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Class Outline

Objectives
What Is Workholding?
The Role of Workholding Devices
The Importance of Repeatability
Standard Workholding Devices for the Lathe
Standard Workholding Devices for the Mill
Standard vs. Customized Workholding Devices
The Basic Jig
The Basic Fixture
Modular Fixtures
Fixed Locating Components
Adjustable Locating Components
Clamping Components
Cycle Times and Changeovers
Indexing Workholding Devices
Power Clamping
Workholding Devices by Application
Summary
Lesson: 1/18

Objectives
- Describe workholding.
- Describe the role of workholding devices.
- Define repeatability.
- Identify standard workholding devices for the lathe.
- Identify standard workholding devices for the mill.
- Describe standard and customized workholding devices.
- Describe the jig.
- Identify basic fixtures.
- Describe modular fixtures.
- Describe fixed locating components.
- Describe adjustable locating components.
- Identify common clamps.
- Describe how workholding devices influence cycle times and changeovers.
- Describe indexing workholding devices.
- Describe power clamping.
- Describe other applications for workholding devices.

Figure 1. Without reliable workholding, manufacturers cannot meet the specifications required for the intended use of the part.

Figure 2. Fixtures are customized workholding devices that support, locate, and clamp workpieces.

Figure 3. Locating pins are added to a fixture to help secure a workpiece.

Figure 4. Once a workpiece is supported and located, it is clamped and ready for machining.
Lesson: 2/18

What Is Workholding?
Manufacturing companies perform a wide range of operations that shape, cut, form, or join parts or components. For example, Figure 1 shows a part that is being made on a lathe. No matter what type of part you are making, you must be sure that your part is properly located and clamped securely in place. This involves workholding.

Workholding is the process of securely supporting, locating, and clamping a workpiece for a manufacturing operation. In particular, workholding devices play a vital role in the interaction between the workpiece and a machine tool, as shown in Figure 2. During manufacturing, a workholding device holds a workpiece in an exact location. More importantly, each workpiece loaded on the machine must be positioned in the same location to ensure that all parts are identical and made to the same specifications.

Without reliable workholding methods, manufacturing would not be productive, and it would be more difficult to meet the specifications required for the intended use of the part. This class will teach you about the most common types of workholding devices used in the shop, as well as the most important characteristics that each workholding device must meet.

Figure 1. Manufacturers perform a wide range of operations that shape, cut, form, or join parts or components.

Figure 2. Workholding devices play a vital role in the interaction between the workpiece and a machine tool.
The Role of Workholding Devices
An effective workholding device establishes and maintains a direct relationship between the cutting tool and the workpiece by properly **supporting, locating,** and **clamping** the workpiece. If a device does not meet these three tasks, it is not a true workholding device.

Supporting and locating are closely related. Both involve the accurate positioning of the part. As you can see in Figure 1, supporting is the secure foundation that "holds" a workpiece, usually from underneath. As shown in Figure 2, locating is the accurate orienting and positioning of a workpiece. By properly supporting and locating a workpiece, you establish a relationship between the machine tool and the workpiece that can be repeated for each part throughout a production run.

As shown in Figure 3, clamping refers to the secure holding of the workpiece in its location throughout the operation. Clamping must often resist the significant forces that occur during machining. Plus, clamping forces must be maintained throughout the production run.

Supporting, locating, and clamping collectively affect the accuracy of a part. If a workholding device cannot accurately position a workpiece and maintain that position during an operation, the result is often a scrapped part.
Lesson: 4/18

The Importance of Repeatability

Workholding devices must first be able to accurately support, locate, and clamp a workpiece. More importantly, the workholding device must do this task over and over again with the same result. This ability to reliably support, locate, and clamp a workpiece accurately over time is called repeatability.

Machining accuracy and repeatability are dependent upon all aspects of the process. As shown in Figures 1-3, the machine tool, the workpiece stock, the workholding device, and even temperature changes or vibration can introduce variation or errors that affect part quality. Unlike certain aspects that may be difficult to detect, the workholding device plays a central role in reducing variation and maintaining part quality.

The blueprint and specifications for a part include tolerances for each part feature. Tolerances tell you how accurate a feature must be to meet its specifications. Variation or errors make it much more difficult to meet these tolerances.

Manufacturers seek to limit the variation introduced by a workholding device. As a general rule, a workholding device must have stricter tolerances than the part it holds. For example, if a part requires a tolerance of ±0.005 in. (0.127 mm), a workholding device with a ±0.0005 in. (0.0127 mm) is most likely acceptable. Remember that the machine tool and the workholding device can both "eat into" the available tolerances of a part. A part that has tight tolerances must have very accurate machine tools and workholding devices. This helps assure that any variation introduced by the workholding device is limited.
Standard Workholding Devices for the Lathe

The lathe is one of the most common machines used in today's shops. Figure 1 shows a basic lathe. Lathes are used to manufacture cylindrical parts from bar stock. Two common workholding devices for the lathe are chucks and collets, which are attached to the spindle. These devices locate and hold the workpiece while it rotates on the lathe.

As shown in Figure 2, the most common chucks used on the lathe have either three or four jaws that are tightened to clamp the workpiece. The chuck is mounted onto the machine spindle and can accommodate a range of part sizes. Chuck jaws must be strong enough to resist the often extreme forces of rotation and the severe forces of deflection caused as the cutting tool contacts the workpiece.

Collets, shown in Figure 3, are workholding devices that fit into the spindle of a machine tool. Collets are available as a set, and each collet is designed to hold a specific size part. Collets allow the automatic machining of a series of parts from bar stock. Stock moves through the spindle into the collet and is held firm until one part is finished. At that time, more stock is either pushed or pulled through the collet, and the process begins again. Most chucks and collets are standard components that are purchased "off-the-shelf" with specifications that are consistent with industry standards.
Lesson: 6/18

Standard Workholding Devices for the Mill
Another common machine tool used in the shop is the milling machine, or mill. Figure 1 shows a basic manual milling machine. The milling machine is most often used to make cuts in flat, rectangular workpieces. A milling machine can cut along both straight and curved lines. Unlike the lathe, on the mill the workpiece is held stationary while the tool rotates.

The standard workholding device for the mill is the vise, which can hold workpieces with simple dimensions. The vise has one fixed jaw and one moveable jaw. A lever is used to turn a screw that tightens the moveable jaw against the fixed jaw, as shown in Figure 2.

Vises are familiar to most people because they are common household workholding devices. The vise in a typical household workshop is permanently fixed to a worktable, as shown in Figure 3. In the machine shop, a vise must be able to hold much tighter tolerances. The vise adjusts to accommodate workpieces of varying sizes.

![Figure 1. The milling machine is one of the most common machines used in today’s shops.](image)

![Figure 2. On the vise, a lever slides a moveable jaw against a fixed jaw.](image)
Describe workholding.

Standard Workholding Devices for the Mill

A workholding device for the mill is the vise. Jigs and fixtures are customized workholding devices that support, locate, and clamp a workpiece. A workholding device may also be designed to prevent the workpiece from moving and/or rotate, in addition to hold it. An example of this is a rotating vise. To further customize your setup, you can add a workholding device with a longer reach to the tool or the machine. Both workholding devices and fixtures can include standard clamp types. Each type of clamp has its own strengths and weaknesses. You should choose the type of clamp that best suits your needs.

Clamping devices are used to support and locate a workpiece. Clamping includes cam clamps, hydraulic clamps, and pneumatic clamps.

Hydraulic clamping uses the force of fluid pressure to immobilize a workpiece. Pneumatic clamping devices use pressurized air to hold workpieces in place. Both of these clamping methods are the most common types of clamps used in the industry.

Cycle Times and Changeovers

Cycle times and changeovers are important factors that determine the type of clamp. As the cycle time of the process increases, the time required to changeover the machine decreases. This allows you to incorporate more types of clamps into your system. The next time you change your setup, you will be able to incorporate the new workholding device before the previous setup is completed. The time required to changeovers between setups is reduced to a minimum.

The above clamps may be considered applied to protect a workpiece from damage. Note that most clamps are designed to hold a workpiece as it rotates on a lathe. Some clamps are designed to hold a workpiece as it rotates on a machine. These clamps are designed to hold the workpiece as it rotates on a lathe. These clamps are designed to hold the workpiece as it rotates on a lathe.

Supporting, locating, and clamping collectively affect the accuracy of a part. If a workholding device is unable to properly support, locate, and clamp a workpiece, the part will be manufactured with an error. The most critical aspect of workholding is to properly support, locate, and clamp the workpiece. This ability to reliably support, locate, and clamp a workpiece accurately over time is called consistent accuracy. The above clamps may be considered applied to protect a workpiece from damage.

Summary

A part that is being worked on. It may be subject to cutting, welding, forming, or other operations. The vise adjusts to hold a workpiece. The vise in a typical household workshop is permanently fixed on a worktable. In general, if a workholding device has a locating pin, the locating pin is used to both support and locate a workpiece. Customized jigs and fixtures are ideal for parts with uncommon and specifications for a part include tolerances.

Lesson:

Fixtures are common in machine shops. Most fixtures have the same basic components, including a fixture plate, clamps, locators, and a base. The fixture plate is the shelf with specifications that are consistent with industry standards. A plate fixture has locators and rests. A short locating pin that is used to both support and locate a workpiece.

Lesson:

A workholding device used to position a workpiece within a jig or fixture. Locators establish a relationship between the machine tool and the workpiece by properly supporting, locating, and clamping the workpiece. A workholding device used to position a workpiece within a jig or fixture. Locators establish a relationship between the machine tool and the workpiece by properly supporting, locating, and clamping the workpiece.

Figure 1. The vise in a typical household workshop is permanently fixed on a worktable.
Lesson: 7/18

Standard vs. Customized Workholding Devices
Many parts can be made with standard workholding devices. However, in some cases, standard workholding devices are not the best choice. Manufacturers may find that standard workholding devices do not adequately support, locate, and clamp parts with uncommon or complicated dimensions and features, like the part shown in Figure 1. For complex parts, manufacturers will either alter a standard workholding device or use customized devices that are designed specifically for the part.

To accommodate cylindrical parts with uncommon dimensions, chucks can be customized through boring. After boring, the operator knows that the jaws of the chuck are properly aligned with the ways of the lathe. Because the design of a vise is relatively simplistic, vises can be altered or manufactured to hold a variety of different workpiece shapes. Figure 2 shows a vise that has been changed to hold an irregular workpiece.

Generally speaking, as the complexity of a workpiece increases, the need for a customized workholding device increases as well. For difficult workholding applications, manufacturers may construct their own custom workholding devices. The two most common customized workholding devices are jigs and fixtures. Customized jigs and fixtures are ideal for parts with uncommon critical surfaces and locating points. The design of a jig or fixture should allow a workpiece to be loaded only one way. The jig in Figure 3 and the fixture in Figure 4 should also allow room for cutting tools and the chips created by the cutting process.
Lesson: Cycle Times and Changeovers

Objectives

- Locate the importance of cycle times and changeovers
- Describe power clamping
- Identify standard workholding devices for the mill
- Describe indexing workholding devices

The performance of a workholding device depends on how well it supports, locates, and clamps a workpiece accurately over time. A workholding device’s ability to reliably support, locate, and clamp a workpiece accurately over time is called repeatability. Manufacturers expect this characteristic from workholding devices so that all parts are identical and made to the same specifications.

Besides supporting, locating, and clamping, manufacturers also expect other characteristics from workholding devices. Since inactive machines are not making parts, manufacturers strive to keep cycle times short. Cycle times are the time between setups and the time between parts. Without reliable workholding, both setup and cycle times can be increased.

Indexing workholding devices are used for drilling holes in patterns, usually circular, and for accurate positioning of parts. Indexing jigs allow manufacturers to drill holes in a pattern. Figure 1 shows a milling machine, which is a common machine tool used for drilling holes around a workpiece.

Many parts require machining in regular patterns prior to completion. These patterns consist of holes with different diameters that may be located at different positions or rotated at different angles. While there are many workholding devices, the most commonly used types are strap clamps, locators, locators, locating nests, locating pins, and rest buttons. Figure 2 shows a milling machine with strap clamps.

Figure 2. A milling machine with strap clamps.

Figure 4. Customized fixtures are ideal for parts with uncommon critical surfaces and locating points.
Lesson: 8/18

The Basic Jig
Like other workholding devices, jigs support, locate, and hold workpieces during machining. Jigs are capable of establishing location dimensions. This means that jigs help guide tools to precise locations. For example, a jig can direct a tool to the precise location of a hole that is centered 2.000 in. (5.080 cm) from the bottom edge and 1.000 in. (2.540 cm) from the right edge of a workpiece.

As shown in Figure 1, a jig is used for holemaking operations such as drilling, tapping, reaming, and counterboring. In general, if a workholding device has a bushing, it is called a jig. As you can see in Figure 2, a bushing is a hardened steel tube with a specific diameter used to guide a tool. Bushings sit in the drill plate of a jig for drilling and related operations.

Jigs are less common in today’s shops. Manufacturers strive to perform as many operations in the same setup as possible. The typical jig limits the number of operations performed on a workpiece. As the use of CNC machining centers becomes increasingly common, the use of jigs continues to decline. Nowadays, fixtures are being used instead to hold parts for hole-making operations performed on CNC machines, as shown in Figure 3.

Figure 1. A jig is used for hole-making operations such as drilling, tapping, reaming, and counterboring.

Figure 2. A bushing is a hardened steel tube with a specific diameter used to guide a tool.

Figure 3. CNC turning centers (TC) and machining centers (MC) have contributed to the decline in jig usage.
Lesson: 9/18

The Basic Fixture

Fixtures are customized workholding devices that can be attached to the machine tool performing the operation. These devices can be divided into four general types:

- **Plate fixtures** (Figure 1) are the most common fixture type. They hold workpieces parallel to the machine table and have locators and clamps mounted on the plate.
- **Angle-plate fixtures** (Figure 2) are related to plate fixtures. They are used to reorient a plate fixture from a horizontal to a vertical position.
- **Tombstones** (Figure 3) are large two-sided rectangular devices that accommodate the mounting of fixtures.
- **Columns** (Figure 4) are four-, six-, or eight-sided devices that accommodate the mounting of fixtures or vises.

Fixtures are common on **milling machines**, **boring machines**, and **CNC machining centers**. In some cases, a fixture may be mounted on a lathe to hold irregular workpieces that do not fit easily in a chuck. Because they are customized for a specific part, fixtures appear in an incredible range of designs. The most appropriate fixture depends on the part you are making and the number of parts to be manufactured.

Figure 1. A plate fixture has locators and clamps mounted on the plate that position a workpiece parallel to the machine table.

Figure 2. An angle-plate fixture reorients a workpiece from the horizontal to the vertical position.

Figure 3. A tombstone is a large two-sided rectangular device that accommodates the mounting of fixtures.
Welcome to the Tooling University. This course is designed to be used in conjunction with the online version of this course for a comprehensive learning experience. Standard and customized workholding devices are crucial in manufacturing processes. These devices include jigs, fixtures, and various clamps that support, locate, and immobilize workpieces during machining operations.

### Standard Workholding Devices for the Lathe

- **Threaded Adjustable Locator**: Adjustable locators such as threaded adjustable locators are useful for parts with varying dimensions. They provide flexibility in clamping forces.
- **Fixed Locators**: Fixed locators such as V-blocks and centers are used for precise positioning of cylindrical workpieces.

### Clamping Components

- **Eccentric Clamps**: An adjustable clamp with a metal button or tang that pushes a workpiece up against fixed locators.
- **Screw Clamps**: Screw clamps are secure but time-consuming to open and close.

### Workholding Device for the Mill

- **Vise**: The vise is a workholding device that supports, locates, and clamps parts. It is a standard toolholding device for the mill.

### Workholding Devices by Application

- **Hydraulic Clamping**: Uses the force of fluid pressure to immobilize a workpiece. It is ideal for applications requiring high clamping forces.
- **Pneumatic Clamping**: Utilizes compressed air to apply clamping forces. It is more suitable for lighter applications.
- **Strap Clamps**: Strap clamps are manually adjustable and are used for securing workpieces in a fixed position. They are suitable for light to medium clamping forces.

### The Importance of Repeatability

- Consistent clamping forces are needed to ensure accurate machining. Manufacturers use various workholding devices to limit the variation introduced by these devices.

### Lesson:

The performance of a workholding device depends on how well it supports, locates, and clamps a workpiece. Manufacturers seek to limit the variation introduced by a workholding device. As a general rule, a workholding device should be selected based on the size and shape of the workpiece and the machining process. The importance of selecting the right workholding device cannot be overstated, as it directly affects the quality and efficiency of the machining process.
Lesson: 10/18

Modular Fixtures
One of the drawbacks of customized workholding devices is that they are useful for only one unique part. Some of these permanent fixtures cannot be altered to suit the needs of another part. Thus, if the part they hold is not being produced at the moment, they must be stored until they are needed again, as shown in Figure 1. To overcome this limitation, some manufacturers use modular fixtures.

Modular fixtures, like the assembled device in Figure 2, are durable workholding devices without the permanence of customized fixtures. Like chucks, modular fixtures consist of standard components that may be adjusted from part to part. A modular fixture is broken down to its component parts after a part run, and reassembled in a different configuration to accommodate another part run.

The adaptability of this type of workholding device is an advantage over the permanence of custom devices. However, modular workholding devices can meet only some of the complexity and precision of customized devices. In the long run, the adaptability of modular devices may save time and money devoted to creating customized workholding devices for certain applications.

Figure 1. Some permanent fixtures cannot be altered to suit the needs of another part and must be stored until they are needed again.

Figure 2. Modular fixtures are durable workholding devices without the permanence of customized fixtures.
Fixed Locating Components
Most fixtures have the same basic components, including a base plate, locators, and clamps. The base plate is the foundation for all other components and provides the surface to mount locators and clamps.

Locators establish an accurate relationship between the workpiece and the workholding device. Locators can be divided into integral locators, which are built into the workholding device, and assembled locators, which are separate components that are fastened to the workholding device. Assembled locators are either fixed or adjustable. Common fixed locators are designed to locate a workpiece in a fixed position:

- **V-locators** (Figure 1) contain an angled interior that positions a cylindrical surface. These locators are available as either long blocks or smaller pads.
- **Locating nests** (Figure 2) completely surround the perimeter of a workpiece to hold it securely in place. Partial locating nests (Figure 3) surround only a small portion of the workpiece.
- **Locating pins** (Figure 4) are one of the most common locating devices. External locating pins use an outside surface of the workpiece, while internal locating pins use an internal hole in the workpiece.
- **Rest buttons** are short locating pins that both support the workpiece and locate the height of the workpiece from below.

![Figure 1. V-locators contain angled interiors that effectively position cylindrical surfaces.](image1)

![Figure 2. Locating nests completely surround the perimeter of a workpiece to hold it securely in place.](image2)

![Figure 3. Partial locating nests surround only a small portion of the workpiece.](image3)
Describe adjustable locating components.

Identify basic fixtures.

Locating pins

Describe indexing workholding devices.

During

Describe power clamping.

During

Describe modular fixtures.

Spring locating pins

Describe the role of workholding devices.

Identify common clamps.

Today’s businesses face the challenge of maintaining a trained workforce. Companies must locate apprenticeship programs, cover travel and lodging.

Lesson:

Assembled locators are either fixed or adjustable. Common

workpiece in a fixed position:

The process of positioning the workpiece in a designated location. Locating is also used to describe the

of customized devices. In the long run, the adaptability of modular devices may save time and

accommodate workpieces of varying sizes.

For difficult workholding applications, manufacturers may

tested to see if it performs as it is intended.

Workholding device supports, locates, and clamps parts components in their

Critical Surface

As you can see in Figure 1, supporting is the secure foundation that “holds” a workpiece, usually from

A workholding device used to position a workpiece within a jig or fixture. Locators establish a relationship

A part that is being worked on. It may be subject to cutting, welding, forming, or other operations.

Workpiece

A part run, and reassembled in a different configuration to accommodate another part run.

Standard workholding devices for the lathe include collets and chucks. The most common standard

device’s ability to reliably support, locate, and clamp a workpiece accurately over time is called

As shown in Figure 3, clamping refers to the secure holding of the workpiece in its location

By properly supporting and locating a workpiece, you establish a relationship between the machine

The examination of a part to ensure that it meets its design specifications.

An inspection

Extra toughness is required.

Internal Locating Pin

Threaded Adjustable Locator

External Locating Pin

Class Outline

Lesson:

Clamping Components

There is an advantage to using adjustable locators when dealing with workpieces with large

that may be difficult to detect, the workholding device plays a central role in reducing variation and

workholding device supports, locates, and clamps part components in their

Fixed Locator

Figure 4. Locating pins are some of the most common locating components.

Figure 2 shows a configuration of pneumatic clamps.
Lesson: 12/18

Adjustable Locating Components
Unlike fixed locators, **adjustable locators** contain springs, threads, or other devices that account for small differences in workpiece sizes. If workpieces in a batch are irregular, fixed locators are impractical because they cannot move to accommodate the differences in size. Manufacturers use these common adjustable locators to handle variations in part size:

- **Threaded adjustable locators** (Figure 1) use a threaded screw that is turned to push the button against the part.
- **Spring locating pins** (Figure 2) contain a plastic or metal bulb that uses a spring to push a workpiece against locators on the opposite side.
- **Spring stop buttons** (Figure 3) function similarly to spring locating pins, except these devices exert more force against the workpiece.

There is an advantage to using adjustable locators when dealing with workpieces with large variations. However, the goal of locating is to accurately position a workpiece. For this reason, fixed locators are the better choice over adjustable locators for better accuracy. Typically, adjustable locators are used only when workpieces vary significantly in size and shape. Even then, workpieces are referenced according to the fixed locating component opposite the adjustable locating component, as shown in Figure 4.

![Figure 1](image1.png)

*Figure 1. Threaded adjustable locators use a threaded screw that is turned to push the button against the part.*

![Figure 2](image2.png)

*Figure 2. Spring locating pins contain a plastic or metal bulb that uses a spring to push a workpiece against locators on the opposite side.*

![Figure 3](image3.png)

*Figure 3. Spring stop buttons function similarly to spring locating pins, except these devices exert more force against the workpiece.*
Identify standard workholding devices for the mill.

Describe the role of workholding devices.

**Locators**

A device used to position and hold a workpiece. The workholding device references the tool performing the operation and locates the workpiece during the machining operation. A workpiece is often loaded on an einzel locus to hold the part against locators. On a basic vise, the moveable jaw acts as the clamp that holds the part against locators. On a basic vise, the moveable jaw acts as the clamp that holds the part against locators. On a basic vise, the moveable jaw acts as the clamp that holds the part against locators. On a basic vise, the moveable jaw acts as the clamp that holds the part against locators.

A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. A fixed locater is one that is permanently locked in place. 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Lesson: 13/18

Clamping Components
Once the part has been properly supported and located, clamps must provide the necessary forces to hold the part against locators. On a basic vise, the moveable jaw acts as the clamp that holds the part against the stationary locating jaw. Customized fixtures use an assortment of different clamp types:

- **Strap clamps** (Figure 1) consist of a rigid metal bar that reaches over the workpiece and is secured in two places. Strap clamps use either screws or cams to lock in place.
- **Toggle clamps** (Figure 2) operate with a pivot and lever system.
- **Swing clamps** (Figure 3) rotate out of the way for easy loading and unloading of workpieces.
- **Toe clamps** use an edge to clamp the side of the workpiece. They often have a serrated surface for better grip.

The above clamps may be considered manual clamps if they are secured by operators by hand. The type of clamp you use differs according to the needs of particular machining applications.

Clamps may be secured in different ways. Two common methods for securing clamps are with screws and cams. **Screw clamps** use threads to provide a locking force. Screw clamps are very secure but time consuming to open and close. **Cam clamps** consist of a lever attached to a circular area with an off-center pivot. When the clamp is closed, increasing pressure and friction from the eccentric area of the clamp lock the workpiece in place. Figure 4 compares a strap clamp secured with a screw and a cam.

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**Figure 1.** A strap clamp consists of a rigid metal bar that reaches over the workpiece and is secured in two places.

**Figure 2.** A toggle clamp in the open position (A) and the closed position (B).

**Figure 3.** A swing clamp in the open position (A) and the closed position (B).
Welcome to the Tooling University. This course is designed to be used in conjunction with the online version of this ... held. 

Workpiece A part that is being worked on. It may be subject to cutting, welding, forming, or other operations.

Locate a workpiece in a fixed position. Adjustable locators such as threaded adjustable locators, workholding device for the mill is the vise. Jigs and fixtures are customized workholding devices that all parts are identical and made to the same specifications.

Lesson:

There is an advantage to using adjustable locators when dealing with workpieces with large changes or vibration can introduce variation or errors that affect part quality. Unlike certain aspects of the process. As shown in Figure 2, a bushing is a hardened steel tube with a specific diameter used to guide a tool.

Locators can be divided into types of parts you are making, you must be sure that your part is properly located and clamped.

Locators establish an accurate relationship between the workpiece and the workholding device. Base plate is the foundation for all other components and provides the surface to mount locators and clamps.

Lesson:

A device used to position and hold a workpiece. The workholding device supports, locates, and clamps part components while machining accuracy and repeatability are dependent upon all aspects of the process. As shown in Figure 3, clamping refers to the secure holding of the workpiece in its location.

As shown in Figure 3, a workholding device supports, locates, and clamps part components while the tool and the workpiece that can be repeated for each part throughout a production run.

Objectives

Indexing Workholding Devices

Standard Workholding Devices for the Lathe

Indexing Jig

Cycle Time

Power clamping offers two advantages over traditional clamping: speed and consistent clamping. Power clamping provides uniform pressure with little or no variation in clamping time and money. Power clamping is widely used in manufacturing because it is faster and more consistent than traditional clamping methods.

There are two main types of power clamping: manual and hydraulic. Manual clamps are the most common type of power clamp and are used to hold parts in place during machining operations. They are operated by hand and are easy to use and maintain. Hydraulic clamps are more powerful than manual clamps and are used for holding heavy parts. They are operated by a hydraulic system and are more expensive than manual clamps.

Figure 4. Strap clamps may be secured by screws (above) and cams (below).
Lesson: 14/18

Cycle Times and Changeovers

The performance of a workholding device depends on how well it supports, locates, and clamps a workpiece before and during machining. Workholding devices that limit the amount of variation in the creation of parts are a valuable component of the manufacturing process. The consistent performance of workholding devices contributes to the production of consistent parts, which eliminates waste.

Besides supporting, locating, and clamping, manufacturers also expect other characteristics from workholding devices. Since inactive machines are not making parts, manufacturers strive to keep machines active and running. The best way to keep machines active is by reducing the time between parts and the time between setups.

Efficient workholding devices enable reduced cycle times, which means operators can quickly move between one part and the next. Some workholding devices are better than others regarding loading and unloading parts. Quick-release workholding devices are generally more efficient than those that require manual screwing and unscrewing.

Likewise, workholding devices are judged by their performance during changeovers from one setup to the next. Workholding devices that enable swift changeovers between lots without sacrificing consistency greatly contribute to speedy production of finished parts. For simple parts and short production runs, the basic vise, shown in Figure 1, is a suitable option. The moveable jaw quickly adjusts to accommodate various parts in a similar size range. If an entirely new workholding device is needed, the vise is relatively easy to remove and reclamp to the worktable.

Figure 1. The jaws of a vise can adjust for a new part, or the entire vise can be removed if a new workholding device is needed.
Lesson: 15/18

Indexing Workholding Devices
Many parts require machining in regular patterns prior to completion. These patterns consist of pockets, slots, or holes at prescribed increments. To enable the cutting of regular patterns into a metal workpiece, manufacturers may use **indexing workholding devices**.

The two most common indexing workholding devices are the **indexing jig** and the **indexing fixture**. Indexing jigs allow manufacturers to drill holes in a pattern, usually circular. Indexing fixtures usually divide a workpiece into a number of equal zones. This allows the cutting tool to cut the desired pattern into the workpiece. The chuck in Figure 1 is indexable, which allows a drill to create holes at regular increments around the circumference of a cylindrical workpiece.

Indexable workholding devices are also a productivity solution. Indexable tombstones and columns give machine operators more available space to mount workpieces. Tombstones double the available area, while columns, like the device in Figure 2, increase the workholding area by four, six, or eight times, depending on the number of sides. The increased workholding area allows you to make more parts in each cycle.

*Figure 1. This indexing chuck allows a drill to create holes at regular increments around the circumference of a cylindrical workpiece.*

*Figure 2. A four-sided column increases the available work area.*
Lesson: 16/18

Power Clamping
In general, traditional clamping methods are satisfactory for most jobs. When fast changeovers and ultra-consistent clamping forces are needed, manufacturers can turn to power clamping. There are two methods of power clamping: hydraulic clamping and pneumatic clamping. Hydraulic clamping uses the force of fluid pressure to immobilize a workpiece. Pneumatic clamping uses the force of air pressure to immobilize a workpiece. Figure 1 shows the source of hydraulic pressure for a hydraulic clamping device. Figure 2 shows a configuration of pneumatic clamps.

Power clamping offers two advantages over traditional clamping: speed and consistent clamping force. During changeovers, time can be wasted when unclamping workpieces from workholding devices. Power clamps exert pressure and release at the touch of a button. Also during changeovers, variation in clamping forces can lead to errors and scrap, which is an expense in both time and money. Power clamping provides uniform pressure with little or no variation in clamping force.

**Figure 1.** Hydraulic clamping uses the force of fluid pressure to immobilize a workpiece.

**Figure 2.** This fixture has multiple pneumatic clamps that use the force of air pressure to immobilize workpieces.
Lesson: 17/18

Workholding Devices by Application

Workholding devices are used at every stage of manufacturing. Workholders support, locate, and clamp workpieces during machining, such as turning or milling. They also hold workpieces during layout, assembly, inspection, finishing, and testing processes.

Workpieces must be supported, located, and clamped in some fashion at each stage:

- During **layout**, a workholding device supports, locates, and clamps part components in their proper places prior to assembly.
- During **assembly**, a workholding device supports, locates, and clamps part components while they are being welded, soldered, or mechanically joined.
- During **inspection**, a workholding device supports, locates, and clamps a part while it is being checked for accuracy. Figure 1 shows a fixture used for inspection.
- During **finishing**, a workholding device supports, locates, and clamps a part while it is being honed, polished, plated, or painted.
- During **testing**, a workholding device supports, locates, and clamps a part while it is being tested to see if it performs as it is intended.

As you can see, workholding devices are an integral component of the part creation process.

Figure 1. Fixtures support, locate, and clamp workpieces during inspection.
Lesson: 18/18

Summary
Workholding is the process of securely supporting, locating, and clamping a workpiece for a manufacturing operation. During manufacturing, a workholding device holds a workpiece in an exact location. Each workpiece loaded on the machine must be positioned in the same location to ensure that all parts are identical and made to the same specifications.

An effective workholding device establishes and maintains a direct relationship between the cutting tool and the workpiece by properly supporting, locating, and clamping the workpiece. A workholding device’s ability to reliably support, locate, and clamp a workpiece accurately over time is called repeatability.

Standard workholding devices for the lathe include collets and chucks. The most common standard workholding device for the mill is the vise. Jigs and fixtures are customized workholding devices built for a specific part design. Basic fixtures include plate fixtures, angle-plate fixtures, tombstones, and columns. Modular workholding devices are non-permanent fixtures that may be altered to suit particular setup needs.

Fixed locators such as V-locators, locating nests, locating pins, and rest buttons are designed to locate a workpiece in a fixed position. Adjustable locators such as threaded adjustable locators, spring locating pins, and spring stop buttons, are designed to accommodate workpieces with dimensional variations. While many clamps, such as screw clamps, strap clamps, and toggle clamps, are manually tightened, power clamps are widely used today.

Figure 1. Chucks are standard workholding devices used to hold cylindrical parts on a lathe.

Figure 2. Standard workholding devices may not adequately support, locate, and clamp parts with uncommon or complicated dimensions or features.

Figure 3. Customized fixtures are ideal for parts with uncommon critical surfaces and locating points.
Describe how workholding devices influence cycle times and changeovers. During setup to the next. Workholding devices that enable swift changeovers between parts to be manufactured.

Standard workholding devices may hold a workpiece in place. This column holds four tools remove material. Turning is a common operation performed on the lathe.

Cam clamps may be dislodged by excessive vibration. Changeover The process of switching a machine from one part setup to another. Changeover

Chucks are standard workholding devices. The jaws of a vise can adjust for a tolerance of .500 in. (5.080 cm) from the bottom edge and 1.000 in. (2.540 cm) from the right edge of a workpiece. Countersinking Using a pointed tool to penetrate the surface of a workpiece and make a round hole.


class vocabulary

Adjustable Locator A locating component that is moveable and is used for workpieces of varying size. Adjustable locators are frequently used for cast parts.

Angle-Plate Fixture A fixture that positions the locating surface of the workpiece at an angle to the machining table.

Assembled Locator A locating component that is fastened to the workholding device.

Assembly The process by which two or more objects are joined together.

Base Plate The foundation or frame of a fixture that provides a mounting surface for locators and clamps. The base plate is also called a tool body or subplate.

Blueprint A document containing all the instructions necessary to manufacture a part. The key sections of a blueprint are the drawing, dimensions, and notes.

Boring The process of using a single-point tool to enlarge a preexisting hole. Boring can also be performed to customize chuck jaws on a lathe for a particular part.

Boring Machine A turning machine used to enlarge preexisting holes with single-point and multi-point cutting tools.

Bushing A hardened steel tube used to guide cutting tools such as drills and reamers.

Cam A clamping device consisting of a lever and a circular base with an eccentric pivot. As the cam is closed for locking, increasing pressure from the eccentric base holds a workpiece in place.

Cam Clamp A clamp that uses a gradually curved surface to lock itself in place. Cam clamps may be dislodged by excessive vibration.

Changeover The process of switching a machine from one part setup to another.

Chuck A workholding device with three or four jaws that clamp and hold a cylindrical workpiece. The chuck is commonly used to hold a workpiece as it rotates on a lathe.

Clamp A workholding device that maintains the position of a workpiece by holding it in place against locators.

Clamping The secure holding of a workpiece against locators. Clamping must be strong enough to resist the forces that occur during machining.

CNC Machining Center A sophisticated machine tool controlled by a computer that can perform multiple machining operations in the same setup with a variety of tools.

Collet A slitted device that holds a workpiece in place as it rotates. A collet has a hole through which the workpiece passes, and it is designed to hold specific dimensions.

Column A large four-, six-, or eight-sided device that accommodates the mounting of fixtures, usually on a horizontal milling machine.

Counterboring An operation that enlarges the end of a predrilled hole to allow room for a head of a screw or nut.

Critical Surface An important surface of the workpiece that determines the appropriate workholder design.

Cycle Time The time it takes to make one part, or the time it takes to execute a series of operations on a single machine tool.

Drill Plate The top plate of a jig that contains the bushings.

Drilling The process of using a multi-point tool to penetrate the surface of a workpiece and make a round hole.

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External Locating Pin | A locating device that uses an outside surface to locate a workpiece.
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Finishing | The final operations performed for obtaining desired tolerance and/or surface finish.
Fixed Locator | A locating component that is designed to locate a workpiece in a fixed position.
Fixture | A customized workholding device used on machine tools to position and hold a part during various machining operations. A fixture is built to hold a specific part design.
Hydraulic Clamping | A clamping system that uses high-pressure liquids to power clamps and hold a workpiece in place.
Indexing Fixture | A workholding device that pivots to expose additional machining areas.
Indexing Jig | A jig designed to position a workpiece at specific locations around a rotational axis. Indexing jigs can be used for drilling holes around a workpiece.
Indexing Workholding Device | A workholding device that either enables metal cutting in regular increments or pivots to expose other available machining space.
Inspection | The examination of a part to ensure that it meets its design specifications.
Integral Locator | A locating component that is built into the workholding device.
Internal Locating Pin | A locating device that uses an internal surface to locate a workpiece.
Jig | A customized workholding device used to position and hold a workpiece while guiding the location of the cutting tool. Jigs are not as common as fixtures and are not used with CNC machines.
Lathe | A machine tool that holds a cylindrical workpiece at one or both ends and rotates it while various cutting tools remove material. Turning is a common operation performed on the lathe.
Layout | A manufacturing process by which the component parts of a product are arranged prior to assembly.
Locating | The process of positioning the workpiece in a designated location. Locating is also used to describe the precise positioning of the workpiece in the horizontal plane.
Locating Nest | A fixed locator that completely surrounds the dimensions of a workpiece. The workpiece rests within the locating nest.
Locating Pin | An assembled locating device that can be used to locate either an outside workpiece surface or an interior hole. Locating pins are available in numerous shapes and sizes.
Locating Point | A point on the workholding device that is meant to contact the workpiece while it is being positioned.
Location Dimension | A dimension that establishes the position of shapes relative to each other. For example, a hole center that is 3 inches from the edge specifies a location dimension.
Locator | A workholding device used to position a workpiece within a jig or fixture. Locators establish a relationship between the workpiece and the workholding device.
Lot | The number of parts made in one setup.
Machine Tool | A power-driven machine that uses a cutting tool to create chips and remove metal from a workpiece.
Manual Clamp | A clamp that is secured by hand by the operator. Cam, screw, and toggle clamps may all be manually operated.
Milling Machine | A machine that uses a multi-point tool to remove metal from the surface of a workpiece. Milling machines are commonly used to machine slots, grooves, and flat surfaces in rectangular workpieces.
Modular Fixture | A workholding device that uses standard reusable components to construct a customized workholding device.
Plate Fixture | The most basic type of fixture that contains mounted clamps and locators on a plate for holding the workpiece parallel to the machine table.
Pneumatic Clamping | A clamping system that uses high-pressure air to power clamps and hold a workpiece in place.
Power Clamping | A clamping system that converts hydraulic or pneumatic power into mechanical clamping forces.
Reaming
The use of a cutting tool to smooth or enlarge a previously drilled hole.

Repeatability
The ability of a workholding device to position workpieces in the same place, part after part.

Rest Button
A short locating pin that is used to both support and locate a workpiece.

Screw Clamp
A type of clamp that locks securely in place by the turning of threaded devices. A screw clamp is often slow but secure.

Spindle
The part of the machine tool that spins or rotates. On the mill, the spindle holds a cutting tool. On the lathe, the spindle holds the workpiece.

Spring Locating Pin
An adjustable locator with a metal or plastic bulb that is used to push a workpiece up against fixed locators on the opposite side.

Spring Stop Button
An adjustable locator with a metal button or tang that pushes a workpiece up against fixed locators on the opposite side. Spring stop buttons exert more force than spring locating pins.

Strap Clamp
A type of clamp that reaches over the workpiece to hold it in place. Strap clamps are often used when extra toughness is required.

Supporting
The secure location of a workpiece that typically contacts the bottom surface of a workpiece. Supporting is one of the three roles of a workholding device.

Swing Clamp
A clamp containing a swinging arm that moves to facilitate the quick loading and unloading of workpieces.

Tapping
The process of cutting internal threads in a hole with a rotating multi-point tool.

Testing
The examination of a part to ensure that it performs its intended function.

Threaded Adjustable Locator
A locating device consisting of a threaded screw that adjusts to the varying dimensions of workpieces.

Toe Clamp
A type of clamp with a serrated surface that reaches forward and down to grip the workpiece.

Toggle Clamp
A type of clamp that operates on a pivot and lever system. Toggle clamps lock just past the center of the pivot points.

Tolerance
The unwanted but acceptable deviation from the desired dimension.

Tombstone
A large two-sided rectangular device that accommodates the mounting of fixtures.

Vise
A workholding device with one fixed jaw and one moveable jaw. Vises are often used to hold simple rectangular or cubic workpieces on a mill or machining center.

V-Locator
A fixed locator that uses an angled interior to position and center the cylindrical surface of a workpiece.

Ways
Two precisely measured, parallel tracks that support and guide the movement of the carriage and cross slide of the lathe.

Workholding
The process of securely supporting, locating, and clamping a workpiece for a manufacturing operation.

Workholding Device
A device used to position and hold a workpiece. The workholding device references the tool performing the operation on the part being held.

Workpiece
A part that is being worked on. It may be subject to cutting, welding, forming, or other operations.