Sorin HERLE

DIGITAL CONTROL OF MACHINE TOOLS

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DIGITAL CONTROL OF MACHINE TOOLS

- PRACTICAL EXERCISES -

"For the things we have to learn before we can do them, we learn by doing them."

(Aristotle)

CNC machines are automatic devices computer controlled, capable of carrying out a series of machining operations with very high accuracy.

In modern manufacturing systems, with a high degree of flexibility, the CNC machines became virtually indispensable.

Originally, the numerical control has been used mainly to automate lathes and milling machines. Today, computer numerical control is used for many types of equipment such as robots, laser cutting machines, water jet cutting machines, plasma cutting machines, 3D printers, etc. However, most often, computer numerical control is used for milling and turning machines.

This volume is addressed primarily to students enrolled in the Automation and Applied Informatics study program, but it can be useful to anyone interested in the field of computer numerical control.

This volume contains 14 units that gradually make the transition from the programming basics of CNC machines, to more advanced concepts related to design and automatic generation of CNC programs using CAD-CAM systems.

Each unit presents some theoretical aspects accompanied by practical examples explained step by step. To deepen the knowledge presented, some exercises are proposed at the end of each unit.

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I hope this book will be useful to anyone interested in programming CNC machines. Suggestions and comments for improving this work are welcome.

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CONTENTS

CODE	DESCRPTION
G00	Rapid traverse
G01	Linear movement
G02	Clockwise circular movement.
G03	Counterclockwise circular movement
G04	Dwell
G17	Select X-Y plane.
G18	Select Z-X plane.
G19	Select Y-Z plane.
G20	Program coordinates are inches
G21	Program coordinates are mm
G40	Cancel tool radius compensation
G41	Left tool radius compensation
G42	Right tool radius compensation
G54	Work coordinates system
G55	Work coordinates system
G56	Work coordinates system
G57	Work coordinates system
G90	Absolute coordinates
G91	Incremental coordinates
M0	Program stop
M1	Optional stop
M2	End of program
M3	Spindle rotates clockwise

M4	Spindle rotates counterclockwise
M5	Spindle stop.
M6	Tool changer
M7	Mist coolant ON
M8	Flood coolant ON
M9	Coolant OFF
M17	End of subprogram
M30	End of program
F	Feed rate
S	Spindle speed
T	Tool
D	Tool correction
CYCLE71	Face milling cycle
CYCLE 72	Path milling cycle
POCKET1	Rectangular pocket milling cycle
POCKET2	Circular pocket milling cycle
CYCLE90	Thread cutting cycle.
SLOT 1	Slot on a circle cycle
SLOT 2	Circumferential slot cycle
CYCLE83	Stepwise drilling cycle
HOLES1	Row of holes cycle
HOLES2	Hole circle cycle

CODE	DESCRIPTION
G00	Rapid traverse
G01	Linear movement
G02	Clockwise circular movement.
G03	Counterclockwise circular movement
G20	Program coordinates are inches
G21	Program coordinates are mm
G33	Thread cutting with constant lead
G34	Thread cutting with linear increasing lead
G35	Thread cutting with linear decreasing lead
G40	Cancel tool nose radius compensation
G41	Left tool nose radius compensation
G42	Right tool nose radius compensation
G54	Work coordinates system
G55	Work coordinates system
G56	Work coordinates system
G57	Work coordinates system
G90	Absolute coordinates
G91	Incremental coordinates
G94	Feed per minute
G95	Feed per revolution
G96	Constant cutting speed, feed per revolution
G97	Constant spindle speed
M0	Program stop

M1	Optional stop
M2	End of program
M3	Spindle rotates clockwise
M4	Spindle rotates counterclockwise
M5	Spindle stop.
M6	Tool changer
M7	Mist coolant ON
M8	Flood coolant ON
M9	Coolant OFF
M17	End of subprogram
M30	End of program
F	Feed rate
S	Spindle speed
T	Tool
D	Tool correction
L	Prefix of the name of a subprogram
L93	Grooving cycle
L95	Paraxial turning cycle
L97	Threading cycle
L98	Deep-hole drilling cycle

EXPRESION	DESCRIPTION
Absolute coordinates	A series of numerical positions that are calculated from a fixed point of origin.
Approach distance	The distance between the lateral edge of the workpiece and lateral edge of the tool, before the tool enter into the workpiece or after the tool exit from the workpiece.
Blind hole	It is a hole that does not penetrate the workpiece
Boring	The process of enlarging a hole that has already been drilled.
Chamfering	Machining an angled edge around the end of a cylindrical workpiece.
Clearance	Any useful space that is intentionally maintained between components.
Contouring	It is a turning operation along the contour of a cylindrical workpiece.
Countersinking	It is an operation that enlarges an existing hole in a conical shape, to a required depth.
Cycle	Special command that allows programming of certain machining operations in a single line of program (rarely two lines for certain types of controllers).
Deep drilling	It involves a stepwise motion with return to a fixed point for chips removal.
Drill	A machining tool used to penetrate the surface of a workpiece and make a round hole.
Drilling	It involves a continuous motion in the longitudinal direction of the hole.
Face turning	The face turning operation is performed by moving the cutting tool on the transverse direction of the workpiece.
Feed rate	The rate of tool travel through the workpiece per unit of time, generally expressed in inch or mm per revolution (turning) or inch or mm per tooth.
Helical motion	It is a circular motion in a plane (X-Y, X-Z, Y-Z), combined with a linear motion in the direction perpendicular to the plane in which the circular motion take place.
Incremental coordinates	A series of numerical positions that use the previous position as the point of origin for the next position.
MCALL	It is used for modal calling of a cycle.
Modal command	The command that remains in a certain mode until it is canceled by an equivalent mode.
Non-modal command	The non-modal command affects only the line on which it occurs.
Peck drilling	It involves a stepwise motion with return to a variable point for chips breaking.
Plain turning	The plain turning operation produces a cylindrical surface by removing excess material from the blank, while the tool moves along the blank.
Pocket	An interior recess that is cut into the surface of a workpiece. Pockets may be round or rectangular.

Preparatory G codes	Preparatory codes identify the type of activities the machine will execute.
Spot drill	A short, sturdy drill used to start a hole and accurately locate it. The spot drills have a 90^0 or 60^0 tips.
Tap	Tool used for machining internal threads
Threading	Threading is the process of creating a screw thread.
Through hole	It is a hole that penetrates the workpiece
Tool entry/exit	It refers to the trajectory followed by the cutting tool to get in contact with the workpiece.
Tool nose radius compensation	An offset feature used on a turning center that slightly shifts the toolpath for the rounded tip of an insert during contouring, chamfering, and other multi-axis operations.
Tool radius compensation	It adjusts the position of the tool center so that its edge to be in contact with the workpiece.
Turning	The machining process used to make cylindrical parts.
Width of cut (step-over)	Width of cut or step-over is the contact area between the tool and the workpiece during machining. It is usually expressed as a percentage of the tool diameter.

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