

EML2322L – Design & Manufacturing Laboratory

CNC Facts (Summary of CNC Machining Notes)

1. **Definition.** CNC stands for *computer numeric controlled* and refers to any machine (i.e. mill, lathe, sheetmetal brake) which uses a computer to electronically control the motion of one or more axes. The name originated in the 1950's when the need was recognized for machines to be able to manufacture complex jet aircraft parts. Modern CNC machines use software programs to provide the instructions necessary to control the axis motions, spindle speeds, tool changes, etcetera.
2. **Advantages of CNC technology.** There are two primary benefits to CNC machines:
 - a. **CNC machines allow multiple axes of simultaneous motion, resulting in 2D and 3D contouring ability.** In other words, a CNC milling machine [can move and endmill along a sloped line or circular trajectory](#) (which requires simultaneous X and Y motion), or a CNC lathe [can move the cutting tool around the corner of a part to produce a fillet](#) (which requires simultaneous X and Z motion).
 - b. **CNC machines allow for efficient mass production.** Once one good part is produced on a CNC, it's going to do the exact same thing every time; therefore, [CNC machines are hugely beneficial for the purpose of mass production](#) (i.e. producing large quantities of identical parts).
3. **Disadvantages of CNC technology.** There are four principal disadvantages to CNC machines:
 - a. **More expensive.** The CNC milling machine used in the lab to drill and tap the polar bolt pattern in the wheel hubs costs about \$60k, whereas the manual milling machines cost about \$15k. Machine tooling is roughly twice as expensive as well.
 - b. **Requires programming skill set.** For anyone who has taken a programming class, you know it requires a specialized skill set to write [and debug](#) programs in a timely manner. Consequently, CNC machines require more knowledgeable and thus higher paid operators.
 - c. **Requires more space, electricity and maintenance than manual machines.** Because of the enclosures and electrical cabinets, CNC machines require more floor space, their larger spindles require more power and like any other computer, there will be times when hardware fails and requires more frequent maintenance than manual machines which have no computers.
 - d. **Slower and/or more expensive for making one simple part.** Because of the amount of time required to write a program, debug the inevitable errors, load the tools and teach the machine how long they are, etcetera, it is often faster to make one simple part on a manual machine.
4. **Reasons for increased productivity.** The following are some of the reasons CNC machines are more productive than manual machines when producing multiple identical parts:
 - a. CNCs can [automatically change tools](#) after they are loaded the first time.
 - b. CNCs use [high pressure coolant](#) to flush away chips and remove heat from the cutting zone
 - c. CNCs use [electronic high speed probing](#) to find part and tool datums/zeros
 - d. Because the machine design does not need to accommodate a manual operator, CNCs can be designed so they are stiffer and use more powerful motors; consequently, CNCs can typically take larger and deeper cuts than manual machines
5. **Common misconceptions of CNC machines.**
 - a. As stated previously, CNC machines are *not* always the quickest or cheapest way to make a part
 - b. CNC does not inherently imply increased part accuracy. An old CNC with a lot of hours of use may produce less accurate features than a new quality manual machine and vice-versa; so don't automatically associate higher accuracy with CNC machines. (Accuracy has more to do with machine design, component selection, mechanical wear and operator skill.)

6. **Methods of CNC programming.** There are two basic ways to program CNC machines:
- a. **Conversational programming.** This is the simpler of the two methods. In effect, this is a macro programming language used to instruct the machine to perform pre-programmed cycles (i.e. facing, drilling holes in arrays, etc.). When writing a conversational program, you enter the appropriate parameters associated with each machining cycle. *This is analogous to using the polar array function in SolidWorks; you don't have to do the layout or trig to find the location of the features, you just specify the essential parameters and the software does the rest for you.*
 - b. **CAM programming.** This is the more powerful of the two methods. Using this method, you import your part model into a CAM (computer aided manufacturing) program and define the parameters associated with each and every machined feature on the part. These parameters include tool diameter and length, depth of cut, tool path geometry, etc.
7. **CAM programming steps.**
- a. Create a solid 3D model of the part to be produced
 - b. Import the solid model into the CAM (computer aided manufacturing) software
 - c. Input the raw material stock size and set the virtual part's coordinate origin
 - d. Input the necessary information for each tool used in machining the part features; typically, a tool library will exist, which is simply a database of tools and their related parameters.
 - e. For each part feature, select the appropriate tool from the library and set the parameters necessary for machining that feature; typical parameters include spindle speed, depth of cut, feedrate, number of passes, tool path pattern, etc.
 - f. Verify the programmed tool path(s) by running the CAM software's virtual machining cycle