Introduction to Workholding Solutions

What's the best way to ensure product quality in an industrial machining process?

Use workholding devices to properly locate the workpiece and secure it against the forces of machining.

Workholding refers to any device used to securely position and firmly hold a workpiece in its proper orientation to the tooling with enough force to resist the forces of machining without deforming the part. The importance of proper workholding should not be underestimated.

If put in place properly, workholding devices allow a machine to work at its full potential while efficiently and consistently producing quality parts.

But, if workholding is underestimated, it can lead to failure.

In milling operations, for example, failures often occur due to the work being pushed out of position by the force of the cutting tool or the workpiece flexing because it was not properly supported, both consequences of improper workholding.

Although workholding methods have advanced considerably, the basic principles of clamping and locating remain the same.

Think of clamps, vises, and fixtures with the same respect you give to cutting tools. Workholding devices don't remove any material, but they do add value. You can't machine it right if you can't hold it right. Workholding devices are the most important "non-cutting" tools in the machine shop and are usually where most of the money is spent. Why? Because, while you may serve many different customers, you may purchase only one CNC lathe. But you will purchase many different workholding devices, jigs and fixtures which are expensive.

Our goal in this article is to give you an overview of the main workholding devices that you'll need when working on CNC milling machines, turning centers and lathes. We'll also talk about workholding systems, products, jigs and fixtures.

In this article we will take a closer look at:

CNC Workholding

CNC machining is a traditional manufacturing method that utilizes cutting tools and rotation to make a predetermined series of cuts to a solid block of material. The cutting operations are derived from digital design files, which can be distributed to multiple CNC machines simultaneously, enabling manufacturers to produce multiple copies of a part more expeditiously.

While machining is a versatile process capable of reliably producing highly precise and accurate parts - it's often used to create critical automotive, medical and aerospace components - the inherent nature of the process creates limitations to the geometry that's possible to create with CNC machining. Design elements like sharp internal corners, for instance, are difficult to create with round, rotating tools, while undercut features like dovetails and T-slots are hard, if not impossible, to reach with standard tools.

Workholding, or how the workpiece is fixed in position during the machining process is another potential issue. If workpieces are hard to grasp or grasped improperly, the part's viability, production timeline, and per-unit cost may all be negatively impacted.

Workholding is a catchall term referring to any device or apparatus used to keep a workpiece stable and immobile. Some common examples are chucks, ***toggle clamps***, ***power clamps***, end stops, soft or hard jaws, ***locators***, vises, fixtures, and jigs.

Ideal workholding devices have easily repeatable setups. Some CNC machines even have standard built-in workholding devices. Typically, vises are used with milling machines while chucks or collets are used when running a lathe. Sometimes, a part may need a customized CNC workholding set up to secure the piece properly during machining. Fixtures and jigs are examples of customized devices.

There is no one-size-fits-all solution to CNC workholding. The goal for manufacturers is to determine the best-fit combination of machining operations and workholding solutions that maximize spindle usage time, reduce the need for changeovers, and improve production throughput.

Among the most common CNC machining operations are:

DRILLING

MILLING

TURNING

Before the operator runs the CNC program, they must prepare the CNC machine for operation. These preparations include fastening the workpiece directly into the machine, onto machinery spindles or into machine vises or similar workholding devices and then attaching the required tooling, such as drill bits and end mills, to the proper machine components. Some of the more typical workholding devices include:

Milling/Drilling Machine Workholding Devices

> T-Slots - All the workpieces or workholding tools installed on the milling table are held in position with the help of the table T-slots.

> Clamps - Clamps are the simplest tools available to secure anything to the T-slot. There is a wide array of clamps available depending on the size and shape of the workpiece or workholding tool.

> Fixture Plates - Fixtures plates, also called tooling plates, are plates installed on top of a T-Slot table to provide a new way to position and secure Workholding. They typically feature a grid of holes that alternate threaded holes for fasteners and precision dowel pins for positioning.

The grid makes workholding positioning significantly easier and repeatable. Tooling Plates are typically made of either Cast Iron or Aluminum, though steel plates are also available.

> Vises - The most basic type of workholding in milling is the Machinist Vise. Both jaws have great parallelism and perpendicularity, along with great strength, so they're ideal for gripping stock and not letting go.

> Parallel Bars - Parallels are often used with vises to hold the work at a height off the bottom of the vise, giving clearance for side milling and through-hole drilling.

> Jaw Plates - Unlike parallels, jaw plates are positioned in the outboard position of the vise jaws and are generally used to clamp larger plates.

> V-Blocks - Vee blocks are generally used when the workpiece has a cylindrical shape, such as bars. Their design allows them to locate the Y-axis center quickly and accurately.

> Angle Plates - Table slotted angle plates are used in setups when the workpiece being machine needs to be held at a true 90 degrees angle to the table.

These plates are heavy and available in a wide array of sizes.

When angle plates are used, the work is generally clamped or bolted to the T-plate.

Lathe Workholding Devices

Unlike in milling, workholding ***devices used in lathes/turning*** operations have a dual function:

- They hold the workpiece firmly

- They rotate the workpiece along with the spindle.

The choice of the most practical device to use generally depends on the shape, length, diameter, and weight of the workpiece. The type of cuts you take also plays a fundamental role in the selection of workholding devices. Typical devices for turning operations include:

> Chucks - Chucks are probably the most widely adopted type of workholding device on the lathe. They are efficient and accurate and work well with most types of workpieces.

Chucks can be divided into four main types:

1. Three Jaw Chucks – self-centering and hold regular shapes, such as round or hexagonal workpieces.
2. Four Jaw Chucks – not self-centering and hold eccentric or irregular workpieces.
3. Magnetic Chucks - hold the job by magnetic force.
4. Collet Chucks - used for holding small or very long workpieces.

> Face Plates - Faceplates generally have a circular shape and have a threaded hole at their center so that they can be screwed to the threaded nose of the spindle.They are used to hold large, heavy and irregular-shaped workpieces which cannot be conveniently held between centers.

> Driving Plates and Catch Plates - Driving plates and catch plates are generally used to drive a workpiece that is held between centers. While both types of plates have a disk shape, driving plates have a driving pin on the face that is used to engage with straight tail carriers while catch plates feature 'U' slots that are designed to fit "bent tail" carriers.

> Carriers - Carriers, also known as lathe dogs, are used along with driving plates. The workpiece is inserted into the eye of the lathe dog and then firmly secured with a screw. They can be divided into two categories depending on the type of tail:

1. Straight tail (paired with driving plates)
2. Bent tail (paired with catch plates)

> Centers - Centers are useful in holding the work in a lathe between centers. The shank of a center has Morse taper on it and the face is conical in shape. There are two types of centers.

1. Live center – rotates with the work
2. Dead center – doesn't rotate with the workpiece

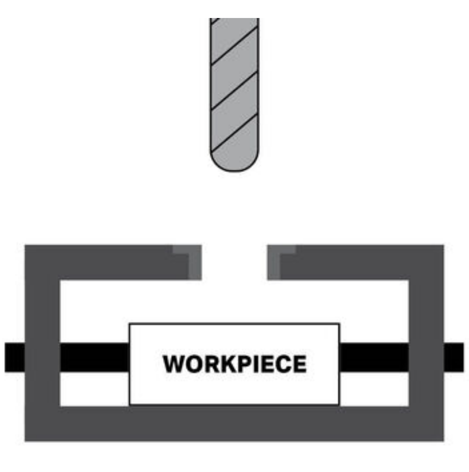
> Rests - Rests are used to support a long slender workpiece. They are typically placed at some intermediate point to prevent the workpiece from deflection.

> Mandrels - Mandrels, also called arbors, are used to hold previously drilled or bored holes for outer surface machining. The workpiece is loaded over the mandrels between the centers. Mandrels are generally tapered, and their ends are slightly smaller than the original diameter for effective gripping.

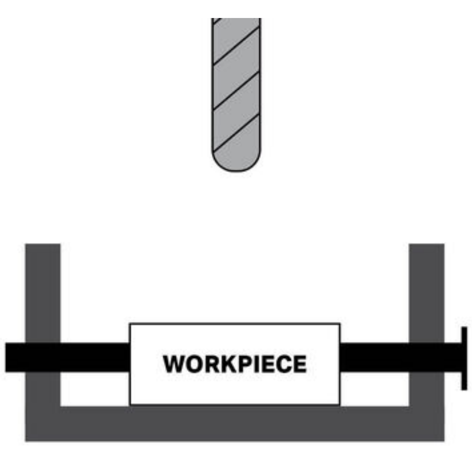
Jigs and Fixtures

Jigs are tools that hold a cutting tool in place or guide it as it performs a repetitive task like drilling or tapping holes. ***Fixtures***, on the other hand, don't guide a cutting tool, but hold a workpiece steady in a fixed position, orientation, or location. Since the advent of automation and computer numerical controlled (CNC) machines, jigs are often not required because the tool path is digitally programmed and stored in the machine's memory.

Differences aside, both jigs and fixtures are tools that make a significant difference. They increase productivity, improve the repeatability of parts, make part assembly and disassembly easier and help create a safer working environment. Nearly all automated industrial manufacturing processes rely on jigs and fixtures to consistently build parts that function properly.



JIG



FIXTURE

Jigs

A jig is a workholding device that holds, supports and locates the workpiece and guides the cutting tool for a specific operation. Jigs are usually fitted with hardened steel bushings or guides for cutting tools. A jig is used to control the location and/or motion of a cutting tool. A jig's primary purpose is to provide repeatability, accuracy, and interchangeability in the manufacturing of products. A device that does both functions (holding the work and guiding a tool) is called a jig.

Jigs are typically used on drilling, reaming, tapping, counterboring and other one-dimensional machining operations. A drill bushing which helps guide a drill bit through the surface of a workpiece to ensure correct positioning and angle is a common application for a jig.

Another example of a jig is when a key is duplicated, the original key is used as a jig, so the new key shape is cut using the same path and shape as the original key.

Fixtures

A fixture is a workholding device that holds, supports and locates the workpiece for a specific operation but does not guide the cutting tool. It provides only a reference surface for a device. What makes a fixture unique is that each one is built to fit a particular part or shape. The main purpose of a fixture is to locate and, in some cases, hold a workpiece during a machining operation. A jig differs from a fixture in that it guides the tool to its correct position in addition to locating and supporting the workpiece.

Fixtures are used in turning, milling, slotting, grinding, shaping, planing, boring and other multidimensional machining operations. Fixtures are also essential on an automobile assembly line to secure and guide vehicles during welding and dimensional verification processes.

A vise on a workbench, a material block clamped inside a CNC machine and lathe chucks are examples of simple, proven fixtures.

Summary

Ultimately, there is no one-size-fits-all solution to CNC workholding. The goal for manufacturers is to determine the best-fit combination of machining operations and workholding solutions that maximize spindle time, reduce the need for changeovers, and improve production throughput.

Workholding solutions range from simple vises or clamps to more complex jigs or fixtures. The choice of the most practical solution to use generally depends on the shape, length, diameter, and weight of the workpiece. The type of cuts you take also plays a fundamental role in the selection of workholding devices.

No matter how sophisticated and powerful your milling machine or lathe is, there is no way you will be able to cut metal precisely and repeatably if your workpiece is not safely and strongly held in place by a proper ***workholding device***.