

Trade of Toolmaking	
Module 6:	Introduction to CNC
Unit 4:	CNC Setting & Operation
	Phase 2

Published by



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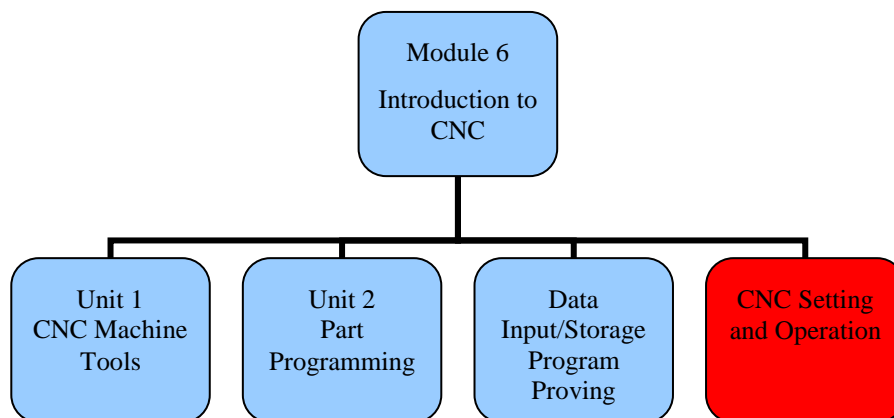
Unit Objective

On completion of this unit you will be able setup the workpiece, load the tools and set the machine axis datum. You will also be able to explain how to operate the CNC machine and components.

Introduction

Module six of this course covers CNC machining. This is the fourth unit in module six and explains how to setup the workpiece using various methods and then use a probe to find the workpiece datum point. This is important as all the dimensional values in the part program will be referenced to this datum point. The tools will need to be inserted into the tool changer where each tool position has a unique number that corresponds with the tool number in the part program.

When clamping the workpiece in the vice or in a chuck care must be taken to ensure that there is sufficient clearance between the cutter paths and the holding device. This is most important when the tool is moving at a rapid feed rate from the tool holder to the workpiece. When running the program for the first time, it is important to observe the tool movements at all times. A feed rate over-ride dial will allow the operator to slow down or even stop the movements of the tool. Always know where the emergency stop button is and in the event of an emergence and press it immediately.



By the end of this unit you will be able to:

- State the procedure for loading work pieces and installing tooling.
- State the procedure for setting machine axis datum.
- Analyse the procedure for producing simple milled or turned components having prepared a part program.
- Operate and produce components on the CNC machine.

1.0 Procedures For Loading Work Pieces And Installing Tooling

Key Learning Points

Clamping and work piece holding. Workpiece and tool setting. Collision free tool setting. Hazards associated with setting and operation of CNC machines.

1.1 Clamping And Work Piece Holding

For CNC milling machines, workpieces can either be held in a vice, a grid plate or clamped directly onto table with bridge clamps. It is important to position the vice or the clamping arrangement in the middle of the work table, as this ensures the greatest support and minimises deflection of the machine table due to the weight of the component and the vice. The direction of the cutting forces should always be directed towards a positive fixed location.

For CNC lathes, workpieces are normally held in chucks, collet chucks or turning fixtures. The *chuck* can be manual or power assisted, which reduces time when loading and unloading parts. Such chucks are either pneumatic or hydraulic, where the hydraulic system provides greater gripping power. The *collet chuck* is quick acting fixed diameter work-holding device. If the components are to be machined from lengths of bar, the bar stock can be fed through the centre of the collet onto a fixed stop. *Turning fixtures* are special purpose fixtures manufactured for holding irregular shaped parts. The fixture is mounted directly onto the machine spindle.

Ref: Timings, R.L. 1998, *Manufacturing technology*, vol. 1, 3rd edn, Pearson Education Limited, chapter 5, *Numerical control part programming*, sec. 5.13, *Workholding*, p. 195.
ISBN-13: 9780582356931

1.2 Workpiece And Tool Setting

When the workpiece needs to be machined it is clamped on the machine table. A setting probe is jogged manually to the workpiece, which is then probed to establish a new datum point in the X, Y and Z axis, called the *workpiece datum*. The workpiece datum is registered as the new datum point from which all programmed positional moves will be made.

The tools are inserted manually into the tool changer, where each tool position has a unique number that corresponds with the tool number in the part program. The tool tip is jogged to the workpiece and when it touches, the position is set to zero. The difference between this setting and the position that was originally set by the probe is registered and saved in the machine control unit, which sets up the correct offset for the tool. All other tools are setup in the same way.

Ref: Timings, R.L. 1998, *Manufacturing technology*, vol. 1, 3rd edn, Pearson Education Limited, chapter 5, *Numerical control part programming*, sec. 5.10, *Tool length offset*, p. 190.
ISBN-13: 9780582356931

1.3 Collision Free Tool Setting

When preparing the program it is important to ensure that the cutting tool does not run into the workpiece when tools are being changed or collide with the clamping arrangement. This may occur when the tool is running at rapid speed to and from the workpiece. Therefore when running the program for the first time, single-step machining should be used. Also the feed rate over-ride button should be used to reduce the speed of the incoming and out going tools during the first program run.

1.4 Hazards Associated With Setting And Operation Of Cnc Machines

When setting up the workpiece for the first time care must be taken when inserting the tools into the tool changer. Hold the body of the tool holder, otherwise your finger may be pinched between the tool holder and the tool changer when it is pulled up and engages in the tool changer. Also you should not grab the tool itself as the sharp edges can cause injury. Care must be taken when touching the tool off the work when setting up the offset against the workpiece surface.

When running a part program for the first time, it is important to keep your eye on the cutting operation and keep your hand on the *feed rate over-ride dial*, which will allow you to slow down or even stop the movement of the cutter in the event that the feed rate being too fast or if it is about to collide with the vice or the clamping arrangement.

2.0 Procedure For Setting Machine Axis Datum

Key Learning Points

Floating zero facility (reposition the datum). Probing of the workpiece.

2.1 Floating Zero Facility (Reposition The Datum)

The machine datum is the point within the machine's range of movement from which the machine makes its programmed moves. It is an exact point that the machine can find even after power loss and also this is the point that the machine slides move to when you reference the machine. This point is often called the *zero datum* or the *machine reference point*, which is normally positioned above the bottom left hand corner of the table.

When the workpiece needs to be machined it is clamped on the machine table. A setting probe is jogged manually to the workpiece, which is then probed to establish a new datum point in the X, Y and Z axis, called the *workpiece datum*. The *workpiece datum* and the *zero datum* are now in different positions. The workpiece datum now needs to be registered as the new datum point from which all programmed positional moves will be made. On some machines a button marked *axis zero* is pressed to confirm this action, but the method of doing this will vary and will depend on the type of machine being used.

2.1 Probing Of The Workpiece

A probe or digital edge finder is held in the spindle of the machine and used to locate the spindle over the datum point of the workpiece. This is done by touching the datum edges of workpiece with the probe. An LED lights up when an electrical circuit is established between the workpiece and the probe. At this point the position is set to zero and the operator moves it upwards away from the workpiece. The slide is then moved by half the diameter of the probe. The spindle is now positioned exactly over the datum edge. This is repeated for the other datum edge. The top of the workpiece is also probed to establish a datum in the Z axis.

3.0 Procedure For Producing Simple Milled Or Turned Components

Key Learning Points

Demonstration of CNC setting and operation. Safety precautions with swarf removal from cutting zone. Observation of cutting conditions/corrective action where necessary. Feed rate over-ride at machine console.

3.1 Demonstration Of CNC Setting And Operation

When the part needs to be machined, the program number is called up using the keyboard and screen on the console of the CNC machine. The workpiece is clamped, the tools are then setup and the program is checked in a number of ways such as, using the simulation package, doing a dry run, machining a substitute material or doing single step operation. Normally the program is check by first running the simulation package and then doing a full demonstration using one of the methods mentioned above. This will highlight any problems associated with the program or the tool settings. The part program can now be run to manufacture the parts.

3.2 Safety Precautions With Swarf Removal From Cutting Zone

Swarf removal from the cutting area may have to be carried out during machining. The program cycle may have to be stopped at pre-determined intervals using program codes to enable the operator to clean away swarf. It is important remove the swarf with a brush.

3.3 Observation Of Cutting Conditions/Corrective Action Where Necessary

When running the program for the first time, it is important to observe the tool movements and machining operations at all times. A feed rate over-ride dial will allow the operator to slow down or even stop the movements of the tool. Always know where the *Emergency Stop* button is and in the event of an emergence and press it immediately.

3.4 Feed Rate Over-Ride At Machine Console

The feed rate over-ride dial will allow the operator to slow down or even stop the movements of the tool if required.

4.0 Operating And Producing Components On The CNC Machine

Key Learning Points

Emergency shut down considerations. Stop – restart procedure in event of a crash. Quality: CNC machined components versus manually machined components.

4.1 Emergency Shut Down Considerations

Always know where the *Emergency Stop* button is and in the event of an emergency and press it immediately. As mentioned above, when running a part program for the first time, it is important to keep your eye on the cutting operation and keep your hand on the *feed rate over-ride dial*, which will allow you to slow down or even stop the movement of the cutter if you decide that the feed rate is too fast. This could occur if for example the feed was incorrectly calculated or if a rapid feed rate was entered into the program by mistake. In this case the operator may avoid having to press the emergency stop, which would mean having to reset at the program start position.

4.2 Stop – Restart Procedure In Event Of A Crash

Before using the machine the operator must be aware of the location of the emergency stop button. Emergency stops invariably require the program and the cutting tool to be re-set at the program start position before machining can re-start.

4.3 Quality: Cnc Machined Components Versus Manually Machined Components

CNC machines are more expensive than conventional machines and require more training for the operator, but one of the advantages that the CNC machine has over the conventional machine is that the overall quality of the parts are much better. Provided that the program is correct and has been proved in advance of production and that the tools and the workpiece are setup correctly, no errors should occur in the work. When the CNC machine is running, the quality of the parts is not affected by operator fatigue, boredom or inattention, which could occur when using a conventional machine.

The parts can be machined to a high degree of accuracy and consistently, therefore the machining of scrap parts is much reduced. If the first part is correct then all other parts in the batch will also be correct.

Ref: Timings, R.L. 1998, *Manufacturing technology*, vol. 1, 3rd edn, Pearson Education Limited, chapter 5, *Numerical control part programming*, sec. 5.3, *Advantages and limitations*, p. 173.
ISBN-13: 9780582356931

Summary

Procedures for loading work pieces and installing tooling: For CNC milling machines, workpieces can either be held in a vice, a grid plate or clamped directly onto table with bridge clamps. It is important to position the vice or the clamping arrangement in the middle of the work table, as this ensures the greatest support and minimises deflection of the machine table due to the weight of the component and the vice. The direction of the cutting forces should always be directed towards a positive fixed location.

For CNC lathes, workpieces are normally held in chucks, collet chucks or turning fixtures.

The tools are inserted manually into the tool changer, where each tool position has a unique number that corresponds with the tool number in the part program. The tool tip is jogged to the workpiece and when it touches, the position is set to zero. The difference between this setting and the position that was originally set by the probe is registered and saved in the machine control unit, which sets up the correct offset for the tool. All other tools are setup in the same way.

Procedure for setting machine axis datum: When the workpiece needs to be machined it is clamped on the machine table. A setting probe is jogged manually to the workpiece, which is then probed to establish a new datum point in the X, Y and Z axis, called the *workpiece datum*. The *workpiece datum* and the *zero datum* are now in different positions. The workpiece datum now needs to be registered as the new datum point from which all programmed positional moves will be made. On some machines a button marked *axis zero* is pressed to confirm this action, but the method of doing this will vary and will depend on the type of machine being used.

Procedure for producing simple milled or turned components: When the part needs to be machined, the program number is called up using the keyboard and screen on the console of the CNC machine. The workpiece is clamped, the tools are then setup and the program is checked in a number of ways such as, using the simulation package, doing a dry run, machining a substitute material or doing single step operation. Normally the program is checked by first running the simulation package and then doing a full demonstration using one of the methods mentioned above. This will highlight any problems associated with the program or the tool settings. The part program can now be run to manufacture the parts.

Operating and producing components on the CNC machine: CNC machines are more expensive than conventional machines and require more training for the operator, but one of the advantages that the CNC machine has over the conventional machine is that the overall quality of the parts are much better. Provided that the program is correct and has been proved in advance of production and that the tools and the workpiece are setup correctly, no errors should occur in the work. When the CNC machine is running, the quality of the parts is not affected by operator fatigue, boredom or inattention, which could occur when using a conventional machine.

The parts can be machined to a high degree of accuracy and consistently, therefore the machining of scrap parts is much reduced. If the first part is correct then all other parts in the batch will also be correct.

Suggested Exercises

1. Sketch three methods of holding a workpiece in a CNC milling machine.
2. Explain how the tool height is set in a CNC milling machine using sketches.
3. What is the purpose of the feed rate over-ride dial?
4. List the advantages of a CNC machine over a conventional machine
5. Under the supervision of your instructor, setup a workpiece in the CNC milling machine and use a digital probe to position the datum over the bottom left corner.

Questions

1. List three methods of clamping a workpiece in a CNC milling machine.
2. List three methods of clamping a workpiece in a CNC lathe.
3. What is the 'Machine Datum Point'?
4. What is the 'Workpiece Datum Point'?
5. What is single-step machining and why should it be used when running the CNC program for the first time?

Answers

1. Workpieces can either be held in a vice, a grid plate or clamped directly onto table with bridge clamps.
2. Workpieces can either be held in a chuck, collet chuck or a turning fixture.
3. The machine datum is the point from which the machine makes its programmed moves. It is an exact point that the machine can find even after power loss and also this is the point that the machine slides move to when you reference the machine. This point is often called the zero datum or the machine reference point.
4. The setting probe is jogged manually to the workpiece, which is probed to establish the workpiece datum. The workpiece datum is registered as the new datum point from which all programmed positional moves will be made.
5. Single Step machining means running the program line by line. Care should be taken when running the CNC program to for the first time, because the Graphic Simulation system will not take into consideration other devices outside the workpiece such as the vice or the clamping arrangement, which may be in the way of the cutting tool.

Recommended Additional Resources

Reference Books

Timings, R.L. 1998, *Manufacturing technology*, vol. 1, 3rd edn, Pearson Education Limited.

ISBN-13: 9780582356931

Black, Bruce J 2004, *Workshop processes, practices and materials*, 3rd edn, Elsevier Science & Technology.

ISBN-13: 9780750660730