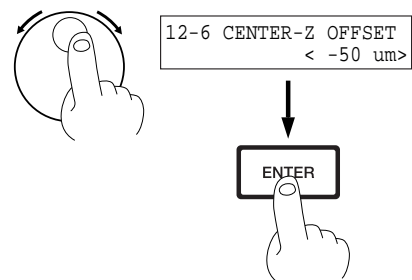
- 8** Use the coordinates a and b that you noted in steps 4 and 7 to calculate the theoretical value for the finished thickness. Also, use Vernier calipers or the like to measure the actual thickness of the cut workpiece. The difference between the theoretical value and the actual measured value is the amount of error. As a general guide, the offset value should be one-half of this.



**Theoretical thickness = coordinate a + coordinate b**  
**Offset value = (theoretical thickness - actual measured value) / 2**

For example, if coordinate a is -80 and coordinate b is 2,250, the theoretical thickness is 21.7 mm. If the actual measured value is 21.8 mm, the estimated offset value is -50 μm.

- 9** Press the [EXIT] key. Use the dial to select [12 ROTARY CONTROL], then press the [ENTER] key. In the same way, go to the [12-6 CENTER-Z OFFSET] menu and use the dial to set the offset value. Press the [ENTER] key.



- 10** Repeat steps 3 through 9 as required to fine-tune the offset value.

**If the actual measured value is larger:**  
 Make the offset value smaller (more of a negative value).  
**If the actual measured value is the smaller of the two:**  
 Make the offset value larger (more of a positive value).

# 5-3. How to Adjust the Center-Y Offset

To adjust the offset, you perform actual cutting of material and evaluate the amount of misalignment. There are no special rules about the particular cutting you should use. This section explains a simple method that lets you perform cutting without using any software. We recommend using modeling wax or chemical wood as the workpiece with this method.



Running [Y CENTER MODE] initializes the [CENTER-Y OFFSET] value to zero.

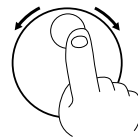
**1** From the MDX-650, run [Y CENTER MODE]. For more information, see "3-3. Setting the Y- and Z- axis Origin Point at the A-axis Center of Rotation."

When you have finished, install a square end mill having sufficient blade length (at least one-half of the thickness of the workpiece).

**2** Load a box-shaped workpiece, then set the A-axis origin point at a place where the surface is level. Hold down the [JOG] key for 0.5 seconds or longer to return the [▲] and [▼] keys to Y-axis operation.

For more information, refer to "3-1. Rotating the A Axis Using the Operation Panel" and "3-2. Setting the A-axis Origin Point."

**3** Hold down the [SPINDLE] key for 0.5 seconds or longer to rotate the spindle. Press the [JOG] key to line up the [\*] with the spindle speed, then use the dial to make the setting for about 8,000 to 10,000 rpm.



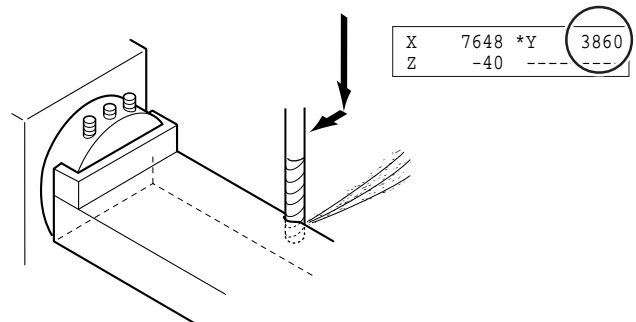
**(RML-1)**

X	0	Y	0
Z	0	*8000	RPM

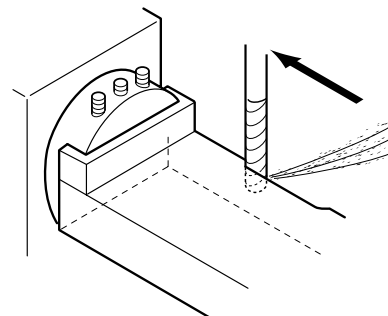
**(NC-CODE)**

X	0	Y	0
Z	0	*S80	OFS

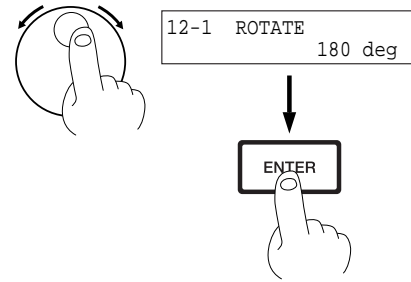
**4** Move the tool to the far (back) side of the workpiece and lower the tool by about half the thickness of the workpiece. Use the [▲] key and the dial to gradually approach the workpiece and perform 0.2 to 0.5 mm of cutting-in. Make a note of the Y-axis coordinate value that appears on the display at this time.



**5** Press the [JOG] key to line up the [\*] with the X axis. Turn the dial to cut a width of about 2 to 3 cm (1 in.).

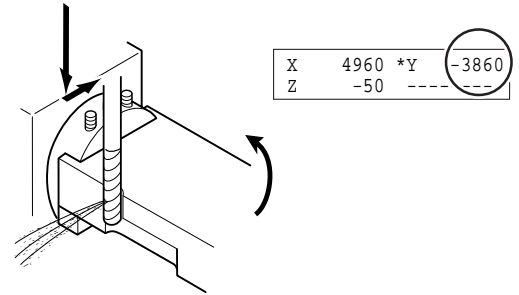


**6** Press the [EXIT] key. Use the dial to select [12 ROTARY CONTROL], then press the [ENTER] key. In the same way, go to the [12-1 ROTATE] menu, then use the dial to make the setting for [180 deg]. Press the [ENTER] key. The workpiece is flipped over and the surface cut in step 5 comes to face the front of the machine.



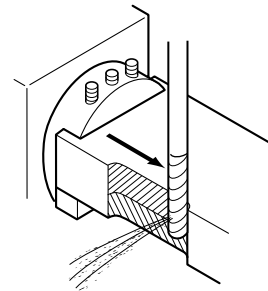
Use the [EXIT] key to go back to the coordinate-value screen.

**7** Move the tool to the side of the workpiece facing the front of the machine, then lower the tool until it overlaps with the surface you cut in step 5 by about 1 mm (1/16 in.).



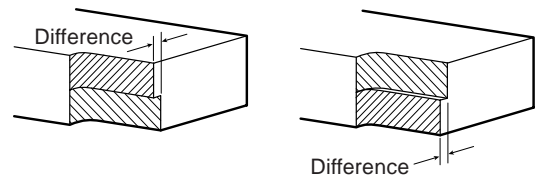
Use the [▼] key and the dial to gradually cut into the workpiece. Watch the Y-axis coordinate value on the display, and perform cutting-in until you reach a value that is the negative of the value you noted down in step 4. For example, if in step 4 you performed cutting-in to a value of Y = 3,860, then here you need to perform cutting-in to Y = -3,860.

**8** Press the [JOG] key to line up the [\*] with the X axis. Turn the dial to cut the same width you cut in step 5.



When you have finished, use the [+Z] key to raise the tool, then press the [SPINDLE] key to stop the spindle.

**9** Examine the difference in height between the two cuttings. Whether the offset value should be positive or negative is determined by whether the upper cut surface (the surface cut second) is displaced toward the front or the back of the machine. Also, as a general guide, the offset value should be one-half the amount of difference in heights.



**When the upper side is displaced toward the front: Positive offset value**  
**When the upper side is displaced toward the back: Negative offset value**

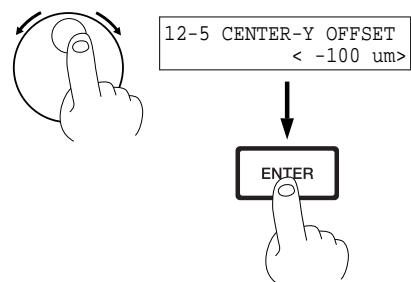
Enter a positive offset value.

Enter a negative offset value.

$$\text{Offset value} = \text{difference in heights} / 2$$

For example, if the upper side is displaced toward the back and the difference in heights is 0.2 mm, the estimated offset value is -100 μm.

**10** Press the [EXIT] key. Use the dial to select [12 ROTARY CONTROL], then press the [ENTER] key. In the same way, go to the [12-5 CENTER-Y OFFSET] menu, then use the dial to set the offset value. Press the [ENTER] key.



**11** Repeat steps 3 through 10 as required to fine-tune the offset value.

**When the upper side is displaced toward the front:**  
**Make the offset value larger (more of a positive value).**  
**When the upper side is displaced toward the back:**  
**Make the offset value smaller (more of a negative value).**

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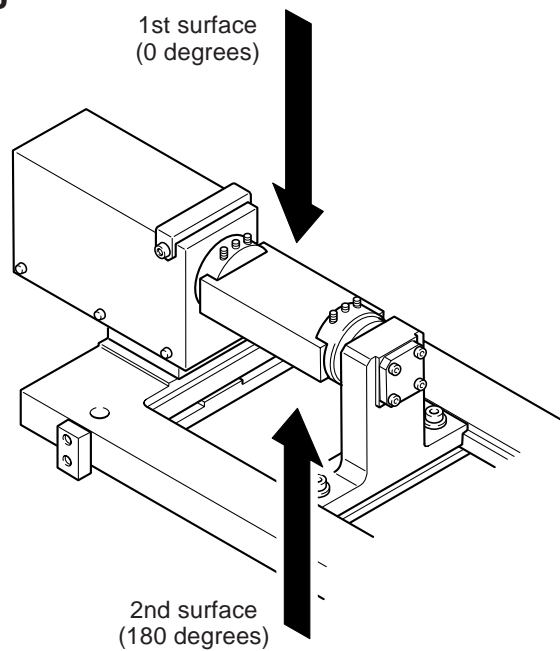
# Part 6 Cutting Using MODELA Player

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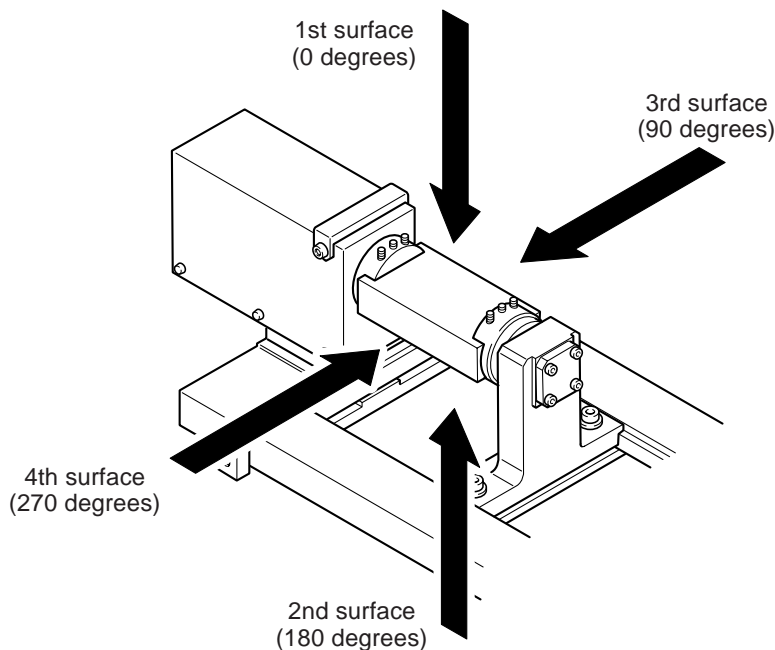
MODELA Player included with the MDX-650 has added features for A-axis control and multiple-surface cutting. These make it easy to perform two- and four-surface cutting.

For more information about the installation, setup, and basic operation of MODELA Player, refer to "MDX-650/500 User's Manual 2 (Cutting Using the Included Software)." This section describes the special features for ZCL-650 support.

## Two-surface Cutting



## Four-surface Cutting



## 6-1. Settings When Using the ZCL-650

- 1** First, install MODELA Player and make the basic settings. Refer to "**MDX-650/500 User's Manual 2 (Cutting Using the Included Software).**"
- 2** Next, make the following settings. In MODELA Player, go to the [Options] menu and click [Machines]. The [Model Selection] dialog box appears.
- 3** Select [MDX-650 Rotary (RML-1)], then click [OK].
- 4** Set the command set for the MDX-650 to "RML-1." For more information, refer to "**MDX-650/500 User's Manual 2 (Cutting Using the Included Software)**" and see "**Introduction.**"


When you set MODELA Player to [MDX-650 Rotary (RML-1)] as just described, the following happens.

- The [Settings for Multiple-surface Cutting] wizard is added.
- The functioning of the [Rotate] check box on the [Select the direction of object] screen is expanded. Each time you click the check box, the object rotates 90 degrees along the Z axis.
- A [Rotary Option] is added to the [Set the maximum cutting depth] screen. This lets you specify the maximum cutting depth individually for the first through fourth surfaces.
- The [Finish] selection (specifying either [Draft] or [Fine] cutting) becomes unavailable. This is performed using the [Settings for Multiple-surface Cutting] wizard instead.
- The [Layout] command on the [Options] menu becomes unavailable. Specifying the cutting-start position and surfacing are performed using the [Settings for Multiple-surface Cutting] wizard. Also, [Margin] is set to zero at all times.
- The [Abstract] command on the [Options] menu becomes unavailable. [Abstract] is set to [Off] at all times.
- Cutting simulations using Virtual MODELA are not possible.
- During four-surface cutting, cutting of the third surface (90 degrees) and the fourth surface (270 degrees) is 0.05 mm deeper than the set value.



## 6-2. The Tool Movement Range for MODELA Player

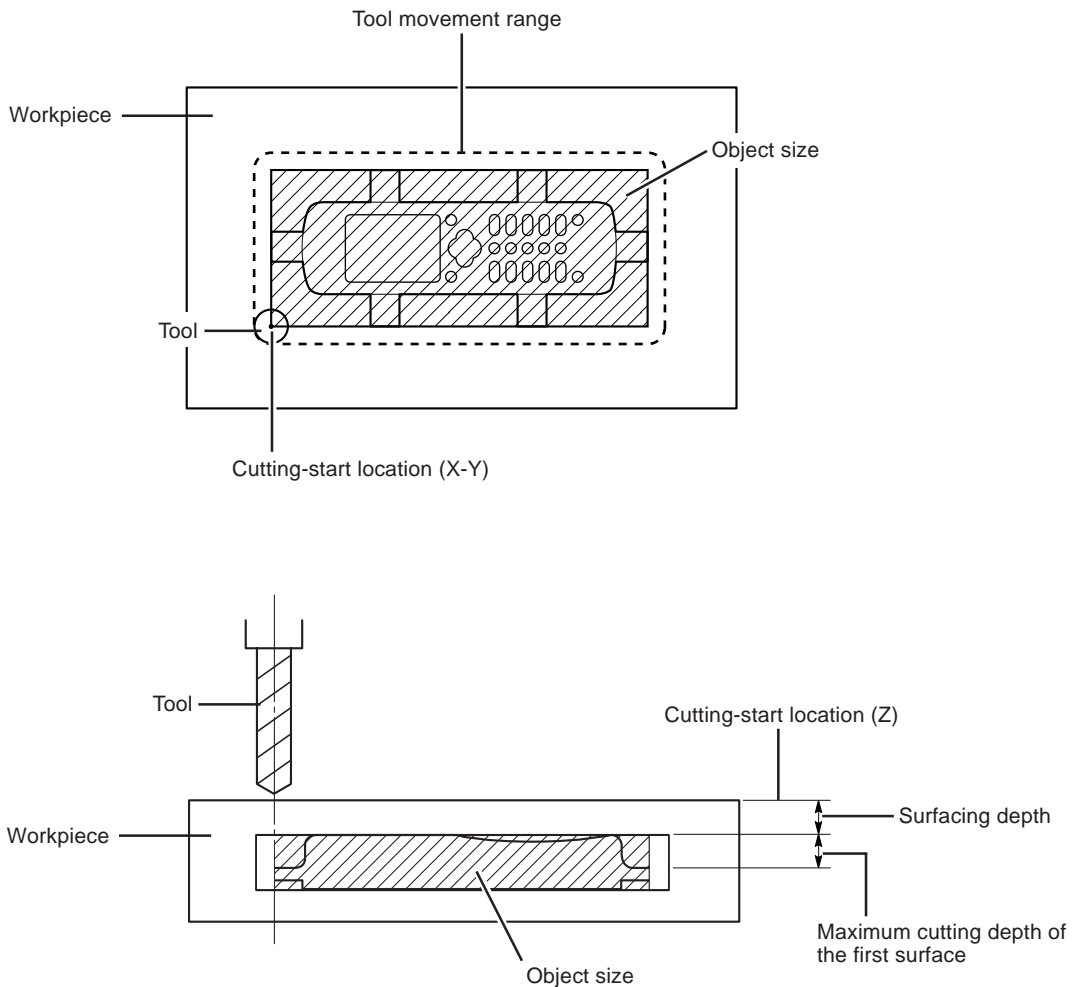
### CAUTION

 Set the cutting area so that the tool does not contact the rotary axis unit or the like.

Pieces of the tool or workpiece may fly off, resulting in injury.

The tool movement range during cutting is determined by the cutting-start location, the object size set at the [Set the Dimension] screen, and the setting for maximum cutting depth (see the figures below). Refer to these when you are making sure there is no interference between the tool and the spindle.

For more information about how to make the setting for the cutting-start location and the like, refer to "6-5. Operation of MODELA Player" later in this part.



## 6-3. Getting Ready for Cutting

Before you start cutting, give thought to the following matters.

### Method of Object Support

The method of support for an object depends on its shape, but examples may include the following methods.

For four-surface cutting, two-point support is used (Figure 1). For two-surface cutting, supports are added to the object's 3D data to provide support at four or more points (Figure 2). (MODELA Player itself has no function for adding supports. It's necessary to include the supports in the 3D data for the object.)

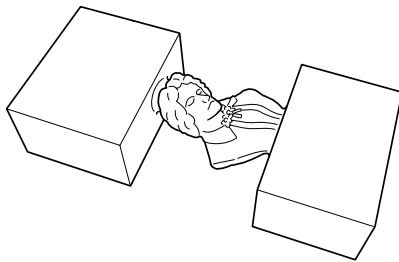


Figure 1

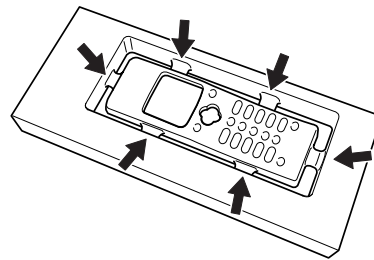


Figure 2

Two-surface cutting is possible even with two-point support, but uncut portions equal to the tool diameter occur at both the front and rear (Figure 3). Careful use of supports can minimize such uncut portions. The number of supports and their thickness should be determined so as to withstand cutting.

The supports must be of a length that allows the tool to avoid the object and pass underneath it. That is, to eliminate uncut areas as shown in figure 3 and separate the object from the surround walls, the supports must be of a certain length. The required length is determined by the tool diameter and the cutting parameters for MODELA Player.

$$\text{Support length} \geq \text{Tool diameter} + [\text{Path Spacing}] + [\text{Fine Margin}]$$

To display the values for [Path Spacing] and [Fine Margin], use MODELA Player to make the sets for tool diameter and the workpiece, then go to [Options] and click [Custom Parameters].

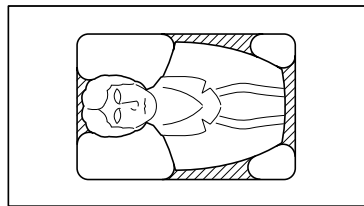


Figure 3

Vertical walls remain as an outer border around the object. When the cutting depth is considerable, this becomes a factor for increased cutting resistance. Accordingly, give thought to the following.

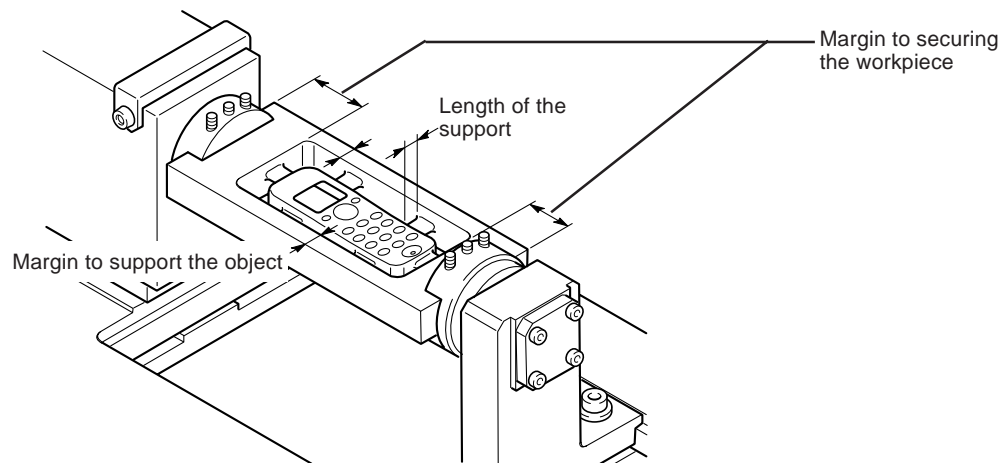
- For two-point support, set the cutting-start location as close as possible to the front edge of the workpiece. Also, make the front-to-back size of the workpiece not greater than the size of the object plus the tool diameter. This ensures that no outer border remains at the front and back.
- Angle the walls slightly so as to make them sloped. To do this, you need to include the data for the outer border in the object's 3D data ahead of time. Two slopes must be made on each wall to prevent undercutting on the front and back. It's also necessary to take into account the relative positioning of the supports and the cutting depths of the respective surfaces.
- Use an end mill suited to deep cutting (such as one whose shank diameter is somewhat narrower than its tool diameter).

## Cutting Parameters

If the object is thin, it may flex or rattle under the resistance caused by cutting. In the worst case, the object may even bend or break. In such cases, change the preset cutting parameters for MODELA Player. Go to the [Options] menu and click [Custom Parameters] to display the [Customize Parameters] dialog box, then add a new material. Then make the settings for the new cutting parameters. For instance, it may be a good idea to reduce the values for settings such as [Z Step], [Z Speed], [XY Speed], and [Spindle rpm].

## Workpiece Shape and Size

The ideal workpiece shape is an oblong block with square corners. Take into account the margins required for supporting the object, such as the necessary margin for securing the workpiece to the retainer attachment, the supports, and so on, and determine the minimum required size. You can achieve efficient cutting by trimming the workpiece to that size ahead of time.



## Maximum Cutting Depth of the Cutting Surfaces

You need to decide on the cutting depth for each of the surfaces, from the first to the fourth. The values depend on the shape of the particular object. Decide on the values while taking into account the undercutting for the object and considering how to minimize uncut portions corresponding to the tool diameter.

You also need to take into account the amount of overlap for a surface and the surface on the opposite side. When you're using a square end mill, zero overlap is theoretically acceptable, but it results in a seam between the front and back. It may be possible to reduce this by applying very slight overlap. Also, when you're using a ball end mill, overlap greater than the tool diameter is always necessary.

## Check of Required Tool Length and Check for Interference

Adequate consideration must be given ahead of time to ensuring that the tool and spindle unit do not strike such objects as the workpiece retainer attachment or the workpiece itself during cutting. After loading the workpiece, try lowering the tool to the maximum cutting depth. Make sure the tool length is sufficient while taking into account the X- and Y-direction cutting range during cutting (refer to "**6-2. The Tool Movement Range for MODELA Player**"). Then decide where the cutting start point should be set.

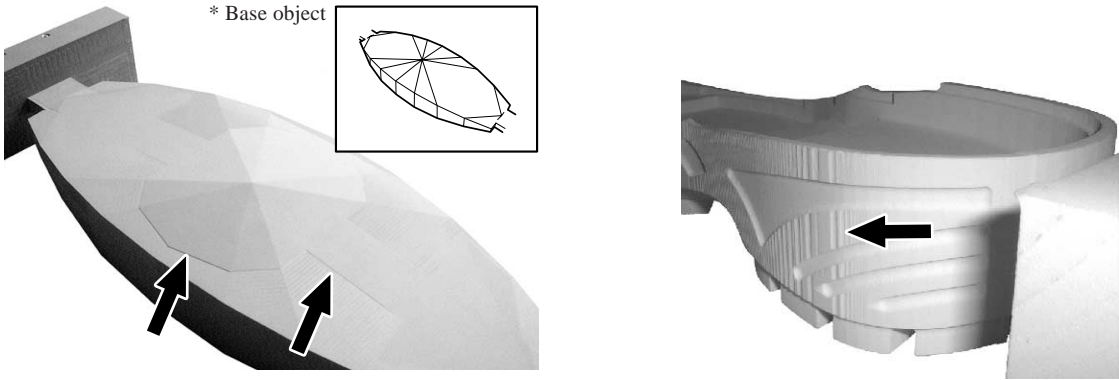
It's also necessary to make sure that the tool is not struck when the cutting surface is changed -- that is, when the ZCL-650 rotates the workpiece. Raise the tool to its limit position then perform movement above the workpiece (near the center of rotation of the ZCL-650). While the machine is in this state, rotate the A axis and make sure the tool does not strike the workpiece.

# 6-4. Actual Four-surface Cutting

This section describes some points you should give attention to when performing four-surface cutting.

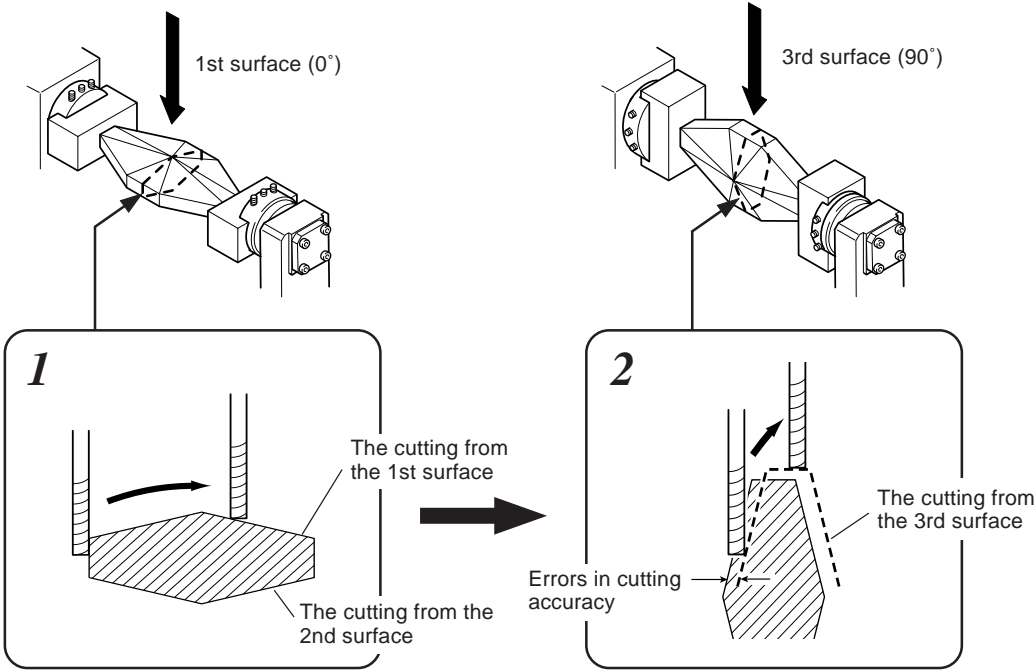
## Effects of Errors in Cutting Accuracy on Finished Results

In four-surface cutting, slight errors in cutting accuracy can affect the finished results. Even errors that have nearly no effect in two-surface cutting may produce complicated differences in height, wavy cutting marks, or otherwise detract from attractive finished results for cut surfaces in the case of four-surface cutting.



Examples using unsuitable settings

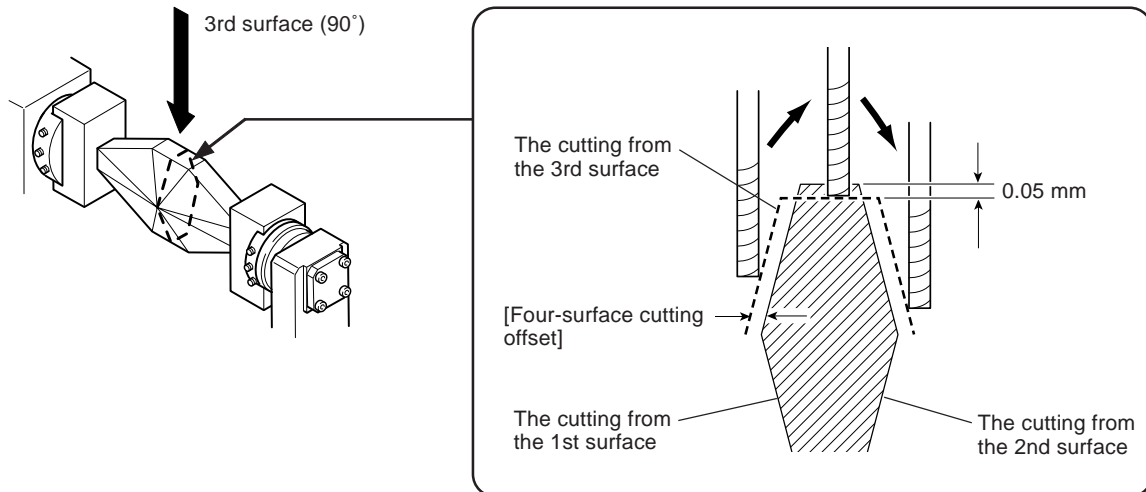
The cause of unattractive cut surfaces may be, for example, the side of the tool (the outer peripheral tool) damaging the first surface while performing cutting from the third surface.



When there is absolutely no error in accuracy, the cutting from the third surface should be perfectly flush with the first surface and inflict no damage on the finished surface. In actual practice, however, eliminating error in accuracy completely is difficult. There may be any number of possible causes, including mechanical precision, tool wobble, the precision of the tool itself, and deflection of the workpiece. It is important to reduce errors in cutting accuracy as much as possible, of course, but in actual four-surface cutting, it's also necessary to take these effects into account.

## A Cutting Method Taking Error in Accuracy into Account

MODELA Player has a feature that can help reduce these effects on finished results. The following method avoids damage to finished surfaces.



This actively uses the bottom surface of the tool (the bottom tool) by cutting deeply. It also uses [Four-surface cutting offset] to make the tool move away toward the outer side to keep the side of the tool (the outer peripheral tool) from touching surfaces that have already been finished. You can adjust [Four-surface cutting offset] to match the size of the error in accuracy.



### Important Notes About Finished Dimensions

- This cuts only the third and fourth surfaces by 0.05 mm deeper than their original settings. Note that the third and fourth surfaces are finished to a dimension that is a total of 0.1 mm smaller than their original combined dimensions.
- Increasing the [Four-surface cutting offset] value produces a correspondingly greater effect on the finished dimensions.

### About [Four-surface cutting offset]

- [Four-surface cutting offset] is a feature that makes the tool move away toward the outer side when cutting the third or fourth surface. Increasing the value of the setting makes the amount of escape correspondingly larger, making it progressively less likely that finished surfaces will be damaged.
- The amount of escape of the tool to the outer side makes the finished size of islands and the like correspondingly larger and the finished size of grooves and the like correspondingly narrower (third and fourth surfaces only).
- Increasing the value of [Four-surface cutting offset] makes it difficult for the tool to enter narrow grooves and the like, and may increase the number of uncut areas. You may wish to consider using a narrower tool.

## A Method for Reducing Errors in Cutting Accuracy

Misalignment of the Y-axis and Z-axis origin points can affect finished results. Refer to "**Part 5 Offset Adjustment for the Y-axis and Z-axis Origin Points**" and carry out adjustments.

Displacement of the Z-axis origin point in the positive direction can have a large effect on the finished results. This is because the side of the tool (the outer peripheral tool) is prone to striking the first and second surfaces during thick finishing and prone to striking the third and fourth surfaces during cutting.

If the finished results are poor even when you have made the value for [Four-surface cutting offset] in MODELA Player larger, then try setting [Center-Z Offset] to a value that is more negative than the optimal setting. Note, however, that this produces finished results that are correspondingly smaller.

It's important not to make the amount of tool extension longer than necessary. MODELA Player may not be able to correct for tool wobble if such wobble becomes large.

It's also very important to keep the workpiece from bending or twisting during cutting. Give careful thought to how you load and support the workpiece.

# 6-5. Operation of MODELA Player

## Step 1. Setting the Origin Point for the MDX-650

- 1 First make sure that [Y CENTER MODE] has been executed on the MDX-650 (or, make sure that [RESET Y POS] has already been executed). Also executed [Z CENTER MODE] for the tool to use for cutting.
- 2 Set the A-axis origin point with the MDX-650. If the workpiece is an oblong block, it is a good idea to set the origin point at a location where the surface is level. When setting the origin point, don't forget that the cutting range for the A axis is from 0 to 1,080 degrees (three rotations). It is necessary to provide for a cutting range of at least 360 degrees in the positive direction from the origin point you set here.



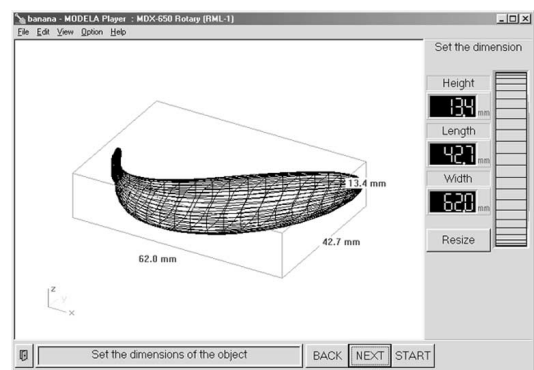
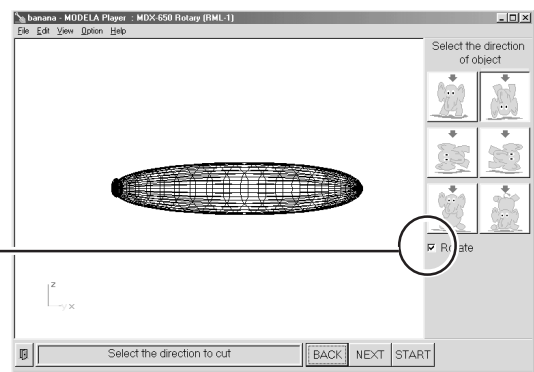
We recommend adjusting [Center-Z Offset] and [Center-Y Offset] on the MDX-650. This adjustment may affect the finished results of the cut surface, especially in the case of four-surface cutting. For more information, see "Part 5 Offset Adjustment for the Y-axis and Z-axis Origin Points" and "6-4. Actual Four-surface Cutting."

## Step 2. Setting the Cutting Parameters

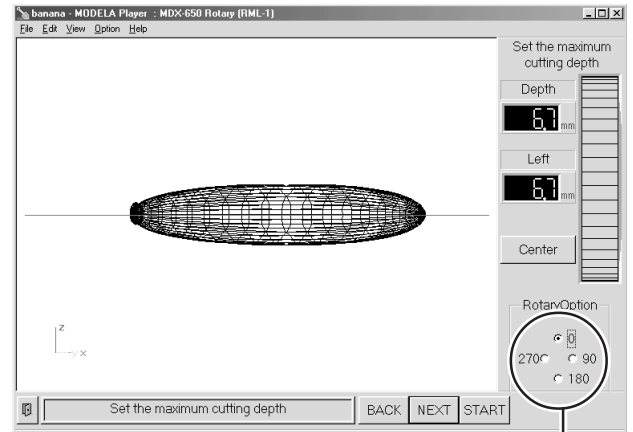
- 1 Change to the settings for MODELA Player. In "MDX-650/500 User's Manual 2 (Cutting Using the Included Software)," refer to "3-3. Cutting Using MODELA Player" and make the settings for importing data and for the cutting parameters. As you set the cutting parameters, give attention to the following points.

A) At the [Select the direction of the object] screen, choose a suitable orientation for multiple-surface cutting, then at the subsequent [Set the Dimension] screen, carefully make sure that the cutting area is not restricted by interference or the like.

Each time you click the check box, the object rotates 90 degree along the Z axis.

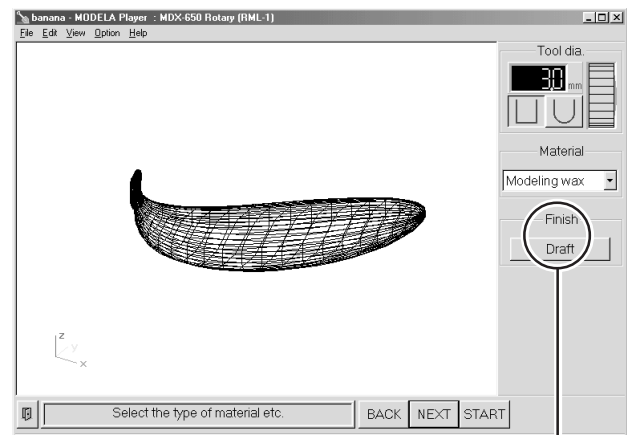


**B)** At the [Set the maximum cutting depth] screen, for [Rotary Option], click [0] and make the setting for [Depth]. Next, click [180], for example, and set the depth for the second surface. Continue in this way to set the depth for all of the respective cutting surfaces. You can also change these values using the [Settings for Multiple-surface Cutting] wizard.



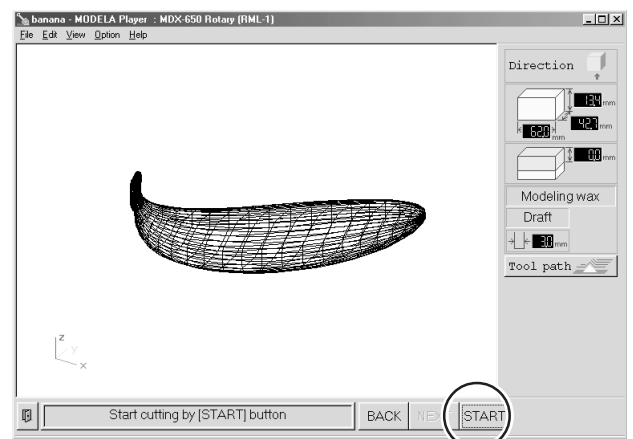
Click each [degree] and make the setting for [Depth].

**C)** The setting for [Finish] is not made here. It is made below, using the [Settings for Multiple-surface Cutting] wizard.



The setting for [Finish] is not made here.

**2** Click [Start] to display the [Settings for Multiple-surface Cutting] wizard.





## Step 3. Use the [Settings for Multiple-surface Cutting] Wizard

Using this wizard, you first select either two surfaces or four surfaces, then proceed with cutting in the sequence of 1) surfacing, 2) draft cutting, and 3) finishing. These three processes make up a single set. You cannot skip surfacing and proceed straight to draft cutting. Also, you cannot change from two surfaces to four surfaces or vice versa while the processes are in progress.

### Wizard Operation (1) - Surfacing Process

**1** Click either [Two surfaces] or [Four surfaces].

**2** Click [Surfacing], then click the [Next] button.

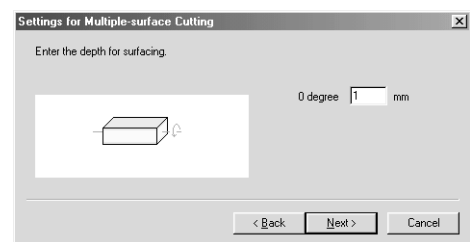
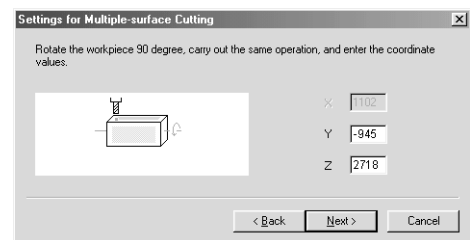
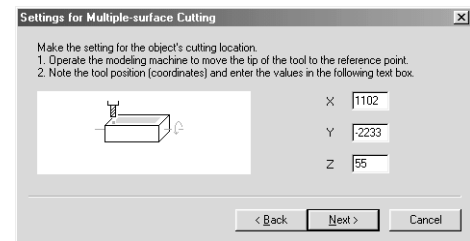
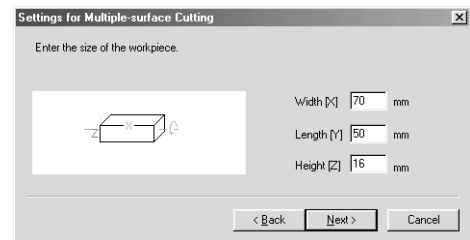
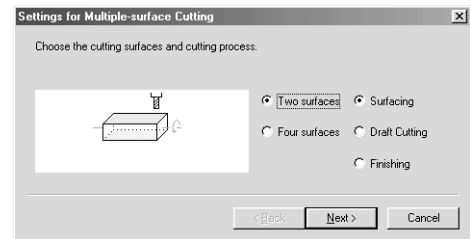
**3** Type in the cuttable dimensions of the workpiece, taking into account possible interference of the tool, workpiece retainer attachment, and so on. Take care to ensure that these values are not the size of the workpiece itself. If a value smaller than the object size (plus the tool diameter) is entered at this time, a message prompting you to enter a suitable value appears. Click [Next].

**4** Decide on the cutting-start location, taking into account tool interference and the like, and move the tool to the cutting-start location. Then note the X, Y, and Z coordinates displayed on the MDX-650 operation panel at this time and accurately type them into the wizard. Click [Next].

**5** If you selected [Four surfaces], the screen for entering the cutting-start location appears again. Accurately rotate the A axis 90 degrees in the positive direction, then use the same procedure as in step 4 to type in the cutting-start location for the third surface (Y and Z only). Click [Next].

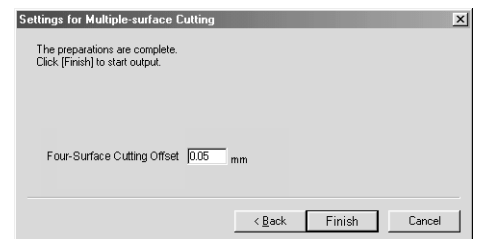
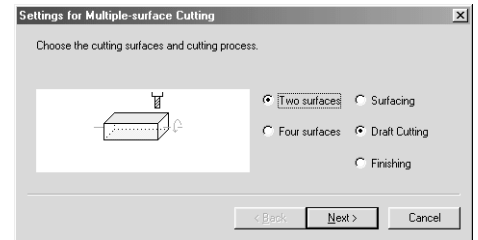
**6** If (and only if) you selected [Two surfaces], then type in the surfacing depth for the first surface (the surfacing depth for the second surface is calculated automatically). If the surfacing depth is not suitable and the cutting area extends beyond the workpiece, a message prompting you to enter a suitable value appears. Click [Next].  
If you selected [Four surfaces], calculation from the cutting-start location is made automatically, and so this screen does not appear.

**7** Click the [Finish] button. The surfacing data is output.



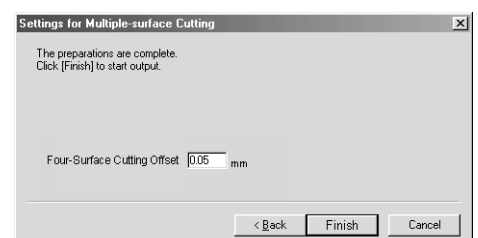
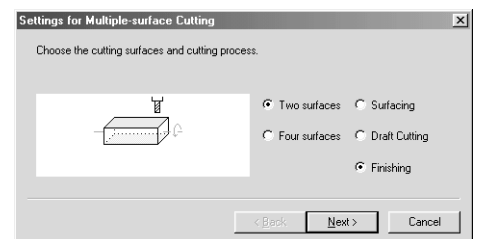
## Wizard Operation (2) - Draft Cutting Process

- 1 Follow the steps in "Setting the Cutting Parameters" in the previous section to make the settings for MODELA Player. (Do this, for example, when you want to use different tools for surfacing and draft cutting. When you're changing to a different tool, don't forget to execute the [Z CENTER MODE] on the MDX-650 again.) Click [Start] to display the [Settings for Multiple-surface Cutting] wizard. If there is no special need to change the settings, then you can simply just click [Start].
- 2 Click [Draft Cutting]. Here you cannot change from [Two surfaces] to [Four surfaces] or vice versa. Click [Next].
- 3 The screen for setting the maximum cutting depth appears. The setting values you entered for "Setting the Cutting Parameters" in the previous section are entered here, and you can change them here if necessary. If the values are too large and extend beyond the workpiece, a message prompting you to enter suitable values appears. Click [Next].
- 4 Click the [Finish] button. The data for draft cutting is output. If you're performing four-surface cutting, enter a value for [Four-surface cutting offset]. The default value is 0.05 mm. Make the set value larger if the finished results are poor.



## Wizard Operation (3) - Finishing Process

- 1 Follow the steps in "Setting the Cutting Parameters" to make the settings for MODELA Player. (Do this, for example, when you want to use different tools for draft cutting and finishing. When you're changing to a different tool, don't forget to execute the [Z CENTER MODE] on the MDX-650 again.) Click [Start] to display the [Settings for Multiple-surface Cutting] wizard. If there is no special need to change the settings, then you can simply just click [Start].
- 2 Click [Finishing]. Here you cannot change from [Two surfaces] to [Four surfaces] or vice versa. Click [Next].
- 3 The screen for setting the maximum cutting depth appears. The setting values you entered for "Setting the Cutting Parameters" in the previous section are entered here, and you can change them here if necessary. If the values are too large and extend beyond the workpiece, a message prompting you to enter suitable values appears. Click [Next].
- 4 Click the [Finish] button. The finishing data is output. If you're performing four-surface cutting, enter a value for [Four-surface cutting offset]. The default value is 0.05 mm. Make the set value larger if the finished results are poor.



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# Part 7 Appendix

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## 7-1. Maintenance

### Cleaning the ZCL-650

Wipe the ZCL-650 with a dry cloth.

### Cleaning After Use

After you have finished operations, use a vacuum cleaner to clean away any buildup of cuttings on the MDX-650 and the ZCL-650. If you're using the optional safety cover (ZBX-650), perform cleaning especially diligently. Buildup of cuttings between the safety cover and the rotary axis unit may cause the motor lock error.

For more information about cleaning the MDX-650, see "**MDX-650/500 User's Manual 1 (Setup & Maintenance)**" and refer to "**Part 2 Maintenance.**"

There is no need for you, the user, to perform such maintenance tasks for the ZCL-650 as lubrication.

### Service Life of the Reduction Gear

2000 hours of working time, or one year, whichever is shorter.

## 7-2. What to Do If...

### The ZCL-650 doesn't run.

If the ZCL-650 cable loose or disconnected? Connect it securely to the EXT.3 connector on the MDX-650.

### "EMERGENCY STOP MOTOR LOCK A" appears on the display.

This message appears when an excessive load is placed on the A axis during the cutting, or when the workpiece is too heavy, or when the moment of inertia is too much.

In this case, turn the power off and back on again. Change the cutting parameters so that the cutting load is lightened. Reduce the weight of the workpiece or the moment of inertia.

# 7-3. Specifications

## ZCL-650 Specifications

	ZCL-650
Supported workpieces	Resins such as chemical wood and modeling wax (metal not supported)
Maximum loadable workpiece size	Items within range of diameter 200 mm x width 410 mm (diameter 7-7/8 in. x width 16-1/8 in.)
Clamping method	Set-screw type (maximum clampable thickness of 50 mm (2 in.))
X-axis effective stroke	385 mm (15-1/8 in.)
Z-axis effective stroke	155 mm (6-1/16 in.)
Maximum angle of rotation	1,080 degrees (3 rotations)
Maximum speed	20 rpm
A-axis mechanical resolution	0.0027 degrees (2.3 μm with workpiece of 100 mm in diameter)
Static precision	Rotation backlash: 3 minutes Eccentricity: 0.3 mm (0.012 in.) or less
Height of center of rotation	123 mm (4.84 in.) from top surface of slider
Maximum workpiece weight	8 kg (17.6 lb.)
Maximum workpiece moment of inertia	0.02 kgm <sup>2</sup>
Unit weight	12 kg (26.5 lb.)
Unit external dimensions	725 (W) x 270 (D) x 170 (H) mm (28-9/16 (W) x 10-5/8 (D) x 6-11/16 (H) in.)
Control methods	4-axis control (3-axis simultaneous control)
Included items	Rotary axis unit, cable clamp, hexagonal wrenches (6 mm: 1, 3 mm: 1), Y-center detection pin (diameter 6 mm), screws: 4, cap screws: 4, washers: 4, spacers: 4, and slider retainer

## Attachment Base Dimensional Drawing

Drive Side

Support Side

