Jomo Kenyatta University of Agriculture and Technology

College of Engineering and Technology

School of Mechanical, Materials, and Manufacturing Engineering

Department of Mechatronic Engineering

EMT 2540: PRACTICAL REPORT I

CNC MACHINING

Bernie Kiplelgo Cheruiyot (ENM221-0054/2017)

Mogire Earl Spencer (ENM221-0074/2017)

July 28, 2022

Contents

List of Figures

1 Introduction

1.1 CNC Machining

Numerical Control (NC) uses a processing language to control the movement of the cutting tool or workpiece or both. The programs contain information about the machine tool and cutting-tool geometry, the part dimensions (from rough to finish size), and the machining parameters (speeds and feeds and depth of cut). Onboard microprocessor which can be directly controlled gives rise to Computer Numerial Control (CNC) Machines.
Controlling CNC machines using variable inputs via a computer program is known as numerical control. The system automatically interprets some parts of the program in order to plot the tool control to create the desired part according to the NC program.

1.2 Objectives

1. To design a program to create a part using CNC Machining.
2. To program the CNC Machine tool.
3. To create and examine a part made from the CNC Machining process.

2 Literature Review

2.1 Numerical Control in Machining

Numerical Control (NC) is a non-conventional machine control method. A computer program is used to control the machine tool rather than a human operator manually controlling the machining parameters such as the speeds, feeds and depth of cut, as well as the part dimensions. Repeatability and quality are greatly improved over conventional machines. The use of NC machines also reduces non-machining times, such as setup times, tool change times and change of cutting speeds and feeds. It also relieves the operator of tasks such as changing machining parameters(cuttingg speeds and feeds), and locating the tool relative to the work. Even the most simple NC forms, and digital readout equipment, provide much greater accuracy and productivity.

2.2 CNC Machining

Computer Numerical Control is an NC method where an on-board microprocessor is directly programmed to control the machine tool. Early NC machines used punched cards for control, while CNC machines use software programming to achieve the machine control.

2.2.1 The CNC Machining System

The main components of the CNC system are shown in Fig. 2.1. These components include:

1. The Machine Tool Unit - This is responsible for the extrication work. It consists of the tools to be used, the attachment mechanism, the spindle and all moving parts involved in machining.

2. The Machine Tool Drives - Classified as either spindle or feed drives.

   (a) Spindle drives rotate over a wide range of velocities, measured in rpm.

   (b) Feed drives convert angular motion of the motors to linear transverse speeds, measured in mm/min.

3. The CNC unit - Runs under a program known as the CNC executive which translates programs written in internationally recognized standard language.

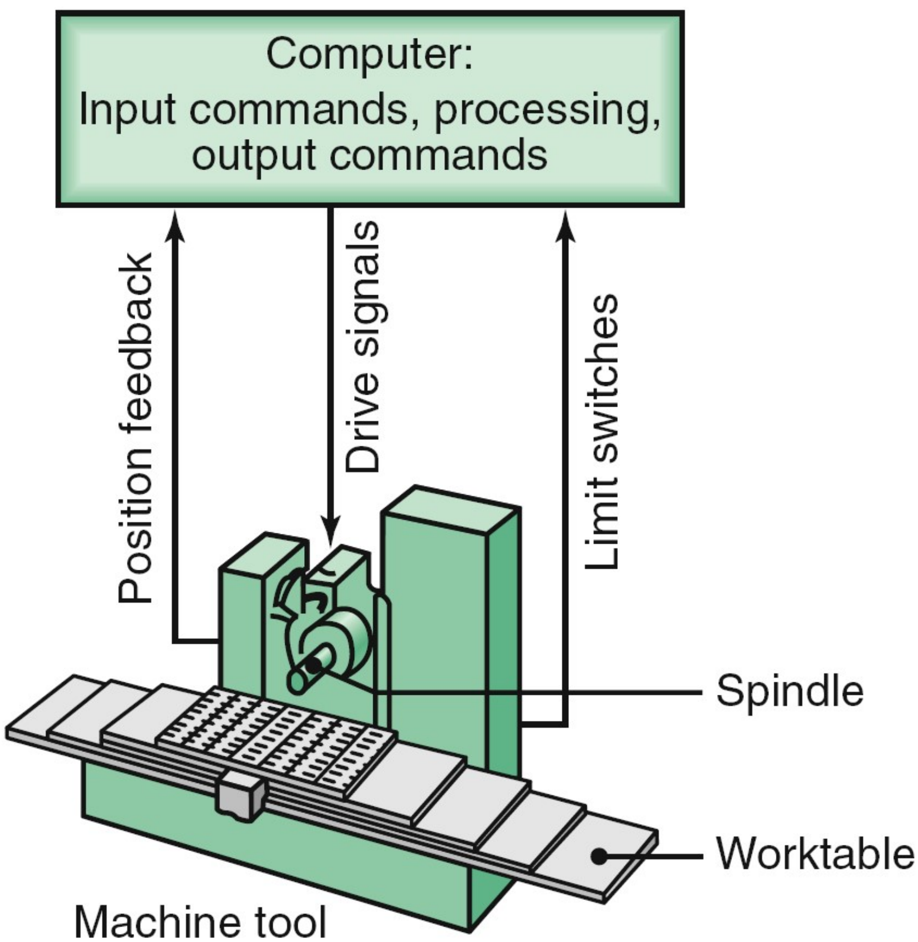

Figure 2.1: CNC Machine Table Location Schematic [2]

2.2.2 CNC Machining Process Parameters

The CNC Machining Process can be used to machine a number of materials including metals and ceramics. Any material that can be machined conventionally can also be machined using a CNC Milling machine. The performance of a CNC Machining operation is determined by a number of properties[2]:

1. Material Removal Rate (MRR)
2. Surface Quality
3. Accuracy
4. Machining time

2.3 Accuracy in Numerical Control

Positioning accuracy in numerical-control machines is defined by how accurately the machine can be positioned with respect to a certain coordinate system. *Repeat accuracy* is defined as the closeness of the agreement of the repeated position movements under the same operating conditions of the machine. Resolution, also called sensitivity, is the smallest increment of motion of the machine components.

The *stiffness* of the machine tool and the *backlash* in gear drives and leadscrews are important factors in achieving dimensional accuracy. Backlash in modern machines is eliminated by using preloaded ball screws. Also, a rapid response to command signals requires that friction in machine slideways and inertia be minimized. The latter can be achieved by reducing the mass of moving components of the machine—for example, by using lightweight materials, including ceramics.

2.4 Applications

CNC Machining can be employed in:

1. Making complex 3D geometries
2. Creation of part profiles to be used in making moulds for casting.
3. Machining centres
4. Academic/Educational institutions for research and teaching.

2.5 Other NC Machining Processes

Numerical control has been applied to a wide variety of other production processes, some of which are listed below[1]:

1. NC Punches - Numerical control is used for X-Y control on the table.
2. CNC Lathe machines
3. CNC Wire EDM Machines
4. Laser and water-jet abrasive machining
5. Flame cutters

2.6 Advantages and Disadvantages of Numerical Control

Numerical Control has several advantages as compared to other conventional methods of control, some of which are[2]:

1. Higher production rates, productivity, and product quality; greater operational flexibility; the capacity to make complicated forms with good dimensional precision and repeatability; and reduced scrap loss.

2. Making machine adjustments is simple.
3. With each setup, more operations can be completed, and the setup and machining lead times are less than with traditional methods.
4. Programs can be quickly created and retrieved at any moment.
5. The level of operator skill needed is lower than that of a skilled machinist, giving the operator more time to focus on other activities around the workspace.

Some of the major limitation of NC machining are:

1. Initially expensive cost of the equipment.
2. The cost of programming and the price of computer time.
3. The unique maintenance needed.
4. Preventive maintenance is essential since these equipment are complicated systems and breakdowns can be expensive.

3 Methodology

The equipment needed and procedures undertaken to carry out CNC Machining are described in the following sections. The experiment was done at ENW-04 (Machine Shop) at the JKUAT Workshops.

3.1 Equipment

1. CNC Machine (available at ENW04 - Machine Shop)
2. Workpiece design as specified by the manual
3. CNC Machine controller (Siemens Sinumerik 828D)
4. Workpiece - Aluminium block

Figure 3.1: CNC Machine Controller - Siemens SINUMERIK®828D

3.2 Procedure

Prior to beginning the machining operation, the machine has to be checked for the required items for its functionality, namely:

1. Oil - This is necessary for lubrication and is contained in an oil tank at the back of the machine.
2. Air - the pneumatic system is used by the tool change mechanism, and is supplied via high-pressure pipes and air ducts from an air compressor.
3. Electricity - 3-ϕ electricity is required for the machine drives to move the various actuators along their respective axes.

The operation chosen was a face milling operation to obtain a flat surface, followed by creation of a pocket at an angle of 15° to the horizontal.

The shape to be created was analyzed and the dimensions obtained. A tool-path was created using G codes to control the CNC Machine. The codes were programmed into the CNC Machine via the controller board.

The workpiece blank was measured to obtain the dimensions, which were programmed into the CNC program. The face milling operation was programmed first, followed by the contouring operation to create the pocket. As the CNC machine is able to interpolate most machining operations internally, for most operations the inputs required are the location of the features as well as their dimensions.

Before beginning the machining operation, a simulation was carried out to ascertain that the program was correctly written, with a visual aid of the tool-paths and the features to be created from the stock billet. This step is essential as it enables the operator to catch mistakes and correct them in the program before it has began executing.

Some machining parameters such as the speed, feed and use of cutting fluids are chosen based on a handbook provided for different materials. In this case, a spindle speed of 2000rpm and a feed of 150mm/min were chosen, as well as coolant on in flood mode.

Machining process once started is carried out to completion unless stopped by an emergency stop button press or the process cancel button in the user interface. Tool changes are done automatically, with the machine stopping the spindle and using pneumatic actuators, the current loaded tool is placed back in the magazine and the tool required for the next operation is automatically loaded.

The machining time depends on the size of the workpiece and the operations being carried out, as well as the cutting speed and feed. Roughing operations were chosen to remove the bulk of the material before carrying out fine machining to achieve the desired surface finish.

Once the machining process was completed, the CNC hatch was opened. and the workpiece retrieved for examination.

Figure 3.2: CNC Machining Process Underway

4 Results

The machined part was created as shown in Figure 4.1 The operations done were:

Figure 4.1: The Machined Part

1. Face Milling

2. Pocket milling

5 Discussion

5.1 CNC Machining

The machining operation was successfully carried out and the workpiece retrieved. G- and M-codes were used in manual part programming. These codes are specific to the CNC machine and are specified by the manufacturer. The CNC Machine M-code list is shown in the appendix.

References

[1] J. T. Black, *DeGarmo's Materials and Processes in Manufacturing*. John Wiley & Sons, 2011.

[2] S. Kalpakjian, *Manufacturing Engineering And Technology*. Prentice Hall, 2010.

Appendix - G and M Modes

.1 G- and M-codes

Table .1: G- and M-codes

G-code	Definition	M-code	Definition
G00	Rapid Transverse	M00	Program Stop
G01	Linear Interpolation	M02	End of Program
G02	Circular Interpolation, CW	M03	Spindle ON, CW
G03	Circular Interpolation, CCW	M05	Spindle OFF
G21	Input in mm	M06	Automatic Tool Change
G28	Return to reference point	M07	Air Blow ON
G40	Cutter diameter compensation cancel	M09	Air blow and Coolant OFF
G42	Cutter compensation, right	M30	Program Reset and End
G49	Tool length compensation cancel		
G80	Canned Cycle cancel		
G81	Basic Drilling Cycle		
G90	Absolute Programming Mode		