CLAMPING METHODS

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Clamping and clamps:
Once a work piece is located it is necessary to press it against the locating surfaces and hold it there against the forces acting upon it. The tool designer refers to this action as clamping and the mechanisms used for this action are known clamps.
Clamping Principles

1. For a specific operation, the selection of general clamping—simple hand-operated clamps, quick-acting hand-operated clamps, power-operated clamps, etc.—should primarily be a function of operation analysis.

2. The cost of the clamp must be balanced against the cost of the operation to obtain the lowest possible total cost for both fixture and operation.

3. The purpose of a clamp is to exert force and press a workpiece against the locating surfaces and hold it there in opposition to the actions of cutting or other processing forces.

4. Clamping forces should be directed within the locating area, preferably through heavy sections of the workpiece directly upon locating spots or supports.

5. Cutting forces should be taken by the fixed locators in a jig or fixture as much as possible, but generally some components of, or moments set up by, the cutting forces must be counteracted by clamping forces.

6. To be effective, a clamp should be designed to exert a minimum force equal to the largest force imposed upon it in the operation.

7. It is essential that the tool designer exercise sound judgment when applying these clamping principles to the job at hand.

8. In general, clamping arrangements should be as simple as possible.
Design and operational factors to be considered

1. **Simple clamps are preferred** because complicated ones lose effectiveness as they wear. Complicated arrangements tend to lose their effectiveness as the parts become worn, necessitating excessive maintenance, which might readily offset the savings of a faster operation.

2. Some clamps are more suitable for large and heavy work, others for small pieces.

3. Rough workpieces call for longer travel of the clamp in the clamping range, but clamps may be made to dig into rough surfaces to hold them firmly.

4. The type of clamp required is determined by the kind of operation to which it is applied. A clamp suitable for holding a drill jig leaf may not be strong enough for a milling fixture.

5. Clamps should not make loading and unloading the work difficult, nor should they interfere with the use of hoists and lifting devices for heavy work.
**Answering the following questions will provide the basis for good clamp design**

<table>
<thead>
<tr>
<th>Question</th>
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<tbody>
<tr>
<td>1. Will the clamp securely hold the part in the tool?</td>
<td>11. Is the clamping solid?</td>
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<td>2. Has an equalizing device been used for multiple clamping tools?</td>
<td>12. Are clamps located over supports?</td>
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<td>3. Does the clamp hold the part against the locators?</td>
<td>13. Can the clamp be operated with one hand?</td>
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<td>4. Does the clamp operate quickly?</td>
<td>14. Does the operator have to reach over or into the tool to activate the clamp?</td>
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<td>5. Are a minimum number of clamps used?</td>
<td>15. Is the tool thrust directed away from the clamps?</td>
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<td>6. Will the clamp location interfere with cutters, loading, or unloading?</td>
<td>16. Will the clamp contact damage the workpiece surface?</td>
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<td>7. Can clamp parts be easily replaced when worn?</td>
<td>17. Are clamps self-contained or must wrenches be used?</td>
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<td>8. Are the clamps easy to operate?</td>
<td>18. Is the clamp positioned away from the tool path?</td>
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<td>9. Does the clamp distort or bend the part?</td>
<td>19. Can the clamps be operated within easy reach of the operator?</td>
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<tr>
<td>10. Can the clamp compensate for in-tolerance variations in part size?</td>
<td>20. Could vibration cause the clamp to loosen during use?</td>
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Types of clamps

According to mechanism, there are 7 basic groups of clamps:
1. Strap
2. Cam
3. Screw
4. Latch
5. Wedge or Key
6. Toggle
7. Rack and pinion clamp

Hydraulic and pneumatic clamps
1. **Strap clamp:**
The simplest and probably most commonly used clamp is the strap clamp. All strap clamps employ the principles of levers.

**Characteristics:**
1. Lever mechanism is used.
2. Most commonly used type.
3. Positive clamping.
4. Slow loading and unloading.

Video link: [https://www.youtube.com/watch?v=cS_KkHOe8dc](https://www.youtube.com/watch?v=cS_KkHOe8dc)
Cont.. **Strap clamp**

Different classes of strap clamps (three classes of levers)

Variations of strap clamp

First-class lever action

Second-class lever action

Third-class lever action
Cont.. Strap clamp: Design of strap clamp

Width of central slot in the strap \( r = 1.6\text{mm} + d \)

Width of strap \( w = 116 + 2.3d \)

Thickness of strap \( h = 0.92 \frac{\sqrt{abd}}{l} \)

In case when the strap is in the middle of the span \( h = 0.46\sqrt{dl} \)

<table>
<thead>
<tr>
<th>Clamping Force Required (N)</th>
<th>Stud size</th>
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<tbody>
<tr>
<td>2224</td>
<td>M6</td>
</tr>
<tr>
<td>4003</td>
<td>M8</td>
</tr>
<tr>
<td>6672</td>
<td>M10</td>
</tr>
<tr>
<td>9786</td>
<td>M12</td>
</tr>
<tr>
<td>17793</td>
<td>M16</td>
</tr>
<tr>
<td>28024</td>
<td>M20</td>
</tr>
<tr>
<td>40034</td>
<td>M24</td>
</tr>
</tbody>
</table>
Cont.. Strap clamp: Other types

Two types of Dog point Clamps or Toe clamps

- Used when clamping is done against the edge of workpiece

Pinch Clamp

- Used when low clamping pressure and quick changeover is required

Quick acting swinging type clamp
2. Cam Clamps

1. Cam-action clamps frequently are used for fast operating clamping devices.

2. The three principle types of cam-action clamps used for work-holders: flat eccentric, flat spiral, and cylindrical.

3. Flat eccentric cams operate on a high center principle and must be positioned exactly at the high center to hold properly.

4. Flat spiral cams, on the other hand, have a locking range, which permits them to hold at any point within the range along the cam surface.

5. Of these two styles, the flat spiral cam is the easiest and safest to use.

6. Both flat eccentric and flat spiral cams can be used for direct- or indirect-pressure applications.

7. Indirect pressure is the most efficient and safest design for jig and fixture work.

8. Direct-pressure cam clamps have a tendency to loosen during machining.

9. Cylindrical cams also are used for workholding applications. With these clamps, the cam surface is generated on a cylindrical surface.
Cont.. Cam Clamps

Eccentric cam is easier to make.

Spiral cam locks the w/p better than the eccentric cam.
Cam and screw clamp assembly
(used when space is limited like under an overhanging part)

Spiral Cam edge clamp
(very compact)

Shaft eccentric clamp assembly
(used when space is limited like under an overhanging part)
3. Screw clamps:

A threaded screw is used to apply the clamping force.

Indirect screw clamp

Direct screw clamps
Cont... **Screw clamps**

**Characteristics:**
1. No tendency of loosening under vibration.
2. Slow loading and unloading.
3. Not suitable for mass production.

**Advantage:**
a. Adequate force can be exerted.
b. Resisting loosening tendencies set up by vibration.

**Limitation:**
1. Relatively slow.
2. Not suitable for mass production.
4. Latch clamps:

**Characteristics:**
1. Quick acting.
2. Suitable for light work.
3. Main advantage is in the ease and speed of manipulation.

**Advantage:**
- a. Quick acting.
- b. Easy to use and manipulate.

**Limitation:**
- a. Suitable for light work only.
- b. Difficult to secure rigidity.

Figure: Simple latch clamp
5. Wedge clamp:

- Wedge-action clamps use the basic principle of the inclined plane to securely hold and clamp workpiece.
- Wedge clamps are flat and conical.
- Flat-wedge clamp works as a flat cam to provide holding force. The clamp is tightened and released by swinging the lever around the fulcrum pivot and contacting the inclined wedge against the spherical head pin.
- Conical wedges, or mandrels, normally are used in two styles, the solid mandrel and expansion mandrel.
- The wedging action of the conical surface directly or indirectly holds the workpiece.
Characteristics of wedge clamps:
1. Tendency to loosen under vibration.
2. Quick acting.
3. The taper angle of a plain angle may range from 6 to 18 degree.

**Advantage**: Quick acting.

**Limitation**: Tendency of loosening under vibration.
6. Toggle clamps:

1. Toggle-action clamps work with four general clamping motions: hold-down, push-pull, squeeze, and straight-pull.

2. The main advantages of using toggle clamps are their fast clamping and release actions, ability to move completely clear of the workpiece, and high ratio of holding force to actuation force. Several variations of toggle clamps are available to suit almost every workholding application.

3. For all their advantages, standard toggle clamps have always caused problems because of their limited range of movement and inability to compensate for different thicknesses.

4. Once set to a clamping height, the standard toggle clamp can only accommodate very slight changes in workpiece thicknesses.

Video link for toggle clamp
https://www.youtube.com/watch?v=oZkBZaJ6Wt8
7. Rack and pinion clamps:
- Rack and pinion method clamps are used extensively on universal jigs.
- Since a rack and pinion is not irreversible (i.e., pressure on the rack will rotate the pinion), a lock must be incorporated to lock or hold the shaft while it is being clamped.

Characteristics:
1. Rack and pinion mechanism used.
2. Used extremely in universal jigs.
3. A locking device should be used to avoid the rotation of pinion due to the movement of the rack.
Hydraulic and pneumatic clamping

• Many of the previously mentioned clamps may be actuated by hydraulic or pneumatic methods when large production quantities justify them.

• Pneumatically operated clamps differ from hydraulically operated ones in the size of the cylinder, which is smaller with hydraulics because of the higher pressures.

Advantages of **Hydraulic and pneumatic clamping:**
1. Faster clamping.
2. Uniform and equalized clamping pressure.
3. Less operator fatigue.
4. Used for mass production.

Video link
https://www.youtube.com/watch?v=lcrK2Po8fJI