ROUTING ALUMINUM

There are many types of aluminum's in two basic conditions. The conditions have more effect on the routing cuts than the types. The conditions are treated, which is hard, and untreated/annealed, which is soft. The hard material forms chips which can be routed much easier than the soft material.

The condition is noted on all materials from the manufacturer i.e. 6061 T-6 or 2024 O. If this is missing from the raw material, a simple bend test will indicate the type. If the material bends like solder, it is probably soft. If the material is difficult to form a bend and tends to spring back, it is likely hard. The common types and the difference in hardness are noted in the chart. Note the hardness can be two to three times the soft condition as compared to the hard in most of the types shown. A good comparison of the two conditions is that they are similar to wood and plastics. Wood has the soft pliable – popular, cedar, pine, cottonwoods, versus the much harder rigid – oak, maple, hickory, teaks. Plastics are split into the soft flexible – ABS, PVC, polyethylene, polypropylene, UMHW, versus the harder rigid – acrylic, nylon, delrins.

ALUMINUM ALLOYS

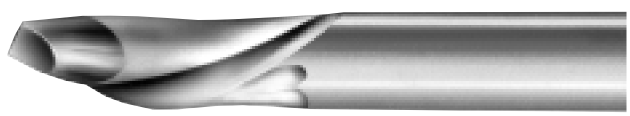
- ALUMINUM HARDNESS CAN VERY WIDELY BECAUSE OF DIFFERENCES IN TEMPER.
- HARDER IS EASIER TO MACHINE.

GENERAL RULE OF THUMB:
0 = Fully Annealed (soft)
Hxx = Strain Hardened (medium)
Tx = Solution Treated (hard)

ALLOY	BRINELL TEMPER	HARDNESS
3003	0	28
3003	H18	55
5052	0	47
5052	H34	68
5052	H38	77
2024	0	47
2024	T3, T4	120
6061	0	30
6061	T6	95
6063	T0	25
6063	T6	73
7075	0	60
7075	T6	150

Traditionally, high-speed steel (HSS) tools in spiral flutes have been used in routing aluminum for over 60 years. This tool material was used because it can carry a very sharp edge and is very tough. Most applications were hand fed or hand controlled and the other materials such as solid carbide (SC) were too brittle to be used in these operations. The advent of more advanced CNC routers, which have very good control of the feed has created more uses for the more refined SC tools. The newer SC tools have sharper stronger edges and are more shock resistant than earlier SC types.

As a general rule of thumb, most aluminum applications are covered by the use of HSS spirals in hand and older CNC applications, SC spirals in more advanced CNC applications, single edge tools for "O" condition aluminum and double edge tools for "T" condition aluminum.



AIR HAND ROUTERS

Most applications with these routers can be tied to material thickness. See the chart for typical loadings and selections. All the tools are downcut because upcut tools will pull the chips into the support bearing in the nose of the router guide and ruin it. Single edge tools are very aggressive and can be used with multiple flute SC tools in a secondary pass for part edge finishes that will be smoother than 125 rms. This can be a key issue for a part that will be formed after routing because the rough edge may propagate cracks during the forming process.

Double edge tools will be more stable in the cut because there is always one flute in contact with the part. They will yield a smoother finish in a single pass.

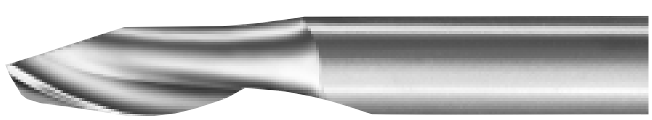
Cutting speeds of the tools are directly related to the tool diameter. A .125" tool will require about twice the spindle speed for the cutting edge to be as effective in shearing the chip from the part as a .250" tool. Note the spindle speeds in the chart.

AIR ROUTER CHART

PART THICKNESS, IN.	TOOL DIAMETER, IN.	SPINDLE SPEED, RPM	HORSEPOWER MIN.
.060	.125	30,000	.3
.090	.188	23,000	.6
.188	.250	18,000	.9
.375	.375	14,000	1.5

Note: Cutting material above .375 by hand is not recommended

ELECTRIC HANDROUTERS



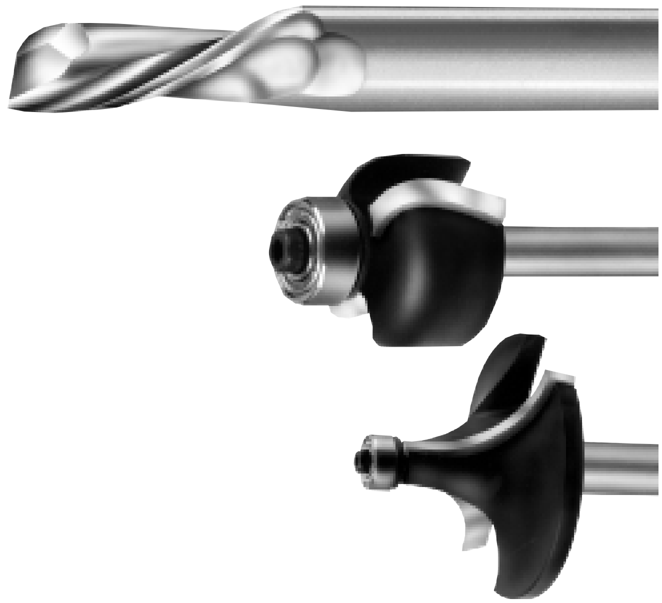
The upcut is used to stabilize and force the part to bottom of the router. Since the chip has an exit path on the top of the part unlike the air router, it can clear itself from the cut path. See the chart under air routers for suggested parameters.

PINROUTERS

The pattern on pin routers is below the part. The downcut tool will push the part into the pattern, which is stabilized by forcing it down to the table. The chips are directed away from the operator's face and into a path used by the guide pin. Single edge tools will cut easier and faster because they cut and release the part. Double edge tools will generate better finishes and are more stable because one flute is always in contact with the part.

BROKEN ARM ROUTERS

Broken arm routers, also called master routers, were used mainly in the aerospace industry. Since CNC routers in most plants have replaced them, this equipment has migrated to the other industries, such as aluminum boats. A routing template, called a master, covers the sheets of thin aluminum. The master is screwed to the plywood tabletop that sandwiches the parts. Since there is no path for the chips to flow down, upcut tools must be used in this application. The stack height of the parts should never be above 1/2" in height. Single edge tools are used in "0" and double edge in "T". If a shop prefers to stock one tool, then use the single edge tool. Normal sizes for most applications are 5/16" CED on 1/2" shanks. This combination allows for small cut paths with the added strength of the larger shank because of the amount of tool required to extend from the collet and into the guide.



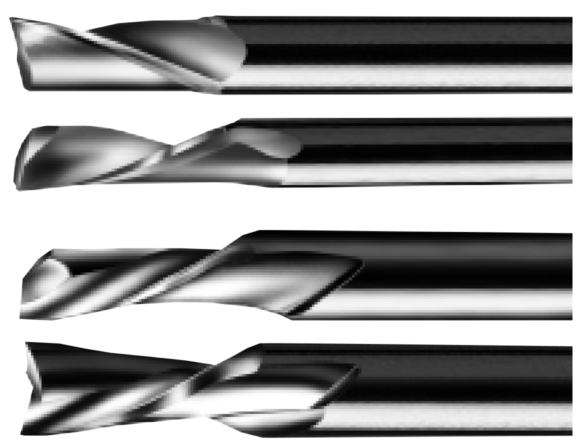
CNC ROUTERS

CNC routers are used for aluminum routing in four modes: single sheet, vacuum held, stack sheet-screw held, stack sheet-rivet held and stack sheet-pressure foot. In all operations conventional cut path is recommended. However, it is suggested that the scrap be examined. If it is cleaner than the part, then use climb cutting.

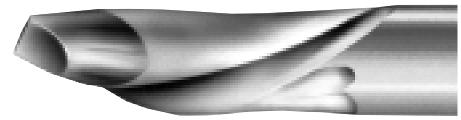
If two passes are needed because of tool deflection, higher requirement for part finish, or it is faster, then leave at least .030" (1/32") of material on the part for the finish cut. Use climb cut direction. Both of these items will stabilize the tool and should yield a better part finish. The single sheet applications run 14,000 to 24,000 RPM and up to 300 IPM feed. Stack sheets run 14,000 to 20,000 RPM and up to 160 IPM feed.

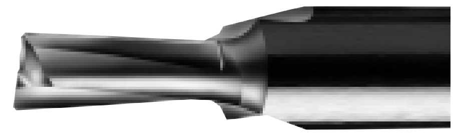
SINGLE SHEET

This operation has a composite wood table. The vacuum draws the part to the table and eliminates the use of fasteners to hold down the parts. Solid carbide tools are required due to the abrasiveness of the table. Skip tabs are recommended for smaller parts because they tend to move after several parts are cut which opens up more area for vacuum loss. Since most parts are less than .125" thickness, 1/8" and 3/16" tools can be used to help minimize vacuum loss by cutting a smaller path. Use the shortest CEL as possible.



STACKED SHEET SCREW





In order to make a solid mounting for the screws, most tables are plywood. This allows the use of HSS spiral upcuts. Because the plies in the plywood are solid wood and not abrasive like the MDF or PB, the stack height should not exceed 1/2". An upcut it required because there is no exit path for the chips. Single edge tools mostly 1/4" to 5/16" on 1/2" shanks provide the most stable cuts and allow chips to be cut and cleared from the path. There will be some tool deflection. A secondary pass can be used to eliminate the variance. If a second pass is used, it should be in a climb cut direction and a minimum of .030" left on the part for the final cut.

STACKED SHEET-RIVET

This application requires the use of these lo-helix upcut tools so the chips can be evacuated without putting undue force on the rivets. If too much force is applied to the rivets, the deflection top sheets will lift from the stack and be ruined. The HSS tools can be used in most applications. The deflection can occur but, the 81-100 series reduces deflection to a minimal level. Solid carbide is used in the more abrasive high silica aluminums and lithium base aluminums. These machines normally use flood coolant. So a TCN or ZRN coating can sometimes increase tool life by 1-1/2 to 2 times normal. Tool tests on the specific machine are the only way to confirm.

STACKED SHEET PRESSURE FOOT

In order to pull the chips from the cut and make a large enough chip to absorb the heat, a single flute tool is required. It is necessary to run test cuts to see which, conventional or climb cutting direction, works best on each material.

COOLANTS

Coolants should be used on all CNC applications. The synthetic or soluble oil mists should be mixed at high water/coolant ratios to provide a greater measure of cooling effect. Flood coolants run best in applications for stack routing where the cut paths are deep. In hand router applications, a brushed on oil or dipping the tool in bee's wax or bar soap will add lubricity to the cutting action and extend tool life.

COOLANTS FOR ALUMINUM ROUTING

- ACTUALLY A LUBRICANT MORE THAN A COOLANT
- CNC ROUTERS
  - FLOOD
  - MIST
    - TYPICALLY WATER SOLUBLE AND ENVIRONMENTALLY FRIENDLY
    - RATIOS CAN VARY FROM 30:1 TO 50:1
    - IMPROPER RATIO CAN DRAMATICALLY AFFECT THE USEFULNESS
- HAND ROUTERS
  - STICK WAX OR WIPED WAX
  - SOAP

CHIP WELDING

This can be caused by many different factors or a combination of them. Spindle run-out and the wrong tool type are the most common errors. Dull tools, poor chip loads, wrong feed direction, loss of coolant during the cut are other factors that contribute to chip welding on the cutting edge. Chips welding back into the cut path occurs when the chip load is too light or the flute of the tool cannot eject it. This can happen when the CEL is not long enough to clear the top of the deep cuts.

HEELING

This is a common occurrence when there is excessive spindle run-out. It also happens when the feed rates are too slow on a CNC router and the chips are forced in to the back of the tool because they cannot be ejected for the cut path.