CREATIVE TECHNOLOGY CORPORATION

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The Ultimate DNC; Direct CNC Networking (DCN)

DNC or Direct Numerical Control is a tool which has gained in popularity over the past few years because of CAD/CAM's success with 3-D contours. The huge cutterpath files combined with relatively small memories in CNC controllers necessitates the "spoon-feeding" of files as they are machined. This article is a follow-up to recent articles concerning the optimization of DNC to support high feedrates. This is an introduction to the ultimate DNC, the elimination of DNC! This is an introduction to Direct CNC Networking.

DNC Review

DNC consists of three components, the CNC on the machine tool, the computer, and the serial (RS-232) line connecting them.

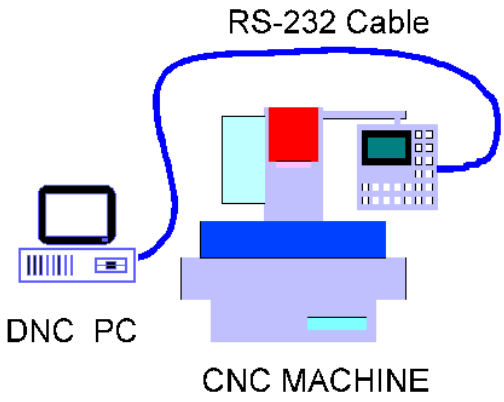

Fig. 1, Minimum DNC Configuration

Although these three components are the essence of DNC, there is more to the process in a typical environment. Getting the data from the CAD/CAM department to the DNC system can be a significant part of the problem. In the simplest case, the program data is simply carried from the CAD/CAM room to the DNC PC by the machine operator or the programmer. This is often

referred to as "sneaker-net" or "Nike-net", because of the extra footsteps required to "network" the components in the communications chain. More streamlined operations often connect the CAD/CAM computer system directly to the DNC PC using computer networking, a high-speed communications link.

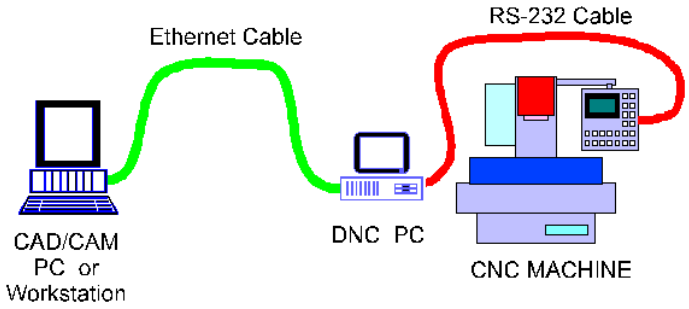

Fig. 2, Common DNC Network

For the sake of clarity, it might help to represent the above as a block diagram representation.

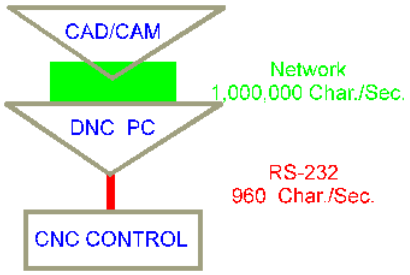

Fig. 3, DNC Network Flow Chart

Direct CNC Networking (DCN)

The ultimate DNC (Direct CNC Networking or DCN) entirely eliminates the DNC PC as well as the serial cable. Rather, the CNC control is connected right onto the same network as the CAD/CAM computer systems. The obvious benefits are the dramatic improvement in data-flow speed and the elimination of components in the process.

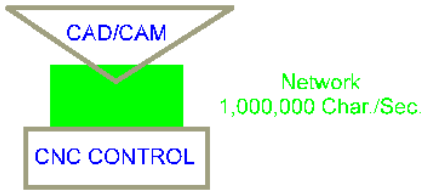

Fig. 4, Direct CNC Network (DCN) Flow Chart

The throughput capacity for Ethernet is 1,000,000 characters-per-second, versus serial communication's typical rate of 960 characters-per-second at 9600 baud. This is nominally a 1,000 times improvement in data transfer speed!

Not all CNC's are capable of direct network connections, though the number of CNC's supporting networking is rising quickly. Moreover, controls with proprietary architectures are more difficult and expensive to network. Controls utilizing variations on "open systems" architecture, commonly based on PC (personal computer) standards, are generally easier to network at low cost. Prices for networking of CNC controls may vary from $0 (included as standard equipment) to as much as $12,000 or more per machine!

Direct CNC Networking capability should be considered as a requirement for complex 3D surface milling in today's rapidly developing CNC technology. As accuracy requirements become more stringent, data density increases and file sizes grow. As data density increases and file sizes grow, DNC can't do the job, requiring DCN.

Optimizing The Work Flow

Before going further, let's review the work flow from the programming stage to finished part.

Using DNC, the work flow from CAD/CAM to machined part is:

1. copy from CAD/CAM computer to floppy disk.
2. (optional) compress and pre-process the cutterpath for efficient DNC.
3. walk to machine.
4. copy from floppy disk to DNC PC.
5. initiate DNC dripfeed.
6. start machine execution.

Using a Direct CNC Network, the work flow from CAD/CAM to machined part is:

1. start machine execution.

You can see that up to 85% of the steps can be eliminated by Direct CNC Networking.

Optimizing The Data Flow

DNC requires two levels of optimization, the one-time optimization of the DNC physical link and setup, and the daily optimization of the data for each DNC transmission. For the physical link, we check and adjust the following:

1. Cable integrity and shielding.
2. Baud rate.
3. Protocol.

4. Error correction and recovery.
5. Data format.

Each DNC transmission may require the following steps to optimize its flow:

1. Data preprocessing.
2. Data compression.

Direct CNC Networking entirely eliminates all the above steps for optimization, and also makes operation more convenient. Networking is preset for cable integrity, baud rate, protocol, and error correction. While RS-232 must be checked for integrity in lengths even under 50 feet, networking is designed and proven to be error free at lengths up to one Kilometer. With networking, data format is no longer an issue, because networking provides ample bandwidth for the most cumbersome of data formats, even with excess comments in the program lines.

Optimizing The Operator

One of the most commonly debated subjects in DNC is the operator convenience. The division of attention between the CNC control panel and the DNC computer is one of the most detracting features of most DNC. Some DNC systems and CNC controllers offer schemes for controlling the entire process from the CNC panel. Still, extra thought and keystrokes should be expected. Direct CNC Networking can eliminate that problem by making programs in the CAD/CAM system appear as if they are right in the CNC's memory or on its hard disk drive. Networking can provide what are known as "logical drives" where remote networked drives are presented to the CNC operator as another floppy or hard disk drive in his CNC controller.

The convenience of direct and transparent access to cutterpaths eliminates another common problem in the shop, programmer and operator interruptions. Using the old-fashioned "sneaker net" necessitates the operator to contact the programmer for a new cutterpath file. Since both are already interrupted, common distractions like extra coffee, cigarette, and restroom breaks add to the interruption time. There is no doubt that breaks are an important requirement for the staff, but they can be less disruptive to productivity when the machine is setup and running, rather than extending the time that the machine is stopped and non-productive. Moreover, the break in the production pace provided by chasing cutterpath files is generally amplified by its own distraction.

A fully networked shop can build on the CAD/CAM network with an integrated direct CNC network, providing all CNC operators direct access to the cutterpaths they require. Note that there is only one continuous network, rather than individual networks for each machine. The network grows as the basic shop communications infrastructure. Not only does it provide a link between CAD/CAM workstations, but also between the CNC's and the CAD/CAM systems. Networking also provides the foundation for real-time machining, MES (Manufacturing Execution Systems), job tracking and control, etc., all of which may be handled automatically and transparently through the networking infrastructure.

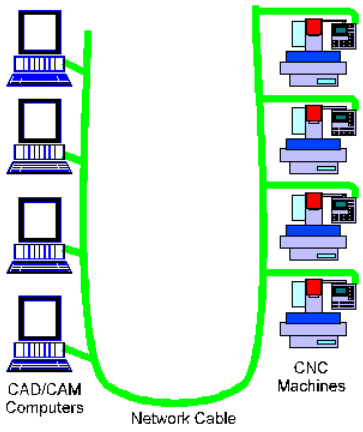

Fig 5, Integrated Shop With DCN and Multiple Workstations

Whenever dealing with large data files, mid-file starts become a necessity. Cutters wear and break, and that can't be allowed to slow productivity. Mid-file starts must allow for easy location of the desired startup point, and application of preparatory data to be sent before resuming the machining process. Moreover, mid-file starts must be considered whenever dealing with large files, whether by DNC or by Direct CNC Networking, and they must be easy to use and efficient. Graphics are often an enhancement used to help locate the position of interruption and verify the preparatory data. The Direct CNC Networking control may also include tools to remember the position of interruption and quickly relocate it.

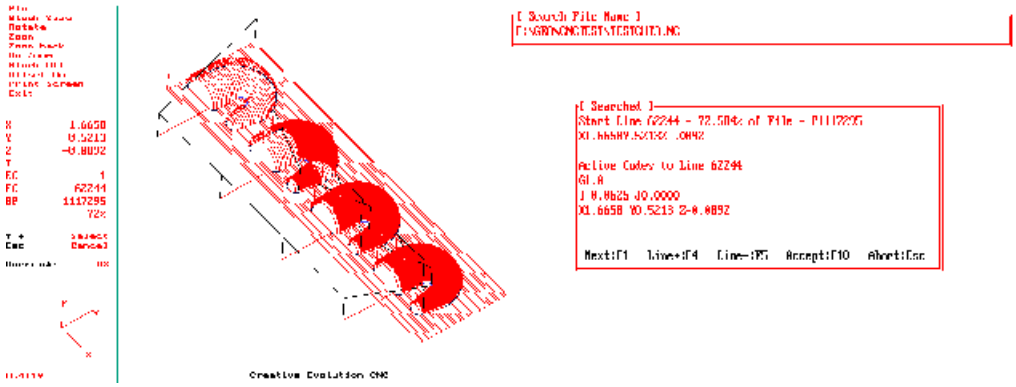

Fig. 6, Graphics Can Speed Up Mid-File Starts

Another improvement in operator efficiency can be provided if the CNC control includes "look ahead". This functionality was referred to by Nick Cravotta in the December issue "DNC-Faster And Better" as a DNC feature, but it is being increasingly supported directly by the CNC, without a performance penalty. What look ahead can do is to automatically prevent overshooting and undershooting at areas of abrupt surface change. This is in contrast with "manual look ahead" commonly used in many shops, where the operator looks at the job surface, and manually slows the feedrate in detail areas. Automatic look ahead can provide accurate surfaces without demanding that the operator attend the feedrate override selector. Time savings for accurate parts with look ahead can be dramatic.

Perhaps the most important benefit for Direct CNC Networking is the overall simplification of the process. By significantly reducing the number of steps the programmers and operators go through to make the end part, and by making the operator's job easier, there is less likelihood of error. Since there are fewer steps in which to make errors, more and better parts can be produced in less time.

Optimizing The CNC

A few CNC's are now boasting performance to 1,000 blocks-per-second and beyond. This seems quite fast, yet this speed can still be a limitation if that high performance is only available in limited modes of operation. In virtually all cases, the highest performance is only available in conjunction with preprocessed and compressed cutterpaths. The high performance is really most needed when the data is not preprocessed or compressed! Besides, preprocessing and compression are simply offloading work that the CNC should do to a different component in the workflow, either to the operator in a separate program, or to the DNC program that is already one of the key bottlenecks in the data flow. Performance of 1,000 blocks-per-second or more should be available to all modes of operation when 3-D surface milling.

In the case that 1,000 blocks-per-second performance is available, that performance can seldom be realized unless there is a fast data path for the CNC. DNC at 38,400 baud, the fastest commonly found today, can only supply 1,000 lines of data that are 3.84 characters long! This does not allow for multiple axis moves with feedrate variations, even when the data is compressed. Complex 3, 4 and 5 axis contours require a faster data channel than RS-232 can supply. Networking is that channel.

Expanded memory capacities are often offered as an alternative to high-speed communications. But how much memory is enough? This author has seen cutterpath files exceeding 100 Megabytes in length. Even at today's lower prices for memory, 100 Megabytes of memory is a large investment. As data capacity requirements continue to grow, memory expansion in CNC could be an endless and costly struggle. Alternately, many CNC's have for years been able to run from files stored on their hard disk drives. Recently, a tool called "remote file execution" has been added to some controllers. This allows one CNC program to call another "remote file", either when completed, or as a subroutine. This can allow continuous operation from one or many files of virtually unlimited length. The advantage that DCN adds to this feature is the "logical drive", the appearance of remote networked drives as if they are a part of the CNC controller itself. Expanded memory is costly and limited, a problem not shared by DCN with remote file calls.

Optimizing Your Profits

Replacing your DNC with Direct CNC Networking can improve your profit picture. You can eliminate your PC's used for DNC, eliminate their maintenance and floorspace, and most important, you can eliminate the extra steps required for those DNC PC's, reducing your likelihood of operator errors.

Costs for DCN versus DNC can vary widely, depending on control manufacturer, existence of a CAD/CAM network in place already, networking topology and software, etc. In general, though, the cost for networking a CNC that is PC based will be less than the cost to add a personal computer near the PC for DNC. This cost or savings, though, is not the main issue in profits. It is normally a one-time cost, that can last for years.

The high cost for DNC is in its ongoing cost as it is used. Direct CNC Networking pays for itself quickly and adds to your profits by significantly reducing operator time. Dan Riedel of Riedel Tool & Machine, Cudahy, Wisconsin estimates that networking his 8 CNC mills and lathes saves his job shop 15 to 20 hours per month over the DNC they used previously. At $50 per hour, those 20 hours can be a supplement of $1,000 each month! Dave Herman, CAD/CAM manager at Estee Mold & Die in Dayton, Ohio states that DNC can easily cost 10 hours per day in a shop like theirs with 10 CNC mills when compared with DCN! Dan Schurr of Modern Mold, Grand Rapids, MI, states that networking improves individual machine productivity from 10% to 30% compared with the local DNC scenario described in figure 1. Averaging that to 20%, over a 50 hour workweek at $50 per hour, this could mean a $25,000 improvement in productivity per machine per year! Over the first year, the savings and improved productivity can easily pay for the replacement of DNC with Direct CNC Networking, even without the abstractions of improved part quality through fewer operator errors.

Potential Hazards

Direct CNC networking can be challenging to implement in some cases, but can also quickly pay big dividends. Because DCN is still fairly new, it may be difficult to find the right answers. Various networking media (thin Ethernet, thick Ethernet, twisted pair, Token Ring, etc.) and network protocols (Novell ODI, Microsoft NDIS, Lantastic, TCP/IP, NFS, etc.) can be confusing. Within the general computer industry, though, networking is so prolific that solutions for most any problems already exist. The only insurmountable problem for DCN is the potential incompatibility with proprietary CNC controllers. In these cases, an efficient DNC system may be the best that is practical. This can still be optimized by networking the DNC computer. Moreover, DCN's big benefits will prove worth any challenges that might be encountered.

Summary

CAD/CAM has made it practical to mill complex 3-D contours by CNC. The problematic side-effect, though, is the dense, huge data files we must work with. DNC can successfully deal with those files up to a point. The next generation of DNC, Direct CNC Networking is actually the elimination of DNC. Direct CNC Networking is available today for many leading CNC's, and will quickly pay for itself through greater productivity of the system, your CAD/CAM and its staff, your machine operators, and your CNC machinery.

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