1. Analysis of Clamping Force
2. Toggle Clamp
3. Cam operated Clamp
4. Screw Clamp, Strap Clamp
5. Limits and Fits
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ANALYSIS OF CLAMPING FORCES
WHAT IS A CLAMP?
- A clamp is a fastening device to hold or secure objects tightly together to prevent movements or separation through the application of inward pressure.

WHAT DOES IT DO?
- Clamping prevents the part from shifting or being pulled from the jig or fixture during the machining operation.
SO WHAT IS CLAMPING FORCE?

- Clamping force is the force required to hold a part against the locators.

- The type and amount of clamping force needed to hold a part is usually determined by tool forces working on the part and the way the part is positioned in the tool.

- Clamping pressure, as a general rule, should only be enough to hold the part against the locators. The locators should resist the bulk of the thrust.

- If a part must be clamped with a great deal of pressure, the tool should be redesigned so that tool thrust is directed at the locators and the tool body.
In strap clamps if the fastener is placed in the centre of the strap then half of the clamping forces are shared equally.

When clamping single part, a better placement is with one-third of strap length between the fastener and workpiece and two-thirds between the fastener and heel support. In this case two-third of the clamping force is applied to the workpiece.
CLAMPING FORCE ANALYSIS OF TOGGLE CLAMP
The range of holding force that may be achieved with these clamps are from 111.209 to 5338.078N. These toggles may be adapted to any types of fixtures.

The pin diameter in figure is,

\[ d = 2\sqrt{\frac{\mu f_o}{S}} \]

\[ f_1 = 4\mu df_o \left[ \frac{A+B}{LB} \right] \]

Where, \( f_o \) = output force, N
\( S \) = allowable shear stress N/m\(^2\)
\( \mu \) = coefficient of friction
\( d \) = diameter of pin, m

The coefficient of friction for steel pins may be taken as \( \mu = 0.22 \) for most toggles. The fixed pin is ‘a’ and the movable pin is ‘b’.
CLAMPING FORCE ANALYSIS OF CAM OPERATED CLAMP

It is the amount of movement perpendicular in the cam face which takes place when Cam is moved through the arc of engagement or throw.

**Throw:** It is the cam rotation through a specified arc.

**Eccentricity:** It is the distance between centre line of pivot point and the centre of radius of radius required to actuate the cam.

\[ e = \frac{x}{1 - \cos \theta} \]

\( e = \text{Eccentricity} \)
\( x = \text{Rise} \)

\[ R = e \left[ \cos \theta + \frac{\sin \theta}{\mu} \right] \]

\( \mu \) maybe generally taken as 0.10

Rise in a spiral cam depends on length of throw and radius of base circle.

\( x = \text{Rise mm} = 0.001 \times R_1 \times \text{angle of throw} \)
The spiral cam is generated from the base circle. The outer and inner circles represent the limits of cam rise. Usually there should be 0.025mm rise per 25mm of radius per degree of throw. Cam throw usually 60-90 degrees. An additional 5 to 10 degrees should be added to each end of throw angle as shown in figure.

Total throw angle = 90 + 2x5
                   = 100°

In spiral cam first base circle is drawn and the inner and outer circle are drawn. The limits of throw are then marked.

\[ x = \text{Rise} \]
CLAMP FORCE ANALYSIS OF SCREW CLAMP

Let,  \( F_s \) – Force development by screw
\( F_h \) – pull or push applied to spanner
\( R \) – pitch radius of screw thread
\( \alpha \) – Helix angle of thread
\( \phi \) – friction angle of thread
\( L \) – length of spanner or lever

Force developed by screw clamp

\[
F_s = \frac{F_h L}{R \tan(\alpha + \phi)}
\]