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Feeds and Speeds Charts

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Introduction

A challenge of getting a good CNC cut is in selecting the best cutting speed (feed rate) and router/spindle RPM (speed of rotation). Feeds and speeds are a critical part of machining and should be fully understood before deviating from recommended settings. A primary concern of machining is chip load, which is a representation of the size of the chips produced during cutting. The goal is to get the maximum chip load possible to increase productivity, reduce heat, and prevent premature dulling. When chip load is too small, bits will get too hot and dull quicker. When chip load is too high, the tool will deflect creating a bad surface finish and, in extreme cases, chip or break the bit.

Chip load is a function of three different parameters: feed rate, RPM, and number of flutes on the tool.

Chip load is the thickness of the chunk of material taken by a tooth of the cutter. This is determined by how fast the cutter is moving forward into the material and how fast it is turning (Chip load = Feed Rate / [RPM x number of flutes]). This formula provides a starting point for determining the most suitable parameters for any cutting situation.

A ShopBot tool has either a router or a spindle. The advantage of a spindle is that speed can be very precisely controlled. This allows for optimization of cuts. A router does not have a precise speed controller, so the actual speed of the router is directly correlated to the depth of cut, material, and feed rate. For routers, these numbers will be a starting point, but will have to be adjusted for real life conditions. This is necessary because routers tend to run lower than the setting on the router indicates; settings should be recorded as they will work for similar cuts in similar material. It is recommended to start with low numbers to ensure it is within an acceptable range for the tool.

There is considerable overlap in the range of parameters; it will be necessary to test in this range for the best speed selection for a particular cutting or machining operation. Below is the strategy that bit manufacturer Onsrud suggests. This works particularly well for routers.

Optimizing feed rates and speeds:

1. Start off using an RPM derived for the chip load for the material being cut (see charts).
2. Increase the cutting speed (feed rate) until the quality of the part's finish starts to decrease or the part is starting to move from hold downs. Then decrease speed by 10%.
3. Decrease RPM until finish deteriorates, then bring RPM back up until finish is acceptable.
4. This optimizes RPM and speed to remove the largest possible chips.

To reduce the amount of work needed, a range of feeds and speeds is provided to start at (step 1 above). To increase performance, optimize feeds and speeds as detailed above. If there are any surface finish problems, adjust until performance is acceptable. If there are a lot of work holding issues, it may be necessary to revisit the hold down method to ensure it is adequate.

Manufacturer settings for bits

Most manufacturers provide optimal speeds and feeds for their bits. There are numerous calculators available online that can provide rough numbers. These calculators should work fine, but may not be optimized for each particular bit. The manufacturer will still be the best resource, as most reputable companies have information and live support available to help users of their tools utilize them properly. ShopBot recommends Onsrud tools.

If doing production work in a certain type of material, it would be best to purchase a bit made for that type of cutting. If performing a number of different materials, then a more general bit could be used.

http://www.onsrud.com/xdoc/FeedSpeeds

Chip Load = per cutting edge.

IPS = Inches Per Second.

IPM = Inches Per Minute.

RPM = Revolutions Per Minute.

# of cutting edges = # of flutes.*

*typically true unless stated otherwise by manufacturer.

Chip Load = Feed Rate (IPM) / (RPM x # of cutting edges)

Feed Rate (IPM) = RPM x # of cutting edges x Chip Load

Speed (RPM) = Feed Rate (IPM) / (# of cutting edges x Chip Load)

IPM = IPS x 60

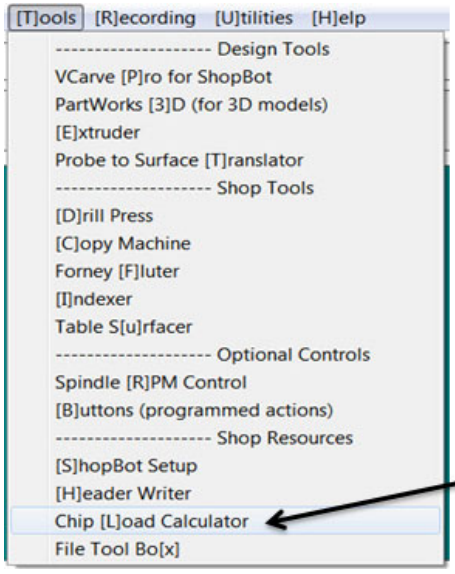
Depth of cut: A function of cutting edge diameter set by manufacturer.

Onsrud bits are typically allowed a cut depth per pass equal to the cutting edge diameter unless otherwise specified. For a deeper cut, it will be necessary to reduce the chip load. For twice the depth of cut, reduce the chip load per tooth by 25% and for triple the depth of cut, reduce the chip load by 50%. If doing this, it will be necessary to calculate the feed rate and speed instead of using the chart.

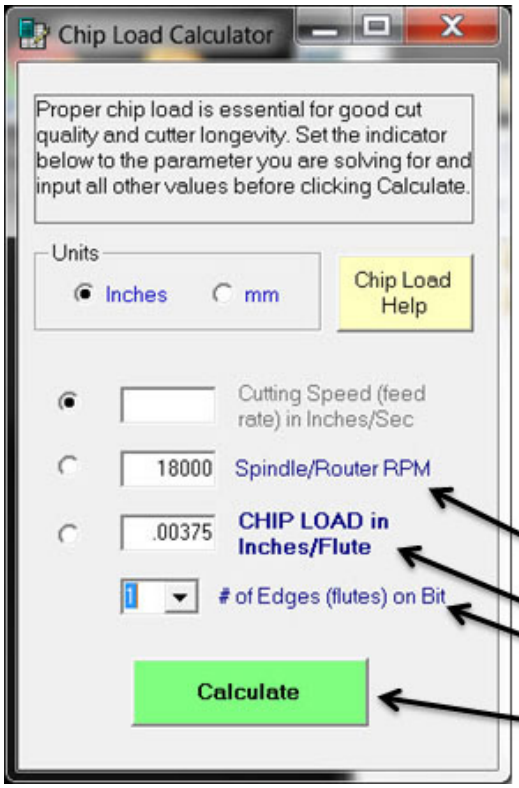
Example using a 1/4” or 0.125” bit – Straight V Carbide Tipped Endmill SB# 13642:

This bit is used for soft wood, at a depth of 1/2” (two times the diameter). The chart cannot be used for this calculation. Start with the middle of the range of recommended chip load provided on the chart ((.006+.004)/2=.005). Reduce that by 25% to allow for the deeper cutting depth (0.75x0.005=0.00375). Assuming that cutting will be performed at an RPM of 18,000 and that this tool only has one flute. Let’s use the ShopBot 3 “Chip Load Calculator” to decide what value to start with.

Chip load calculator



The “Chip Load Calculator” comes included in the ShopBot 3 software. It can be accessed by going to Tools > Chip Load Calculator (TL).

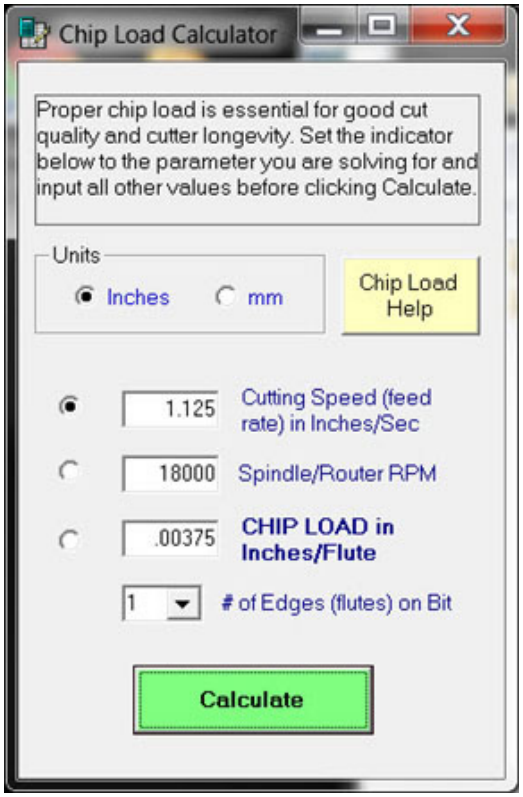


In the previous example values were provided to calculate the feed rate.

RPM: 18,000

Chip load: 0.00375, Depth of cut: 2 x Diameter = 1/2”
Flutes: 1

Enter these into the calculator and click “Calculate.”



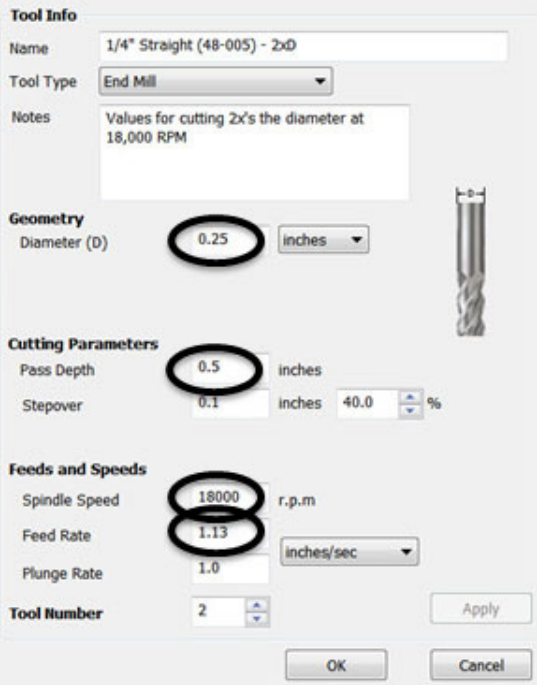
This now provides the values needed to create an entry into the tool database in VCarve Pro.

Diameter: 0.25”

Pass depth: 0.5”

Spindle speed: 18000 RPM

Feed rate: 1.125 inches/sec



The data is now available to input into the CAM software. The tool info sheet for VCarve Pro is shown.

Feeds and speeds charts

These charts have been taken from Onsrud's recommendations and calculated in order to save time for the bits provided in the ShopBot bit kit. For further information, Onsrud series numbers are provided. ShopBot numbers are also provided for an easier, streamlined ordering experience. Onsrud provided numbers are cut depths, chip loads, and flutes. The exception to this rule is the "Carbide Tipped Surfacing Cutter" which has all values provided by Onsrud. Any tools with no values provided are not listed by Onsrud, but if they are contacted about a specific use, they may provide some base numbers from which to calculate.

The "Chip Load Calculator" in ShopBot 3 was utilized with a starting RPM of 18,000 on all tools to find the calculated feed rate. Any deviations from provided numbers should be verified and adjusted through recalculation in ShopBot 3 "Chip Load Calculator."

Soft wood

Name	SB#	Onsrud Series	Cut	Chip Load per leading edge	Flutes	Feed Rate (ips)	Feed rate (ipm)	RPM	Max Cut
1" 60 degree Carbide V cutter	13648	37-82	1 x D	.004-.006	2	2.4-3.6		18,000	
1/4" Straight V Carbide Tipped End Mill	13642	48-005	n/a	n/a	1	n/a	n/a	n/a	
1/2" Straight V Carbide Tipped End Mill	13564	48-072	n/a	n/a	2	n/a	n/a	n/a	
1/4" Upcut Carbide End Mill	13528	52-910	1 x D	.007-.009	2	4.2-5.4		18,000	
1/4" Downcut Carbide End Mill	13507	57-910	1 x D	.007-.009	2	4.2-5.4		18,000	
1/4" Upcut Carbide End Mill	1108	65-025	1 x D	.004-.006	1	1.2-1.8		18,000	
1/8" Tapered Carbide Upcut Ball End Mill	13636	77-102	1 x D	.003-.005	2	1.8-3.0		18,000	
1-1/4" Carbide Tipped Surfacing Cutter	13555	91-000	1/2-3/4 x D		2		200-600	12,000-16,000	1/8"

Hard wood

Name	SB#	Onsrud Series	Cut	Chip Load per leading edge	Flutes	Feed Rate (ips)	Feed rate (ipm)	RPM	Max Cut
1” 60 degree Carbide V cutter	13648	37-82	1 x D	.004-.006	2	2.4-3.6		18,000	
1/4” Straight V Carbide Tipped End Mill	13642	48-005	1 x D	.005-.007	1	1.5-2.1	90-126	18,000	
1/2” Straight V Carbide Tipped End Mill	13564	48-072	1 x D	.006-.008	2	3.6-4.8		18,000	
1/4” Upcut Carbide End Mill	13528	52-910	1 x D	.006-.008	2	3.6-4.8		18,000	
1/4” Downcut Carbide End Mill	13507	57-910	1 x D	.005-.007	2	3.0-4.2		18,000	
1/4” Upcut Carbide End Mill	1108	65-025	1 x D	.004-.006	1	1.2-1.8		18,000	
1/8” Tapered Carbide Upcut Ball End Mill	13636	77-102	1 x D	.003-.005	2	1.8-3.0		18,000	
1-1/4” Carbide Tipped Surfacing Cutter	13555	91-000	1/2-3/4 x D		2		200-600	12,000-16,000	1/8"

Medium Density Fiberboard (MDF)

Name	SB#	Onsrud Series	Cut	Chip Load per leading edge	Flutes	Feed Rate (ips)	Feed rate (ipm)	RPM	Max Cut
1” 60 degree Carbide V cutter	13648	37-82	1 x D	.004-.006	2	2.4-3.6		18,000	
1/4” Straight V Carbide Tipped End Mill	13642	48-005	1 x D	.005-.007	1	1.5-2.1	90-126	18,000	
1/2” Straight V Carbide Tipped End Mill	13564	48-072	1 x D	.005-.007	2	3.0-4.2	**180-252**	18,000	
1/4” Upcut Carbide End Mill	13528	52-910	1 x D	.006-.008	2	3.6-4.8		18,000	
1/4” Downcut Carbide End Mill	13507	57-910	1 x D	.006-.008	2	3.6-4.8		18,000	
1/4” Upcut Carbide End Mill	1108	65-025	1 x D	.004-.006	1	1.2-1.8		18,000	
1/8” Tapered Carbide Upcut Ball End Mill	13636	77-102	1 x D	.003-.005	2	1.8-3.0		18,000	
1-1/4” Carbide Tipped Surfacing Cutter	13555	91-000	1/2-3/4 x D		2		200-600	12,000-16,000	1/8"

Soft Plywood

Name	SB#	Onsrud Series	Cut	Chip Load per leading edge	Flutes	Feed Rate (ips)	Feed rate (ipm)	RPM	Max Cut
1” 60 degree Carbide V cutter	13648	37-82	1 x D	.004-.006	2	2.4-3.6		18,000	
1/4” Straight V Carbide Tipped End Mill	13642	48-005	1 x D	.005-.007	1	1.5-2.1	90-126	18,000	
1/2” Straight V Carbide Tipped End Mill	13564	48-072	1 x D	.007-.009	2	4.2-5.4		18,000	
1/4” Upcut Carbide End Mill	13528	52-910	n/a	n/a	2	n/a	n/a	n/a	n/a
1/4” Downcut Carbide End Mill	13507	57-910	n/a	n/a	2	n/a	n/a	n/a	n/a
1/4” Upcut Carbide End Mill	1108	65-025	1 x D	.004-.006	1	1.2-1.8		18,000	
1/8” Tapered Carbide Upcut Ball End Mill	13636	77-102	n/a	n/a	2	n/a	n/a	n/a	n/a
1-1/4” Carbide Tipped Surfacing Cutter	13555	91-000	1/2-3/4 x D		2		200-600	12,000-16,000	1/8"

Laminated Chipboard

Name	SB#	Onsrud Series	Cut	Chip Load per leading edge	Flutes	Feed Rate (ips)	Feed rate (ipm)	RPM	Max Cut
1” 60 degree Carbide V cutter	13648	37-82	1 x D	.004-.006	2	2.4-3.6		18,000	
1/4” Straight V Carbide Tipped End Mill	13642	48-005	1 x D	.006-.008	1	1.8-2.4		18,000	
1/2” Straight V Carbide Tipped End Mill	13564	48-072	1 x D	.008-.010	2	4.8-6.0		18,000	
1/4” Upcut Carbide End Mill	13528	52-910	n/a	n/a	2	n/a	n/a	n/a	n/a
1/4” Downcut Carbide End Mill	13507	57-910	n/a	n/a	2	n/a	n/a	n/a	n/a
1/4” Upcut Carbide End Mill	1108	65-025	n/a	n/a	1	n/a	n/a	n/a	n/a
1/8” Tapered Carbide Upcut Ball End Mill	13636	77-102	n/a	n/a	2	n/a	n/a	n/a	n/a
1-1/4” Carbide Tipped Surfacing Cutter	13555	91-000	1/2-3/4 x D		2		200-600	12,000-16,000	1/8"

Laminated Plywood

Name	SB#	Onsrud Series	Cut	Chip Load per leading edge	Flutes	Feed Rate (ips)	Feed rate (ipm)	RPM	Max Cut
1” 60 degree Carbide V cutter	13648	37-82	1 x D	.004-.006	2	2.4-3.6		18,000	
1/4” Straight V Carbide Tipped End Mill	13642	48-005	1 x D	.005-.007	1	1.5-2.1		18,000	
1/2” Straight V Carbide Tipped End Mill	13564	48-072	1 x D	.007-.009	2			18,000	
1/4” Upcut Carbide End Mill	13528	52-910	n/a	n/a	2	n/a	n/a	n/a	n/a
1/4” Downcut Carbide End Mill	13507	57-910	n/a	n/a	2	n/a	n/a	n/a	n/a
1/4” Upcut Carbide End Mill	1108	65-025	n/a	n/a	1	n/a	n/a	n/a	n/a
1/8” Tapered Carbide Upcut Ball End Mill	13636	77-102	1 x D	.003-.005	2	1.8-3.0		18,000	
1-1/4” Carbide Tipped Surfacing Cutter	13555	91-000	1/2-3/4 x D		2		200-600	12,000-16,000	1/8"