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UNIVERSITY OF PATRAS

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Αριθμητικός Έλεγχος Εργαλειομηχανών

Ενότητα 4: Tool Changing and Tool Registers

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COMPUTER NUMERICAL CONTROL OF MACHINE TOOLS

Laboratory for Manufacturing Systems and Automation
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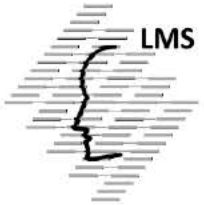

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Objectives of section 4

- Explain why the *speed*, *repeatability*, and *accuracy* of tool changing are important factors in numerical control
- Name the two types of tool changes
- Explain why quick-change tooling is used on NC mills
- Explain how tooling is used in automatic tool change functions
- Name the five types of automatic tool changers and briefly describe the operation of each
- Describe the two basic methods of tool storage
- Explain what tool registers are and what they are used for
- Describe what tool offset length is and how it is determined
- Explain how tool offsets may be entered by the operator during setup and how the programmer allows for this

Tool Changing and Tool Registers

Tool Changes

There are two types of tool changes:

Tool Changes

- Manual
- Automatic Tool Change (ATC)
- CNC mills
- Machining Centers

Tool Changing and Tool Registers

Tool Changes:

It is the tool changing capability that separates the CNC Machining Center from the CNC Milling machines

- Machining Centers like milling machines have the capability to do numerous machining operations (drilling, tapping, milling etc)

- This is opposed to a machine capable of a single function only such as an NC drilling machine

Tool Changing and Tool Registers

Tooling for Manual Tool Change:

What is to be gained by the speed with which a CNC machine can position itself for hole drilling if the tool changes are so lengthy as to cancel the time and accuracy gained by using NC?

Tool changing greatly influences the efficiency of NC so tool changes should take place as quickly and safety as possible

- *The tool must be* **accurate** *located in the spindle to assure proper machining of the workpiece*
- *The tool must be located as accurately as possible in the* **same location**
- *The tool must be located in the* **same relationship** *to the workpiece each time is inserted to the spindle*

> **Note**: *This is known as the* **repeatability** *of a tool – the ability to locate or repeat its position in the spindle each time it is used*

Tool Changing and Tool Registers

Tooling for Manual Tool Change

- Usually NC mills ***(manual tool change)*** are supplied with some type of ***quick-change*** tooling system to accomplish this task
- Most small vertical turret mills are manufactured with an ***R-8 spindle taper*** that will accept ***R-8 collets***
- The R-8 is a standard collet on Bridgeport vertical mills
- Since most vertical turret mills are spin-offs of this design R-8 has become ***pseudo-standard*** for these machines
- R-8 collets and R-8 tool holders require the use of a ***draw-bar***
- For CNC use: a) an automatically tightening draw-bar is supplied with the machine or b) a quick-change tool system is added

Tool Changing and Tool Registers

Tooling for Manual Tool Change

- The quick-change tooling system consists of:
  - A quick-release chuck – held in the machine spindle
  - A set of tool-holders that hold the individual tools needed for a particular part program
- The **chuck** is a separate tool-holding system that **stays in the spindle**
- During the tool change the **tool-holder is removed** from the chuck (it is also called the tool-changer) and
- A **toolholder** containing the next required tool is **installed** in the place
- The tools placed in the toolholders are securely held by means of **set screws**
- Many varieties of quick-change tool systems are available on the market

Tool Changing and Tool Registers

Tooling for Manual Tool Change

- Larger vertical mills and most horizontal mills use another type of spindle taper called the **American Standard Milling Machine Taper**
- Like the R-8 this taper requires the use of a drawbar
- If no automatic drawbar is supplied with the machine, a quick-change tooling system is added for improving tool changing

Tooling for Automatic Tool Change

- When automatic tool change is used the requirements for speed and repeatability are even more critical
- The machine's tool changer can not think for itself or correct misalignments or tool setup errors like a human being

Tool Changing and Tool Registers

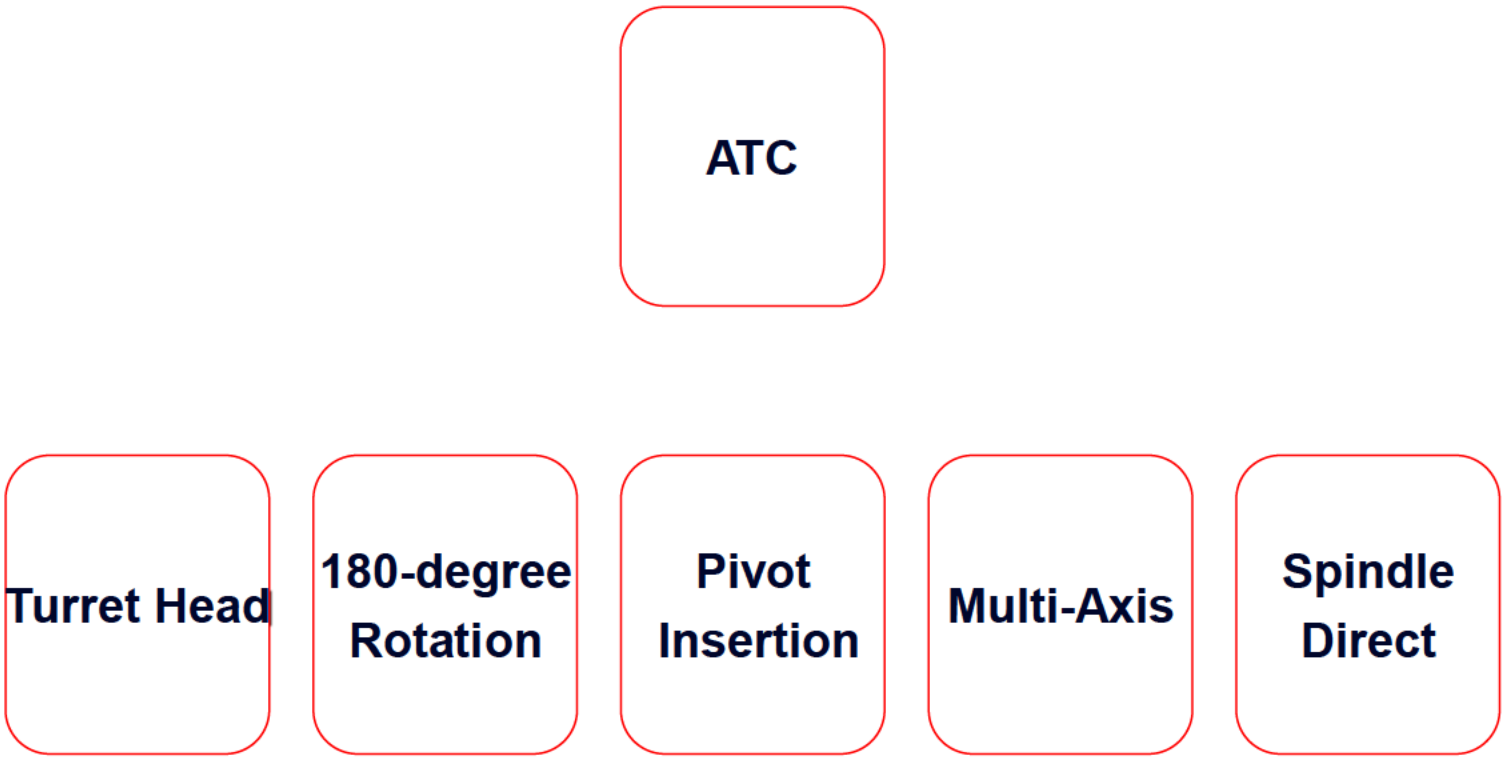
Tooling for Automatic Tool Change

- The tool changer will carry out its tool-changing cycle and ***nothing else*** since that is all it was programmed to do
- Tooling used with a tool changer therefore ***MUST***:
  - Be easy ***to center*** in the spindle
  - Be easy for the tool changer ***to grab***
  - Have some means of providing ***safe disengagement*** of the tool changer from the tool once it is secured in the spindle
- Using this procedure insures:
  - ***Proper alignment*** of the tool with the spindle
  - ***Prevents damage*** from occurring to the spindle or tool holder taper

Tool Changing and Tool Registers

Automatic Tool Changers (ATC)

Automatic Tool changers are made in five basic types:



Tool Changing and Tool Registers

Automatic Tool Changers (ATC)

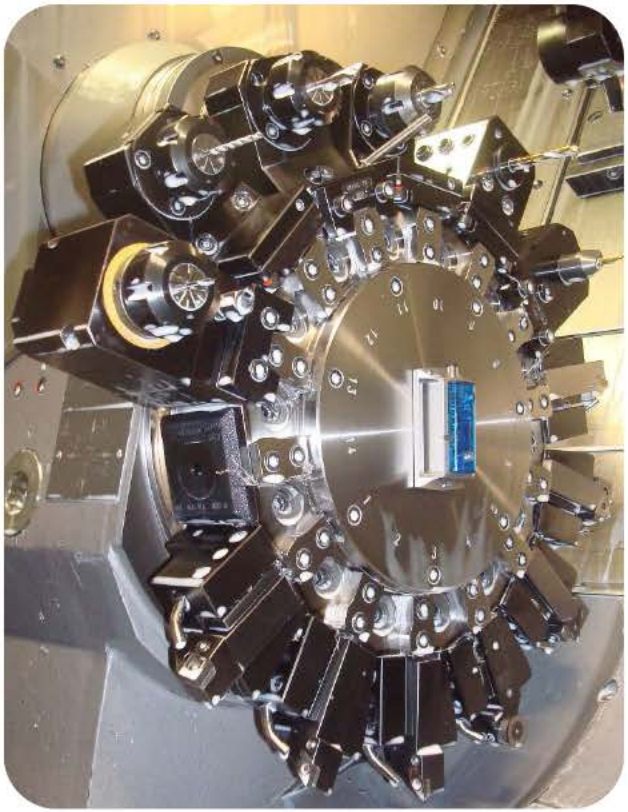


FIGURE 1 Tool Carousel

FIGURE 2 Tool Carousel on the MultiCAM

Tool Changing and Tool Registers

Automatic Tool Changers (ATC)

- Tools used in ATC are ***secured in toolholders*** designed for that purpose
- These toolholders are ***installed directly*** in the spindle by the tool changer

Turret Head

- Tool changing accomplished through the use of ***turret head*** is perhaps the ***oldest form*** of ATC
- Turret Head is a ***number of spindles*** linked to the same milling machine head
- The tools are placed in the spindles ***prior running*** the program
- When another tool is needed the ***head moves*** to the desired position
- ***Disadvantage***: The limited number of tool spindles available
- For using more tools than available spindles the operator must remove tools that have already been used and insert those called for later in the program
- ***Problem:*** More machine operator attention
- Turret Head ATC are still in use (drilling)

Tool Length Offset

General

- Tools used for machining can ***vary in length***
- When using 3-axis NC machinery there are two basic methods to compensate the different tool lengths:
  - ***Pre-measuring*** the tools
  - Using CNC controller's tool ***length compensation*** feature

Preset Tool Method

- Set the tool to a specific length
- The known length is can be then added to the program's Z-axis coordinates
- Setting the tool to a specific length: ***Presetting – Preset Tools***
- Tool set-up drawing may be used
- Special tool-setting equipment is used to measure the tools accurately
  - The ***cost*** of the equipment is ***high***
  - The ***labour*** for tool setting is ***high***
  - The ***replacement*** of broken Preset Tools is ***complicated***
  - The ***Preset tools*** must be set to **specific length** to function properly

Tool Length and Tool Length Offset

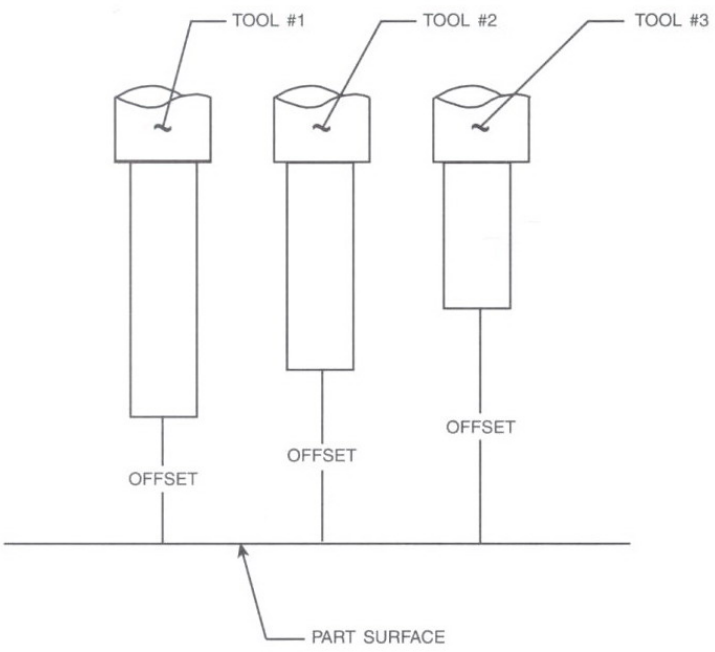


FIGURE 3 Tool length offset, difference of gage tool trim method

Tool Length Offset

- CNC machinery has revolutionized tool setting by the Programmable Tool Register

Tool Register:

- Is a ***memory spot*** in the computer where the length of the tool may be stored
- When a tool is called up the computer checks the Tool Register to see ***how much offset*** has been programmed for that tool
- Check the ***comments*** for tool offset
- The ***MCU sifts the Z-axis*** by the amount stored in the offset register

Methods for Tool Trimming or Offsetting

- Difference of gage tool trim
- Plus direction trim
- Minus direction trim

Tool Length and Tool Length Offset

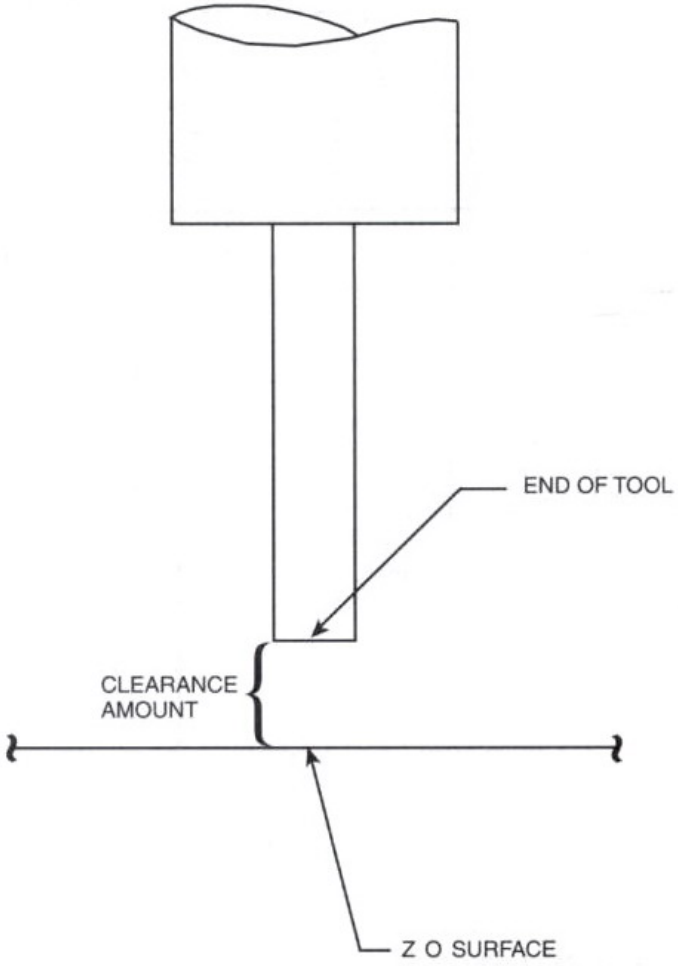


FIGURE 4 Tool clearance

Difference of Gage Tool Trim

- It is a variation of the Preset Tool method

Tool Length and Tool Length Offset

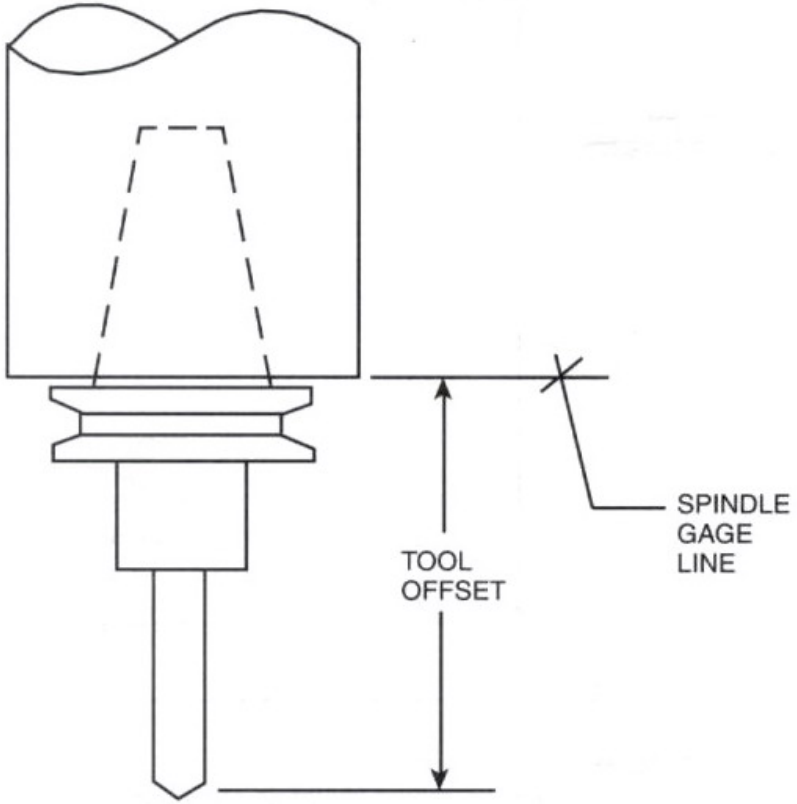


FIGURE 5 Tool length offset, plus direction trimming

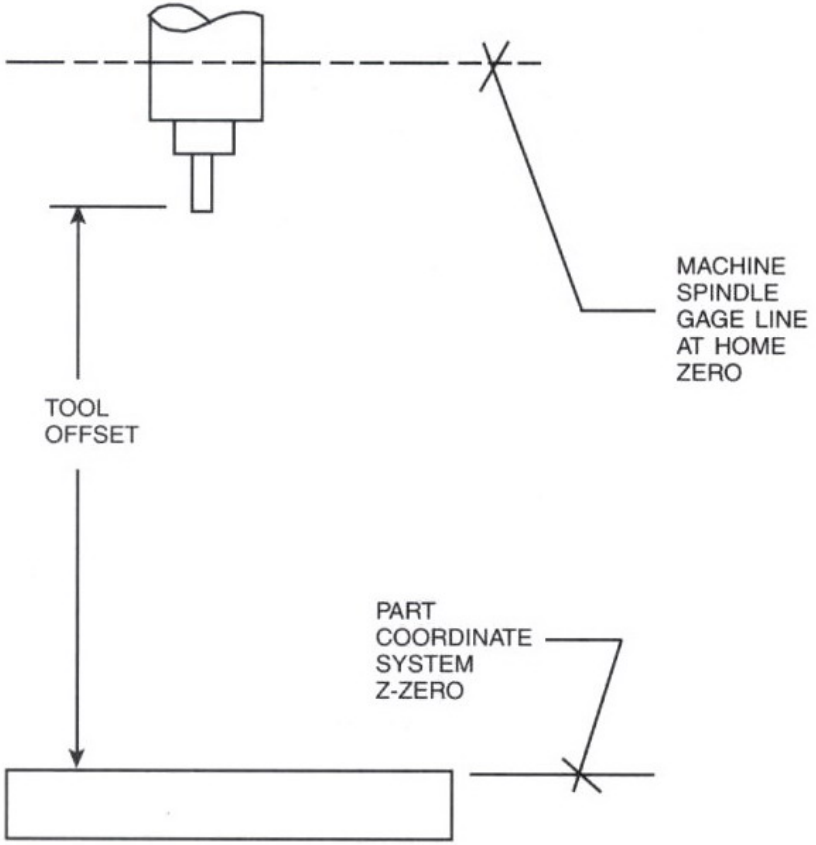


FIGURE 6 Tool length offset, minus direction trimming

Summary

- The speed, repeatability, and accuracy of a tool change greatly influence the efficiency of numerical control
- There are two types of tool change: manual and automatic
- Machinery utilizing manual tool change generally incorporates some type of quick-change tooling system to facilitate the speed and accuracy of tool changes
- Automatic tool changers are grouped into five categories: turret head, 180-degree rotation, pivot insertion, multi-axis, and spindle direct
- Tool storage magazines are grouped into two types: carousel or matrix
- Tool registers are places in the computer's memory to program tool offsets

Vocabulary Introduced in this section

- 180-degree rotation tool changer
- Automatic tool change (ATC)
- Carousel tool magazine
- Manual tool change
- Matrix tool magazine
- Multi-axis tool changer
- Pivot insertion tool changer
- Preset tools
- Quick-change tooling
- Spindle direct tool changer
- Tool length offset
- Tool offset register
- Turret head

End of Section

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Reference Note

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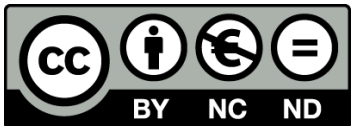

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