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Clamped Tight

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Choosing the best clamping method.

At each stage in a metalcutting operation, workpieces must be held in place. Why? Just imagine trying to cut the hair of a small child who won't sit still.

Workholders securely position and hold parts, and are crucial to an accurate and high-quality operation because they ensure repeatability.

This is where jigs and fixtures step into the spotlight. When a part is secured in the workholder, it can be referenced to the cutting tool or machine. Clamping is one part of a complete workholding process, which also includes supporting, locating and holding the workpiece.

Generally, cutting operations, such as drilling, generate primary and secondary forces. Cutting forces travel through the workpiece in two directions: downward and radially. The support counteracts the downward force and components of the workholder, such as stops, address the radial forces.

The choice of the clamping mechanism can affect the speed and security of the operation.

Clamps resist secondary tool forces, which are generated when the drill breaks through the opposite side of the workpiece. When drilling, the tool tends to lift the workpiece as it breaks through the backside of the hole. Clamps prevent this movement.

The Basics

A good clamping device should:

- securely hold the workpiece against the locators or stops;
- resist vibrations, forces and stresses;
- prevent workpiece damage; and
- permit quick operation during the loading and unloading cycles.

The machining operation and the type and condition of the workpiece should be examined to determine which clamping factors are the most important. Ease of part changeover is secondary, yet adds to the overall efficiency of the fixture. Other important factors in workholding are clamping supports and protection of the workpiece surface.

Problems can arise if workpieces are not properly supported during clamping. The workpiece should be clamped directly over a support whenever possible. The result of clamping between supports would be like placing many heavy books in the middle of long, thin bookshelf. If the bookshelf is supported only at the ends, the middle will eventually sag and become distorted.

Hardened or rotating contact surfaces can often cause surface damage to workpieces. So, when clamping a finished surface, use soft contact points, such as those made of brass or aluminum, to eliminate any surface damage. For screw clamps with a rotating contact, the rotation of the screw against the workpiece may damage the surface, so replace the standard screw with a rotating contact pad. All these factors need to be considered when designing a workholding device.

Manual vs. Power

Both manual- and power-actuated clamping devices are available. Some power clamps are hybrids, meaning that they incorporate both manual and

Figure 1: A screw-strap clamp.

Figure 2: A toggle clamp in the locked position.

Figure 3: A manual hook/swing clamp.

All images: Jergens

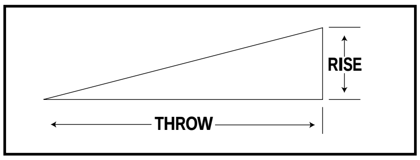


Figure 4: Many conventional clamps operate on the mechanical principle of the inclined plane.

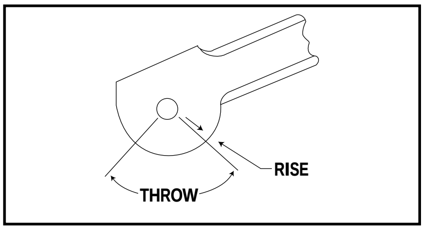


Figure 5: The throw is the amount of radial movement required to generate a complete rise.

power features. This style of clamp holds the workpiece even when power isn't applied. Power has to be reapplied to release the workpiece from the clamp.

The choice of the clamping mechanism can affect the speed and security of the operation. Power-clamping systems utilize hydraulic or pneumatic power to apply the clamping force that secures the part. These systems provide more consistent clamping force than manual clamps. And they are particularly helpful in operations that traditionally cause operator fatigue.

Many clamps used in manual operations can be adapted for use in a power system. The power source merely acts as the moving and/or clamping agent. Swing and retracting-edge clamps are commonly used in hydraulic systems.

Of course, pneumatic systems cost more, typically two to three times more. They do provide distinct benefits, though, such as:

- consistent clamping force;
- no operator fatigue;
- adjustable holding forces;
- remote operation of clamps; and
- automated sequencing of consistent operations.

Some clamps' names reflect how their clamping force is applied. Examples include the cam clamp, screw clamp (Figure 1) and toggle clamp (Figure 2).

Sometimes the name of the clamp indicates its shape or appearance, such as strap clamp, swing clamp (Figure 3), C-clamp and toe clamp.

The geometry of the workpiece frequently determines the choice of clamp shape. However, there is no general rule of thumb for choosing which style of clamp works best in a given operation.

How Clamps Operate

Many conventional clamps operate on the mechanical principle of the inclined plane (Figure 4). In cam-action clamps, the height of the inclined plane resembles the rise of the cam. The length of the wedge represents the throw of the cam. In Figure 5, the rise of a cam used for clamping is the amount of clamping movement of the cam. The throw is the amount of radial movement required to generate a complete rise.

There is always a compromise between the rise and throw of the cam. The ideal design seeks a maximum rise with minimal throw. Commercially available clamps ensure this by incorporating an involute curve on the cam face. The involute curve is different from the curved edge of a cylinder.

The cam relies on friction and can become unreliable if there is too much vibration, which can dislodge the cam clamp from its locked position.

Cam clamps are generally used in low-vibration applications, such as inspection, assembly, and light drilling and milling. It's not recommended to use cam clamps to resist heavy vibrations and/or cutting forces.

Screw clamps are among the slower clamps used for jigs and fixtures. The screw is the part that provides the clamping force and secures the clamp. Although screw clamps lack speed, they are some of the most secure clamps available for workholding.

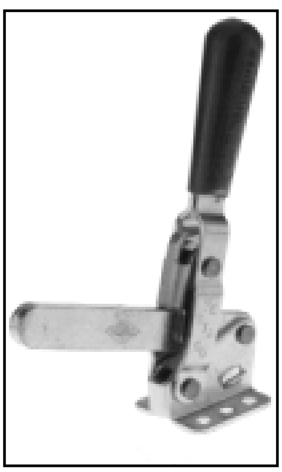
The inclined-plane principle applies to the screw thread. Screw clamps are used in operations where security is critical or the vibration is more than other clamps can endure. Coarse threads tend to offer faster movement, while fine threads offer enhanced locking properties.

Toggle clamps function on a pivot-and-lever system. Their pivot points approach a straight line as the clamp comes to a locked position. The three pivot points lock the clamp in a positive locking position when they are just past the centerline.

Toggle clamps lock and unlock with a single push or pull. Their quick and secure clamping action makes them a stable and economical choice for many light-duty applications (Figure 6). Toggle clamps reduce operator fatigue compared to other manual clamping operations.

Swing and strap clamps each have an extending arm that reaches above the workpiece like a street lamp. The arm of the swing clamp rotates above the plane of the workpiece approximately 90° to allow loading and unloading the workpiece. If you put your hand on top of a book to prevent it from moving, your hand is acting like a swing arm. By pivoting your arm at your elbow, your arm is mimicking the swing-clamp arm. Swing clamps are frequently used in conjunction with hydraulics (Figure 7).

A strap clamp typically incorporates a slot slightly larger than the bolt or stud that passes through it. Strap clamps come in several varieties, including finger, straight and "U". The strap moves around the stud when not secured by a bolt



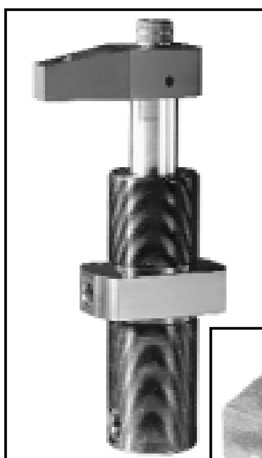


Figure 6, above left: A partially open, vertical toggle clamp.Figure 7, above right: A hydraulic swing clamp. Figure 8, right: A toe clamp.

or cam. Using the arm analogy again, if you put your arm on top of a book to prevent it from moving, your hand is like the strap clamp. If you pick up your entire arm and slide it back, it is mimicking the action of the strap clamp.

Toe clamps (also known as edge clamps) apply clamping forces to the sides or edges of the workpiece. Some have a serrated edge for a better gripping action (Figure 8). The action of the clamp applies force both forward and downward. To illustrate this action, apply the side of your index finger to a book while pushing gently down and into the book at an angle.

The C-clamp is a simple device that incorporates a screw clamp and a C-frame. C-clamps are only appropriate for light-duty applications. The C-shape surrounds the workpiece and whatever surface it is being clamped to. If you pick up a pad of paper between two fingers, your fingers will form a sort of C-clamp.

Workpieces of equal size that are made from different materials require different clamping forces. For example, the force applied to a steel workpiece should not be applied to an aluminum casting with similar dimensions.

The basic requirements of any clamping system are determined by the workpiece. So, choose a clamp that's of adequate size to hold the workpiece against the locators. And, lastly, machining forces should be directed into the locators—not the clamps. This allows for the use of smaller clamps.

About the Author

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