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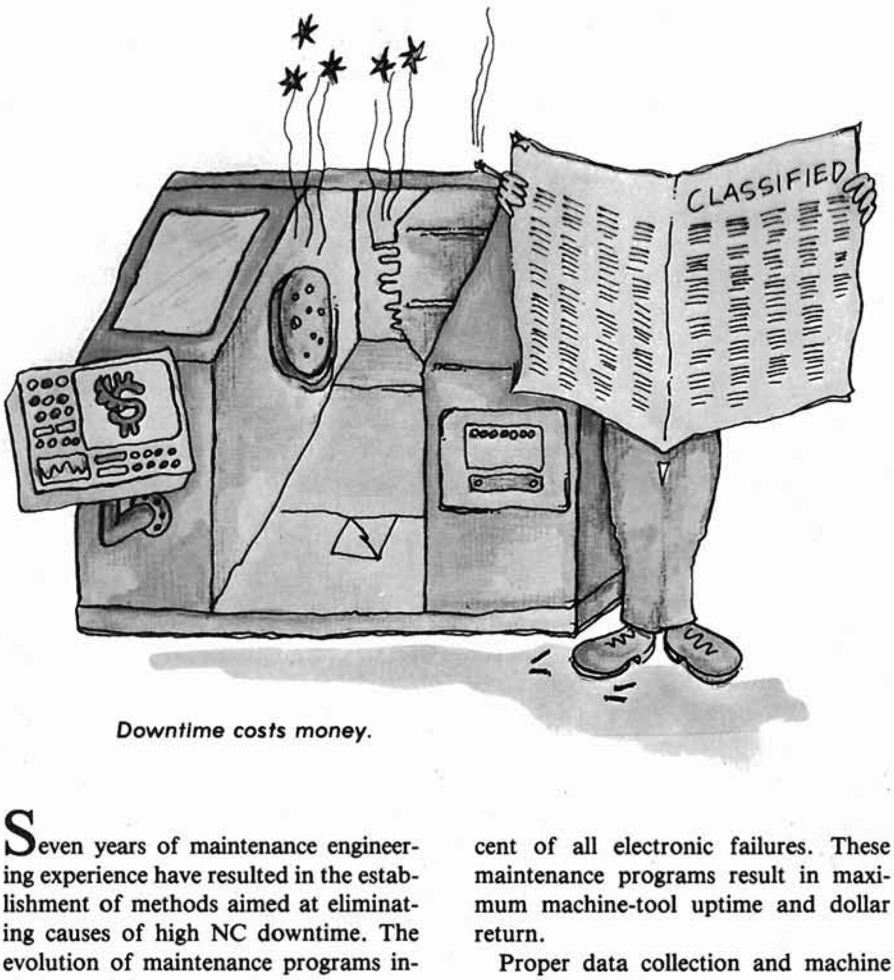
NUMERICAL CONTROLS

Reducing NC downtime



Downtime costs money.

Seven years of maintenance engineering experience have resulted in the establishment of methods aimed at eliminating causes of high NC downtime. The evolution of maintenance programs includes training NC technicians, establishing an organized spare-parts inventory, establishing a flexible electronic-repair lab, preventive maintenance and the elimination of adverse environmental conditions for NC and other industrial controllers. Environmental problems of heat, vibration, oxidation and electric power-line transients cause 80 to 90 percent of all electronic failures. These maintenance programs result in maximum machine-tool uptime and dollar return.

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Proper data collection and machine status reporting are valuable tools for improving productivity and reducing maintenance downtime. Where large numbers of automated machine tools are used, the machine-status reporting system should be computerized. There have been several such real-time reporting systems developed in the past few years, such as the online CNC and DNC systems by White-Sundstrand or Allen-Bradley, or the CICLOPS system which I developed.

In 1974, I filled a newly created position of electrical maintenance engineer for a *Fortune 500* manufacturer, and was charged with the responsibility of combating high NC, CNC and electronic controller downtime. Management felt that they could live with the mechanical downtime being experienced, but electrical downtime was severe—triple the amount of mechanical downtime.

Training program

With this predicament in mind, and knowing that the number of NC machines would grow from 40 to over 100 in the next five years, immediate emphasis was placed on training. The machines are automatic, but they don't repair themselves. An extensive NC maintenance training program was implemented whereby I attended specialized maintenance classes taught by OEM's. I then trained the company electricians.

The recent boom of electrical technology into industrial controls has been so widespread that it has quickly replaced conventional electrical control methodology. Therefore, electrical repairmen must be replaced or retrained to troubleshoot NC problems. As I was familiar with my students and their skill levels, training was directly applicable to troubleshooting needs.

As the training program proceeded from basic electronics to detailed training on specific NC systems, the downtime graphs and charts improved greatly on the machines which had been covered in the training sessions.

As the electricians got a handle on troubleshooting, downtime records still showed a lot of time waiting for parts. Therefore, an extensive program was initiated to review needed electrical spare parts and to purchase them so that they would be readily available when needed. Unlike mechanical repair parts, electronic components and circuit boards *cannot* be fabricated in the machine shop.

Test and repair facility

As spare parts were put into use a slight decrease in downtime was noticed, but the maintenance logs indicated that often the required spare circuit board was out of the shop. Repair turnaround time was excessive—approximately one to three months. Even when the repair modules were expedited, it still took almost a week to get needed parts. Therefore, the next step was to install a flexible circuit board test and repair lab. The lab quickly replaced out-of-plant repairs and OEM exchange on 98 percent of all electronic modules, including tape readers, power supplies, encoders, circuit boards etc.

In-house repair turnaround time averaged 12 hr versus 1 to 3 months. If a board was expedited, in-house repair took only 2 hr. The lab not only reduced our need for multiple spare parts of a particular type, it also increased technical understanding by the NC maintenance force. They were able to minimize time needed to repair the NC system, using spare parts, and then repair the defective module in the lab. This was profitable from two aspects. First, some $300/module was saved over the OEM repair cost; secondly, machine-tool downtime again decreased. The lab consisted of some $40,000 worth of test equipment—approximately $20,000 for general-purpose scopes, DVM's etc, and $20,000 for a sophisticated digital circuit-board test stand.

By this point, most people were satisfied that the electrical downtime problem has been solved because it had been reduced to the same level as mechanical downtime. This allowed us to step back and look at the information which had been collected, and, in retrospect, to analyze the causes of NC downtime. This analysis initiated the establishment of three new programs—preventive maintenance, controls standardization and environmental control.

A detailed report was then written describing each of the programs, and was subsequently circulated by the parent corporation to all plants in the US and Canada as guidelines for efficient NC and CNC operation.

Preventive maintenance

Few companies can dedicate the time to preventive maintenance (PM) to accomplish all of the recommended steps that the OEM specifies. However, there are many practical steps to save downtime as well as repair expense, such as cleaning tape readers, keeping air filters clean, keeping lubrication levels high and replacing DC motor brushes.

It is far better to regularly change spindle blower-motor filters than to let them clog with dirt and have to change a $10,000 spindle motor because it overheated. It is also smart to maintain proper lubrication levels rather than suffer damaged bearings and frequent servo errors. A good PM program will insure that hydraulic oils are run through a 2-micron prefilter as oil is added to the machine. Filters should also be changed on a regular basis and the machines flushed for 24 hr before going back into production. Shops without a formal PM program usually neglect or miss doing these things and then wonder why they have regular $1000 servovalve repair bills. These are only a few of the problems which can be avoided, so it is obvious that a conservative, yet effective, PM program is a must.

When our PM program was instituted, we turned to the PM feedback and to the servo data records to find the causes of repeated downtime. Close analysis indicated three factors: 1) Heat buildup in the electronic cabinets; 2) vibration resulting in intermittent board socket and contact problems; 3) electrical power-line spikes and transient activity disrupting or destructing the electronic components.

Up to this time, many of the problem machines had been tagged as candidates for control retrofit. Some were even new CNC's. Regardless, the repetitive downtime and circuit board failure rate were making a complete control retrofit seem imminent.

Upon discovering the above-mentioned environmental problems (heat, vibration /oxidation and electrical transients), and after effectively eliminating them, these same NC controls were fully reliable without retrofit. All of the CNC controls responded excellently. Only two of the NC controls were ever retrofitted. They had been restored to reliability, but because of limited control functions and deteriorated mechanical tolerances, the decision was made to carry through with a complete machine rebuild and retrofit.

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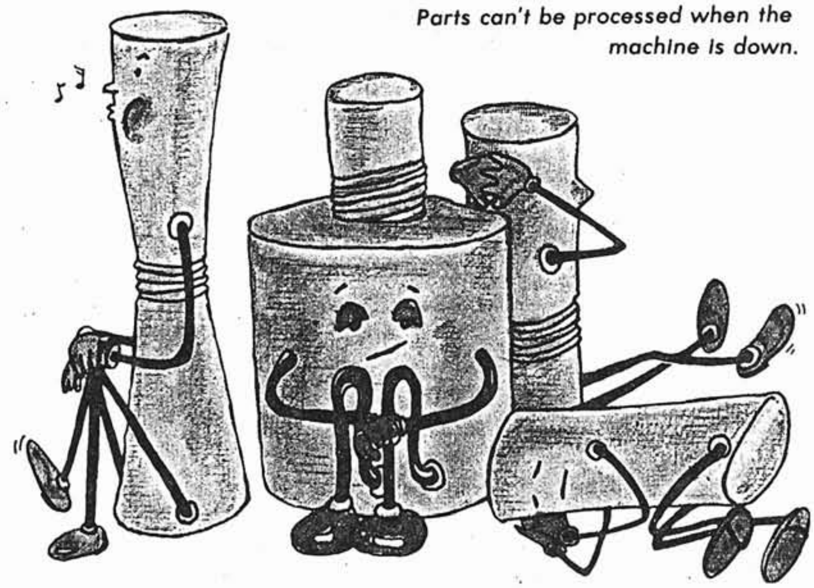

Parts can't be processed when the machine is down.

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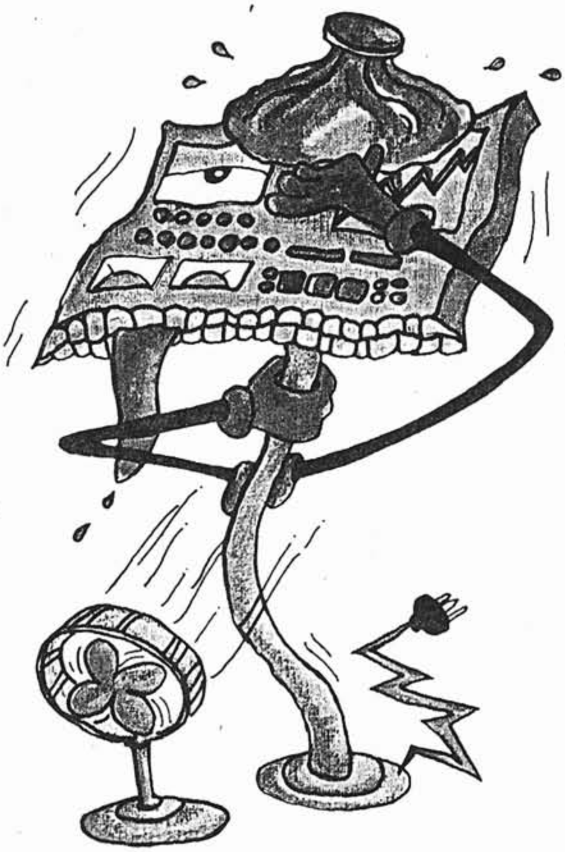

Electrical spikes, heat and vibration adversely affect the control.

The point here is that many NC controls and drives are subject to high maintenance downtime and become candidates for retrofit when the only problem is one of environment. Once we learned how to eliminate these problems, our downtime dropped to half that of mechanical downtime, even though mechanical downtime had decreased greatly due to fewer electrical-caused crashes and no more transient-caused machine jumps. Electronic circuit board failure became almost nonexistent on those machines which had been transient suppressed, and we no longer had memory problems or executive system program losses associated with CNC's.

It makes sense to hire a consultant, or talk to the OEM or a trained field service person to lay out definite plans for properly protecting equipment from environmental problems. There is no need to continually endure what many call "normal maintenance."

If additional cabinet air conditioners are required, get those which can be installed with minimum labor, and which will most reliably stand up in an industrial environment. When selecting transient suppressors, they should have at least 15,000 joule dissipation capability. Do not confuse this with peak watt, peak amp or dB ratings. The suppressors should respond within 6 nsec or less, and should have soft clamping with RF filtering capability. Also important when selecting suppressors are the voltage ratings and their locations within the NC system.

Recommended sequence of programs

When I went to work for another company two years ago, I reflected on the above experiences with this question in mind, "In what sequence should these programs be implemented to provide the greatest results in the least amount of time?" After a period of getting close to the new machines, I determined that most plants have similar environmental conditions, and that downtime causes are generally the same. I realized that the sequence in which the above programs had evolved was exactly backwards.

That is to say, if any industrial plant would first properly install transient suppressors to protect all industrial controllers, then survey to find and eliminate overheating and vibration problems, most electronic and electrical problems would be eliminated. Then, if a practical PM program were established, the NC downtime would become so low that it would be hard to economically justify extensive spare parts, in-house repair labs etc.

Having arrived at this conclusion, such a survey was taken at two of the company's facilities and a capital expense request was written to buy the suppression equipment for all NC and microprocessor controllers.

In June of 1980 we lost a third of our NC technicians and in July during plant shutdown, the suppression equipment and two air conditioners were installed. Since that time, the remaining NC technicians have spent very little time on NC problems. Even though their forces had been cut by 35 percent, electronic failures dropped by 80 to 90 percent.

In conclusion, here are the main points to be learned, in their proper sequence:

1) Proper machine status reports can be very helpful in determining causes of downtime and eliminating NC downtime.

2) *Do not* spend a lot of time and money setting up maintenance programs until your equipment has been surveyed and properly protected from environment impact (heat, vibration and transients). This is inexpensive and is the most cost effective approach. When I survey a plant, it takes about 4 hr to survey 8 to 15 machines, and 8 hr for 20 to 30 machines. A report, specifying the suppressor types, air-conditioner types and electrical connection points for this equipment is then provided. The cost to properly protect an electronic controller ranges from $300 to $2000, depending on suppressor configuration and air-conditioning needs. This can easily be justified with ~~the automatic~~ elimination of the first 24 hr of downtime.

3) Preventive maintenance of subsystems known to deteriorate with time is a must.

4) An effective training program should be established. Training proves very effective in reducing diagnostic time on NC machines.

5) If you have large numbers of electronically controlled machines, it may be advantageous to establish an in-house test and repair lab to reduce spare parts inventories and module repair turnaround time and expense. ■