INTRODUCTION TO COMPUTER NUMERICAL CONTROL

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Introduction to Computer Numerical Control

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Dedication

To my wife, Barbara, and to our delightful children, Sarah and Andrew

James V. Valentino

To my wife, Erica, and to our wonderful children, Janet, Simon, and Victoria, for their endless love, support, and inspiration

Joseph Goldenberg

Preface

One of the greatest challenges facing the United States today is in the area of manufacturing. To a large extent the computer has revolutionized this technology. It has virtually transformed the process of product design, analysis, and manufacture. Industries are finding that the new manufacturing technology demands well-trained personnel. Education is now being viewed as a continuous and long-term investment.

This textbook was written to provide basic training in an important area of modern manufacturing—computer numerical control (CNC). The approach is to gradually develop the most fundamental concepts in CNC technology. Every effort has been made to use language that is easy for beginners to understand. Several learning aids have been designed throughout.

- Each chapter begins with a brief listing of objectives and ends with a chapter summary.
- Illustrations and photographs are used liberally throughout.
- In each case an illustration is presented to reinforce pictorially what is being discussed.
- Students are immediately directed to boxed-in key terms and concepts.
- Flowcharts are used to teach CNC process planning and program planning.
- The important topic of job setup is discussed in the many solved programming examples.
- Fundamental word address (G and M code) programming is stressed.
- Industrial standard practices and terms are emphasized in the solved programming examples.
- Needless cross-referencing has been eliminated. Each program is listed with all explanations appearing on the same page.
- Pattern recognition is emphasized. The student is taught to recognize a certain group of programming commands as a programming pattern. For example, pattern A commands start up the CNC machine, whereas pattern B commands cause a tool change to take place, and so forth.
- An excellent assortment of review exercises is provided at the end of each chapter. These exercises are complete in supplying the student such important information as the operation to be performed, tooling, tool speed, tool feed, and job setup data.
- The industry standard Fanuc controller is emphasized throughout the text.
- Important mathematical principles are reviewed before programming is presented. A special chapter on right-triangle trigonometry provides the student with the critical mathematical information needed to understand programming.
- The student is exposed to the big picture of CNC shop activities. A special chapter explains the most important operations to be carried out in manufacturing a part.
- Appendixes contain information useful to the CNC student. They include a list of important safety precautions; summaries of G and M codes for milling and turning operations; recommended speeds and feeds for different materials with respect to drilling, milling, and turning operations; and important and easy-to-use machining formulas.
- A comprehensive glossary of key CNC terms is provided at the end of the book.

Modern Computer Numerical Control Technology can be applied as an entry-level text for many different types of training applications. These include

- Undergraduate one-semester or two-semester CNC courses
- Manual component of a CNC programming course
- Industry training course
- Seminar on CNC programming
- Adult education course
- Reference text for self-study

This textbook is designed to be used in many types of educational institutions such as

- Four-year engineering schools
- Four-year technology schools
- Community colleges
- Trade schools
- Industrial training centers

This work is the result of several years of experience in running CNC courses for both industrial personnel and the students at Queensborough Community College. It was found that many existing texts were either too general or too advanced for direct application. As a result, supplementary notes containing step-by-step information were drafted. The notes were enhanced and tested extensively in the classroom. Several colleagues, both in industry as well as in education, were called upon for their inputs. A thorough market survey also influenced the final content. It should be noted that all the programs presented have been thoroughly tested. The student is advised to take the appropriate safety precautions when running them on a CNC machine.

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Introduction to Computer Numerical Control

Contents

chapter 1

Introduction to Computer Numerical Control Manufacturing

1-1 CHAPTER OBJECTIVES

At the conclusion of this chapter you will be able to

1. Explain what computer numerical control (CNC) is and what basic components comprise CNC systems.
2. State the objectives, advantages, and special requirements concerning CNC use.
3. Identify the different media used to input and store CNC programs.
4. Describe the two different punched-tape formats used with CNC machines.

1-2 INTRODUCTION

The basic concepts of numerical control (NC) and computer numerical control (CNC) technology are discussed. Traditional NC and contemporary CNC hardware configurations are described. The important benefits to be derived from CNC operations are listed and explained. The different types of media used for storage and input of CNC programs are then explored. The reader is introduced to different formats for punched tape. Machining centers with automatic tool changers are the latest development in CNC and are considered.

1-3 NUMERICAL CONTROL DEFINITION, ITS CONCEPTS AND ADVANTAGES

Numerical control has been used in industry for over 40 years. Simply put, numerical control is a method of automatically operating a manufacturing machine based on a code of letters, numbers, and special characters. A complete set of coded instructions for executing an operation is called a program. The program is translated into

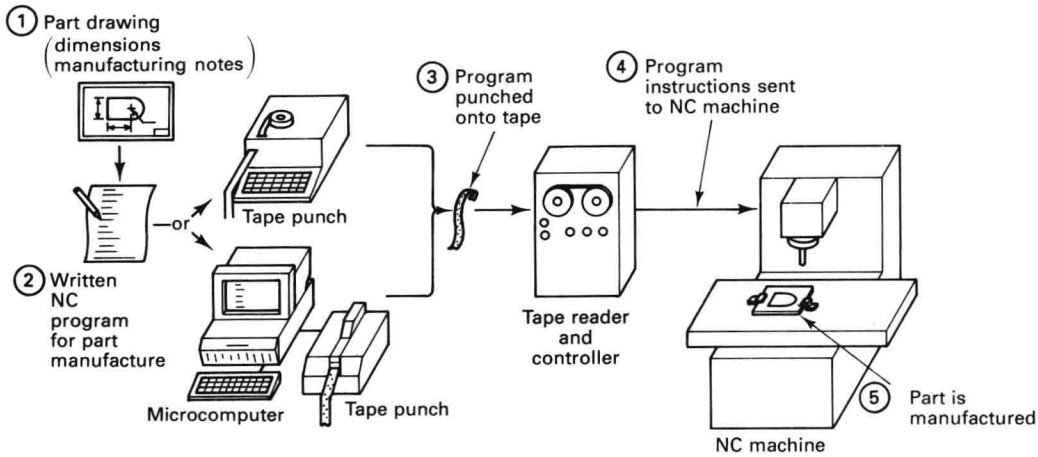

Figure 1-1 Components of traditional NC systems.

corresponding electrical signals for input to motors which run the machine. Numerical control machines can be programmed manually. If a computer is used to create a program, the process is known as computer-aided programming. The approach taken in this text will be in the form of manual programming.

Traditionally, numerical control systems have been composed of the following components:

Tape punch: converts written instructions into a corresponding hole pattern. The hole pattern is punched into tape which passes through this device. Much older units used a typewriter device called a Flexowriter. Newer devices include a microcomputer coupled with a tape punch unit.

Tape reader: reads the hole pattern on the tape and converts the pattern to a corresponding electrical signal code.

Controller: receives the electrical signal code from the tape reader and subsequently causes the NC machine to respond.

NC machine: responds to programmed signals from the controller. Accordingly, the machine executes the required motions to manufacture a part (spindle rotation on/off, table and or spindle movement along programmed axis directions, etc.).

See Figure 1-1.

NC systems offer some of the following advantages over manual methods of production:

1. Better control of tool motions under optimum cutting conditions.
2. Improved part quality and repeatability.
3. Reduced tooling costs, tool wear, and job setup time.
4. Reduced time to manufacture parts.
5. Reduced scrap.
6. Better production planning and placement of machining operations in the hands of engineering.

1-4 DEFINITION OF COMPUTER NUMERICAL CONTROL AND ITS COMPONENTS

A computer numerical control (CNC) machine is an NC machine with the added feature of an on-board computer. The on-board computer is often referred to as the machine control unit or MCU. Control units for NC machines are usually hard wired. This means that all machine functions are controlled by the physical electronic

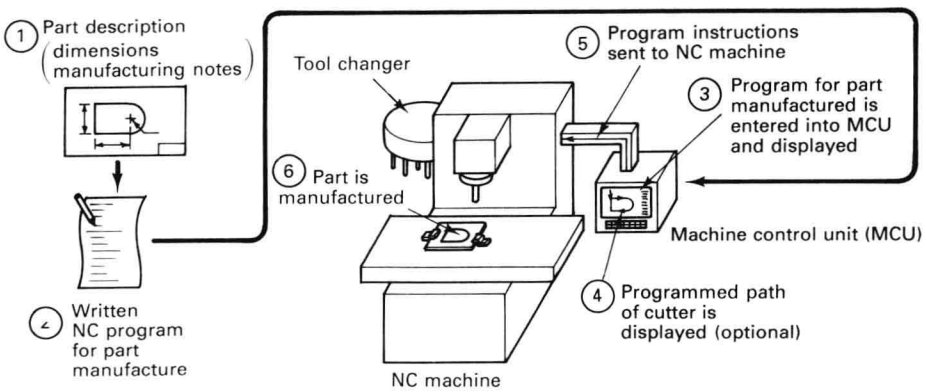

Figure 1-2 Components of modern CNC systems.

elements that are built into the controller. The on-board computer, on the other hand, is "soft" wired. Thus, the machine functions are encoded into the computer at the time of manufacture. They will not be erased when the CNC machine is turned off. Computer memory that holds such information is known as ROM or read-only memory. The MCU usually has an alphanumeric keyboard for direct or manual data input (MDI) of part programs. Such programs are stored in RAM or the random-access memory portion of the computer. They can be played back, edited, and processed by the control. All programs residing in RAM, however, are lost when the CNC machine is turned off. These programs can be saved on auxiliary storage devices such as punched tape, magnetic tape, or magnetic disk. Newer MCU units have graphics screens that can display not only the CNC program but the cutter paths generated and any errors in the program.

The components found in many CNC systems are shown in Figure 1-2.

***Machine control unit*:** generates, stores, and processes CNC programs. The machine control unit also contains the machine motion controller in the form of an executive software program. See Figure 1-3.

***NC machine*:** responds to programmed signals from the machine control unit and manufactures the part.

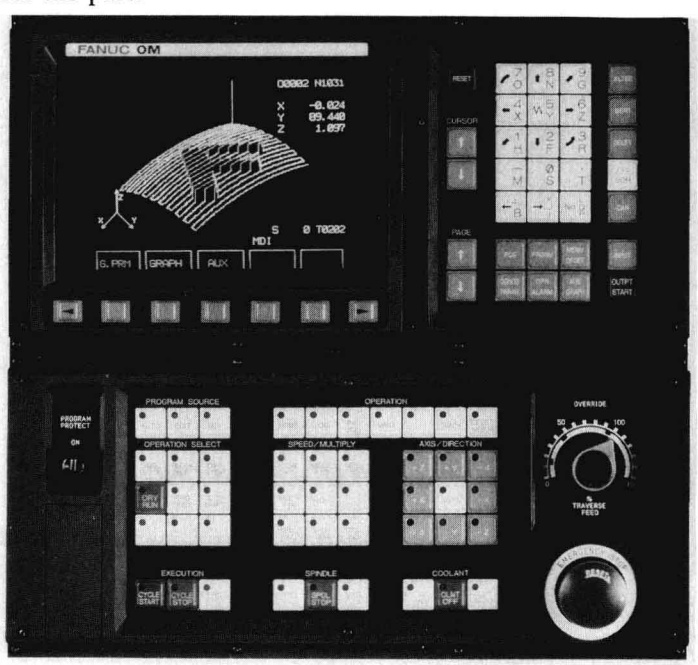

Figure 1-3 A modern machine control unit.