Shopbot CNC Zone SBU

Lesson 1: Introduction to the Shopbot CNC Router

A CNC router is a computer-controlled machine for cutting various hard materials, such as wood, *composites, plastics, and more.*

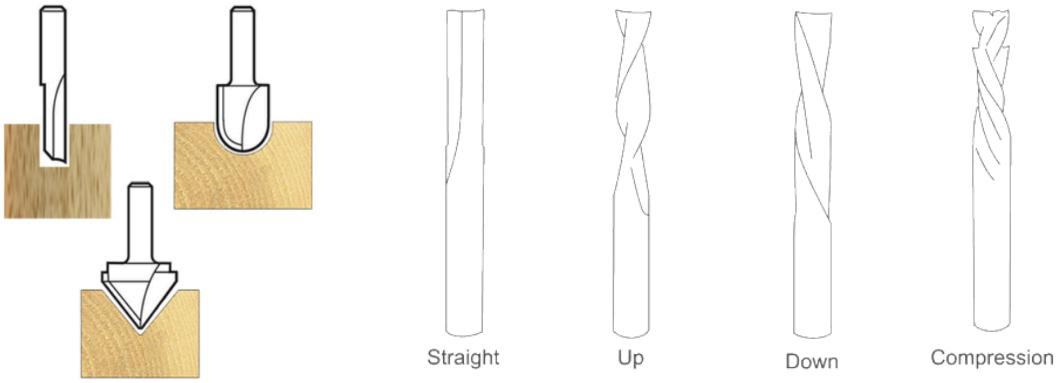
A router is normally a handheld power tool similar to an electric drill, except the ***bit*** is designed to move ***sideways*** through material in addition to moving up and down through materials while a drill bit is designed only to move up and down through materials, not sideways. On a CNC router, the router and the bit are moved around by motors on a large XYZ axis system similar to a laser cutter or 3D printer. The path that the router takes, called a ***toolpath***, is created with line drawings in a vector drawing program, similar to a laser cutter. The CNC can also carve 3D models. In this case, a 3D model is loaded into the software to create the toolpath.

Here is a basic description of the steps involved in operating the CNC Router.

1. Design is downloaded or created on a graphic design program such as CorelDraw or Adobe Illustrator for vector based designs or a 3D design program for 3D model based designs.
2. Design is imported into ***Partworks*** software, where it is turned into a toolpath file for the CNC machine.
3. Toolpath file is saved to the computer.
4. Material is placed on the CNC bed and attached firmly so it will not move during cutting.
5. Router bit is inserted into router.
6. The ***Shopbot3*** software is started on the computer.
7. Toolpath file is opened in Shopbot3 software.
8. Router and dust-collector are turned on.
9. Start Button on Shopbot3 software is pressed to begin cutting.

Lesson 2: Choosing a bit

Choose a bit that's specific to the job and material. Bit geometry determines its usefulness and purpose.



Profile - Bits are named by the shape of their cutting face. For example, the diagram above shows straight flute, ball nose, and v-carve bits.

Flutes –The Number of flutes refers to the number of cutting edges on body of the tool. More flutes increases the strength of the tool, but reduces space for chip evacuation. You can cut fast with a single flute tool, but the finish of the three flute will be smoother. CNC router bits are commonly available in 1, 2 and less commonly 3 flute configurations. There are 4 main types of flute patterns for router bits, plus many types of specialty bits.

a. **Straight Flute** – Straight bits have their cutting edges parallel to the body or shank of the bit. Good all around bit, decent chip removal.
b. **Up Cut** –The flutes on this type of spiral bit shear from the bottom up, pulling chips up.This clearing or cleaning action allows for deep cuts with less stress on the tool. The major disadvantage of this geometry is that the up-cut action can lift the part off the spoil board. Also, up cutting action can splinter the top face of veneered or other fragile materials.
c. **Down Cut**– The “down-cut” spiral bit flutes are designed to cut from the top surface down, leaving a smooth edge at the surface. It pushes down on the material being cut, and helps hold the material in place on the table surface. Some operators like this bit as it packs the sawdust in the groove being cut, which helps hold parts in position and helps maintain vacuum when that type of hold down system is used. Disadvantages are the packed sawdust is not removed by the dust collector and must be scraped or brushed off manually. Also this bit is not appropriate for thermoplastics as the "packing" of the dust re-welds the material together. When making "through cuts" the down cutting force can splinter the bottom face of veneered or other fragile materials. Poor chip removal, no tear out, slower feed rate.
d. **Compression** – Combination of up and down spiral Great all around bit, great for plywood or laminated sheet goods.

1. Select the appropriate bit for your job. There may be used bits available for you to use, however their quality is not guaranteed and you are advised to bring your own.
2. Tighten router ***collet*** to secure the bit in the router. (The collet is the threaded piece that holds the bit)

An internet search will reveal a huge array of bit suppliers. Here are some of our favorite online suppliers.

- www.cripedistributing.com
- www.ebay.com
- www.rockler.com
- www.mlcswoodworking.com
- www.woodcraft.com

- www.amazon.com
- www.onsrud.com
- www.jesada.com
- www.mscdirect.com
- www.vortextool.com
- www.woodpeck.com
- www.woodwork.com
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Lesson 3: Attaching Your Material

Using screws or the composite nail gun (which uses special plastic nails) or any other method, secure your material to the spoil board. The benefit of using composite nails is the reduced risk of damaging the router bit if you hit a nail.

For small pieces, one nail in each corner is sufficient. For large pieces or sheets, place nails every few feet. You want to make sure that your material is secure and that it isn't bowing up in the middle. Ideally, your material is perfectly level.

For oddly shaped pieces of material, you can build custom hold downs from 2 x 4's, plywood, etc. Just be sure that your toolpath isn't going to run your bit into any metal and that your toolpath will not run the body of the router into any material that is sticking up.

Lesson 4: Creating a Toolpath

We have Partworks available, which is a basic, easy-to-use design program for the Shopbot. If you wish to take it further there are a large variety of CAD/CAM programs to make 2D and 3D toolpaths including Autodesk 360 or Inventor, Solidworks etc. This SBU will describe the steps to make a toolpath from vectors in Partworks. Look for advanced courses for ***Shopbot 3d Toolpaths, Autodesk 360, Solidworks.***

1. Open Partworks -> Create new file -> Define material size and units. Select your desired zero (home) point. Choices are top right, top left, bottom right, bottom left, or center.
2. Create a design or import file. PartWorks can import the following file types: PDF, DXF, EPS (i.e. Adobe Illustrator and Corel Draw)
3. Make a Toolpath
    a. V-Carve: Requires a V bit. This type of tool path is used to produce a 3D effect, and is commonly used in sign making and typography.
    b. Profile: Profile machining is used to cut ***inside***, ***outside***, or ***on*** a vector. With optional tabs (places where the bit leaves some material) to ensure the project stays attached to the waste material.
    c. Pocket: This forms cavities in the material by carving out all the material inside an enclosed vector. These tool paths automatically compensate for the tool geometry - diameter and angle.
    d. Drilling: Drilling allows the centers of selected closed vectors to be drilled to a specified depth.
4. Select Depth
    a. Start Depth (D) specifies the depth at which the tool path is calculated, allowing a toolpath to be machined inside a pocket region.
    b. Cut Depth (C) is the depth of the pocket or profile tool path relative to the Start Depth.
5. Select Tool. V-Bit, End mill, and Ball nose are supported and the toolpaths will automatically compensate for the geometry of the selected tool. Next, input the following:
    a. Step Down: The distance in the z direction per pass that the bit plunges into the material. This should not exceed the radius of the bit.

    b. Step Over: The distance in the x/y direction that the bit removes with each pass. This should also be no more than the bit's radius.
    c. Spindle Speed: The rotational speed of the cutting tool. This is adjusted on the router dial.
    d. Feed Rate: The lateral speed of the bit moving across the material. Start slow, at 1 or 2 inches per second. Depending on the material density, you can adjust the speed to be faster or slower if necessary.
    e. Plunge Rate: The vertical speed of the cutting tool moving down into the material. Try 0.5 or 1 inches per second.
6. Save the tool path (.sbp file)
7. Save the project (.crv file)

Lesson 5: Zeroing the Bit to the Table

1. Turn on the power to the Shopbot Motor Driver Box then on the PC, open Shopbot 3 software(SB3 on the desktop, toolbar or start menu).
2. Type "K" to open the keyboard control window. Use the up, down, left, right arrow keys to move laterally, and page up/page down to move vertically, then move the bit to your desired zero (home) point (usually the bottom left corner of your material). You can adjust the move speed for fine control when zeroing by clicking *[M]oves* > *move [S]peeds* in the SB3 window, or typing "MS".
3. Next, select *[Z]ero -> zero [2]* or type "Z2". The bit is now zeroed along the X and Y axis to its current position. Confirm that the bit's position is now "0.000"on both the "X" and "Y" axis in the red window.
4. To zero the Z axis, use the Z-axis Zero plate that's located along the Y gantry. Connect the alligator clip to the bit or collet. To test the connection, tap the plate to the bottom of the bit. On the Shopbot window, a green light under "Input 1" will illuminate. This indicates that the connection is complete and you are ready to run the zeroing sequence. Next, place the plate under the bit. In the main window, select *[C]uts* > *C2 - Zero Z Axis w/ Zzero Plate*, or type "C2". The bit will move down to touch the plate, move back up, then repeat the motion more slowly for a second reading. The bit is now zeroed to the top of the material, accounting for the thickness of the plate. Confirm that the bit's position is now "0.000"on the "Z" axis in the red window.
5. REMOVE THE ALLIGATOR CLIP AND PLATE, and replace in its home along the gantry.

Lesson 6: Running a Toolpath

1. In SB3 software: Select File -> choose the toolpath file that you created in Partworks.
2. Click "OK".
3. Turn on dust collector.
4. Set speed on router by adjusting the speed dial on the top of the router. Speeds settings are based on bit/material. 12,000 rpm is a good starting speed for most wood.
5. Turn on router with red switch on top of router.
6. Make sure all objects and persons are clear of the machine. Remove all objects from the table.
7. Click start on screen (job will begin cutting).

Helpful Keystrokes

- **K-** enter keyboard mode.
- **MX, MY, MX-** move with respect to zero position, input distance then press enter. Ex- "MX, 2" will put you 2 inches to the right of your zero position.
- **MH-** move home.
- **JH-** jog home. Differs from move, you can input different speeds for each.
- **ZX, ZY, ZZ, Z2, Z3-** zero each axis, respectively. Z2 zeroes X and Y, Z3 zeroes all axes.
- **C2-** zero Z axis with Z zero plate. Attach alligator clip to bit, place z zero plate under bit, press enter.

Lesson 8: Stopping the CNC
In Case of Emergency

There are two emergency stop buttons:

1. You can press spacebar on the keyboard
2. You can click pause with the mouse

Lesson 8:Shopbot CNC Safety

Before using the shopbot, please be sure you understand the following rules to prevent injury to yourself, others, the machine, or the building.

- Wear protective gear including eye protection, ear protection and closed toe shoes.

- Keep eyes, hands, hair and clothing away from the ShopBot and router when it is operating. Tie long hair back. Avoid loosely-fitting clothing and remove dangling jewelry. Do not use your hands to hold down parts that may come loose as they are cut out.

- Read and follow the safety information for the router, bits and other accessories. Unplug or shut down power to the router or spindle when changing bits.

- Listen for changes in sound that may indicate a problem while running the tool. ALWAYS be near enough to the Space Bar on the computer keyboard to be able to stop the gantries should a problem arise.

- Use a bit that is appropriate to the task. Most bit manufacturing companies have information on their website and in their literature about what kind of bit is appropriate for what application.

    - Buy good quality bits and take care of them. Inspect your bits for wear, burning, dullness and cracks each time you use them. Replace them if they are not in good condition.
    - Choose bit with the largest shank and the shortest bit length to fit the task to avoid excessive bit deflection and stress.
    - Follow the manufacturer's recommendations for move speed through the material and rpm for the router, as well as for the configuration of the bit (for example, number of flutes, upcut, downcut, straight)
    - Never cut deeper than the radius of the bit in a single pass. Not only will two passes make a cleaner cut but a shallower cut will cause less bit deflection and danger of breakage.

- Check your collets frequently. Collets do wear out, and a loose collet can result in greater deflection which equals poorer quality cuts and greater chance of breakage.

- Avoid unsafe holddown practices that can shatter a bit or allow parts to move during cutting. Composite nails will not shatter a bit.

- Create cutting files that avoid small parts flying out when being cut.

    - If you are clearing a small part (for example, a circle) that will become waste, spiral from the inside out so that you are machining away the waste as you cut. Flying pieces released from their substrate can get caught in the dust collection system or become effective shrapnel.
    - Plan your toolpaths so that you cut out details and small parts before cutting out the big parts. For example, if you wanted to cut out a rectangular serving tray with a circle pocketed or cut out to hold a drink glass, design the file to cut out or pocket the circle first, then cut out the larger rectangle. That will reduce the problems with holding down small parts while machining them.

- Make the production routine as safe as you can for you and the people around you. Make sure that everyone understands the safety rules. Emphasize that hands are to be kept away from the router and ShopBot while it is running.