MECHANICAL ASSEMBLY

- Threaded Fasteners
- Rivets and Eyelets
- Assembly Methods Based on Interference Fits
- Other Mechanical Fastening Methods
- Molding Inserts and Integral Fasteners
- Design for Assembly

Mechanical Assembly Defined

Use of various fastening methods to mechanically attach two or more parts together

- In most cases, discrete hardware components, called *fasteners*, are added to the parts during assembly
- In other cases, fastening involves shaping or reshaping of a component, and no separate fasteners are required

Products of Mechanical Assembly

- Many consumer products are assembled largely by mechanical fastening methods
  - Examples: automobiles, large and small appliances, telephones
- Many capital goods products are assembled using mechanical fastening methods
  - Examples: commercial airplanes, trucks, railway locomotives and cars, machine tools

Two Major Classes of Mechanical Assembly

1. Methods that allow for disassembly
   - Example: threaded fasteners
2. Methods that create a permanent joint
   - Example: rivets

Reasons Why Mechanical Assembly is Often Preferred Over Other Methods

- *Ease of assembly* – can be accomplished with relative ease by unskilled workers using a minimum of special tooling and in a relatively short time
- *Ease of disassembly* – at least for the methods that permit disassembly
  - Some disassembly is required for most products so maintenance and repair can be performed

Threaded Fasteners

Discrete hardware components that have external or internal threads for assembly of parts

- Most important category of mechanical assembly
- In nearly all cases, threaded fasteners permit disassembly
- Common threaded fastener types are screws, bolts, and nuts

Screws, Bolts, and Nuts

Screw - externally threaded fastener generally assembled into a blind threaded hole

Bolt - externally threaded fastener inserted through holes and "screwed" into a nut on the opposite side

Nut - internally threaded fastener having standard threads that match those on bolts of the same diameter, pitch, and thread form

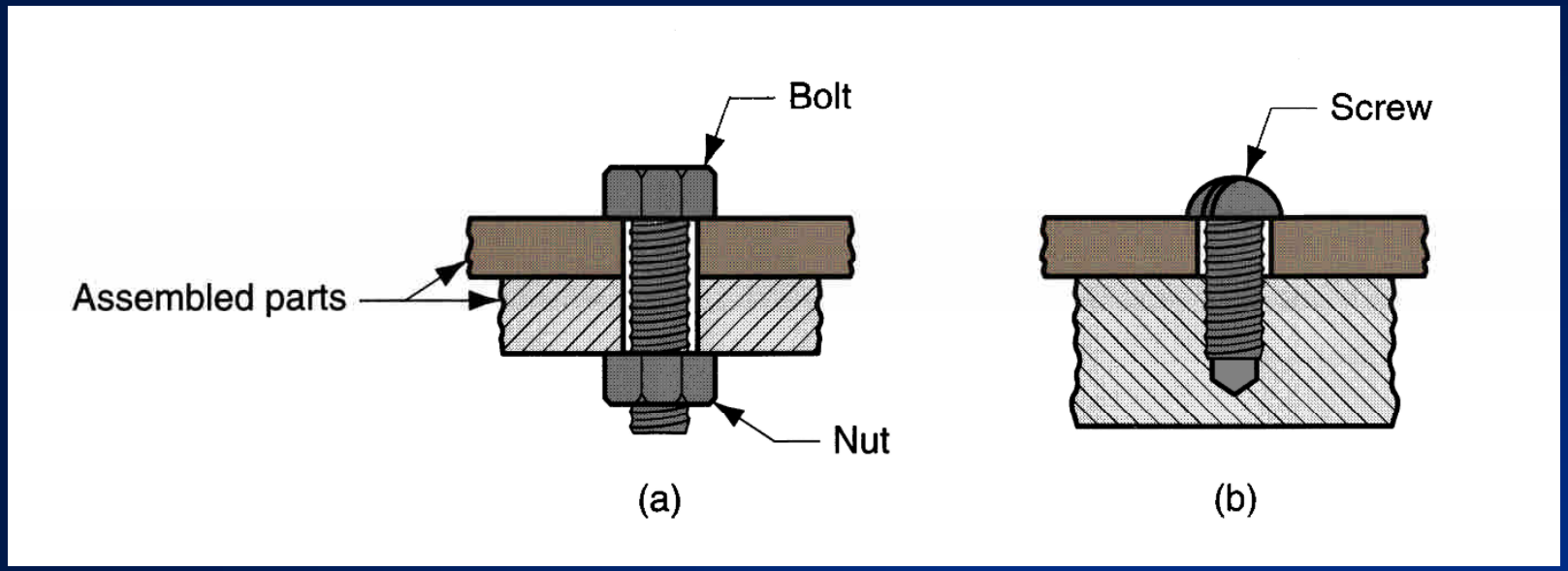

Figure 33.1 - Typical assemblies when screws and bolts are used

Some Facts About Screws and Bolts

- Screws and bolts come in a variety of sizes, threads, and shapes
- There is much standardization in threaded fasteners, which promotes interchangeability
- U.S. is converting to metric, further reducing variations
- Differences between threaded fasteners affect tooling
  - Example: different screw head styles and sizes require different screwdriver designs

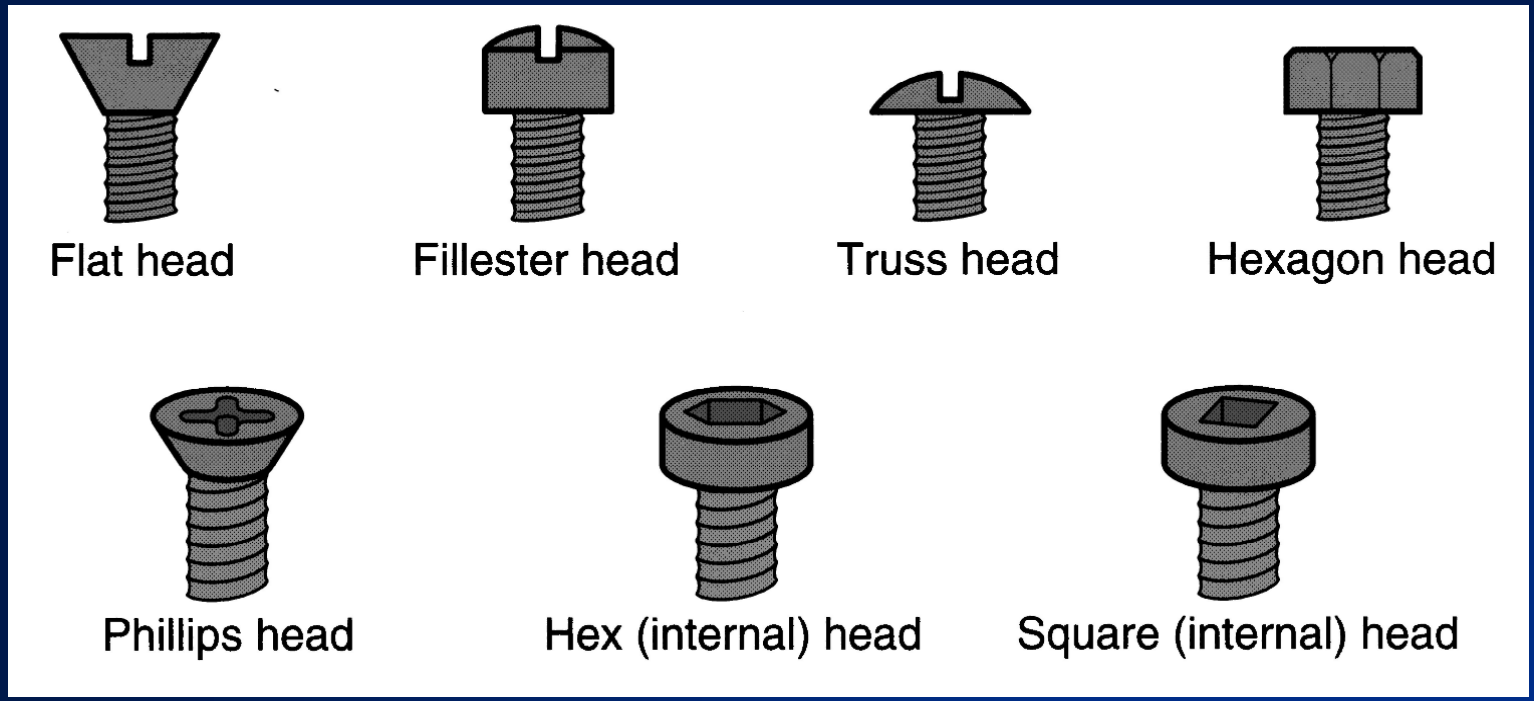

Figure 33.2 - Various head styles available on screws and bolts

Types of Screws

- Greater variety than bolts, since functions vary more
- Examples:
  - *Machine screws* - generic type, generally designed for assembly into tapped holes
  - *Capscrews* - same geometry as machine screws but made of higher strength metals and to closer tolerances

Setscrews

Hardened and designed for assembly functions such as fastening collars, gears, and pulleys to shafts

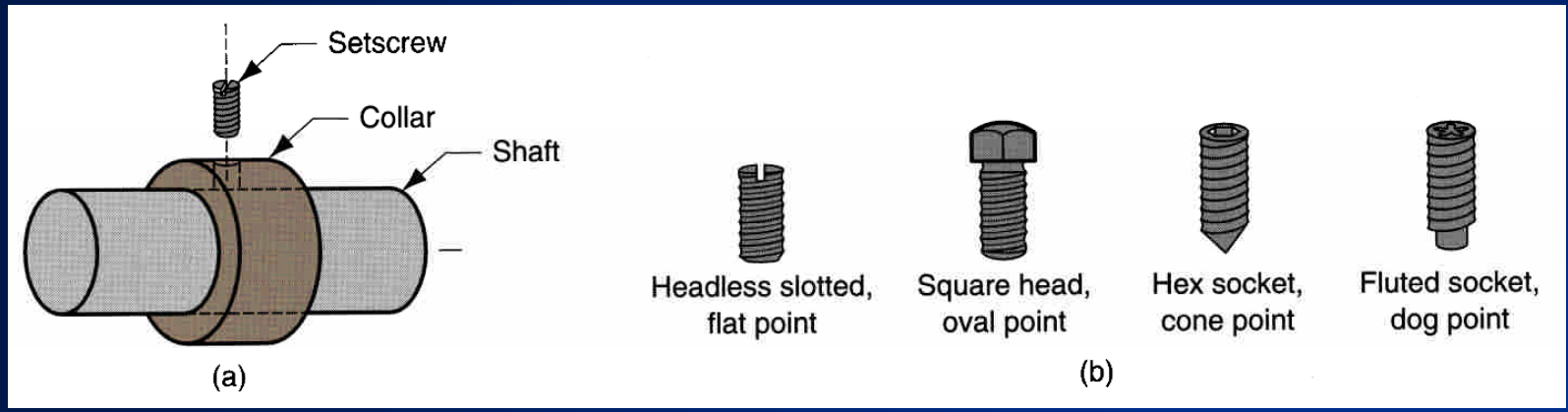

Figure 33.3 - (a) Assembly of collar to shaft using a setscrew; (b) various setscrew geometries (head types and points)

Self-Tapping Screws

- Designed to form or cut threads in a pre-existing hole into which it is being turned
- Also called a *tapping screw*

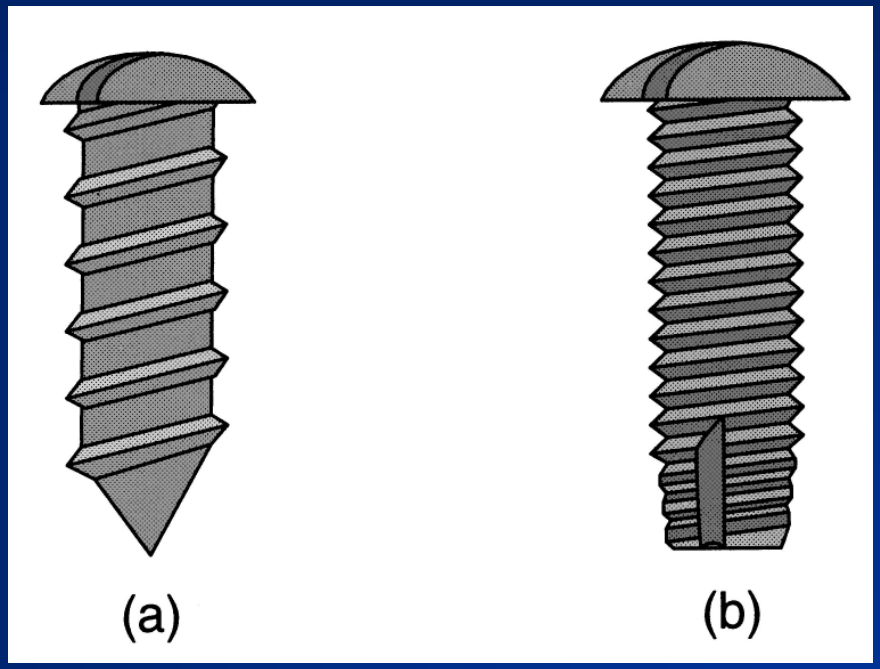

Figure 33.4 -

Self-tapping screws:

(a) thread-forming, and

(b) thread-cutting

Screw Thread Inserts

Internally threaded plugs or wire coils designed to be inserted into an unthreaded hole and accept an externally threaded fastener

- Assembled into weaker materials to provide strong threads
- Upon assembly of screw into insert, insert barrel expands into hole to secure the assembly

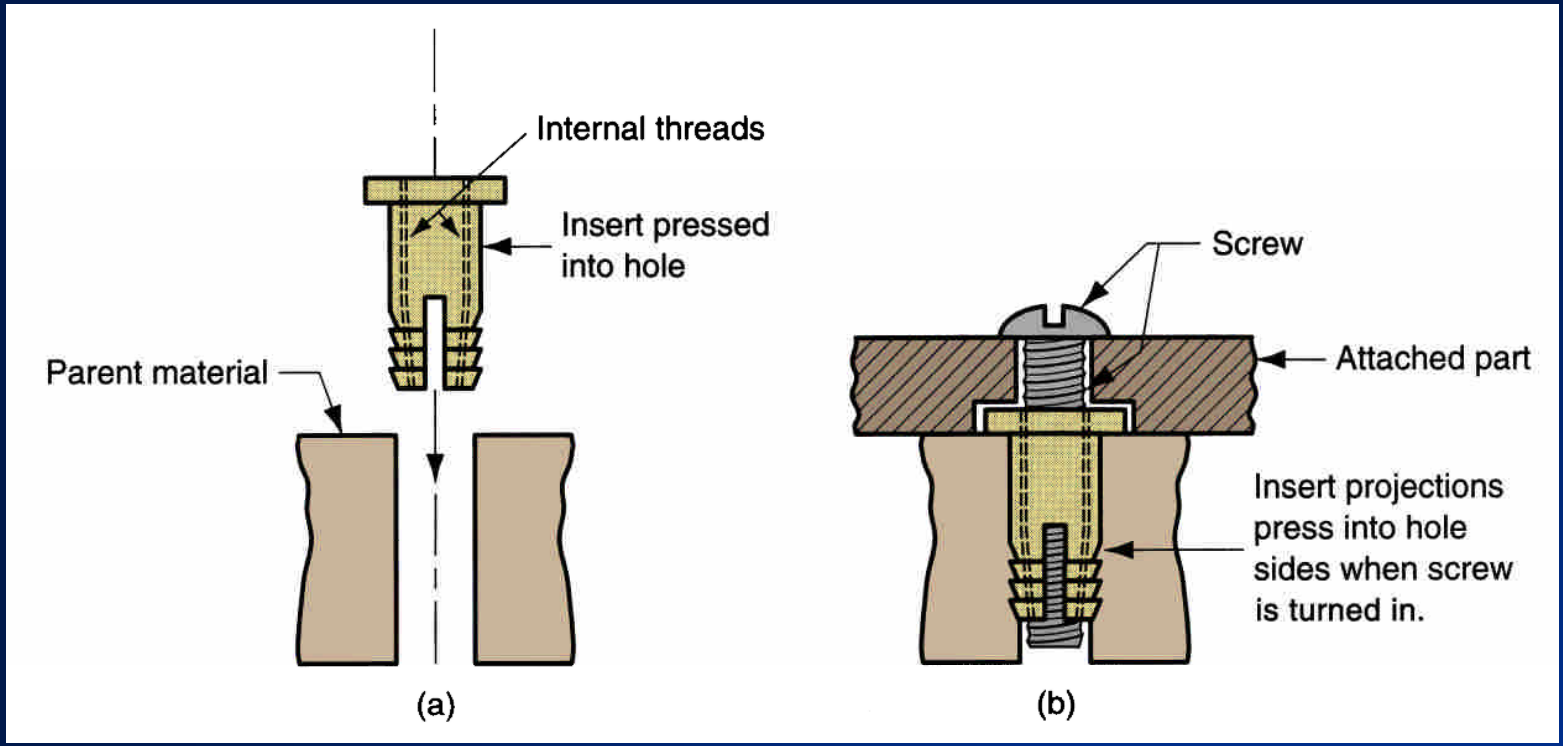

Figure 33.6 - Screw thread inserts: (a) before insertion, and (b) after insertion into hole and screw is turned into insert

Washer

Hardware component often used with threaded fasteners to ensure tightness of the mechanical joint

- Simplest form = flat thin ring of sheet metal
- Functions:
  - Distribute stresses
  - Provide support for large clearance holes
  - Protect part surfaces and seal the joint
  - Increase spring tension
  - Resist inadvertent unfastening

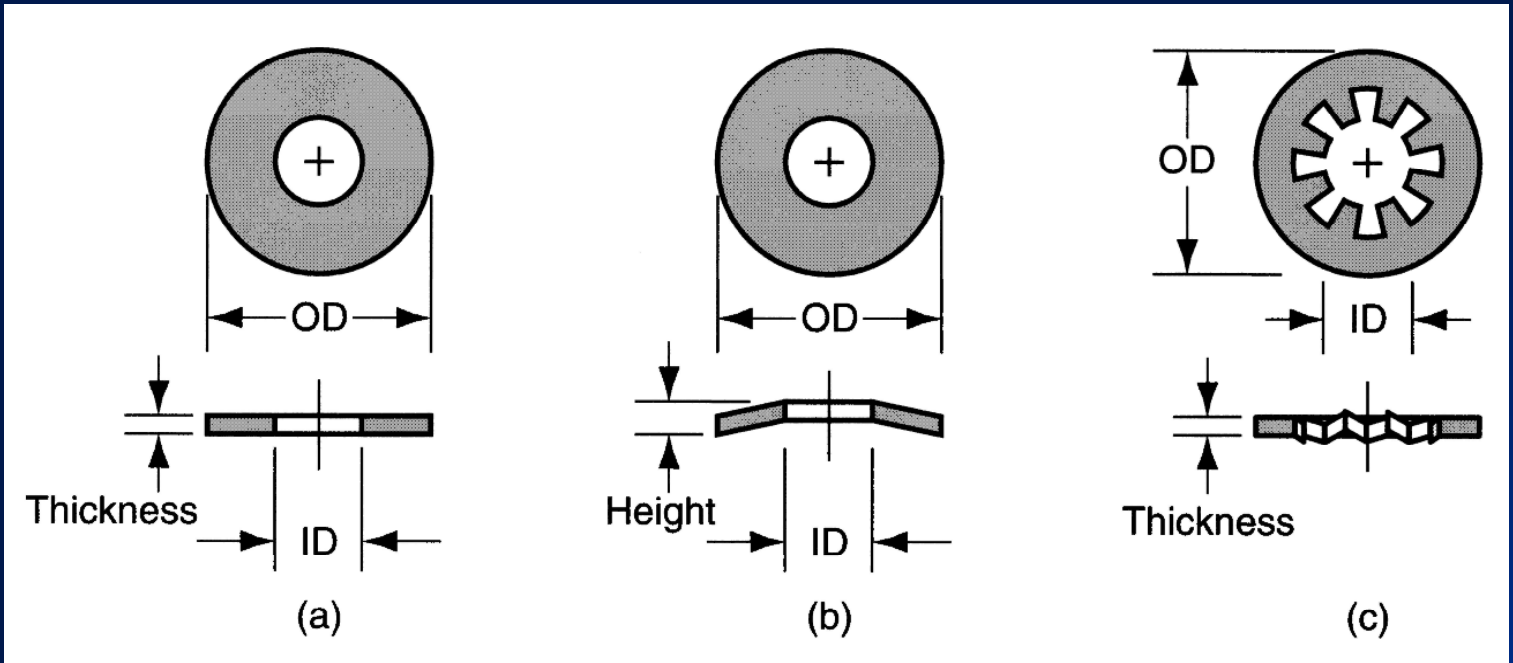

Figure 33.8 - Types of washers: (a) plain (flat) washers; (b) spring washers, used to dampen vibration or compensate for wear; and (c) lockwasher designed to resist loosening of the bolt or screw

Bolt Strength

Two measures:

- *Tensile strength*, which has the traditional definition
- *Proof strength* - roughly equivalent to yield strength
  - Maximum tensile stress without permanent deformation

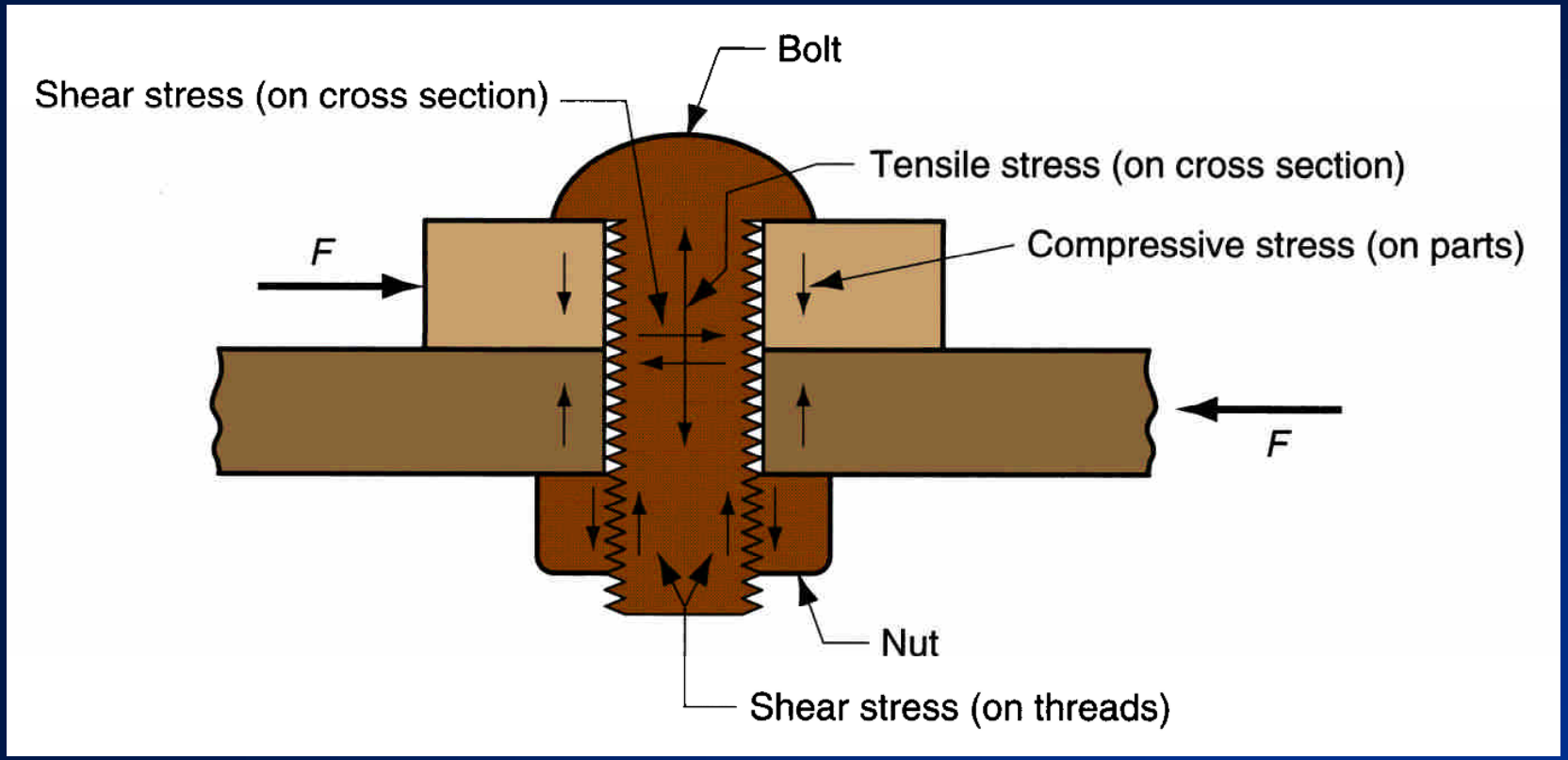

Figure 33.9 - Typical stresses acting on a bolted joint

Overtightening in Bolted Joints

- Potential problem in assembly, causing stresses that exceed strength of fastener or nut
- Failure can occur in one of the following ways:
  1. Stripping of external threads
  2. Stripping of internal threads
  3. Bolt fails due to excessive tensile stresses on cross-sectional area
- Tensile failure is most common problem

Tools and Methods for Threaded Fasteners - Basic Functions:

- To provide relative rotation between external and internal threads during fastening process
- To apply sufficient torque to secure the assembly
  - Product designer often specifies required preload to secure assembly
  - Assembly operator must apply the right torque to achieve the specified preload

Methods to Apply Required Torque for Threaded Fasteners

1. Operator feel - not very accurate, but adequate for most assemblies
2. Torque wrench – indicates amount of torque during tightening
3. Stall-motor - motorized wrench is set to stall when required torque is reached
4. Torque-turn tightening - fastener is initially tightened to a low torque level and then rotated a specified additional amount

Rivets

Unthreaded, headed pin used to join two or more parts by passing pin through holes in parts and forming a second head in the pin on the opposite side

- Widely used fasteners for achieving a permanent mechanically fastened joint
- Clearance hole into which rivet is inserted must be close to the diameter of the rivet

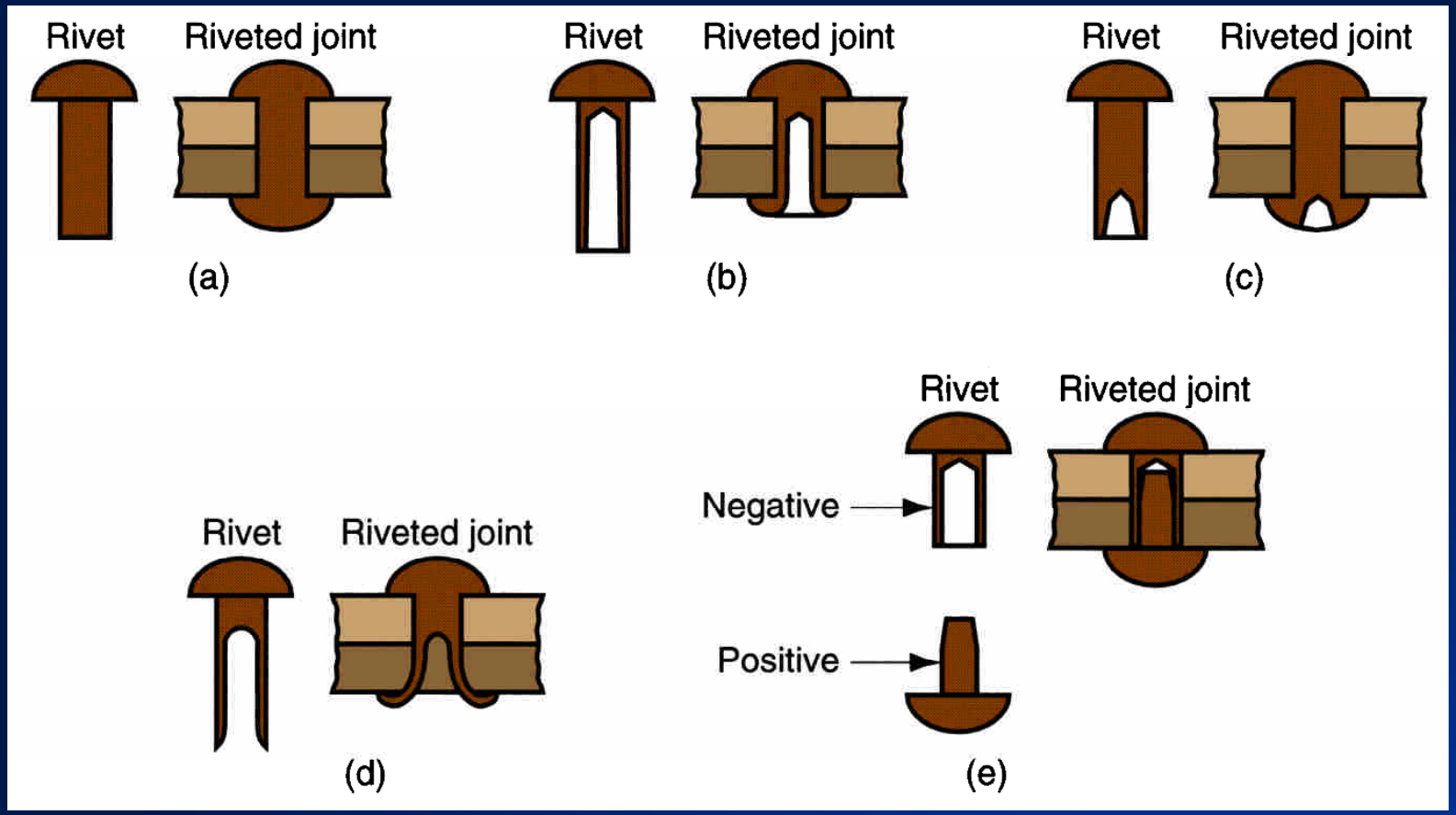

Figure 33.10 - Five basic rivet types, also shown in assembled configuration: (a) solid, (b) tubular, (c) semitubular, (d) bifurcated, and (e) compression

Rivets – Applications and Advantages

- Used primarily for lap joints
- Example: a primary fastening method in aircraft and aerospace industries
- Advantages:
  - High production rates
  - Simplicity
  - Dependability
  - Low cost

Tooling and Methods for Rivets

1. Impact - pneumatic hammer delivers a succession of blows to upset the rivet
2. Steady compression - riveting tool applies a continuous squeezing pressure to upset the rivet
3. Combination of impact and compression

Interference Fits

Assembly methods based on mechanical interference between the two mating parts being joined

- The interference, either during assembly or after joining, holds the parts together
- Interference fit methods include:
  - Press fitting
  - Shrink and expansion fits
  - Snap fits
  - Retaining rings

Press Fitting

- Typical case is where a pin (e.g., a straight cylindrical pin) of a certain diameter is pressed into a hole of a slightly smaller diameter
- Possible functions:
  - Locating and locking components - to augment threaded fasteners by holding parts in fixed alignment with each other
  - Pivot points - to permit rotation of one component about the other
  - Shear pins

Shrink and Expansion Fits

Assembly of two parts (e.g., shaft in collar) that have an interference fit at room temperature

- *Shrink fitting* - external part is enlarged by heating, and internal part either stays at room temperature or is contracted by cooling
- *Expansion fitting* - internal part is contracted by cooling and inserted into mating component - when at room temperature, expansion creates interference

- Used to fit gears, pulleys, sleeves, and other components onto solid and hollow shafts

Snap Fits

Joining of two parts in which mating elements possess a temporary interference during assembly, but once assembled they interlock

- During assembly, one or both parts elastically deform to accommodate temporary interference
- Usually designed for slight interference after assembly

- Originally conceived as a method ideally suited for industrial robots
  - Eureka! – it's easier for humans too

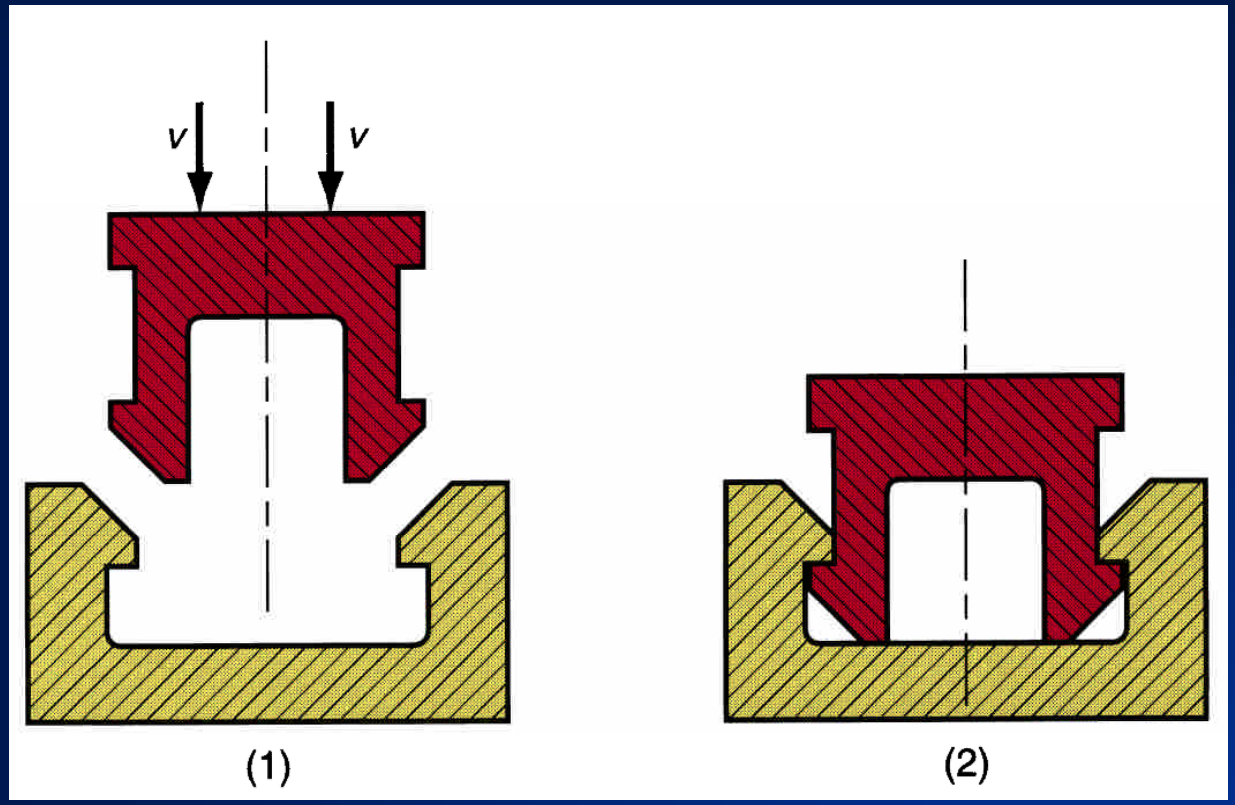

Figure 33.13 - Snap fit assembly, showing cross-sections of two mating parts: (1) before assembly, and (2) parts snapped together

Retaining Ring

Fastener that snaps into a circumferential groove on a shaft or tube to form a shoulder

- Used to locate or restrict movement of parts on a shaft

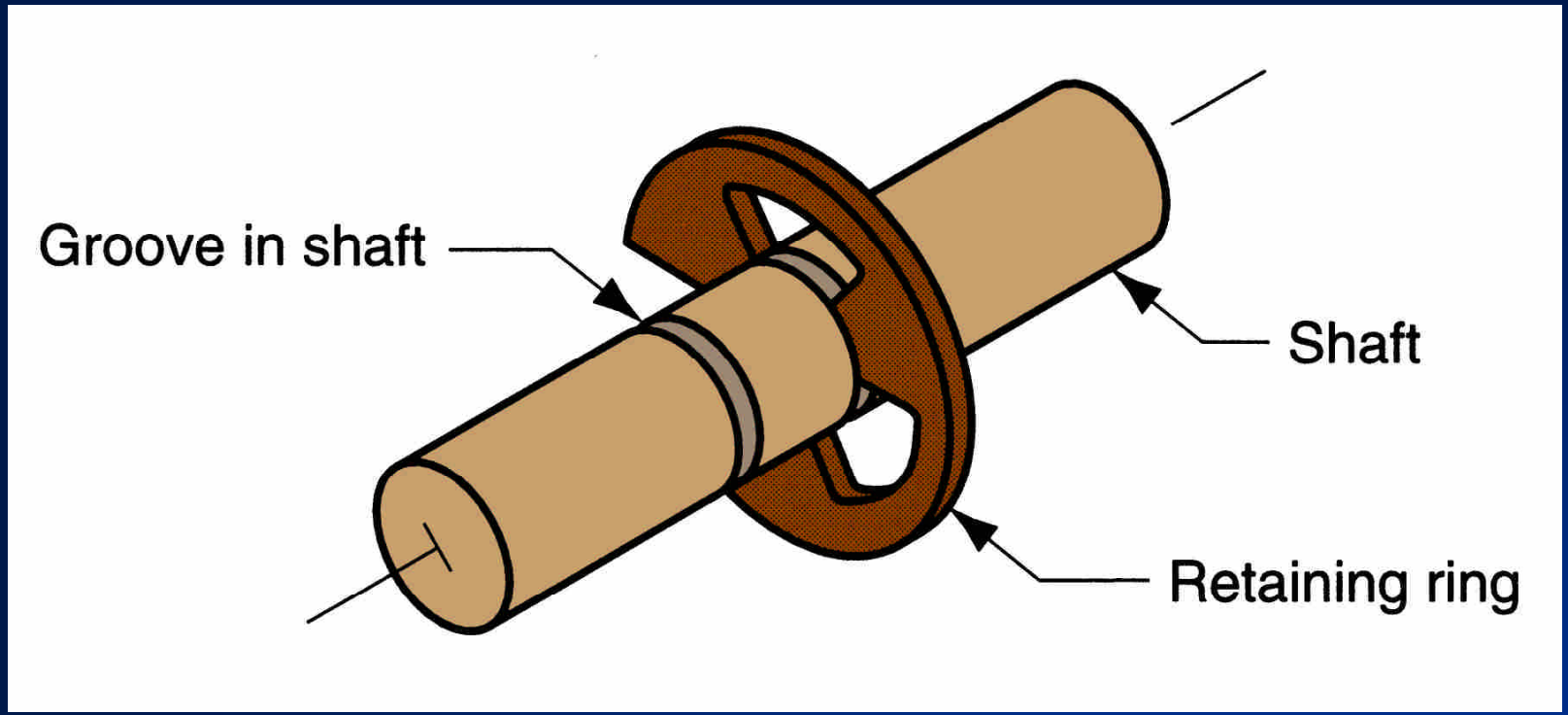

Figure 33.14 - Retaining ring assembled into a groove on a shaft

Stitching

Fastening operation in which U-shaped stitches are formed one-at-a-time from steel wire and immediately driven through the two parts to be joined

- Applications: sheetmetal assembly, metal hinges, magazine binding, corrugated boxes

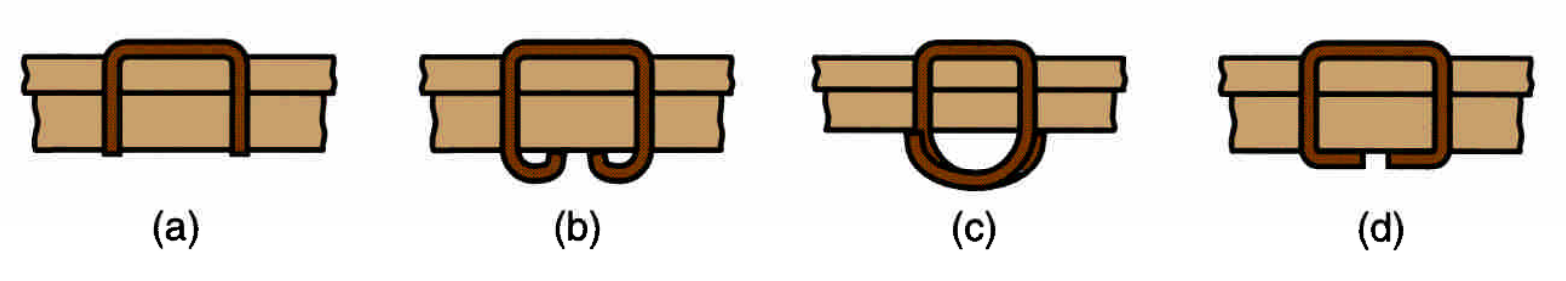

Figure 33.15 - Common types of wire stitches: (a) unclinched, (b) standard loop, (c) bypass loop, and (d) flat clinch

Stapling

Preformed U-shaped staples are punched through the two parts to be attached

- Supplied in convenient strips
- Usually applied by portable pneumatic guns
- Applications: furniture and upholstery, car seats, various light-gage sheetmetal and plastic assembly jobs

Molding Inserts and Integral Fasteners

Permanent joining methods that involve shaping or reshaping one of the components by a manufacturing process such as:

- Casting
- Molding
- Sheet-metal forming

Placement of a component into a mold prior to plastic molding or metal casting, so that it becomes a permanent and integral part of the molding or casting

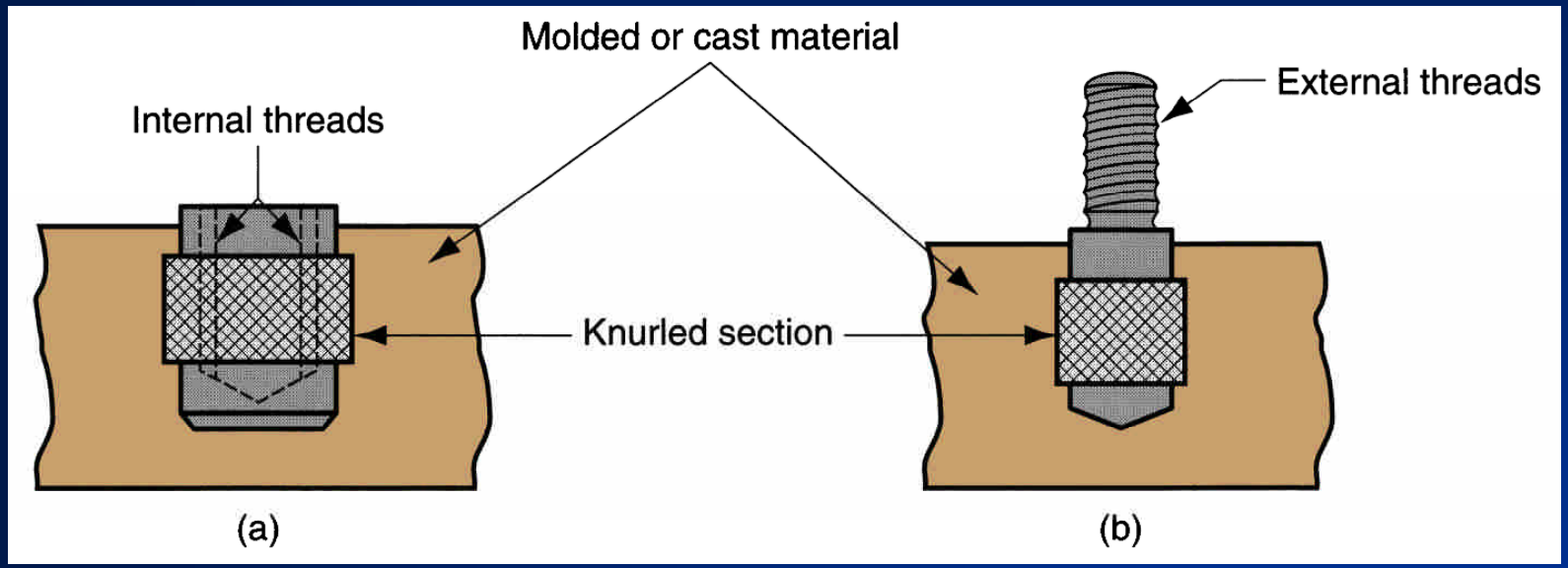

Figure 33.17 - Examples of molded-in inserts: (a) threaded bushing, and (b) threaded stud

Reasons for Molding Inserts and Examples of Applications

- Insert has better properties than molded or cast material
- Insert geometry is too complex or intricate to incorporate into the mold
- Examples of applications:
  - Internally threaded bushings and nuts
  - Externally threaded studs
  - Bearings
  - Electrical contacts

Integral Fasteners

Components are deformed so they interlock as a mechanically fastened joint

- Methods include:
  - Lanced tabs
  - Seaming
  - Beading

Lanced Tabs

To attach wires or shafts to sheetmetal parts

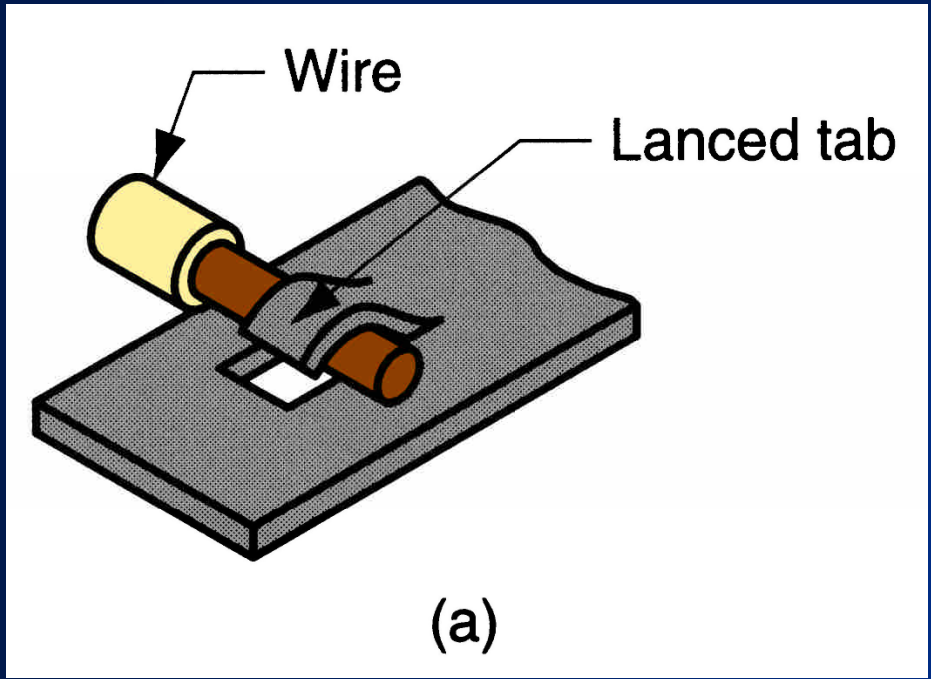

Figure 33.18

(a) lanced tabs to attach wires or shafts to sheetmetal

Seaming

Edges of two separate sheetmetal parts or the opposite edges of the same part are bent over to form the fastening seam

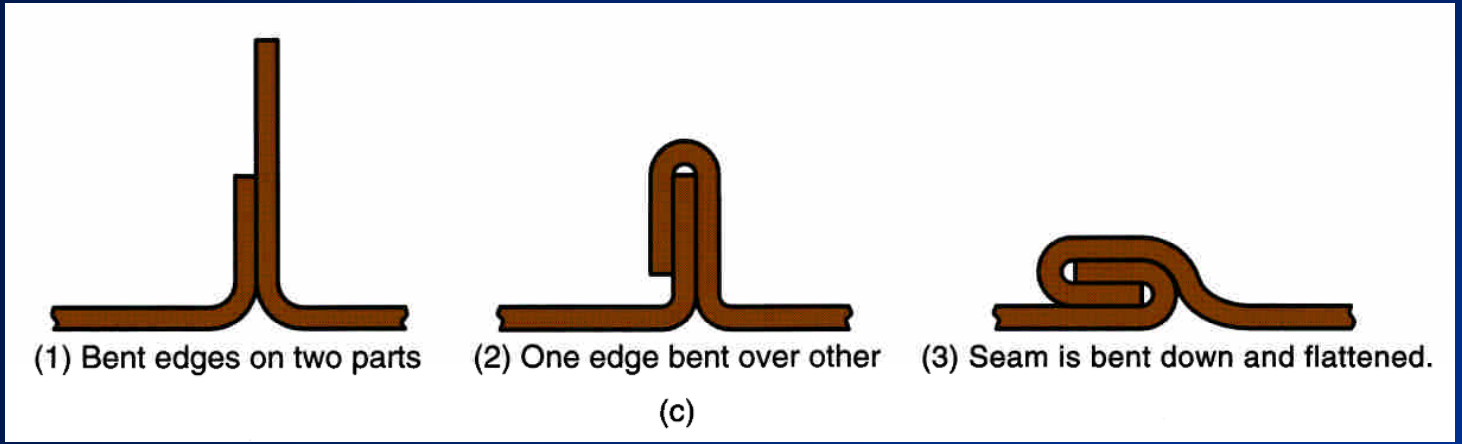

Figure 33.18 (c) single-lock seaming

Design for Assembly (DFA)

- Keys to successful DFA:
  1. Design the product with as few parts as possible
  2. Design the remaining parts so they are easy to assemble
- Assembly cost is determined largely in product design, when the number of components in the product and how they are assembled is decided
  - Once these decisions are made, little can be done in manufacturing to reduce assembly costs

DFA Guidelines

- Use modularity in product design
  - Each subassembly should have a maximum of 12 or so parts
  - Design the subassembly around a base part to which other components are added
- Reduce the need for multiple components to be handled at once

More DFA Guidelines

- Limit the required directions of access
  - Adding all components vertically from above is the ideal
- Use high quality components
  - Poor quality parts jams feeding and assembly mechanisms
- Minimize threaded fasteners
- Use snap fit assembly