Frequently Asked Questions in the Routing of Plastics #3

The following are a list of questions that are commonly asked during the setup or actual machining of plastics. The topics discussed relate to machine condition and fixture design. The answers are general in nature, but should provide a starting point for further optimization of the cutting processes.

After following the manufacturer's recommendations on cutter selection, cut direction, and feeds & speeds, why will acrylic sometimes still show heavy knife marks after cutting?

The number of factors that must be in perfect alignment for a high quality cut in acrylic is truly staggering. Consider the fact that a router bit is typically gouging out between .002" and .010" of material in each revolution and the desired surface finishes are in the neighborhood of 20mInches. (That means the average differential in height between knife marks is .00002"!) The geometry of the cutter is what allows the knife mark heights to be reduced from the chipload amount down to an acceptable surface finish, but unless all other factors are perfectly dialed in, there is little chance of success.

There are two critical factors in maintaining the operational characteristics required for routing acrylics: fixturing and machine condition. Unless the fixturing is rock solid throughout the entire cutting cycle, any tiny movements of the part can cause erratic finishes throughout the cut. When attempting to maintain a finish measured in the millionths of an inch, a few thousandths of movement can wreak havoc.

Machine condition is a more difficult factor to evaluate and possibly fix. A thorough evaluation will involve examining each portion of the machine and determining its impact upon the cutting cycle.

Can machine condition be objectively evaluated without the having the manufacturer visit or using expensive tools such as laser alignment devices?

Absolutely. There are many checks that can be performed that will give a good indication of whether further action needs to be taken.

The first area to examine is almost always the tool clamping system. Collets need to be in perfect condition and replaced on a regular basis. These are not merely devices to hold the tools during cutting, but are the primary means of aligning router bits along a perfect centerline. Any out-of-round condition will cause multi-fluted tools to remove differing amounts of material with each cutting edge. When this occurs it is impossible to form a homogenous finish across a machined surface. Single edge tools will also show degraded cutting characteristics and will be extremely sensitive to feed rate fluctuations due to the constantly changing chipload present with an out-of-round tool.

All mating surfaces from tool changing taper through clamping nut need to be cleaned every shift and examined for wear indications. Broken shanks on tools or severe crashes should always be reason for a detailed examination of the collet and probable replacement. Collets should be considered perishable tooling just as the cutting tools are and replaced on a regular basis. Regular evaluations of the concentricity of the clamping system should be performed with a dial indicator and

plug gage or cylindrical round. Remember to take multiple concentricity readings and to disassemble and reassemble the chuck between each reading. This will ensure an accurate determination of repeatability and accuracy.

If the colleting system is in good condition the next area for evaluation is the spindle and drive systems. There should be no play within the spindle bearings and the spindle mount should be solid to the back plate. Any movement here should be cause for concern and may require remounting of the spindle or a rebuild of the bearing packs. If the spindle is in good shape, check the axis movement next. A quick check is to turn the drive motors on and check for play. There should be no room for movement in any of the axes when the servos are engaged. If there is any play, most likely the nuts on the ball screws are showing signs of wear and there will be backlash present in the system. This can lead to unsteady movements particularly during acceleration and deceleration that will show up as poor finishes on the part.

A final check that can be an effective demonstration of machine condition is to make a series of cuts at various locations on the vacuum table. Straight cuts along each axis, a diagonal cut across both the X and Y-axis, and a large diameter and small diameter circular cutout can provide a very good indication of how smoothly the table and head are traveling as well as how well the axes are performing in simultaneous movement. If any of these cuts appear significantly worse than the others, a more detailed examination of the involved axes is required. Making these cuts at various locations on the table will allow the operator to see if there are problems at the extreme ends of the travel distances or if one particular portion of the ball screws or ways has been worn out due to repeated use.

What is the expected lifetime of spindles and other components before they affect the quality of the cut?

This is an impossible question as it pertains to machine components. Ways, ball screws, and ball nuts are constantly being improved and are showing longer and longer service life. The same can be said of spindle components and the bearings within them. The one item that has remained relatively constant over the last five years is the collet. Shops that have the best success typically replace their collets every 400 - 800 hours. If this number seems extremely low, remember it is the only flexible piece of equipment in the entire machine and it is expected to maintain tolerances in the range of a few ten-thousandths of an inch over repeated cycles. Using 5HP to 10HP motors to drive solid carbide tooling with a piece of spring steel in between seems like an awfully tenuous method of achieving premium finishes. For this reason its better to be safe and maintain all of the clamping components in optimum conditions at all times.

What is the best way to fixture small or intricate parts such as letters or logos?

This is always a difficult question without specifics, but there are some options to try. First decide whether to use universal (flow-through) or dedicated (discreet) vacuum. This will determine the best methods of fixturing. Universal vacuum systems can be setup so that their need for large surface areas to hold on to is accomplished through the intelligent use of scrap and appropriate tool diameters. Typically small diameter tools (those causing less lateral pressure on the part) in conjunction with skin cutting or tabbing have had the best success rates. Low vacuum loss is essential in this type of configuration and it is not uncommon to see problems with holdown as a large panel is gradually machined into smaller parts. Skin cutting to the masking can eliminate vacuum loss, as can the use of

scrap pieces to gradually cover cutouts and reseal the cut paths as the program advances. It is also essential to seal the edges of the universal vacuum spoilboard and any unused areas on the board face.

Dedicated systems offer some challenges to small part routing but can be a more effective method than universal systems if designed properly. The most important factors when designing sealed systems is to completely eliminate any areas of vacuum loss, increase the frictional contact area of the part to the board, and to have a spoilboard that distributes vacuum over as much of the part surface as possible.

To reach the optimum operating conditions it is a good idea to use some type of sealant on the spoilboard surfaces to prevent vacuum loss. Good results can be achieved with enamel or latex primers and paints as well as rubberized coatings. The rubberized coatings can also add additional frictional hold down capability with minimal effort. Using channels is typically the best method of distributing vacuum throughout the part while maintaining an adequate amount of material/spoilboard contact area. If the parts are very small or intricate, using channels as small as 1/16" with 1/16" walls between them can provide adequate support with good vacuum distribution. Using spoilboards without channels or using gasket tape on top of the board without recessing it can cause long term headaches. The tape will typically wear faster due to the higher compression amounts and the lateral stresses placed against it. In many cases the part will also warp toward the vacuum supply and slightly deform itself or seal the vacuum supply hole.