ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΑΤΡΩΝ
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ΑΝΟΙΚΤΑ ακαδημαϊκά μαθήματα ΠΠ

Αριθμητικός Έλεγχος Εργαλειομηχανών

Ενότητα 15: The Future of CNC

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COMPUTER NUMERICAL CONTROL OF MACHINE TOOLS

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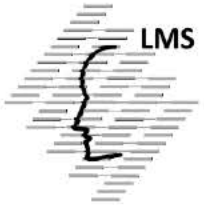

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Objectives of section

Upon completion of this section, you will be able to:

- Explain why the use of CNC will increase in prototype and small lot job shops
- Describe a flexible machining system
- Describe a machining cell
- Describe the responsibilities of the NC electronics technician, machine operator/setup operator, and part programmer

NC IN PROTOTYPE AND JOB SHOPS

- The on-going development of **less expensive** numerical control systems will offer increasing options to companies that today cannot justify a numerical control system

- The **lower cost** of acquiring machining and turning centres - coupled with the **ease of programming** and other features of the newest generation of CNC controllers - will result in the **adoption of CNC machinery by more and more small job shops**

- Competition from foreign sources is forcing all companies to look for ways to **improve quality while making the changes in design** that market conditions so often require

NC IN PROTOTYPE AND JOB SHOPS

- **CNC machinery can fulfil both requirements:**

- The ***repeatability*** of CNC can improve the overall quality of parts produced

- Since CNC uses ***software programs*** to produce part shapes, what would have been major retooling, becomes the editing and revising of the part program

- ✓ The pressure from foreign producers continues to force companies to look for cheaper, faster, and more flexible ways to produce the goods they sell
- ✓ The average machine shop of today shows that many smaller shops have **adopted CNC machines**

NC IN PROTOTYPE AND JOB SHOPS

Issues faced by Companies Nowadays

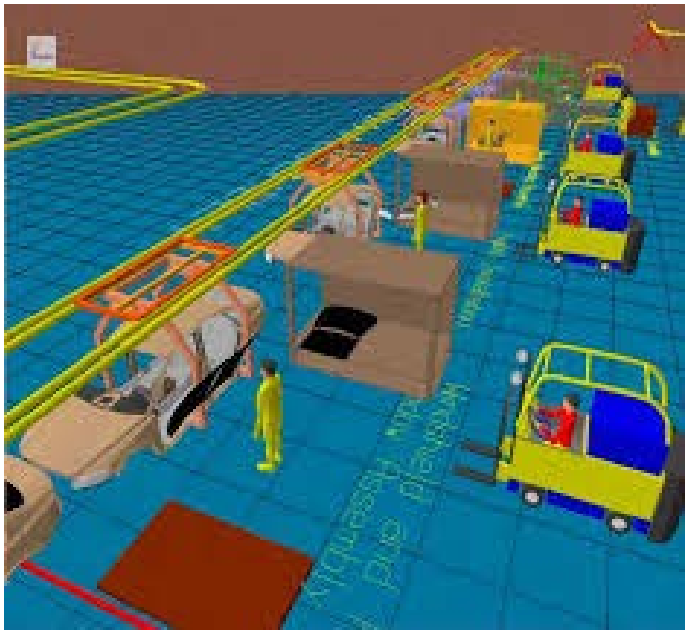
- A problem common to all companies is the **shortage of skilled machinists**
- Especially in smaller companies the shortage of general machinists, tool, die and mould makers is acute
- **In coming years the shortage of skilled prototype machinists and instrument makers is likely to be felt by scientific and research organizations that have their own prototype shops**
- In addition, **increasingly complex part geometries** are being required for new technology applications

- **CNC offers solutions to all these problems!!!**

CNC IN MANUFACTURING

Developments in NC applications

- The most exciting developments in NC applications are taking place in large-scale manufacturing, where **the entire manufacturing process is computer integrated**



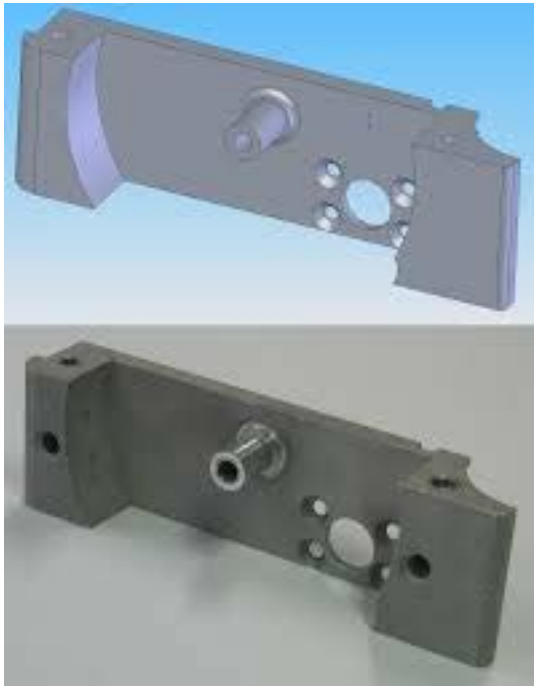


FIGURE 1 Manufacturing Systems Integration Program

CNC IN MANUFACTURING

Developments in NC applications

●Network Adapter Cards

- The latest generation of **CNC** controls exploits embedded **network adapter cards** in the controls.
- The network card allows the **CNC** control to plug into a company's local area network (LAN) and send / receive information over the company's LAN, using specific software, allowing:

✓ Plant managers or manufacturing supervisors to view the ***production status of work running*** on the CNC equipment from a desktop PC

✓ ***Continuous monitoring*** of the production process can be accomplished, leading to preventive actions by continuous fine-tuning

CNC IN MANUFACTURING

Flexible Manufacturing System

- A **Flexible Manufacturing System (FMS)** is a system of CNC machines, robots, and part transfer vehicles that can take a part from raw stock or casting and perform all necessary machining, part handling, and inspection operations to make a finished part or assembly

- An FMS is an entire unmanned, software-based, manufacturing / assembly line

- An FMS consists of **four major components**:
  1. CNC machines
  2. Coordinate measuring machines
  3. Part handling and assembly robots
  4. Part / tool transfer vehicles

CNC IN MANUFACTURING

Flexible Manufacturing System

- The **automatic tool changing capability** of these machines allows them to run **unattended,** exploiting **tool monitoring systems**, built into the CNC machine, that are used to **detect and replace worn tools**

! The major obstacles in an FMS are not the machining centres but the **support systems** of the machines, such as part load/unload and part transfer.

- **Inspection** in an FMS is accomplished using **coordinate measuring machines (CMM)** that operate much like CNC machinery in that they are programmed to move to different positions on a work piece.

CNC IN MANUFACTURING

- Instead of using a rotating spindle and a cutting tool, they are equipped with electronic gaging probes which measure features on a work piece

- The results of the gaging are compared to acceptable limits programmed into the machine

FIGURE 2 Coordinate Measuring Machine

CNC IN MANUFACTURING

Flexible Machining System

- **Robots** are frequently used in an FMS to load/unload parts from the machines

- Since robots are programmed pieces of equipment that **lack the ability to make judgments:**
  - Special work-holding fixtures are employed on the transfer vehicles to orient the work piece so that the robot can handle it correctly
  - Specially designed machine fixtures and clamping mechanisms are employed to ensure correct placement and clamping of the part on the machine.

Future robots will probably employ some type of **artificial intelligence** which will enable them to make **limited judgments** as to work piece orientation and take the necessary **corrective actions**.

CNC IN MANUFACTURING

Robots

FIGURE 3 FANUC 6-axis welding robot

CNC IN MANUFACTURING

Flexible Machining System

- The third critical component of an FMS is the **tool and work piece transfer vehicle**
- These vehicles shuttle work pieces from machine to machine
- They also shuttle tool magazines to and from the machinery to maintain an adequate supply of sharp cutting tools at each CNC machine
- Transfer vehicles employed in current flexible manufacturing systems are of four major types:

1. Automatic guided vehicles (AGV)
2. Wire guided vehicles
3. Air cushion vehicles
4. Hardware guided vehicles

A large FMS may employ several different types of vehicles, depending on the requirements of different parts of the manufacturing line

CNC IN MANUFACTURING

Automatic guided vehicles (AGV)

- **Automatic guided vehicles (AGV)** rely on on-board sensors and/or a program to determine the path they take - No hardware connecting them to the system

✓ An **advantage** of AGVs is that they can be **reprogrammed to take different routes**, eliminating the need to run tracks or wires for each route change

✗ The **disadvantage** of AGVs is that they are the most difficult of the part delivery vehicles to make function, because of the **lack of hardware connection**

CNC IN MANUFACTURING

Automatic guided vehicles (AGV)

FIGURE 4 Intellicart

FIGURE 5 AGV

CNC IN MANUFACTURING

Wire Guided Vehicles

- A **Wire Guided Vehicle** uses sensors to detect a wires buried in the floor to define its path

✓ A major **advantage** of Wire Guided Vehicles is the **ability to use the wire as opposed to an AGV** without the need to have a hardware system such as an overhead wire or track on the floor

✗ The disadvantage of wire guided vehicles is **the necessity of installing new wire in the floor if a route change is required**

CNC IN MANUFACTURING

Air cushion vehicle

- An **air cushion vehicle** is guided by some external hardware device, such as an overhead wire, but glides on a cushion of air rather than a track system

- When using **air cushioned** vehicles, particular attention to chip removal and control must be built into the FMS, Chips in the path of an air cushion vehicle will stop its progress

These vehicles are generally used for straight paths and for moving heavy equipment

CNC IN MANUFACTURING

Hardware guided vehicles

- **Hardware guided vehicles** are the most reliable but least flexible of the transfer vehicles

- A track on the floor or an overhead guide rail controls the vehicle path

✓ The advantages of these vehicles are their reliability and the ease of coordinating them with the rest of the system

✗ The major disadvantage is, of course, the need to run new rail or track whenever a vehicle route change or new route is deemed necessary

MACHINING CELLS

- Large, flexible machining systems are often a collection of smaller coordinated units called **machining cells**

- A **machining cell** is a system consisting of one or more CNC machines and a parts handling device such as a robot.

Application of Machining Cells

1. The cell performs a machining operation or a specific sequence of operations
2. Another way cells are being used in manufacturing companies is in a demand flow line (also known as a single-piece flow line). **Demand flow** is a concept that grew out of the old "just in time" inventory systems of the 1980s. Pioneered by John Costanza, **demand flow dictates that production should occur according to customer demand, in a straight-line process**

MACHINING CELLS

- **In the normal production process, a company:**
  - forecasts the amount of product that should be produced
  - schedules its plants to produce that amount of product
  - inventories the product until the customer places an order

- Typically, jobs are run in a batch mode.

Example:

- Operation 30, was scheduled to run on a specific machine at a specific time
- Operation 40 was scheduled to run on another machine, based on the time estimated that operation 30 would complete
- All the parts were run at operation 30, before the job was moved to operation 40.

EMPLOYMENT OPPORTUNITIES IN NUMERICAL CONTROL

- Numerical control and computer numerical control equipment are electrical systems interfaced to a machine tool. The electronics necessary for a CNC machine to function are complex

- A number of skilled positions have been created by numerical control. The most common jobs are:

1. **NC electronics technician**
2. **Machine operator / setup operator**
3. **Part programmer**

EMPLOYMENT OPPORTUNITIES IN NUMERICAL CONTROL

Electronics Technician

- **The NC electronics technician is a skilled technician who specializes in the maintenance of numerical control equipment**

- The NC technician must be well trained in digital electronics and possess a knowledge of the cycles and functions of NC machinery

- The technician must be able to troubleshoot and correct problems that occur in the electronic circuitry of various NC machines

Training

- Generally, NC technicians acquire their skills through a two-year junior college program in digital electronics.
- Additional education in numerical control is often provided by the employer in the form of NC manufacturers technical school classes and seminars

EMPLOYMENT OPPORTUNITIES IN NUMERICAL CONTROL

Machine Operator/Setup Operator

- **The machine operator/setup operator is responsible for preparing an NC machine to run a program and for setting up the fixtures, tools, and work-pieces**

- The operator must possess a knowledge of general machine shop practices and techniques, as well as the cycles and functions of an NC machine

- The operator is responsible for overriding programmed speeds and feeds if required during machining

- The operator also assigns the tool length offsets to the appropriate tool registers and may be called on to single-step a program through Its first cycle

EMPLOYMENT OPPORTUNITIES IN NUMERICAL CONTROL

- The operator must also be trained in the use of precision measuring Instruments since he or she is often responsible for measuring the parts as they are finished

Training

- Machine operators/setup operators acquire their training either by years of running other types of manufacturing equipment and then transferring to an NC operator's position, or through a two-year junior college program

- Factory seminars and other coursework may be provided by the employer as required

EMPLOYMENT OPPORTUNITIES IN NUMERICAL CONTROL

Part Programmer

- **The part programmer is a highly skilled individual responsible for writing the programs that run on numerically controlled equipment.**

- He/she must be trained in general machine shop practice, mathematics, and the use of computers

- Based on the part drawing, the **programmer selects equipment to machine the part and devises a machining strategy**, listing the tools to be used and the coordinates necessary to accomplish the operations

- This information is then assembled into a part program written for the particular machine selected

EMPLOYMENT OPPORTUNITIES IN NUMERICAL CONTROL

Part Programmer

Training

- An NC programmer may acquire training through a two-year junior college, a four-year engineering technology degree program, or by transferring from positions as journeyman machinists or tool and die makers

- NC programmers take additional course work and factory seminars as required by their employers. The educational requirements for a programmer vary with each employer

SUMMARY 1/2

The important concepts presented in this section are:

- The use of CNC will increase in prototype and small job shops due to the arrival of lower cost controllers containing many advanced programming features

- A Flexible Manufacturing System is an unmanned manufacturing/assembly line that can take a part from raw stock and perform all the necessary operations to produce a finished part or assembly

- A machining cell is a system of one or more CNC machines and part handling robots that performs a specific sequence of operations. Demand flow lines make extensive use of machining cells

SUMMARY 2/2

- An NC electronics technician is responsible for maintaining the electronics of an NC or CNC system
- An NC operator/setup operator is responsible for preparing a machine prior to running a program and monitoring the machine during the program execution
- An NC part programmer is responsible for creating the part program

End of Section

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