

Optimize Your Cutterpath Process

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Imagine eliminating your CAM department *and* getting more efficient cutterpaths for free! This is the prospective promise of moving your cutterpathing process to the shop floor in specific application areas like molds, dies, models, prototypes, etc. Experience shows that your existing machine operators can make better, more efficient cutterpaths, while actually reducing their machining time!

The following pages will introduce you to two techniques available today to help eliminate your time and cost for cutterpaths. Shop floor programming simply involves moving your cutterpathing process from the office onto the shop floor. Real time machining is an extension of shop floor programming which allows machining to begin just minutes after starting the cutterpathing process, without waiting for completion of the cutterpath.

What is real time machining?

Amongst those who are already familiar with real time machining, most of the benefits commonly associated with it are actually derived solely from the implementation of shop floor programming.

Real time machining is a simple enhancement to CAM and CNC that enables the CNC to execute cutterpaths from CAM while they are still being created. With real time machining, the machining operation can begin before the completion of the cutterpath. The net effect is that the normal waiting period for cutterpath completion need not be unproductive on the CNC. Rather, it can be machining the beginning of a cutterpath file while the CAM system is adding onto the end of the file!

Real time machining is dependent upon two key components that are not unique to real time. First is the reliability factor. If the cutterpaths used in real time machining are not consistently reliable, the risk is unacceptable, especially since real time machining does not allow for graphical verification as a separate phase prior to milling. The second key

component is cutterpath automation. Many 3-D cutterpathing systems have historically required extensive "human intervention" to make ongoing choices about the cutterpath, and then additional choices in the verification process. Real time machining requires a high level of automation in the user interface, in order to relieve the amount of input, and the expertise to make that input. Both automation and reliability are critical to real time machining's success.

Shop floor programming

Real time machining is a simple enhancement to CAM and CNC that enables the CNC to execute cutterpaths from CAM while they are still being created.

Real time machining is often confused with shop floor programming. Shop floor programming is an increasingly popular implementation of CAM on the shop floor rather than isolated within a CAD/CAM room. As with real time machining, shop floor programming relies on both reliability and automation. Still, shop floor programming without real time machining takes allows for completion of individual cutterpath segments to be completed prior to machining, permitting graphical verification prior to machining.

Real time machining is virtually always implemented with shop floor programming. The opposite is not as likely. Many companies who implement shop floor programming are not inclined to use real time machining. It can be important to distinguish between the two because the cost of implementation and the choices available can make a big difference in your results and the costs to get there.

Work Flow Examples

The work flow chart above shows an imaginary case where a shop works from 7:00 AM until 5:30 PM daily with a ½ hour lunch break at 12:00 Noon. A relatively small new job enters the shop as a CAD wireframe at the beginning of the work day. See how dramatic the process time difference is with the various programming methods! Note that displaying just the cutterpathing and machining time could show an even more dramatic, though somewhat unrealistic time reduction.













The benefits of shop floor programming and real time machining can be impressive. The cost of cutterpath is cut dramatically by combining that task with the machining process. Disputes over cutting methods, cutter size discrepancies, and so forth is eliminated. The machine operators seem to consistently gain better machine performance with cutterpaths they generate themselves. The quality of work improves as the machinist assume responsibility or "ownership" for their work. Moreover, shop floor programming and real time machining give a better product for less money, in less time!

A win-win scheme

The results with shop floor programming vary widely depending upon company culture, policies, and the individual personalities and talents involved. In general, though, within the skilled trades, everyone wins with shop floor programming. The saturated CAM operator can enjoy relief and concentrate on the most complex of tasks which may not lend themselves to shop floor programming. The machine operator enjoys more ownership of his projects, gaining the ability to cut in the manner he deems most efficient. He is returned to the esteem of a skilled tradesman from the abyss of being just a "machine operator". Management gains from the virtual elimination of the common infighting between CAD/CAM and shop floor over the responsibility for poor cutting methods, cutterpaths that don't work, etc.

Most of the benefits commonly attributed to real time machining are actually derived solely from the implementation of shop floor programming.

The entire operation is smoother. Finger-pointing is dramatically reduced or eliminated, and mutual productivity goes up. It is amazing the additional productivity that the machine operator can extract from a machine when he is given the possibility to make choices on his own!

Process Phase	Conventional	Shop Floor	Real Time
A relatively small new job enters the work flow as CAD wireframe data and begins surfacing.			
4 ½ hours' surfacing is completed and cutterpathing begins.			
5 hours' machining begins. With shop floor programming, the machining can begin as soon as the first cutterpath segment is complete. Real time machining allows starting the milling even sooner, after just minutes of waiting for the cutterpathing to begin.			
The job is completed.	 day 2	 day 1	 day 1
Total process time.	12:30	10:00	9:45

To real time, or not to run real time?

You may ask "why would I want to run a cutterpath that hasn't been graphically plotted or proven?" Before this capability was first demonstrated in 1989, several officials at a major U.S. auto manufacturer lamented that cutterpathing an inner body panel for a car took a full week. Machining also took about one full week. By making it possible to start machining as soon as the cutterpathing process began, 50% of the process time was immediately eliminated! The time was further reduced by improvements in the cutting methodology derived from operator input on the process. The investment in additional training for the machine operators was quickly rewarded with "agility"; dramatic productivity gains and an overall reduction in process time, resulting in the possibility of faster time to market.

That was then, but now things are quite different. That same cutterpath that formerly took a full week now takes just hours. More efficient CAM combined with computers that are magnitudes faster result in equivalent cutterpaths in just hours! Again, why run real time?

Cutterpath Strategy Comparison			
	Conventional	Shop Floor	Realtime
Surfacing	4.5	4.5	4.5
Cutterpathing	3	0.5	0.25
Milling	5	5	5
Total Hours	12.5	10	9.75

There are times and applications where even an hours' wait for cutterpath may be too much. Real time machining makes it possible to start milling virtually as soon as cutterpathing begins. Many would argue against milling unproved data, yet that debate grows weaker as CAM continues to improve in reliability. Still, the argument favoring real time machining also grows weaker as CAM systems continue to gain speed.

Perhaps the most compelling argument against real time machining comes from the operators themselves! When empowered with shop floor programming, they can generally prevent the need for immediate cutterpaths through more effective planning. Their job becomes a more prideful task of constant conspiracy for the ultimate in both machine and personal productivity. When given both the responsibility and the tools for productivity, there is no one else to blame. In every case I've seen, the operators have surprised all critics by "stepping up to the plate" with surprising ingenuity. Creative operators combining experience with shop floor programming can consistently prevent the need for real time machining.

Another argument against real time machining is the limited choices for cutterpath styles. Zig-zag or sliced style finishing passes are the only methods of real time milling available today. This seems to be the consequence of the long compute times and sometimes unstructured data flow to process complex cutterpath styles like Z-level roughing and finishing, surface optimization, drive curve, and corner cleanout routines. Development of real time machining for these styles of cutterpaths is lacking today, in spite of the fact that they would benefit prospective users the most. Again, the organized operator chooses

how to balance the advantages of such advanced cutterpaths with the consequence of long processing time.

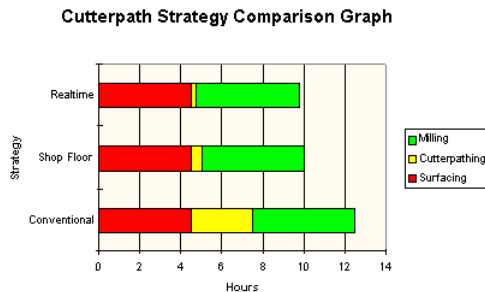
The future of real time machining

Does all that mean that I'm opposed to real time machining? Well, not really. In fact, my vision of the future includes a convergence of CAM and CNC into a seamless environment where the CAM system will have a "MILL" button, just as all CAD and CAM systems today have a "GRAPHICS" button. What I don't see is a CAM concern making CNC, and I sure don't see CNC builders making their own CAM. Rather, open systems architectures with PC based CNC's will allow us to join the applications from different vendors, just as the computer I'm writing on combines graphics, word processing, and other applications from different companies within one harmonious environment. You might think of the CNC machine as manufacturing's counterpart of my computer's printer. Each makes a particular kind of "hard copy" from computer data. The same OLE (Object Linking and Embedding) that allows my word processor to call a different software manufacturer's graphics program will allow a CAM program to call a CNC in order to run data that is being created.

How does real time machining enter into that? Well, perhaps the CAM will be fast enough that the separate cutterpath creation won't be noticeable. Perhaps the CAM won't even make a cutterpath file, but will rather drive the CNC through "pipes" a computer data pipeline. In any case, as cutterpathing systems grow more reliable, the viability of machining data that's unproven will become indisputable.

Implementing shop floor programming

The beauty of shop floor programming is that is simple to implement, yet the productivity gains can be amazing! Many companies simply move their existing CAM system to the shop floor and change the responsibility to the machine operators. With the level of automation being achieved by some CAM systems today, that transition can be very short.



Designcraft Corporation, located in Elk Grove Village, Illinois is a great example. They simply installed their existing CAM system in the CNC control of their mill, maintaining the same system they had been using for over two years. Owner Greg Borucki first resisted the idea. Now he reports "I wouldn't have believed it if I hadn't seen it! Over just

days, my machine operator was making more efficient cutterpaths in less time." The machines became more productive along with the operator. The former CAM operator is now able to focus all his attention on surfacing and modeling to keep the machines and the rest of the shop running more smoothly.

Many CAM systems lend themselves to shop floor programming implementation. If your company is already enjoying good success with the system you own, perhaps simply moving that system to the shop floor will help you. If your CAM system is too complex, perhaps a change is in order. If the CAM system you own is working well, but wouldn't work out for shop floor programming, perhaps it is more complex than you'd like to admit and a change is in order anyway. Most CAM system vendors will provide thorough demonstrations, and even install systems for competitive evaluations.

How to make real time machining

Real time machining involves a few simple enhancements to CAM and CNC. First, the CAM system must work in a sequential manor, building a cutterpath in a logical sequence for machining. Next the CAM system and CNC must allow sharing of the cutterpath file so that the file can be read by the CNC even as the CAM system is building the file. Last, the CNC must know what to do in case it catches up with the file creation. "How can it be that the CNC would ever catch up with file creation?" you may ask. In some cases, machining may actually take less time than cutter path creation today. Impressive machine and cutter performance get the machining done quickly. Preventing the possibility of error in case the machining outperforms the toolpathing is an important feature of real time machining.

Unfortunately, creation of real time machining is not really up to you. It's up to your CAM and CNC vendors. Though first introduced as a proprietary system with both the CAM and CNC built by one vendor, it is now available through various CAM and CNC vendors, with interoperability. This gives you choices in your selection of the CAM system and the CNC controller. Just as different computer products work better for some than others, different CAM systems and CNC controls can give you advantages for your ways of working. Moreover, today you have choices if real time machining is the way you choose to go.

Real time machining viability

Did our brief explanation of real time machining make it all sound simple? It really is quite simple, but is it something that **you** can use? Would it be useful **now**? That is a personal decision for your shop management, and then for your individual machine operators. Overall, you probably seldom need real time machining, if ever! Still, it can give somewhat of a time advantage to those who use it. Start today by simply moving your cutterpathing phase onto the shop floor. A well-organized approach to your cutterpathing can eliminate the waits for cutterpath that might otherwise help you justify real time machining. Still, CAM and CNC will surely converge to where they interact transparently. Real time machining is just one step along that evolutionary path.

Author's note

A technical paper for developers of CAM and CNC is available from the author detailing the process in depth. Sample program source code and executable code to demonstrate real time mode can also be provided. They are available from Creative Technology Corporation at the above address, or on the Creative Technology Corporation Internet "World Wide Web" page at <http://www.creat.com>.

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