

## Preface

*CNC machining centers are among the most popular forms of CNC metal-cutting machine tools. Just about every company that uses metal-cutting CNC machines has at least one machining center:*

It is the intention of this text to introduce beginners and experienced shop people alike to the programming techniques needed for utilizing CNC machining centers. We will begin in a basic manner, ensuring that even newcomers to the machine shop environment will be able to follow the presentations. And we use a building blocks approach – so as you get deeper into the material – we will be adding to what you already know. When you're finished, you will have a thorough understanding of what it takes to program a CNC machining center.

While we will discuss a few setup- and operation-related topics, setting up and running a CNC machining center are beyond the scope of this text. Indeed, they are prerequisites to this text. If you wish to learn how to setup and run CNC machining centers, we do offer a separate text that will teach you these skills (to get the *CNC Machining Center Setup and Operation* manual, please use our contact information on the back cover of this text).

We use a *Key Concepts* approach to presenting CNC. The Key Concepts allow us to minimize the number of major topics you must master in order to become proficient with CNC machining center usage. With this approach, there are six Key Concepts related to programming CNC machining centers.

Beginners should concentrate most on understanding the points made early in each Key Concept. It is as important to know *why* you are doing things as it is to know how to do them. Concentrate first on the *whys*. It will be impossible for beginners to totally memorize and comprehend every technique used with machining centers the very first time it is presented or read. Rest assured that if you can understand the basic reasoning behind why each CNC feature is required, it will be much easier to master the use of the feature. Once this basic reasoning is understood, it will be relatively easy to review the related material to extract specific details of how each CNC feature is used – so you can start putting your CNC machining center to good use.

For experienced CNC people, this text will provide you with alternatives. You'll be able to compare your current methods to our recommendations. If you have previous CNC machining center experience for other types of CNC controls, you will find it relatively easy to adapt what you already know to the most popular CNC control in the industry, the Fanuc control. If you have had experience with other types of CNC machine tools, such as turning centers or wire EDM machines, this text will help you adapt what you know to CNC machining centers.

As experienced people know, there are many ways to utilize CNC equipment. This text will show you one or two safe ways to accomplish your tasks. You can use your own common sense and past experience to develop your own style.

### Prerequisites

Rest assured that this text will cover CNC machining center programming from the ground up. We will, however, assume that you possess some basic machining practice skills. And we will assume that you are acquainted with CNC machining center setup and operation. A CNC programmer must be able to create the

documentation used to setup and run the workpieces for which they create programs. They must, of course, understand what it takes to setup and run a CNC machining center in order to do so. Again, these topics are addressed in a separate text: *CNC Machining Center Setup and Operation*, which is sold separately.

### **Basic machining practice experience**

The more you know about basic machining practices, the easier it will be to learn how to program a CNC machining center. If, for example, you have worked on conventional machine tools in the machine shop, much of what you already know can be directly applied to CNC machining centers.

The more shop experience you have, the easier it will be to learn how to program CNC machining centers. If you have no previous shop experience, again, the needed topics are addressed in the manual entitled *CNC Machining Center Setup and Operation*.

### **Math**

The word *numerical* in computer numerical control implies that numbers are highly involved with CNC. Indeed, CNC programmers will be making countless calculations every day. However, most calculations are quite simple to make. The types of arithmetic calculations required to create a typical CNC machining center program include addition, subtraction, multiplication, and division. Some programs do require more complex math, including right-angle trigonometry, as some programs require the use of trigonometry to develop. As with basic machining practices, the more you already know about math, the easier it will be to learn CNC programming.

### **Motivation**

This should go without saying. We assume that you are motivated to learn. If you are highly motivated to learn about CNC machining centers, it will make your task much easier. Your motivation will help you overcome any obstacles you may have with learning the material in this text. With motivation, you'll stick to it until you understand.

### **Controls covered**

Since the Fanuc control is the most popular CNC control available, specific presentations in this text are provided in Fanuc format. Keep in mind, however, that the Key Concepts approach we use throughout this text will make it possible for you to learn techniques that can be applied to just about any CNC control in use today. Also keep in mind that several control manufacturers claim that their controls are *Fanuc compatible*. These manufacturers include Yasnac, Mitsubishi, Tasnac, Mazatrol (EIA option), Haas, Fadal, and Flashcut (among others). Even if you do not have one of these controls, we truly feel that if you understand the basic concepts, and if you understand how specific techniques are applied to one particular control type, it will be relatively easy to apply what you know to just about any CNC machining center control being used today.

### **Limitations**

Please take note that our first goal will be to acquaint you with the usage of three axis machining centers (having X, Y, and Z axes). For the bulk of this text, only these three linear axes will be discussed. Certain machining centers do have additional axes, and will be beyond the scope of this text.

We will be discussing both vertical as well as horizontal machining centers throughout this text. Since vertical machining centers are easier to work with and visualize, and since vertical machining centers are much more popular than horizontals, most of the examples given will be for vertical machining centers.

This text will not specifically address five axis machining centers. Though many of the same principles apply, we do not wish to present five axis machines during this introductory text.

### **Programming method**

This text teaches *manual programming* – also called G code level programming. While we're listing this as a limitation, knowledge of G code is extremely important. With this method of programming, a programmer

provides commands in the same “language” that the machine uses to execute it. While there are other ways to develop programs (using a computer aided manufacturing [CAM] system or a conversational CNC control) every CNC programmer must understand G code. CAM system programmers must, for example, be able to modify CNC programs at the machine when changes are required. These changes must be made at G code level.

### The need for hands-on practice

We cannot overstate the need for practice on an actual machining center in order to fully master what you have learned in this text. If you are enrolled in a CNC course at a technical school, your instructor will probably provide hands-on practice with one of the machining centers in the school’s lab.

If you are reading this text on your own, you will not get this needed practice. We cannot, of course, provide the experience you would get from practicing on a real CNC machining center in this text. No text can provide such practice. We can, however, provide you with the principles and concepts that you must understand before you can spend any meaningful time at the machine.

### Instruction method

This text is commonly used with a formal CNC course. Possibly you are enrolled in a technical school’s CNC course. Or maybe you are attending a company’s in-plant CNC training course. In either case, you have an instructor who is making presentations and available to help you understand the material. Or you may be using this text in conjunction with a video or CD-rom course, meaning your instructor is recorded. Either way, audio presentations should help you understand the concepts more easily. And with video and CD-roms, you can review the material as often as necessary.

If you have purchased this manual separately and do not have the benefit of an instructor, your task will be a little harder. While all of the key points made during live presentations are included in this text, you will be left on your own to study hard enough to grasp the material presented.

### Scope

As the name of this text implies, we address but one of the three tasks a person must master in order to fully utilize a CNC machining center: programming.

**Programming** (which the focus of this text) is the act of preparing a series of commands that tell the CNC machining center how to machine a workpiece. It involves coming up with a machining process, selecting cutting tools, designing and documenting a setup, and actually creating the CNC program.

**Setup** is the act of preparing the CNC machining center to run a series of workpieces (called a *job* or *production run*). Tasks involve (among other things) making the workholding setup, assembling, measuring, and loading cutting tools, entering certain offsets, loading the program, and verifying that the program is correct. In this text, we will be discussing the related tasks in the approximate order that setups are made.

**Operation** actually involves two things. First, you must be comfortable with the general manipulation of a CNC machining center. This involves knowing the various components on the machine, its buttons and switches, and how to perform several important procedures. Second, and more importantly, you must be able to complete a production run once the setup is made. Tasks involve (among other things) workpiece load and unload, cycle activation, measuring completed workpieces and making sizing adjustments if necessary, and dull tool replacement.

### Key Concepts approach

This effective presentation method will allow you to organize your thoughts as you read this text. This text includes six Key Concepts. Here are several benefits to this presentation method.

- 1) Any good training program should *put a light at the end of the tunnel*. All students want to know where they stand throughout any training course. With our Key Concepts approach, you will always have a clear understanding of your progress.

- 2) During each Key Concept, we will first present the main idea behind the concept. Again, it is at least as important to understand why you are doing things as it is to understand how to do them. Think of these early presentations for each Key Concept as the *why*. From there, we will present the specific techniques that are related to each concept.
- 3) The Key Concepts allow us to use a *building blocks approach* and present information in a very tutorial manner. We will be constantly building on previously presented information.
- 4) The Key Concepts approach allows us to limit the number of new ideas you must understand in order to grasp information presented within the text. Think of it this way: If you can understand but six basic ideas, you will be well on your way to becoming a proficient CNC programmer!

### **Lesson structure**

We divide the six Key Concepts into nineteen lessons. This makes it possible to further organize the most important topics related to machining center usage.

### **Practice makes perfect**

In this edition, we've included lots of practice and exercises within the text to help you confirm your understanding of the presented material. Answers are provided right in the text so you can quickly check your own work. This practice – and the ability to check your answers – changes this text from a book into a self-study course.

If you are using this text in conjunction with a technical school's CNC courses, you may be asked to submit your exercises without checking your answers. We ask that you do so honestly.

### **Key Concepts and lessons**

Here is a list of the six Key Concepts and the sixteen lessons that comprise this text.

#### **Key Concept 1: Know your machine from a programmer's viewpoint**

- 1: Machine configurations
- 2: Visualizing program execution
- 3: Program zero and the rectangular coordinate system
- 4: Introduction to programming words

#### **Key Concept 2: You must prepare to write programs**

- 5: Preparation steps for programming

#### **Key Concept 3: Understand the motion types**

- 6: Programming the three most basic motion types

#### **Key Concept 4: Know the compensation types**

- 7: Introduction to compensation
- 8: Tool length compensation
- 9: Cutter radius compensation
- 10: Fixture offsets

#### **Key Concept 5: You must provide structure to your CNC programs**

- 11: Introduction to program structure
- 12: Four types of program format

#### **Key Concept 6: Special features that help with programming**

- 13: Hole-machining canned cycles
- 14: Working with subprograms
- 15: Other special programming features
- 16: Programming rotary devices

### **Enjoy!**

We at CNC Concepts, Inc. wish you the best of luck with this text. We hope you find it easy to understand our written presentations and the presentations of your instructor (live or recorded). Once completed, we hope this text makes your introduction to CNC machining centers as easy and enjoyable as possible.