History and Definition of CNC 100
Class Outline

Objectives
Modern Manufacturing
Computer Numerical Control (CNC)
CNC Versatility
History of NC Machines
Increases in NC Use
Changes From NC to CNC Systems
Common CNC Machines
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Summary
Lesson: 1/13

Objectives
- Describe the demands of modern manufacturing.
- Identify the essential components of CNC.
- Describe factors that contribute to the versatility of CNC.
- Describe the origin of NC machinery.
- Identify factors influencing the early use of NC.
- Distinguish between NC and CNC.
- Identify common CNC machines.
- Identify less common CNC machines.
- Describe the advantages of CNC.
- Describe the benefits of CNC.
- Describe the disadvantages of CNC.

Figure 1. An old NC machine.

Figure 2. A CNC machining center.
Lesson: 2/13

Modern Manufacturing
Over the past four generations, the shop floor has experienced a computer revolution. Mass manufacturing is no longer a series of human operations. Manufacturing is no longer limited to fixed processes, where machining steps and their sequences are determined by equipment setups that cannot easily be changed. The multi-station drill press in Figure 1 demonstrates this limitation.

Fixed processes continue to earn a place in today’s manufacturing centers where a high number of products are made at a low cost. The biggest drawback of fixed automation is an inability to quickly adapt to product changes.

What would you do to deal with product changes? Companies cannot expect to buy a separate machine for every part change. The changeover time required on fixed automation equipment makes short lot runs impractical. A machine with more versatility is needed, and the addition of computers increases the options for manufacturing operations. Figure 2 shows one of many CNC machines that offer this flexibility.

Figure 1. Fixed processes involve equipment setups that cannot easily be changed, as with this multi-station drill press.

Figure 2. The addition of a computer increases the manufacturing options available on the CNC machining center.
Lesson: 3/13

Computer Numerical Control (CNC)
CNC stands for computer numerical control. CNC uses numerical data to control a machine tool. Machining instructions are communicated to the CNC machine, like the ones shown in Figure 1. The instructions needed to machine a workpiece include feed, speed, depth of cut, and all the necessary tool motions. This set of instructions is known as a part program.

A microcomputer known as a machine control unit (MCU) reads and executes the machining instructions coded in the part program. The CNC can store multiple programs. This lets an operator create, or run, different parts by calling up and executing different part programs. Figure 2 shows a typical CNC control panel.

Figure 1. CNC machines use numerical data to control machine tools.

Figure 2. The CNC control panel is where an operator communicates with the CNC machine.
Lesson: 4/13

CNC Versatility
Because CNC processes involve the storage of a variety of different programs, CNC is more versatile than processes involving fixed automation. Directing the machine's hardware with a computer controller creates this versatility. Control with a computer does several things:

- It makes it easy to change existing programs.
- It allows fast changeover from one part to the next.
- It provides a useful interface between machine and operator.

The CNC part program controls how a tool is fed into the workpiece, the rate at which the tool moves, the direction of its movement, the depth of the cut, the spindle speed, and more. The CNC machine can store many programs. Programs can also be modified to reflect a part change. Figure 1 shows the CNC control interface while it is operating.

Figure 1. The CNC control panel during an operation.
History of NC Machines
Numerical control machining began in the aircraft industry. Engineers wanted to make complex aircraft parts quickly and accurately. In 1947, two aircraft component contractors for the U.S. Air Force, John Parsons and Frank Stulen, perfected the use of three-axis curvature data to control machine tool motion.

In 1951, the government funded the Servomechanisms Lab of the Massachusetts Institute of Technology to design and build the first NC machine. The first prototype of a three-axis vertical milling machine debuted in 1952. Parsons was able to end mill and face mill an aluminum plate. Figure 1 shows an old NC milling machine.

Figure 1. Numerical control machining began in the aircraft industry.
Lesson: 6/13

Increases in NC Use
Though the first NC machine was a success, private businesses lacked the funding to make it practical. So from 1955-1956, the Air Force sponsored NC development at several companies across the nation, and NC machining gained popularity.

As the benefits to NC machining became more apparent between 1958 and 1960, aerospace company managers started to place their orders for the new equipment, and some even began to build their own machines. NC machines soon after began competing with manual machines like the manual mill in Figure 1. In many shops, manual machines have been retrofitted with CNC, like the mill in Figure 2.

NC machines quickly displayed their worth. They were more accurate, held better tolerances, and produced more uniform dimensions than the manual machining methods of the day. In addition to increasing accuracy, NC machines reduced the amount of nonproductive time in the machining cycle.

Figure 1. NC machines began competing with manual machines, such as this manual mill.

Figure 2. Instead of buying new machines, some companies retrofit their existing mills with CNC.
Lesson: 7/13

Changes From NC to CNC Systems
The first CNC machines were actually called NC machines. They existed before small computers were common. NC machines were controlled by complex electrical circuitry.

NC machines read and executed one line of code at a time from a part program punched into a paper tape or mylar tape. When the entire program was executed, the tape reader, like the one in Figure 1, would rewind back to the beginning of the program.

With further development of small computers, machine tool builders began using computers to control machine tools. The term CNC was born. CNC machines can now hold hundreds of programs in memory. Any one of these programs can be instantly called up for execution through a control panel like the one in Figure 2. Many CNC machines also contain multiple tools, as shown in Figure 3. This greatly boosts productivity.

Figure 1. NC machines read and executed one line of code at a time from a part program punched into paper or mylar tape.

Figure 2. The machine operator calls and executes a part program from the control panel.

Figure 3. CNC machines may contain many tools.
Describe the benefits of CNC.

Efficiency. Operators do not get tired during the production process.
Punch presses
Definition
Grinders
Identify common CNC machines.

Computers have revolutionized manufacturing processes. Today machines are both highly efficient and more expensive to repair. CNC machines demand a larger initial investment than similar manual machines. The sophisticated service, but companies pay for the performance they receive.

Cost is the major drawback when purchasing and operating CNC machines. They do a fine job in handling time.

With CNC machines, there is fast performance. In other words, they treat each part in the same manner.

Lesson:
The goal of CNC is always the same: to use these machines and systems as efficiently and productively as possible. While CNC has solved numerous manufacturing problems, it is not a cure for all issues.

The original test model of a product.

In 1951, the government funded the Servomechanisms Lab of the Massachusetts Institute of Technology. John Parsons and Frank Stulen, perfected the use of NC machines. Numerical control machining began in the aircraft industry. Engineers wanted to make complex cutting tools perform their work.

NC machines quickly displayed their worth. They were more accurate, held better tolerances, and increasing accuracy, NC machines reduced the amount of nonproductive time in the machining cycle.

As the benefits to NC machining became more apparent between 1958 and 1960, aerospace fixed processes continue to earn a place in today's shops.

Fixed processes continue to earn a place in today's shops.

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Common CNC Machines
There are many types of CNC machines. The two most common CNC machines in the metalworking industry are:

- **Mills**, or machining centers (Figure 1): Generally, the workpiece is held on the table while cutting tools perform their work.
- **Lathes**, or turning centers (Figure 2): A workpiece spins as the cutting tools are brought in contact with it. Lathes create symmetrical pieces.

In every CNC use, a programmer plans the best way to cut the workpiece and then codes the movement of the tool. These instructions are interpreted by the computer controller. The controller then ensures that every part is handled in exactly the same manner for both small and large production runs. This process eliminates guesswork and the **downtime** involved while a human operator decides the best method for machining a part in the middle of production.

Figure 1. A CNC mill, often called a machining center, holds a part while a rotating tool cuts metal.

Figure 2. A CNC lathe, often called a turning center, rotates a workpiece while a tool cuts metal.
Describe the benefits of CNC.

- Efficiency. Operators do not get tired during the production process.

Describe the advantages of CNC.

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Other CNC Machines

Besides mills and lathes, you will find CNC systems in these machines as well:

- **Grinders**: There are many different types of grinders, one of which is shown in Figure 1. Grinding is a finishing operation that creates a smoother surface.
- **Punch presses**: Punching, or stamping, can apply large forces to sheet metal to create holes or bends. Some punch presses have one tool, as shown in Figure 2. The **turret press** is a punch press with several available tools, as shown in Figure 3.
- **Welders**: There are several types of welding. The welder applies heat and a filler to fasten the pieces together.

You will also find CNC systems in operations that involve robotics, laser cutting, automatic testing machines, drafting systems, electronic assembly systems, and more. As you can see, computers have proven very useful in many aspects of manufacturing.

Figure 1. A CNC grinder creates a smoother surface on a workpiece.

Figure 2. A CNC punch press uses one tool.

Figure 3. A CNC turret press uses many tools.
Key Advantages of CNC
The goal of CNC is always the same: to use these machines and systems as efficiently and productively as possible. While CNC has solved numerous manufacturing problems, it is not a cure-all. There are times when a CNC process may not be the best approach. However, you should always keep in mind three key advantages of CNC systems:

- Efficiency. Operators do not get tired during the production process.
- Accuracy. The devices of CNC machines provide an extraordinary level of accuracy and control to the machine tool motions.
- Productivity. Wasted motion is cut out of the CNC operations program. More time is spent working on the part.

![CNC Systems are:](image)

| Efficient | Accurate | Productive |

Figure 1. The key advantages of CNC are efficiency, accuracy, and productivity.
Lesson: 11/13

CNC Benefits
Besides the three key advantages just mentioned in the previous lesson, there are other benefits of CNC systems as well. CNC machines provide consistent, dependable, and repeatable performance. In other words, they treat each part in the same manner.

With CNC machines, there is fast job changeover. Many CNC machines store necessary tools in magazines, shown in Figure 1. Like the disc changers that can play from numerous discs, tool magazines include the tools necessary to perform several operations. This creates less downtime and reduces part-handling time.

Because one CNC machine, like the one in Figure 2, can conduct multiple operations, there is no need to route parts to other machines. This streamlines the production process. In essence, CNCs offer great manufacturing flexibility, speedy changeovers, and improved efficiency.

Figure 1. A tool magazine holds several tools.

Figure 2. A CNC machine can conduct multiple operations, making it unnecessary to route parts to other machines.
Lesson: 12/13

CNC Costs
Cost is the major drawback when purchasing and operating CNC machines. They do a fine job in service, but companies pay for the performance they receive.

CNC machines demand a larger initial investment than similar manual machines. The sophisticated components of CNC machines come with higher price tags. The complex wiring of the CNC machine is shown in Figure 1. Plus, CNCs require steep maintenance costs. They are often more costly to keep running than manual machines, and they are more expensive to repair.

Also, CNC machines demand greater skills from operators. CNC operators must learn the controls, which takes time, talent, and training to master. The cost of attracting, training, and retaining qualified personnel to run CNC equipment must be considered.

Figure 1. CNC machines are very complex and expensive.
Lesson: 13/13

Summary
Computers have revolutionized manufacturing processes. Today’s machines are both highly efficient and versatile. The original NC machines evolved into today’s CNC machines. CNC machines can store multiple programs that allow the machine to perform a variety of operations.

The first NC machine prototype was designed in 1952 because engineers wanted to be able to efficiently manufacture the complex parts of aircraft. Advances in computer technology then led to the development of CNC machines that simplified the programming process.

The most common CNC machines are mills and lathes, like the ones in Figure 1 and 2. CNC machines are highly efficient, accurate, and productive. Unfortunately, they are also very costly. Nevertheless, this technology has completely transformed the manufacturing industry.

Figure 1. A CNC mill, often called a machining center, holds a part while a rotating tool cuts metal.

Figure 2. A CNC lathe, often called a turning center, rotates a workpiece while a tool cuts metal.
Class Vocabulary

**Code**  To create programmable sets of instructions for a CNC machine.

**Computer Numerical Control**  A type of programmable automation, directed by mathematical data, which uses microcomputers to carry out various machining operations.

**Downtime**  Unproductive blocks of time during which operations cease to function, normally due to mechanical problems or a lack of materials.

**Drill**  A machining tool used to penetrate the surface of a workpiece and make a round hole.

**Electrical Circuitry**  A closed path that an electric current follows, usually through devices and wires.

**End Mill**  A thin, tall mill cutter with cutting edges that wind up the sides. Both the bottom and side of the end mill are used during milling operations. End mills resemble drills.

**Face Mill**  A flat mill cutter with multiple cutting teeth surrounding the tool. The bottom of the face mill is primarily used during milling operations.

**Finishing**  Final operations performed for obtaining desired tolerance and/or surface finish.

**Fixed Automation**  A process using mechanized machinery to perform fixed and repetitive operations in order to produce a high volume of similar parts.

**Grinder**  A machine that uses an abrasive to wear away at the surface of a workpiece.

**Hardware**  The physical components of a CNC machine.

**Interface**  The control panel and displays with which the operator interacts with the machine.

**Job Changeover**  The time it takes to switch from one part to another.

**Lathe**  A tool commonly used to machine cylindrical forms. It is generally considered the backbone of the machine shop.

**Machine Control Unit**  A small, powerful computer that controls and operates a CNC machine.

**Magazine**  An arrangement of multiple tools that allows a CNC machine to rapidly change from one machining operation to the next.

**Mill**  A machining tool used to either horizontally or vertically remove metal from the surface of a workpiece.

**Mylar Tape**  A thin, yet strong polyester film that was used to transmit programs to numerically controlled machines.

**Paper Tape**  A way of transmitting programs to numerically controlled machines. This method is all but extinct.

**Part Program**  A series of numerical instructions used by a CNC machine to perform the necessary sequence of operations to machine a specific workpiece.

**Prototype**  The original test model of a product.

**Punch Presses**  A machine that uses force to either cut or form a workpiece.

**Punching**  Using force to cut or form a workpiece.

**Repeatable**  The ability to position workpieces in the same place part after part.

**Stamping**  Forming metal with the use of dies and punches.
Describe the disadvantages of CNC.

Identify common CNC machines.

Describe the advantages of CNC.

It provides a useful productivity. Wasted motion is cut out of the CNC operations program. More time is spent on added value manufacturing.

Lathes

Efficiency. Operators do not get tired during the production process.

Describe the benefits of CNC.

Describe the origin of NC machinery.

The first NC machine prototype was designed in 1952 because engineers wanted to be able to efficiently manufacture the complex parts of aircraft. Advances in computer technology then led to the development of CNC machines that simplified the programming process.

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Summary

Increases in NC use between 1958 and 1960. Aerospace was the leader, but the rest of the industry soon followed. The benefits to NC machining became more apparent.

Lesson:

Also, CNC machines demand greater skills from operators. CNC operators must learn the controls, programming, and special precautions.

Lesson:

CNC Costs

Objectives

Lesson:

Refer to three key advantages of CNC systems:

1. Repeatability: The CNC system controls the machine tool motion.
2. Direct control: The machine is directly interfaced with the operator.
3. Production flexibility: The CNC system allows for the manufacture of a large variety of parts.

Lesson:

CNC Versatility

Lesson:

CNC Costs

Class Outline

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Lesson:

Three-Axis Curvature Data

Information that describes the motion and position of an object using three-dimensional data.

Turret Press

A CNC punch press that contains several tools.

Welder

A device used to join two pieces of metal together through the application of heat.

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