

Types of CNC Machining

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INTRODUCTION

What is a CNC machine?

Originally milling machines were manual in operation. Movement of the part or tool was often accomplished by manually turning handles that turned the ball screws or manipulated various levers of the machine. Basic automation allowing the machine to move in one direction, once the part location was set by the machinist. CNC is an acronym for Computer Numerical Control, where a computer is connected to the mill, along with electrical drives and sensors for a complete system. This computer controls the movement of the machine axis.

CNC machines are very precise, with precision and repeatability that can exceed what is possible through manual movements. CNC mills can vary in size from just a few inches of travel, to having hundreds and sometimes even thousands of inches of travel. The idea for CNC machines is often credited with John T. Parsons, who was a machinist and salesman at his father's machining company. He wanted a way to make aerospace parts that were lower in cost and more consistent than traditional methods. After various false starts, collaboration between Parson's, the United States Air Force and MIT led to the development of the first NC machines which were run from a punch tape.



Traditional Milling Machine

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COMPONENTS OF A CNC MACHINE

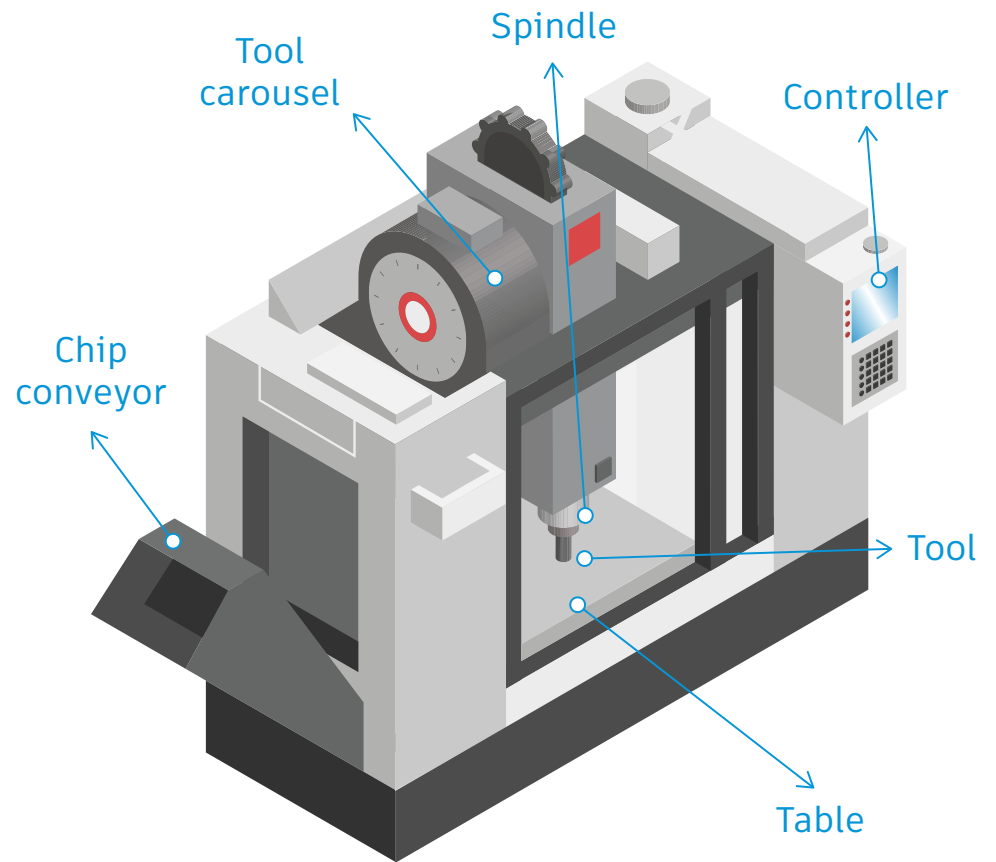
COMPONENTS OF A CNC MACHINE

Most milling machines have some similar components. First you have the machine base. This usually includes the work table and gearing, typically ball screws, for machine movement. This can also include the electric drives that move the various components of the machine.

CNC machines also require what is usually called the “controller”, or the computer part of CNC. This computerized controller utilizes the programmed input values, and data from the feedback loops, to control the movements of the machine.

Additionally, milling machines include a spindle of some sort. The spindle either spins the cutting tools for milling, or in the case of a lathe, it spins the actual part for the lathe tooling.

Lastly, to successfully CNC mill parts, you will need cutting tools compatible with your mill and material being cut.



PROGRAMMING A CNC MACHINE

PROGRAMMING A CNC MACHINE

Location data for CNC milling can be entered into the controller manually, usually via the keyboard and built in screen, often this is done from a blueprint or drawing. Alternatively, a CAD/CAM system can be used to design and program the part, with the resultant program being loaded or fed into the CNC controller.

The code used to run the mill is often referred to as Geometry code, or more commonly, "G-Code". Controllers also have "M-codes" or miscellaneous codes, such as a code to turn on or off the spindle, or coolant. This code was developed in the 1960's when computers had small amounts of memory, and a short hand notation of commands for CNC controllers was needed, to fit larger programs.



Programming with CAD/CAM system



On-machine programming

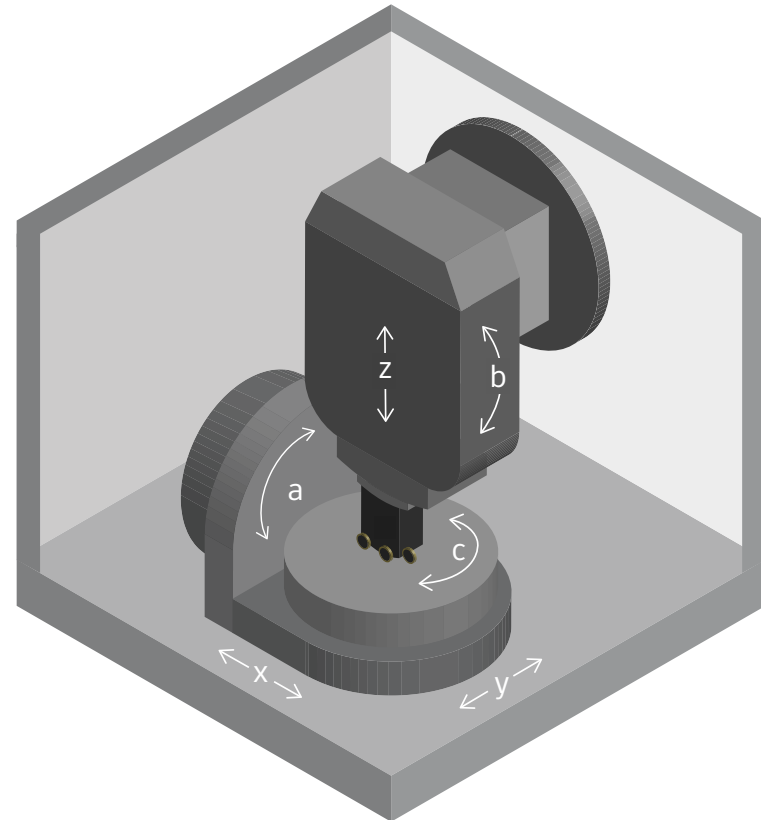
TYPES OF CNC MACHINE

TYPES OF CNC MACHINES

CNC machines will have movement that is either linear, or straight line, in motion or rotational. Typically the X, Y and Z axis are used for linear movements, whereas A, B or C will correspond to rotational axis, with A rotating about the X axis, B about the Y axis, and C about the Z axis.

CNC machine designs will vary greatly. On some styles, the part will move or rotate while the spindle and tool remains stationary, in others the part is stationary and the spindle and tool moves, and a third type is a mixture of either the part and spindle moving.

A list of the common CNC machining operations and the types of CNC machines they run on is outlined on the next page. There are many custom built CNC's which fit outside of these common types.



CNC machine movement

TYPES OF CNC MACHINES

3-AXIS MACHINING

These are the most common CNC machines produced commercially. They can move in the X, Y and Z axes simultaneously. The most common size of the 3 axis machine is one with a work table of 40x20 inches. Work performed on 3-axis machine can be simple prismatic parts, all the way to complex molds, medical or aerospace parts.

3+1 OR 3+2 AXIS MACHINING

This type of machining, and CNC machine, combines rotational movements with linear movements. In this type of machining, the part will first rotate into position, and then a typical 3-axis machining operation will commence after rotation. The rotation and linear movement does not happen simultaneously.

If the machine supports rotation around just one axis, then it is considered 3+1 machining, for 3 linear axis and one rotational axis. If the machine can rotate about two axes, it is referred to as a 3+2 axis machining.

CNC machines can be purpose built as a 3+1 or 3+2 axis mill, but more commonly, they are created by adding a rotating component to an existing 3-axis mill. The latter method will reduce the work envelop size, so that should be taken into consideration when outfitting a mill.

One major advantage to 3+1 and 3+2 machining is in reducing individual setups when milling a part. Some parts may require milling on different sides, and on a 3-axis machine, the machinist would remove and reposition the part between operations. This can sometimes take a long time, where it could rotate into position automatically with 3+1 or 3+2 functionality.

Note that setting up and programming 3+1 and 3+2 axis machines manually, versus programming with a Computer Aided Manufacturing (CAM) system is often difficult, time consuming and prone to errors.

4-AXIS SIMULTANEOUS

The difference in 3+1 and 4-axis simultaneous is that the part can rotate on one axis at the same time it is milling in 3-axis. This type of machining is necessary when part geometry wraps around a part, common in the aerospace and other industries.

While all 4-axis simultaneous milling machines can perform 3+1 axis milling, not all 3+1 axis mills can do 4-axis simultaneous. One needs to make sure of their machine's capabilities before trying to run a program it may not support.

TYPES OF CNC MACHINES

5-AXIS MACHINING

This type of machining allows for the most flexibility in milling the part at different tool orientations. Here, the part can rotate in two separate axes, usually A&C or B&C, at the same time the 3 linear axes are moving.

Machining in simultaneous 5-axis is popular in parts where complex shapes, and small clearances, are the norm; such as impellers, turbines, intake ports and more.

True simultaneous 5-axis machines can run in all the previous modes; 3-axis, 3+1 axis, 3+2 axis, 4-axis simultaneous plus 5-axis simultaneous. While all 5-axis simultaneous machines can perform 3+2 axis machining, not all 3+2 axis machines can do 5-axis simultaneous. It is a function of the machine's design and the CNC controller installed.

These mills are typically more expensive than the other mill types, for the same size, but offer the most flexibility when setting up your jobs.

LATHE

Often referred to as turning, and usually used for round parts, a lathe is slightly different than a milling machine. With a lathe, instead of the part being stationary and the tool spinning, the part is put into a "chuck" and spun. From there, a cutting tool is used to carve out the shape needed.

Some common options on lathes are automatic bar feeder, to feed material through the spindle to the chuck. Other common options are tail stocks to support the spinning part in the front and back.

MILL TURN

This is a special type of lathe. Sometimes referred also as live tooling, it is a lathe where a small spindle with a rotating cutting tool can be added. These types of mills and operations allow users to create round parts that have milled or drilled features on them, without having to mount them into a different mill.

NON MILLING MACHINES

NON MILLING MACHINES

Mills and lathes both use a spindle to either spin a tool or the part. However, there are other CNC machines used in manufacturing that do not have spindles.

WIRE EDM

These types of machines use a special wire, fed from a spool, with an electric current passing through it, to remove material. The wire essentially slices through the metal. These machines are often used on tool steels and stamping die components. Wire EDM machines can be 2 axis or 5 axis. With a 2-axis, the wire cuts a profile. In 5-axis, the wire holders at the top and bottom can move independent of each other to create ruled surface shapes.

WATERJET CUTTER

High pressure water, often with an added abrasive, is used to cut through a variety of materials. Water jet cutters can cut through plastics, metals and even stone and granite.

Most water jet CNC machines are 2 axis, and only cut a profile, however, there are 5-axis water jet machines available as well.

LASER CUTTER

Like a water jet, most laser cutters are 2-axis and used to cut profiles through sheet stock. However, instead of using a pressurized water stream, they use a laser sufficient for the material. Depending on the laser and design, laser cutters can cut through acrylic, polymers, and various metals.

For contoured sheet metal stampings, it's common that they are trimmed with a 5-axis version of a laser cutter.

PLASMA CUTTER

Similar to lasers and water jets, a plasma cutter usually cuts through sheets and plates. Plasma cutters work on electrically conductive materials, and cut by means of an accelerated jet of hot plasma.

Besides cutting metal sheets, plasma cutting is capable of cutting thick plates, often used in boat building. Most plasma cutters are 2 axis, but 5-axis versions are available.

CONCLUSION

WHAT TYPE OF MACHINE IS RIGHT FOR ME?

There are many factors that go into picking a CNC machine. The types of parts you plan to mill will dictate what type of mill you will need. Most prismatic parts, or individual components for mold and die can be done with 3-axis operations. Many medical or power generation components require 3+2 or 5-axis machining. Mill Turn is common in a lot of aerospace applications.

REVIEW

A CNC milling machine consists of the machine base and moving axes, a computerized controller, and some form of spindle to rotate the cutter or part.

These machines are run from data either programmed in by hand, or created by a CAD/CAM system. There is a lot of variety in the types of machining, and types of machines. One should pick a technology suited to the type of part they plan to create. Check our other articles for more detailed descriptions of CNC milling technology.

To explore more information about CAM programming and CNC machining, visit our manufacturing resource center.

[RESOURCE CENTER >](#)



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