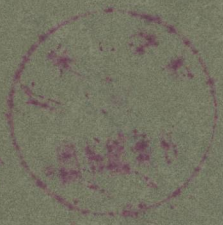
THE INTERNATIONAL FUTURE OF NC/CAM

Edited by Mary A. De Vries



The International Future of NC/CAM

Edited by Mary A. De Vries

Proceedings of the Eleventh Annual Meeting & Technical Conference Numerical Control Society March 31-April 3, 1974

Printed in the United States of America

Conference Committee
Toronto Chapter, NCS

Executive Dir.: William H. White

Conference Chmn.: Alan F. Mundy

National Coord.: G. Ray Gibson

Conference Coord.: Stanley Manchuk

PROGRAM

Technical Program: Ken Adams

Workshops/Panels: Brian Roffey

Publicity: Tony Whitney

Personnel: Theodore Read

Secretary: James E. Crozier

Treasurer: Charles Taylor

Equipment, Hospitality Suites, and Literature Display: Murray Roberts

George Brown College Chapter Coordinator: George Danac

Advisor: Andrew Poulson

ACTIVITIES

Tours: George Goossen

Student Chapter Coordinator: Manfred Garbe

Ladies Program Coordinator: George Danac. *Committee:* Joan Mundy, Ruth Roberts, Jill Roffey, Mary Taylor, Flo Crozier, Carol Goosen, Carol Danac

PAPER SELECTION

Chairman: Ken Adams

Belgium: A. S. Gregory

Canada: Ted Crozier; John Duncan; Doug French

France: J. P. Crestin

United Kingdom: W. H. P. Lesli

United States: Joe Frisch; Ed J. Toton

NUMERICAL CONTROL SOCIETY

A professional organization which provides opportunities to contribute to and learn about the application and technology of numerical control in all industries. NCS is affiliated with AIIE, GAMI, IMMS, SME, and SANCS.

Administrative Offices: P.O. Box 138, Spring Lake, N. J. 07762

Editorial and Advertising Offices: P.O. Box 26, Concord, N. H. 03301

CONTENTS

ECONOMICS AND MANAGEMENT

CAD/CAM

PROGRAMMING

NC/DNC/CNC AND ADAPTIVE CONTROL

APPLICATIONS

SERVICE AND MAINTENANCE

SPECIAL TOPICS

ECONOMICS AND MANAGEMENT

NC Training: Who Needs It?

To NC or Not to NC

Analyzing Costs in Conventional and CAM Systems

NC Training: Who Needs It?

WILLIAM F. HACK
Coordinator, NC Technology
William Rainey Harper College

Recently, the numerical control field turned the corner from a sophisticated technology used by the aerospace industry to smaller shop applications. In the past tool and mold shop management have shown that NC techniques were not applicable to their particular business. This has proven wrong. Without the planning, organizing, and money of large organizations, the small shop has had to look into the problem of staffing, where one man may wear half a dozen hats.

What is available to the manager of an industrial operation in the way of training for his personnel? What are some possible alternatives and activities that are not generally considered to be training programs as such?

The manager of a manufacturing operation, when dealing with the area of training, must be a counselor, evaluator, and, to some degree, an instructor, to get effective results from his personnel. He must consider all available training techniques and must be innovative enough to apply his own ideas and use to his advantage techniques that would not be considered classic training methods.

Because of the proliferation of NC equipment, it has become difficult to find people who are broadly defined as numerical control programmers. There is also difficulty in selecting personnel as NC operators and in knowing who should be trained as maintenance personnel.

It is also obvious that supervisory personnel are not familiar with NC equipment. The tool design department does not understand the NC machine; therefore, it is not designing fixtures at minimum cost. Management is not fully aware of the implications of NC even though they feel it is required. As

managers, they do not know what questions to ask, where to get the answers, or how to evaluate the answers in light o. their particular manufacturing problems.

Many personnel in a manufacturing unit require training. This training does not necessarily have to be formal, but it *is* necessary in many cases due to the complexity of NC systems. What are some of the areas that might require a knowledge of numerical control? The NC programmer needs to understand how to write NC programs. But what of tool design or the shop foreman, the quality control department, the engineering department, the manufacturing manager—what are the needs of these individuals and what kind of training should they have?

Operators

Look at the bottom rung of what you might call the "ladder" of an organization. Here the key individual is obviously the man who operates the machine tool—the NC machine operator. The operator of an NC machine must know what buttons to press and how to load and unload tools. Does he require knowledge of the NC machine setup? Must he understand the mechanics of the control system to be able to locate a part on the table and properly produce it? Must he make his own tape corrections?

Recently some machine tools have been marketed, which suggests that the operator has the ability to intervene in the manufacturing process. The question is, Is the operator competent to do this? The following list suggests areas of operator competence: (1) the operation of the machine tool itself; (2) those pertinent preventive maintenance activities included in his job description; (3) an ability to interpret tape information; (4) the ability to read the holes in the tape, the binary coded decimal information; (5) an understanding of the concepts of speeds and feeds as they apply to various materials; (6) a reasonable understanding of the total machine system, so that he may help in diagnosing system problems; and (7) the ability to make minor corrections in tapes without the direct aid of an NC programmer.

The operator can learn the operation of the machine tool and some of the concepts of the system when the tool is installed. He can help either directly or indirectly in the installation of the machine tool. Knowledge of metal removal, speeds and feeds, and surface feet per minute requires some formal training, along with a basic training in programming.

Shop Foreman

The shop foreman is the next individual of concern. What is required of him in the NC system? First, he must understand that the system is not just a machine and its control. The system includes the operator; for without the

operator pressing the button, telling us what is wrong, and helping us resolve operation problems, the system will not function. The foreman must therefore not only understand the man but also understand the NC system. He must have an idea of how it works, why it works, and what methods are available for effectively changing or modifying the way the system functions. Let us look at some areas of concern to him.

He needs to understand programming techniques. He must understand feeds and speeds. He must understand that tooling is a crucial part of the NC operation. He should understand *why* preventive maintenance is needed. He knows that the machine tool is expensive but does not understand what is required to keep it in good operational order. How do you train this man to supervise or manage the NC system properly? He can learn the basic machine system at installation through informal training. But programming should be learned in a formalized program. From previous experience, he should know material-removal theory; if he doesn't, he requires a condensed presentation of this information. The training activities as related to the shop foreman can also be on-the-job.

There is an inherent fear of NC on the part of those indirectly associated with the system. It behooves management to attack this problem realistically. The level at which this fear begins to generate itself is the shop foreman level. A basic course in NC, teaching the foreman terminology, would suffice to make him feel more comfortable with the NC system as a whole.

Quality Control

Do quality control personnel, either management or shop level, need any knowledge or understanding of this NC system? Without an understanding of the NC system, quality control will either come to a halt or stop the entire manufacturing operation as it is related to NC. Those who have delved into NC recall the many, many hours spent arguing whether a part is one or two thousandths out of print and whether it makes any difference in the quality of the product. They have also observed the technique of inspecting each part completely after machining on an NC machine. Quality control personnel should be introduced to the terminology of NC equipment, the concept of the equipment, and, in addition, be schooled in the techniques of statistical quality control. The ability of NC equipment to make identical products lends itself to the technique of statistical inspection methodology; therefore, it is believed that statistical inspection is necessary for proper NC support.

Tool Design

If the tool designer is defined as the person whose responsibility is planning and design of a fixture to hold a part on an NC machine, it is necessary that

this person understand the problems of the programmer, the machine tool, and tool deflection and cutting. For the tool designer to understand NC tooling problems, he must be able to deal directly with the problems. He should have a formal programming course which should be directed toward tool path operation rather than program-coding problems. Let him debug a program previously written and thus come in contact with problems related to clamp clearances, part loading and unloading, and cutter deflection.

Another problem that should be considered when dealing with the relation of tool design to NC is that of the flexibility built into an NC machine. For example, consider the soft jaw chucking methods used in most manufacturing facilities; with some innovative design parameters, it is possible to chuck parts using soft jaws so that they may be reversed and therefore not require a floor-to-floor handling operation. This requires some mental gymnastics on the part of the tool designer. Training in this area is unavailable at this time.

Manufacturing Planner

The Planner is the one who historically has been considered most likely to become the programmer. His activities include not only selection of existing machines, existing tooling, recommending the tooling methodology, but also liaison between the shop and the engineering design facility. It is important that the training of this person be taken into consideration. If he is to become an NC programmer, he should be taught NC concepts. In addition, he must understand the complexity of machine and tooling problems. He must know what can and cannot be done on NC machinery. He must know what tolerance can be expected from the machine tool. It is management's responsibility to allow the manufacturing engineer to be formally trained in the production planning techniques available so that he may apply his knowledge to the planning and use of NC machines.

Manufacturing Engineering Manager

You, must realize, of course, that the manufacturing manager is not concerned directly with the everyday, step-by-step problems that the programmer, tool designer, and manufacturing planner have when dealing with NC equipment. A lack of understanding of the problems related to numerical control and the problems of the programmer and tool planner when dealing with NC equipment can create environments not conducive to high productivity. Manufacturing managers should be introduced to programming NC machines just as an NC programmer. In addition, the NC programmer be introduced to the available training activities which involve NC—for example, the available coordinator training programs. He should be introduced to the

personnel required to support NC. To do this, he should take some type of general introduction to numerical control, which will enable him to determine the kind of personnel needed for the support of NC machine operations—NC programming, tool planning, and manufacturing engineering. The programmer should be introduced to the economics of NC and spend considerable time reviewing cost factors and some of the variables he may not have considered when purchasing new equipment or reviewing the productivity level of the present manufacturing facilities.

It is advisable for an industrial organization to consider a familiarization program for its design engineers, so they may have an appreciation of the flexibility of this new system of manufacturing.

Maintenance

Obviously a maintenance man must be someone with a knowledge of hydraulics, electronics, and mechanics. Therefore, his training should deal with all of these factors. He must receive formalized training in hydraulics, electronics, and mechanical applications. You cannot take an individual and expect him to learn merely by doing, as you might with conventional equipment. The entire NC machine system is a complex, highly accurate, precise device and therefore requires some knowledge of the system before it is possible to delve into it and do any repairs or service.

Training

The above are some areas of training for NC activities. A wide variety of training facilities and training aids is available. There are the private consulting firms which deal in management training, for example, the NC coordinator training program put together by a number of consulting firms. These firms are also in the area of general NC; in some cases in programming methodology, they use computer or manual programming or both. In addition, you have original equipment manufacturers which have training programs in programming and maintenance. There are programming services with training courses which are made available to those interested in purchasing or who have already purchased a particular programming language. There are scattered throughout the country both two-year colleges, technical colleges, and four-year universities which have specialized programs in numerical control. The Numerical Control Society and other nationally known societies from time to time offer workshops in numerical control, in tooling, general numerical control, and, in some cases, computer programming.

Which of these specific areas managers should use is something which they themselves must evaluate. When they are available, the manager of manufacturing or of any business operation should consider using the available

training programs in formalized educational institutions. In doing so, he should take a close look at the course to make sure that it is particularly relevant to his operation.

The shop employee and the NC operator should be allowed to attend programming courses geared to their level. There is a twofold benefit—the understanding and realization of the problems a programmer has in preparing a program, and the possibility that a programmer may someday be operating the machine tool. It is also possible that this individual is potential supervisory material. In addition, tool design, quality control personnel, machine operators, and manufacturing engineering planners should be given the option of attending other formalized educational subjects related to numerical control.

Your maintenance personnel should be sent when possible to the original equipment manufacturers (OEM) for training in servicing the equipment. One training method available which allows maintenance personnel to work with the OEM assembly facility in the final assembly and check out your NC machine.

In dealing with quality control and statistical analysis, you should consider a formal course. There are many levels of statistical analysis, but the level that you should be considering is a simplified level. A minimum understanding of the concept is necessary.

Consider some areas not necessarily defined as training programs but which could, if properly used, result in some good training. Managers and, in many cases, manufacturing engineers, can learn a good deal from NC sales presentations. The problem is that an *objective* usually has not been pinpointed before personnel attend these training programs. It behooves a manager to carefully review and put in writing what he wants to learn. By contacting two or three manufacturers, he should be able to put together a list from which he can judge whether NC is justified.

Another area not often considered a training activity is the annual NC Conference and those programs presented at Numerical Control Society seminars. Rather than sending your personnel to one of these meetings carte blanche, why not select specific areas of interest which should be investigated and suggest that they respond with a brief critique of each of the sessions they attend? The results could be as valuable—possibly more valuable—than sending them out shotgun style.

You need trained personnel, and you don't have the money to send out personnel for all of these fine ideas. But consider that you are tying up an investment of $15,000 to $500,000. Taking five per cent of an average investment of $100,000, we have $5,000, which is a relatively large sum of money

to spend on training in preparation for the support of an NC system. Five per cent of a $50,000 investment is $2,500, which can go a long way to train personnel for your operation. In relation to the total amount of money spent, isn't a 5 per cent investment to insure a return worthy of consideration? We often fail to realize that this is an area that should be considered very carefully. Without proper training, you are unable to make your investment productive.

To NC or Not to NC

RICHARD M. PENN
Director of Sales and Marketing, Moog, Inc.

NC machining centers are commonly considered suitable for low-to-intermediate-production volumes. The ideal lot size is usually said to range from 20 to 500 pieces, with annual production of 100 to 5,000 pieces. Guided by this rule-of-thumb, when a manufacturing manager must produce quantities from 5,000 to 100,000, his first reaction frequently is to choose a special-purpose, high-production machine. But this rule-of-thumb is highly inaccurate and can result in lost profitability.

Special purpose, high-production machines of the type discussed consist of a dial-type rotary table surrounded by several machining heads that operate simultaneously. Obviously, such a machine has a higher production rate than a single NC machining center with only one machining head. But its productivity is never in direct proportion to the number of machining heads, because the total cycle time can never be less than the cycle time for the head with the longest cutting operation. In addition, since productivity is measured by the ratio of dollar output to dollar input, machine and associated costs are important. The investment in the special machine, its tooling and initial set up, is generally significantly greater than for an NC machining center. Since this cost is amortized over the number of pieces to be manufactured, its effect is reduced as the quantity is increased. Therefore, the special purpose machine becomes more desirable as production increases.

These considerations bring us to the key question: At what production volume does it become more profitable to select a special-purpose, high-production machine rather than an NC machining center? A break-even