Reduce Routing Costs by Getting “Back to the Basics” 5/1/01

When the economy slows down and orders become fewer in number and far more competitive in terms of pricing, it is important to find ways to reduce the cost of manufacturing. In the routing industry there have been numerous technological advances in machines, materials, and tooling aimed at raising the efficiency (and therefore lowering the cost) of production. In the last five years alone there have been great advances in many of these areas. Machines have more than tripled their rapid traverse rates and at the same time managed to increase their rigidity through advancements such as ceramic bearings and HSK tool holders. Materials have increased their resistance to crazing, scratching, and breakage while being offered in more colors, sizes, and composite formulations than ever before. New tooling technology has brought about increased surface finishes, longer tool life, faster feed rates and less induced stresses on cut parts through better materials and engineered geometries.

While these improvements have undeniably helped to increase the state of the art for plastic routing, the unfortunate truth is that most application troubles are still the result of basic and fundamental problems. These troubles, if not found and eliminated, invariably cause increased cycle times, cutter usage, and higher machining costs. Because they are core machining principles, the solutions to these problems haven’t changed since plastic CNC machining started its rapid growth in the mid 1980’s. For that reason, it is always a good idea to occasionally get back to the basics and review what makes for a successful CNC routing operation.

The four core concepts that require addressing for successful and profitable routing operations are: Material, Rigidity, Tooling, and Programming. By reviewing the fundamentals involved with each of these aspects of the routing operation before a job begins the shop owner, machine programmer, or machine operator can find opportunities to produce better parts at a lower cost.

Material
With so many plastic grades in the marketplace today, it makes no sense to ignore the applications support that plastic manufacturers can supply. The fabricator, acting as an intermediary between the customer and the material supplier, has the greatest opportunity to select a material which meets the customer’s specifications but is easier to machine than similar formulations. There are numerous resources for machining information available and they should be utilized as early as possible to help the customer specify the best material grade for all aspects of the design, manufacture and final use of the product.

Whether published or residing in the experience of a seasoned applications engineer, router manufacturers typically have a wealth of knowledge in regards to plastics machining . It is always a good idea to contact the machine manufacturer for some up front advice on different material styles.

Tooling companies can provide very timely information on some of the newer materials as well as the old standbys. Due to the expendable nature of their product, tooling companies typically have more involvement in the day-to-day machining of products and may see a more varied spectrum of successful applications. Knowledge of a material’s benefits and limitations can an invaluable resource to resourceful inquisitors.

Lastly, and most importantly, material manufacturers can be the best resource when it comes to pre-job material selection. They typically have specialized materials that are designed with machining in mind and applications personnel can assist both the fabricator and the end-user in the selection of materials that are router friendly. Most larger companies publish drilling, routing, and sawing specifications for their popular materials and many of them have joined the www.PlasticRouting.com website to help develop a centralized database allowing the comparison of material machinability characteristics between manufacturer, grade, color, and thickness.

By reviewing the characteristics of materials before a job begins in terms of formability, resistance to damage, machinability, and customer specifications, the fabricator can help reduce production costs while increasing the chances of a satisfied customer.

Rigidity

Realistically, material specification can be a difficult parameter for the fabricator to control. Many times the specification is already decided when the job is offered to the fabricator. Fortunately, this is not the case for the next most important variable in the job: Rigidity. This parameter is entirely up to the router operator and is the most critical parameter over which the operator has control.

Rigidity applies both to the machine itself and to the fixturing of the components to be cut. (It can also be applied to the tooling, but that subject is better dealt with in the Tooling section.) A router that is poorly maintained will never be capable of achieving the results of even the oldest machine that has been properly kept up. Plastics machining is entirely different than the routing of other materials in that the feed rates are typically much faster than in standard metal milling and the finish requirements are much more precise than in wood routing.

Properly lubricated and maintained machine slides and drive systems are essential to maintaining optimum feed rates. Since plastic is so sensitive to the relative motion of the cutter, any backlash or worn track or ball areas can have a visually noticeable effect on the part. Any play in the table or spindle mounting systems can cause erratic marring of the work surface. Failure to follow a preventive maintenance schedule with the spindle can cause concentricity problems so severe that no tooling will produce an acceptable finish. It is important to remember that routers are not milling machines. They are typically much larger than a standard horizontal mill and are built with speed as a primary focus and rigidity as a second focus (albeit, still a critical one). Routers are a viable method of production if the operator understands the limitations imposed when using a 10 foot aluminum table versus a 3 foot steel bed as a worksurface. Preventive maintenance of CNC routers is critical to long term operation when part surface finishes are critical.

While machine rigidity is critical to consistent performance, fixturing is equally important to individual performance per part. As has been stated in previous articles, surface finish for metals and plastics is typically measured in millionths of an inch. Consider that even .001” of part movement is 50 times the magnitude of what is generally considered a “good” surface finish. With such a low margin of error, it is essential that everything possible be done to allow the machine and cutting tool a chance to produce optimum finishes.

Fixtures should be rigidly built and mounted to the worksurface. Vacuum supply should be oversized whenever possible and hard fixturing should be securely mounted and without slop. When dealing with 5-axis fixtures, unsupported overhangs should be minimized and vacuum distribution should be brought as close as possible to the area being cut. Friction enhancements such as rubberized coatings or gasketing sheet foam are always a good idea.

Tooling

With the thousands of available choices for tooling, this could seem to be a difficult parameter to optimize. However, the contrary is actually true. The reason for the large selection of available tooling is the fact that it has become so specialized over time. The best methods for specifying tooling for a particular job is either published resources or vendor representatives. Published resources can be recommendations from material suppliers, empirical test data such as www.PlasticRouting.com, or vendor catalogs with tool selection cross references. Experienced vendor representatives or applications engineers can also be of infinite value because of their knowledge of similar applications and the pitfalls to avoid.

The goal for best performance is to find the tool geometry that was developed specifically for the type of material being cut and the machine being used (i.e. 3-axis, 5-axis, carving, etc.). Additional factors that should be considered are:

- Tool Material: Carbide for finish, steel for sharpness, diamond for life.
- Tool Diameter: Is ¼" required or can 3/8" be used to produce a better finish?
- Cutting Length: Are stub length tools available for better rigidity?
- Shank Diameter: Cutting diameters smaller than the shank can lead to tool breakage.
- Helix: What are the part hold down parameters? Should low helix, high helix, or straight cutters be used?

Programming

Once material, machine rigidity, fixturing, and tooling have all been selected for best operating practices the final step is programming the part path. There is a tremendous amount of material published concerning this process, but by just focusing on the basics a good probability of success can be assumed. Some general rules of thumb for routing of plastics:

- Cut Direction Matters: In almost all cases the conventional cut or climb cut side will produce a better finish than its counterpart. The best method for determination is trial and error. Compare both the finished part and the scrap for edge quality. If the scrap is better, reverse the cut direction. For empirical data, once again www.PlasticRouting.com can be consulted. As a starting point, larger tool diameters typically work better in a conventional cut presentation and smaller diameters are workpiece specific.
- Chiploads: Chipload is the size of the chip being formed. It is the result of the number of cutting edges, the spindle RPM, and the feedrate. Router bits work best at a very specific chipload and can perform quite poorly even a few .001" from the optimum value. Consult with the tooling manufacture for a good starting point and then vary feedrates or RPMs to determine the best cutting zone for the particular job.
- Cutter Entry: Router bits that plunge directly into the workpiece can wrap long chips, deform part edges, or melt the surrounding surface. Always ramp or helically plunge into a scrap area and rout to the part edge to prevent these problems.
- Scrap: Try to minimize the amount of unsecured scrap and thin wall scrap that is present. Poor scrap control can lead to part ejection, vibration, and

broken cutters.

A thorough review of each of these fundamental areas – Material, Rigidity, Tooling, Programming – can eliminate many of the problems that arise every day in the routing industry. Far too often fabricators have spent money and time fine tuning programs and part paths for optimum cycle times when building better fixtures or selecting different tooling could have doubled feedrates with minimal additional effort. Poor programming has been solved many times with custom (i.e. expensive) tooling when rewriting cutter entry cycles or part paths could have resulted in immediate solutions and the use of off-the-shelf tooling.

Perhaps the worst example and unfortunately the most common is the application where the machine must be run at a minimal feedrate to prevent chattering of the part. If machine condition is preventing fast feed rates, fix the machine – do not decide that the maintenance cost is prohibitive or the downtime is not possible. Once machine wear begins, it accelerates quickly. It must be caught in the beginning and fixed promptly to prevent a myriad of problems later.

With a solid return of “Back to the Basics” fundamentals in the routing process, delays can be eliminated, cycle times optimized, and costs reduced.