Partnership for CNC Optimization
A Whitepaper from Leitz Tooling

Although machine technology continues to advance, offering improved flexibility, faster production cycles, ease of programing and increased automation, tooling is still the operational constraint. Tooling is the determinant between limiting or optimizing your machine's efficiency, which directly impacts your return on the significant investment you made in your machine. Partnering with a tooling supplier who can guide you through your operational parameters to your best solution is critical. Even the best quality tooling will underperform or fail if not utilized at the correct RPM and feed rates. Informed tooling suppliers will take the time to guide you through all critical machining parameters to maximize the efficiency of the entire process.

Proper Fixturing

As carbide and diamond (PCD) tools have increased in hardness and wear resistance, vibration control has become an increasingly important factor. Vibration due to poor material fixturing, part movement, or tool eccentricity creates a hammering effect on cutting tools. This vibration-induced hammering will very quickly damage or destroy tools, so it's imperative that workpieces be firmly held. Small component pieces can sometimes "break free" of the vacuum table and must be onion-skinning or skip-tabbing to prevent part movement. Close attention must also be paid to vibration and movement of scrap pieces, which are oftentimes not securely held.

Elimination of tool run-out is also critical, as excess run-out prevents tool edges from cutting in the same plane and equally dividing working loads. Tool run-out results in poor cut quality, short tool life and reduced processing speed. Tool run-out typically begins with improper tool holding but can also be induced by spindle bearing run-out. No matter what causes the vibration, this must be addressed before the application can be optimized.

Control Cutting Pressure

Tool cutting pressure and related pre-splitting of wood grain ahead of the knife is responsible for common cutting defects such as crushed grain, tear-out, plucking and fuzzing. The cutting pressure of the knife forces the grain open ahead of the cut, frequently opening the grain underneath the intended cut plane, resulting in plucking of the workpieces and residual voids. Cutting pressure across the grain will force open and unsupported grain to break away perpendicular to the cutting plane, thereby creating crushed/ripped grain and exit blow-out.

Proper tool design helps to minimize and equalize cutting pressure and control pre-splitting ahead of the knife. Cutting angles are set according to predominate wood species being processed with lower or negative angle for hardwoods which are prone to grain splitting and higher for softer woods prone to fuzzing. In all cases, knife to knife run-out must be minimized, so that the workload is divided equally among all knives. Generating proper chip load, or the amount of material removed per each knife rotation is crucial for keeping cutting pressure in an ideal range. Shear is used to reduce cutting pressure by changing the cutting dynamic from chiseling to slicing, and high-shear designs can dramatically reduce cutting pressure. Finally, cutting pressure can be divided between tips of varied geometry such as chip-breaker or ripple finish designs.

Leitz Tooling, 4301 East Paris Avenue S.E., Grand Rapids, MI 49512, 800.253.6070, leitztooling.com

Heat Management

Heat management in tooling is perhaps the most critical but most overlooked factor in efficient routing. Heat management involves the reduction and dispersion of friction heat generated in the cutting process. Controlling heat build-up is essential, as both carbide and diamond (PCD) cutting tips are held together with a cobalt binder which quickly disperses under heat. As the tool heats up and the cobalt dissipates, tungsten and carbon cutting elements are released, causing a thermal corrosion and mechanical dulling effect. This thermal degradation occurs rapidly and can reduce tool service life by more than 50%. Tool overheating is visually evident when tools turn black and resin or pitch builds up on the surface.

Tool heat management is easily accomplished through proper chip loads, which is the calculated and measurable mass of material removed per knife rotation of the tool. The mass of wood fiber, not dust, absorbs heat in the same way pasta absorbs heat when dumped into a pot of boiling water. The mass of wood fiber then carries the friction heat away from the tool, as the tool continues to plunge into cool solid material. A tool which generates dust is not really cutting, but is basically sanding, while creating tremendous friction heat against the part. For this reason, it is also critical that the tool not be allowed to dwell when changing cutting path or when another piece of material has not been fed into a push feed machine.

Proper chip load is generally easily attained through three variables: spindle RPM, feed speed, and number of cutting edges. Target chip load values for each wood species and most man-made materials are readily available online and in the back of the LMT Onsrud catalog. The calculation to achieve the target chip load is then very simple (RPM x number of knives x target chip load = feed speed). For example, a 2+2 compression bit, cutting 3/4″ particleboard at 24,000 RPMs would be calculated as (24,000 RPM x 2 knives x .018″ target chip load = 864″ per minute feed rate). In certain applications where one of the three variables cannot be adjusted (such as RPMs or feed speeds), the tool may have to be exchanged for one with fewer or more cutting edges. This is the case when CNC nesting small parts, and you don't want to slow the spindle below 16,000 RPMs. Given the fact that the top attainable cutting speed may only be 175″ per minute, you will have to use a Z1+1 router in order to keep the chip load at ideal mass.

Attention to and attainment of proper chip load is perhaps the fastest and easiest means of process optimization. By removing sufficient mass and cooling the tool with every knife rotation, the process moves faster, and the tool performs to its maximum potential lifespan. Longest possible tool life results in lower overall tool costs and optimized machine uptime and throughput.

Conclusion

Many tooling and cut component considerations must be taken into account to optimize your CNC efficiency. It's important to align yourself with experts who can guide and help optimize tooling and machine related variables.