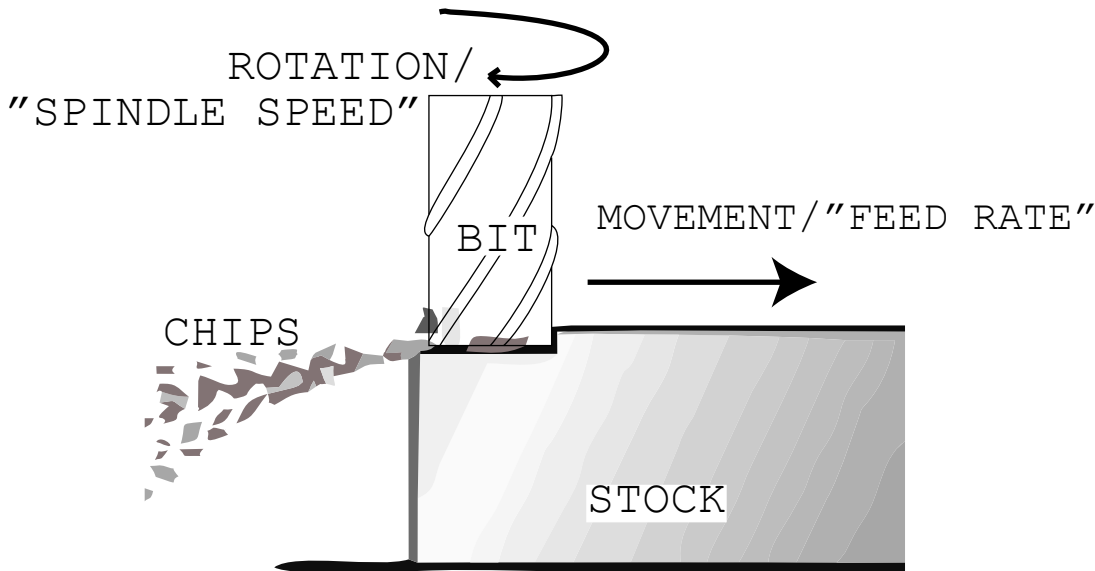


# ShopBot CNC Router Intro

by Mollye Bendell

## General Key Terms and Concepts

### Milling



the machining process of using rotary cutters to remove material from a workpiece feeding in a direction at an angle to the tool

i.e

spinning tool moves through material, carving into desired shape

### CAD



“Computer Aided Design”

the use of computer programs to create two- or three-dimensional (2D or 3D) graphical representations of physical objects

i.e.

Illustrator  
123D Design  
Rhinoceros  
Aspire (ShopBot)

### CAM



“Computer Aided Manufacturing”

the use of computer software to control machine tools and related machinery

i.e.

Aspire (ShopBot)  
RhinoCAM  
MasterCAM

### GCode

Programming language that directs the tool where (X, Y & Z) and how to move.

### Feeds & Speeds

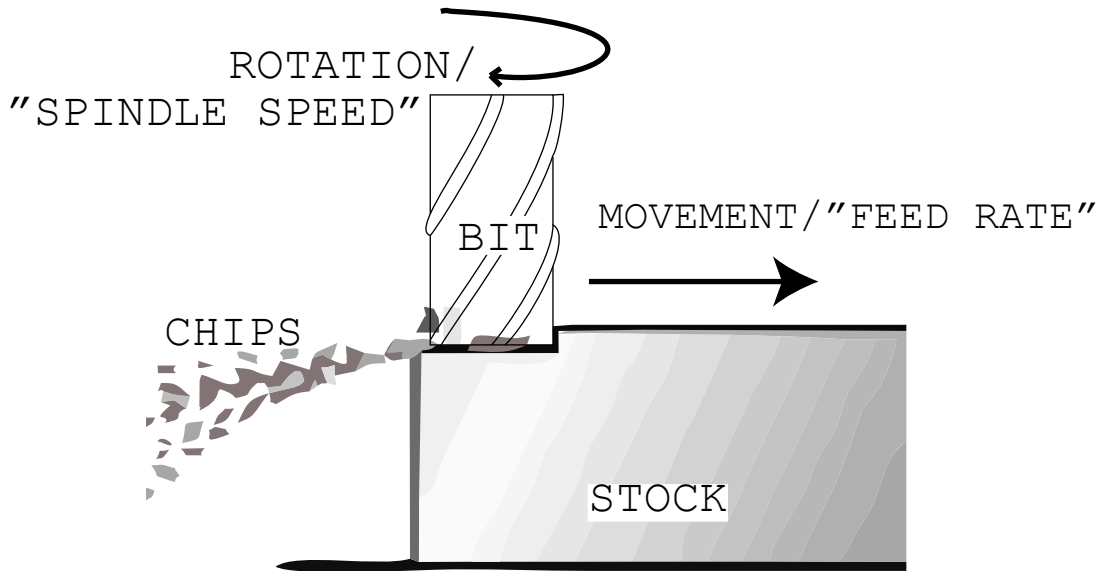
Describes the relationship between the speed with which the tool moves through the material (feed rate) and the RPM of the tool (spindle speed). Ideal balance between the feed and speed extends the life of your tool and gives the best finish on your part. Feeds and speeds are calculated by measuring the size of the chip (see "Chip Load")

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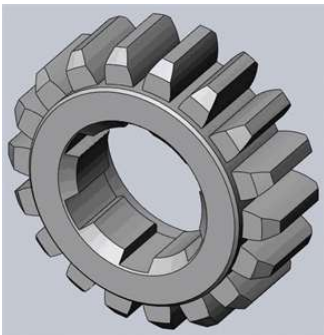


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# Types of CNC Machine

## 3 axis (ours)

- X, Y & Z motion
- Top down

## 5 axis

- X, Y, Z, A & B Motion
- undercuts possible

## Mini Mill

- precision milling for smaller parts
- printed circuit boards and mills

## CNC Lathe

- stock turns as tool mills

## Waterjet

- abrasive garnet waterjet instead of a bit
- more expensive, higher waste, broader range of materials

Machines that Make <http://mtm.cba.mit.edu/>

# Flexures/kerf cuts

Like a "living hinge" on the laser cutter, flexure cuts increase the surface area of the material enough that it becomes flexible. The compression of the cuts gives strength to the joint.



# Chip Load

What is "chip load"? The physical size of the chip is the "chip load." Chip size is an indicator of the balance between spindle speed and feed rate. If the spindle spins too fast for the feed, the chips are smaller and the friction heats the tool, causing it to wear out faster and potentially scorching or igniting your material. If the tool feeds through the material too fast for the spindle, the chips are too big for the flutes, causing poor finish, tear out, and bit breakage. A Chip Load Chart shows appropriate loads for your tool and material.

# Stock

Do not expect blood from a stone! The better your material, the better your finish.

## Wood

- Normal - pine, maple, poplar, oak, etc ,etc
- OSB (oriented strand board) cheap wood composite you see in subflooring
- MDF (medium density fiberboard) no grain but dulls tooling faster, potentially harmful dust, heavy

## Plastic

- acrylic, lexan, polycarbonate, hdpe, corian, PVC
- many plastics with poor finish on a laser have better finish when machined

## Foam

- HDU (High Density Urethane) precise finish, weather resistant, professional grade, expensive
- rigid insulation - stiff foam board in big sheets at the hardware store, cheap, acceptable finish for some applications

## Soft Metals

- Aluminum, copper, brass, zinc
- ShopBot *can* handle metals but is not *built* for metals. Do your research and buy your own bits if you are intending to machine metal on the ShopBot.

# Fixturing

## Screws

- most common way to secure material to bed
- you must accomodate screws in your design
- if the bit hits the screw, you will break it!

## Clamps

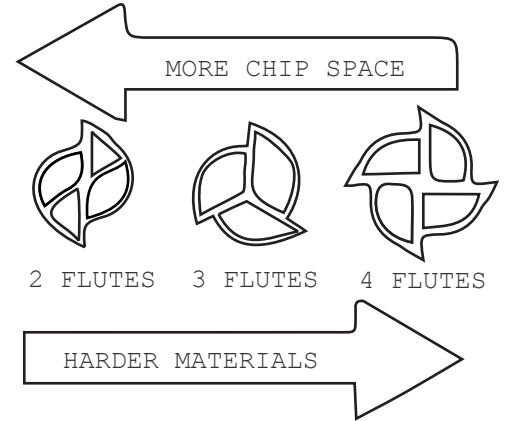
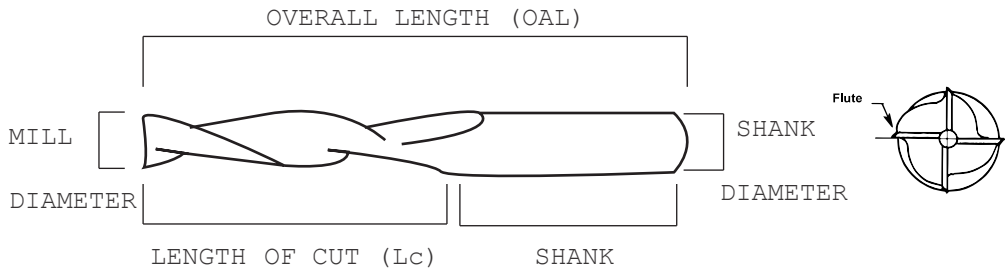
- won't mark material but more challenging to "steer" around

## Adhesives

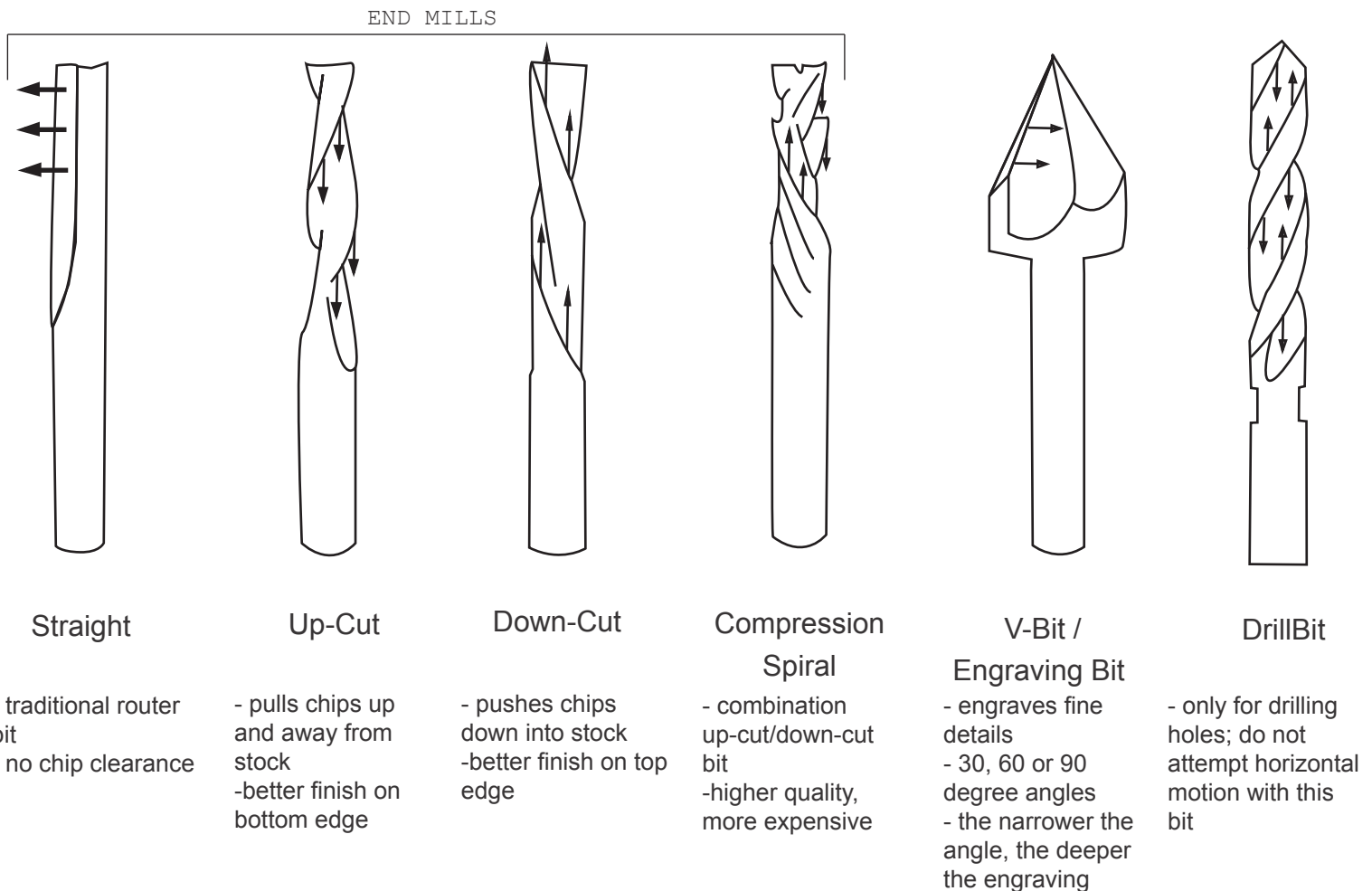
- lightweight materials can be attached to a non-porous spoilboard with double-sided tape, then the spoilboard can be screwed into the bed
- risk bowing your material when you detach

# Tooling

## Router Bit Anatomy



## Common Tooling Geometries



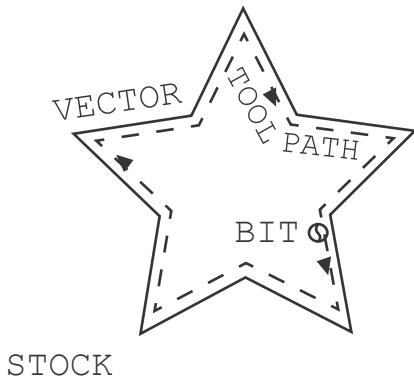
arrows indicate cutting edge

# File Design

## Toolpaths

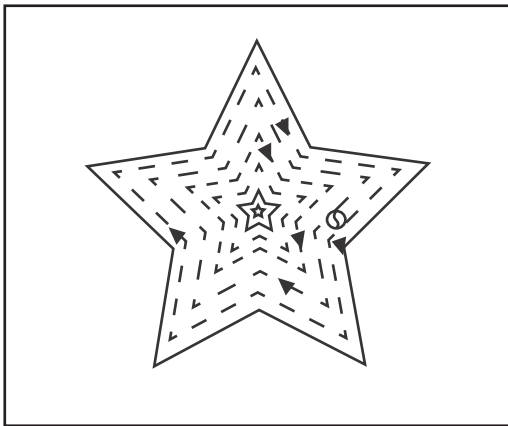
(the path the tool is taking as it moves through your material)

Profile Toolpath



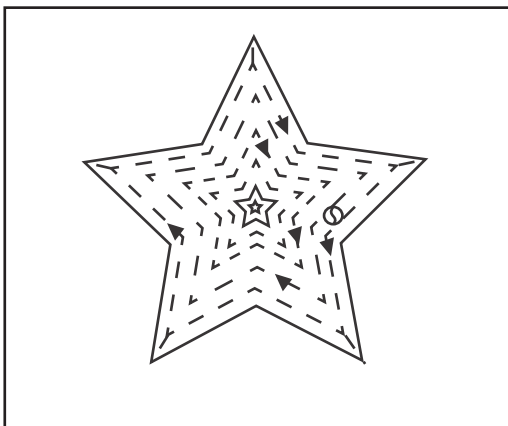
- bit removes material outside, inside, or on the vector at a specified depth
- outside or inside allows the router to compensate for the width of the bit

Pocket Toolpath



- bit removes material from within the shape of the vector at a specified depth

Engraving Toolpath



- end mill tool pockets large, flat areas of the vector
- engraving tool goes back around the inside edges of the vectors to create sharp corners and fill in other contours too thin for the end mill to reach

# ShopBot Workflow

## 1. MATERIAL SECURED TO THE BED

- ensure your material is secured to a spoilboard, and the spoilboard secured to the bed.
- double-check that the tool will not hit any fixtures, keeping in mind the width of the tool.

## 2. CORRECT TOOL IN THE SPINDLE

- pop the spring collet into the collet nut, then insert the bit. fluted bits should leave at least 0.125" between the flutes and the collet to avoid kicking dust back into the machine.
- thread the collet assembly onto the spindle; hand-tighten, then use wrenches fully secure.
- do not over-tighten, you need to be able to get the bit back out of the spindle when you're finished.

## 3. X & Y ZEROED

- in the ShopBot command line, type (K) to bring up the keyboard controls and use the arrow keys to drive the ShopBot to the origin point of your material (bottom-left).
- press (ESC) to exit the keyboard controls and type (Z2) to (z)ero on (2) axes (X & Y).
- to test this, drive the ShopBot somewhere else and type (JH) to (j)og the ShopBot (h)ome. it will pick up and move back to your zero point.

## 4. Z ZEROED

- drive the ShopBot over your material away from any bowing or warped areas
- remove the metal plate from the housing on the side of the spindle and touch it to the bit to test for conductivity - the Input 1 light on the console will light up if the ShopBot recognizes the plate.
- do NOT attempt to run the Auto-Z Zero routine if Input 1 does not light up green.
- place the plate on the stock under the bit and type (C2) to run the Auto-Z Zero routine. The bit will lower, kiss the plate, pull up, and come down more slowly for a more precise measurement.

## 5. CHIPLOAD CALCULATED

- in the ShopBot console, go to Tools > Chip Load Calculator. Enter in two parameters and solve for the third parameter. For example, if you want to move 3 IPS through wood with a Chip Load of 0.012", you will solve for the spindle speed. Change the spindle speed on the side of the ShopBot.

## 6. RUN FILE - YAY!

- File > Part File Load. Click "Start." Make sure dust collector is on, and press the green "start" button to start the spindle when prompted by the software.

# ShopBot Safety

## DO NOT:

- lean on the rails
- go anywhere near the bit when it's moving
- attempt to move/touch/vacuum your material while the spindle is running
- wear loose clothing or jewelry
- attempt to lift heavy pieces by yourself

## DO:

- ask for help if you need it no matter what the situation
- have someone double-check your toolpaths the first couple of times you use the ShopBot
- make sure your bit is secure in the collet
- be within arms reach of an emergency stop at all times while the spindle is running
- wear safety glasses and closed-toed shoes