# CNC

## Background

CNC (Computer Numeric Control) is a collective term for computer controlled machine tools used in the fabrication and manufacture of parts. There are hundreds of different types of CNC machine. CNC technology is constantly developing, with CNC machines performing an increasing range of tasks in large companies and even small workshops. Milling machines and drilling machines are commonly CNC controlled.

## Working in multiple directions with axes

CNC machines work in two dimensions and three dimensions using axes. There are at least three directions – axes X, Y and Z – but machines are also available with four or five axes. The most common type is three axes. On machines with four or five axes, the table can be tilted and rotated and the tool can be tilted and angled.

The cover, which is moved by the axes, houses one or more spindles which can accept different types of rotating tool depending on the job you are doing. The stock is machined according to a predefined pattern, using a combination of automatic tool changes and fast accurate movements of the cutting tool.

## Manual rigging and supervision

The digitally controlled CNC machine is able to fabricate complex parts uniformly and automatically. You can monitor progress either as an on-screen simulation or in real life at the CNC machine.

## Stop and think!

Tool changes are automatic but rigging, supervision and quality control are all manual operations.

## Mechanical feed

In a CNC machine all stock is fed mechanically, in other words the machine brings the tool and the stock together. The tools you use must have the MEC marking, but tools for manual feed (with the MAN marking) may also be used.

## Typical tasks

Typical tasks that suit CNC machines include face milling, form milling, pocket milling and drilling. The machine can drill holes for tenons, screws or fittings, and can execute drilling programs or hole patterns. Specialist woodworking machines are also available, for example for edgebanding of boards and complex three dimensional machining. CNC machines can work with solid timber, engineered wood or plastic.

## Controlling the machine

To be able to control the machine you first need to create or "prepare" a part program. The preparation describes where the part is on the table, the tools to be used, the movements, etc. Older machines use ISO codes, but modern machines often use dedicated software.

If ISO codes are used, each code is a command to be executed by the machine. For example, G1 X200 Y50 F2500 means move the spindle to X200 Y50 at a speed of 2500 mm/min. There are many different codes for machine functions. Certain ISO codes are standard and therefore the same for all machine manufacturers, but others can be adapted by the manufacturer for individual machines.

New machines have special programming software provided by the machine manufacturer. They are usually Windows based, so the program is created on the basis of images and dialog boxes. This means programming is quicker and easier, making the technology increasingly accessible to a wider user group.

For more complex geometric shapes, a CAD/CAM program is now also required (Computer Aided Manufacturing). The CAD/CAM program can take the drawing of the part, interpret the shape and create coordinates for the movements.

**Machine structure**
This section describes some of the main parts of the CNC machine that you will come into contact with. Tools are covered in separate section.

**Frame**
The machine is supported by a strong frame. The movement axes and the table are mounted on the frame.

**Table**
In a standard machine, the table is 1000–4000 mm long and 800–2000 mm wide. There are various types of table, and different tables use different clamping systems:

- Grid tables have a grid pattern milled into a panel, and rubber cord is inserted into the slots to create a seal.
- Console tables are also available, with rails and suction pods. Suction pods hold the workpiece in position on the table. The correct position of the suction pods is specified during programming.

The workpiece is normally clamped in place by vacuum. Both table designs have a wide range of accessories for clamping different types of product.

**Control cabinet**
The control cabinet is positioned to one side of the machine. It contains components to control the moving parts and normally also a PC and display. All signals from the machine's sensors and all input and output data are processed in the PLC module (Programmable Logic Controller).

**Axes and spindles**
The machine works in at least three directions (axes X, Y and Z). The axes control a spindle which holds and rotates the tool.

| Axis | Movement |
|---|---|
| X | along the table |
| Y | away from or towards you |

| | |
|---|---|
| Z | vertical |

**Safety zone**
At the furthest extremity of each axis within the space occupied by the machine, there must be something preventing you or anyone/anything else coming into contact with the moving parts. That is why all modern CNC machines have a safety barrier to prevent access, in the form of fencing, a light curtain, a photocell or pressure mats. Fencing often includes an interlocked door for maintenance and service.

**Stop and think!**
Before starting the machine, make sure there is no one in the safety zone.

**Tools**
In a CNC machine you can use milling tools, drilling tools or saw blades. The tools are kept in a tool magazine, usually on a tool changer drum or chain with space for anything from 1 to 30 tools. The number of tools depends on what and how much you are going to make. Machines with space for 3-14 tools are the most widespread, although specialist woodworking machines can have up to 50 tools which are changed as necessary.

Cutting tools are made of HSS, hard metal or diamond and can rotate at speeds of 1000 to 24,000 rpm. The tool is always mounted in a chuck either using collets or hydraulic clamping. Shrink fit chucks are also available.

**Collet chucks** are the cheapest and produce good results. They are also flexible and allow quick tool changes. Collets are consumable items and must be replaced regularly. Fretting corrosion and deposits on the collet surfaces affect the grip on the tool. To avoid fretting corrosion, grease all surface with a thin lubricant.

**Hydraulic clamping** is used where the finished product must be of higher quality. However, the chucks are more expensive and the tools must have the same shaft diameter.

**Shrink fit chucks** are used to achieve the highest quality in the finished product. The chuck is heated onto the tool to create a solid unit.

**Tool types**
Tools can be
- solid – the same material all the way through,
- tipped – the cutting material is brazed onto the tool body,
- tools with loose inserts – one or more inserts are fixed to the tool body, sometimes with a supporting plate.

It is important to follow the manufacturer's instructions when installing the tool. Suitable torque wrenches must be used when tightening bolts and nuts, to the torques specified by the manufacturer.

**Stop and think!**

If bolts and nuts are tightened to the wrong torque, the inserts may crack or disintegrate during machining, potentially ejecting dangerous fragments.

The machine can rotate in both directions, so it is essential to know the direction when programming and then to ensure that the selected tool is designed to rotate in that direction. The chuck too can be designed to rotate either to the left or to the right.

**Stop and think!**
Always make sure the directions of rotation of the machine, the tool and the chuck all match.

**All new tools must have proper marking**
By purchasing a tool with proper marking, you know that it meets the requirements concerning

- tool design
- kickback testing
- speed testing
- balancing
- tolerances.

According to the SS-EN 847 standard, all new milling tools with a diameter exceeding 16 mm must be properly marked. It is vital for you, the operator, to be able to interpret the information that every tool must be marked with:

- name or logo of manufacturer or supplier
- speed (minimum and maximum)
- dimensions (length, diameter and cutting length)
- material (abbreviation for steel quality of solid/tipped tool)
- marking indicating the minimum clamping length for the specified maximum speed and the maximum permitted eccentricity (a tool is never perfectly round and the eccentricity is the allowed deviation).

**Stop and think!**
Make sure you only use properly marked tools – and learn how to interpret the marking! Always read the tool supplier's instructions before mounting the tool, first in the chuck and then in the machine.

If there is no marking on the tool indicating the minimum clamping length – how far into the chuck the tool must be inserted – the tool shaft must be inserted to at least 2x the tool diameter and always at least 20 mm. If the shaft is 8 mm in diameter it must therefore be inserted at least 20 mm. If the shaft is 16 mm in diameter it must be inserted at least 32 mm.

**Stop and think!**
Never do your own modifications like changing profiles or drilling extra holes into the tool. Any modification affects the weight and balance, with potentially fatal consequences. The vibrations from an unbalanced tool may cause it to come loose.

Many workshops still have tools without proper markings. Unmarked tools must be marked by the tool supplier or discarded.

**Speed and clamping length**

To avoid accidents, you must know the significance of the Nmax speed, which is the maximum speed before imbalance becomes a risk. You must also know the tool clamping length in relation to the weight and speed, and the overhang (the part of the shaft which is not inserted into the clamp).

**Stop and think!**

Each tool has a maximum spindle speed (Nmax). Nmax is not the same thing as the optimum speed.

If the spindle speed is too low, the tool can start "chopping" instead of cutting because the cutting speed through the timber is not high enough.

**Tool library**

Suppliers often have proprietary software to program their own machines. The tool library is an important part of the software. It is a database giving every tool a unique number or name which you use when writing the program. The program specifies which tool is positioned where in the machine.

**Stop and think!**

Care must be taken to ensure that the tool is in the right place in the tool changer. The machine cannot detect which tool is which – the correct tool is determined by the programming and inputs during operation.