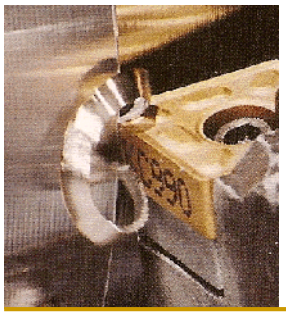
MECHANICAL ASSEMBLY

1. Threaded Fasteners
2. Rivets and Eyelets
3. Assembly Methods Based on Interference Fits
4. Other Mechanical Fastening Methods
5. Molding Inserts and Integral Fasteners
6. Design for Assembly

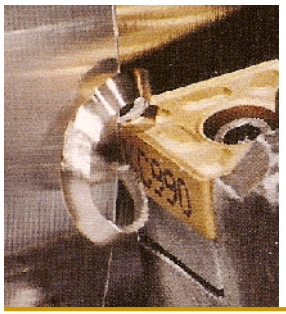
Mechanical Assembly Defined

- 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

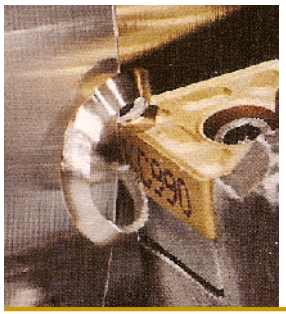


Two Major Classes of Mechanical Assembly

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

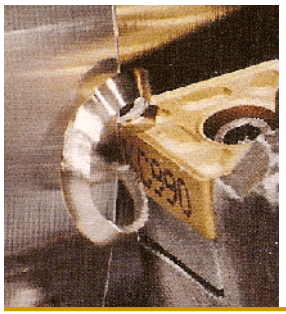
Why Use Mechanical Assembly?

- Ease of assembly – can be accomplished with relative ease by unskilled workers
  - Minimum of special tooling required
  - In a relatively short time
- Ease of disassembly – at least for the methods that permit disassembly
  - Some disassembly is required for most products to perform maintenance and repair



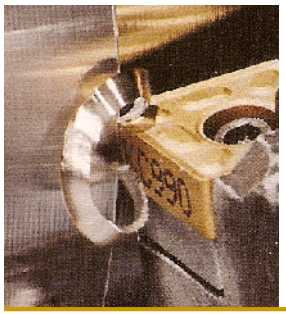
Threaded Fasteners

- 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



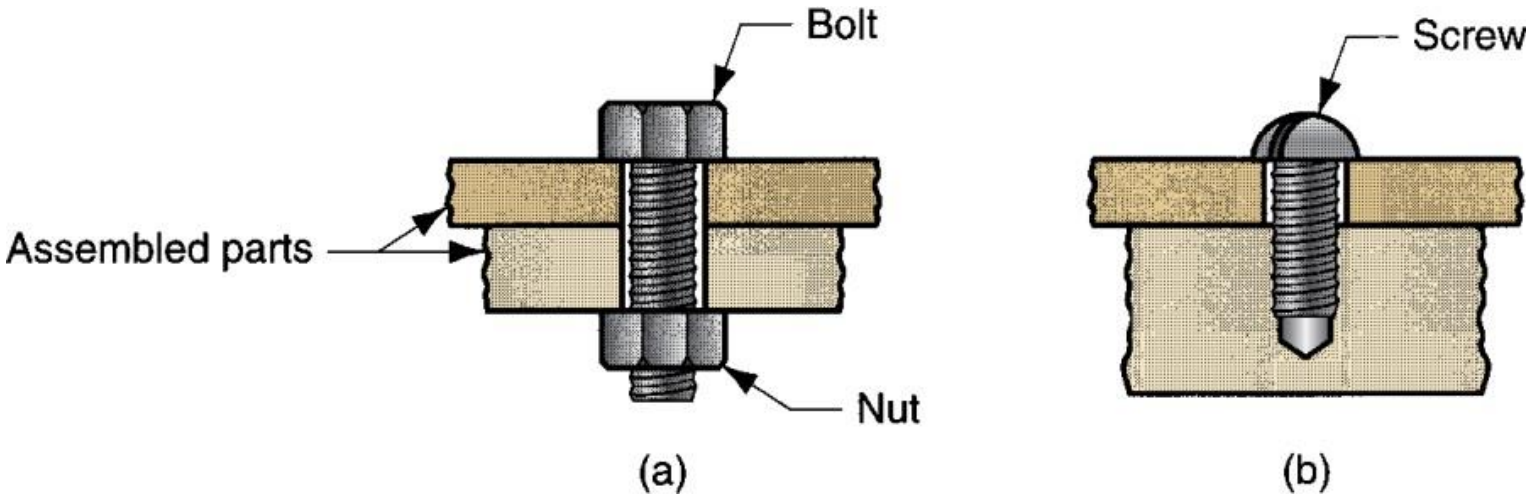
Screws, Bolts, and Nuts

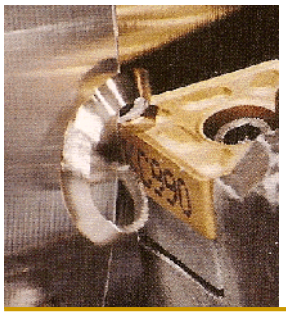
- Screw - externally threaded fastener generally assembled into a blind threaded hole
- Bolt - externally threaded fastener inserted into through holes and "screwed" into a nut on the opposite side
- Nut - internally threaded fastener having standard threads that match those on bolts of the same diameter, pitch, and thread form



Screws, Bolts, and Nuts

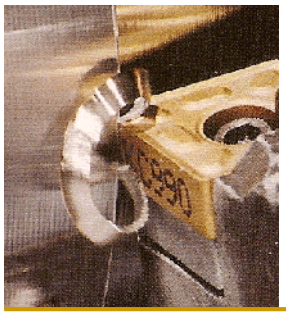
Typical assemblies when screws and bolts are used





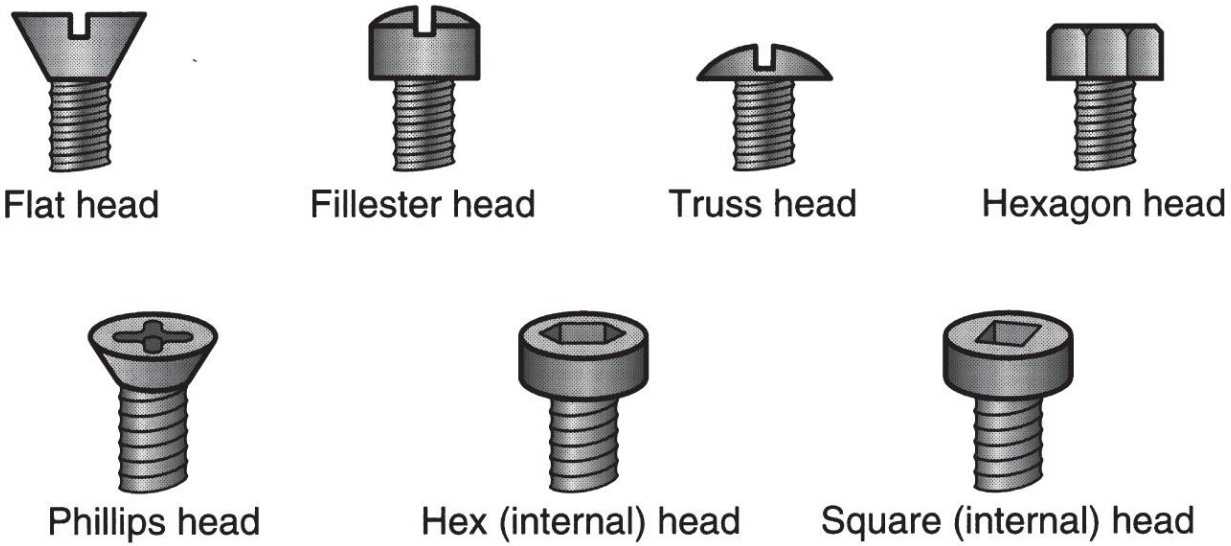
Some Facts About Screws and Bolts

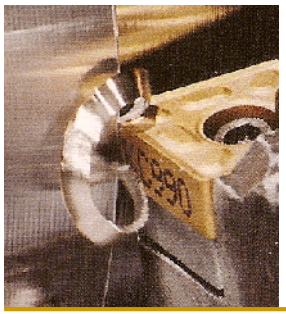
- Screws and bolts come in a variety of sizes, threads, and shapes
- Much standardization in threaded fasteners, which promotes interchangeability
- U.S. is converting to metric, further reducing variations
- Differences between threaded fasteners affect tooling
  - Example: different screw head styles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



Head Styles on Screws and Bolts

Various head styles available on screws and bolts



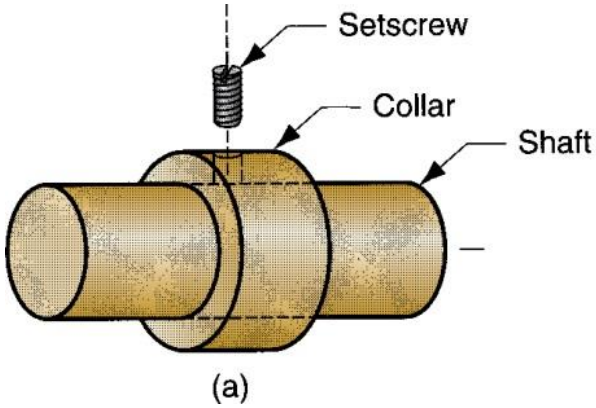


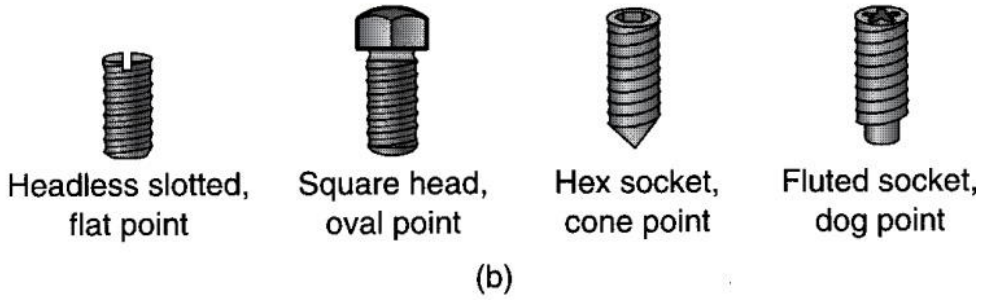
Types of Screws

- 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

Assembly functions such as fastening collars, gears, and pulleys to shafts: (a) Assembly of collar to shaft; (b) various setscrew geometries (head types and points)

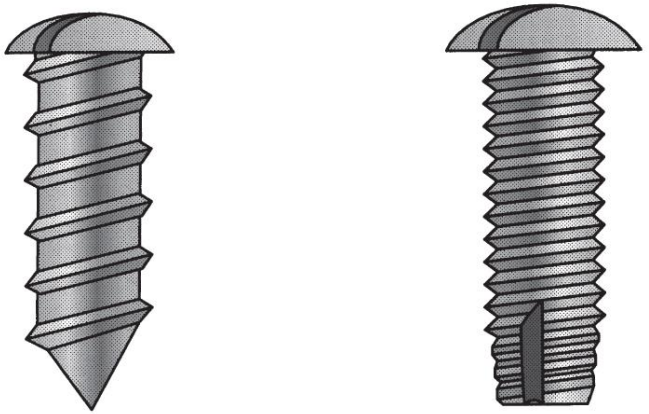


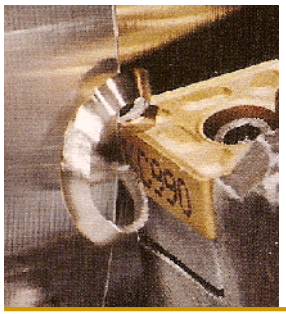


Self-Tapping Screws

Screws designed to form or cut threads in a pre-existing hole into which it is being turned: (a) thread-forming, and (b) thread-cutting

- Also called a *tapping screw*



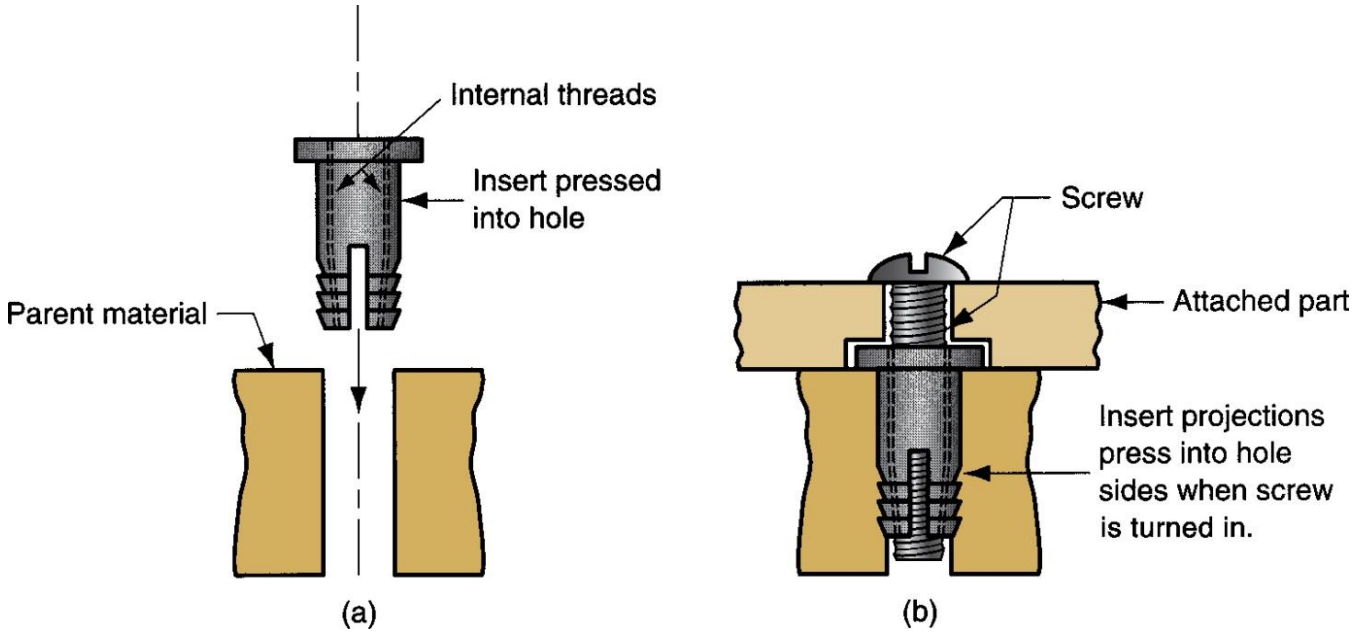


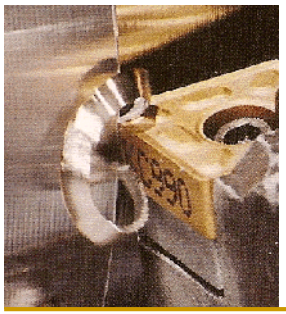
Screw Thread Inserts

- 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

Screw Thread Inserts

(a) Before insertion, and (b) after insertion into hole and screw is turned into insert



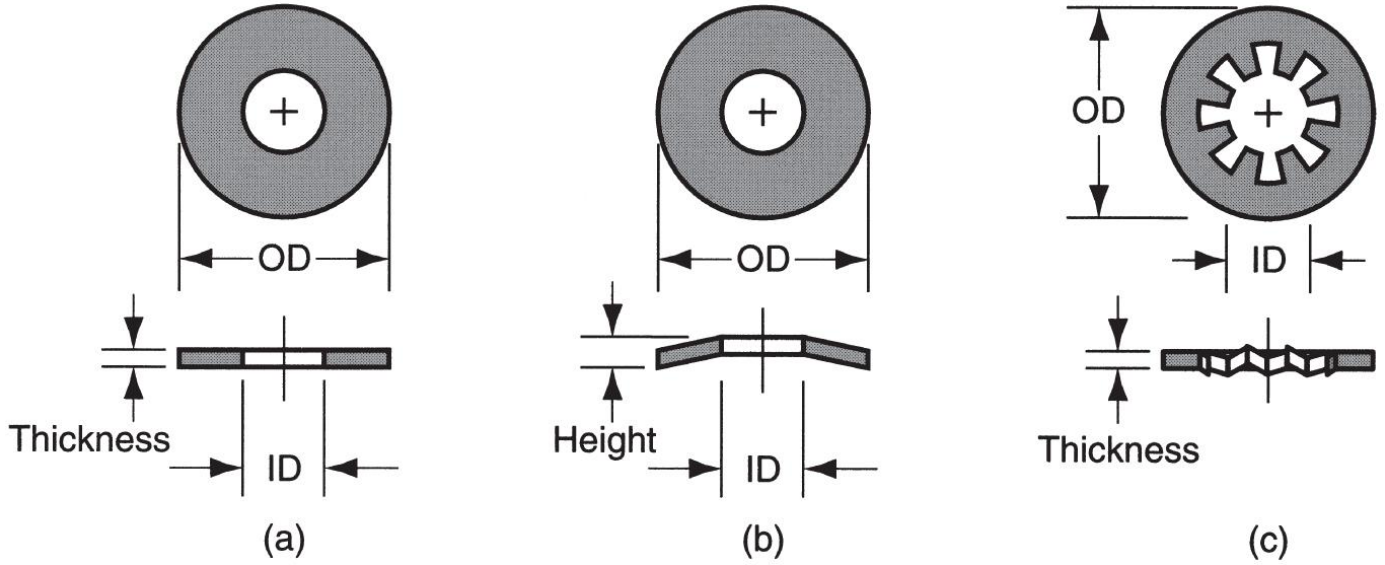


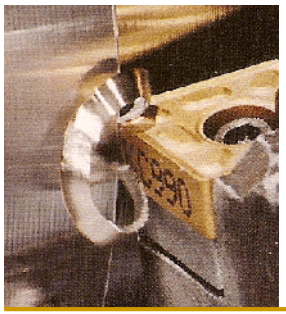
Washer

- Hardware component often used with threaded fasteners to ensure tightness of a mechanical joint
  - Simplest form = flat ring of thin sheet metal
  - Functions:
    - Distribute stresses
    - Provide support for large clearance holes
    - Protect part surfaces and seal the joint
    - Increase spring tension
    - Resist inadvertent unfastening

Washer Types

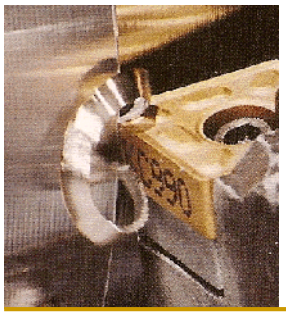
(a) Plain (flat) washers; (b) spring washers, dampens vibration or compensates for wear; and (c) lockwasher designed to resist loosening of bolt or screw



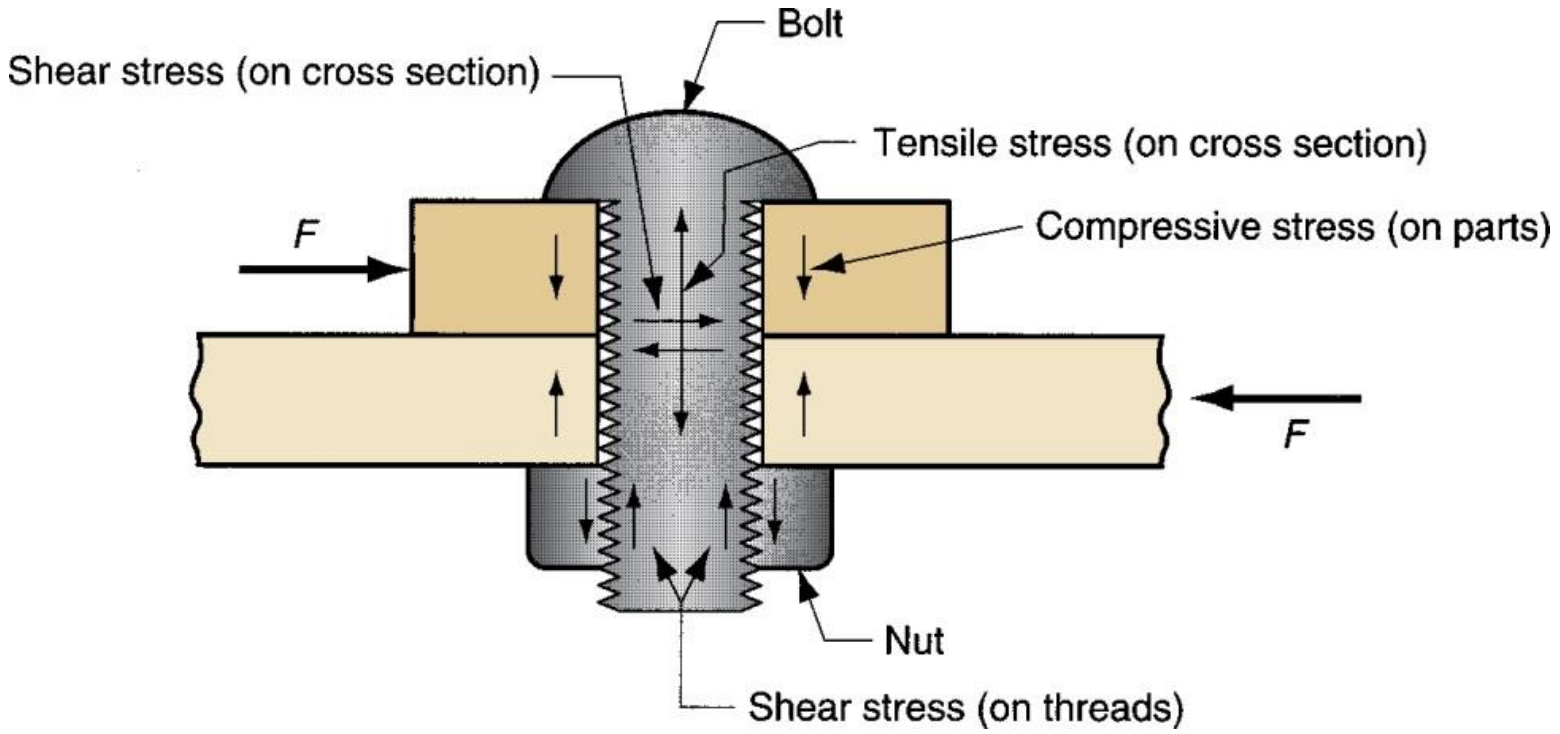


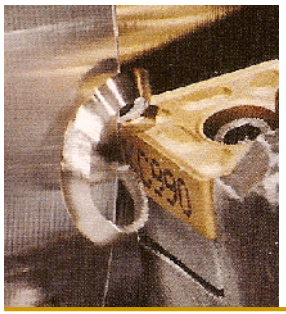
Bolt Strength

- Two measures:
  - Tensile strength, which has the traditional definition
    - Maximum tensile stress at fracture
  - Proof strength - roughly equivalent to yield strength
    - Maximum tensile stress without permanent deformation



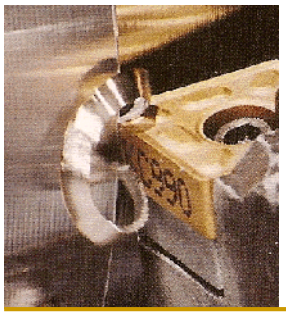
Typical Stresses Acting on a Bolted Joint





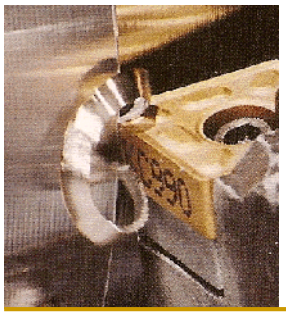
Over-tightening in Bolted Joints

- 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 of cross section is most common problem



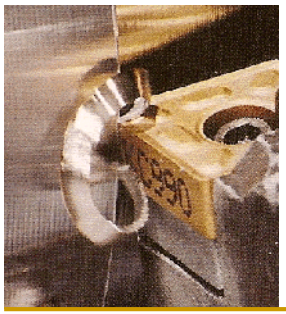
Functions of Tools and Methods Used for Threaded Fasteners

- To provide relative rotation between external and internal threads during fastening
- 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 the Required Torque

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

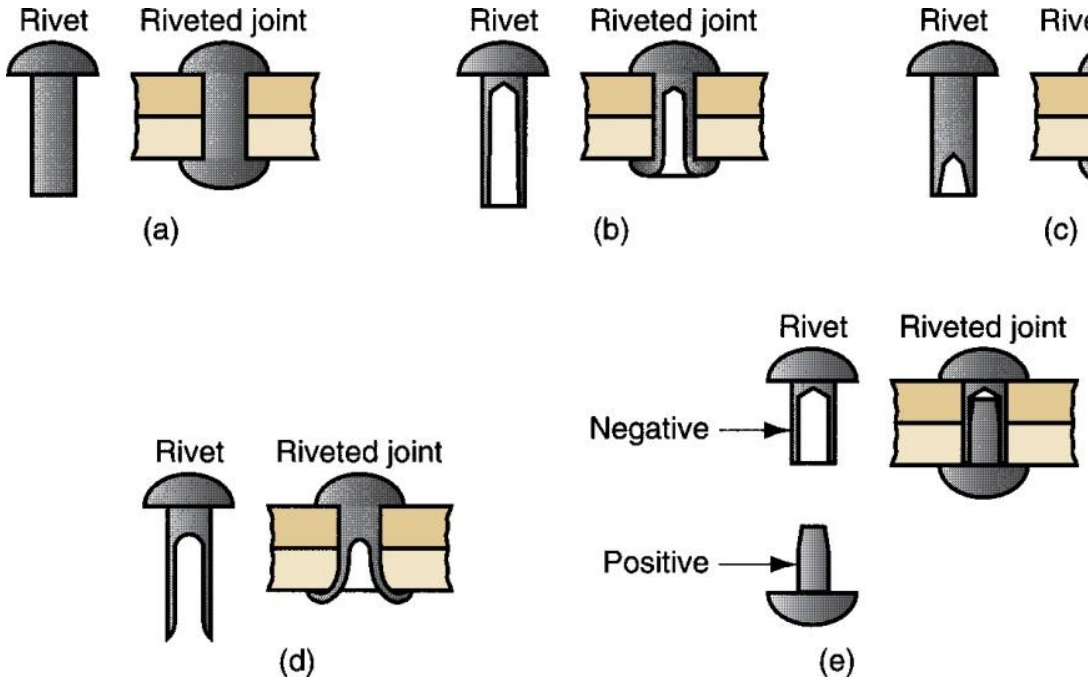


Rivets

- Unthreaded, headed pins used to join two or more parts by passing the 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

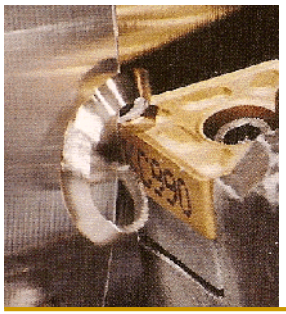
Five Basic Types of Rivets

(a) Solid, (b) tubular, (c) semitubular, (d) bifurcated, and (e) compression



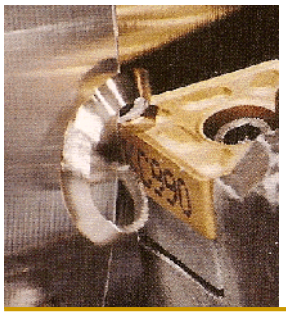
Applications and Advantages of Rivets

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



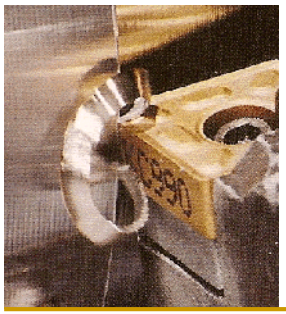
Tooling and Methods for Rivets

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



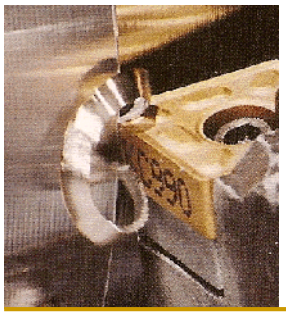
Interference Fits

- Assembly methods based on mechanical interference between 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



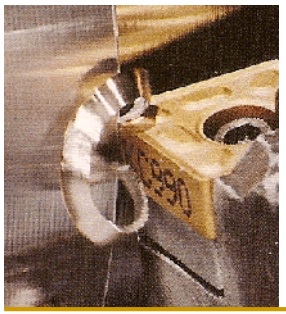
Press Fitting

- Typical case: 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 is inserted
  - *Expansion fitting* - internal part is contracted by cooling and inserted into external part
- When at room temperature, contraction or expansion creates interference fit
- Used to fit gears, pulleys, and sleeves onto solid and hollow shafts

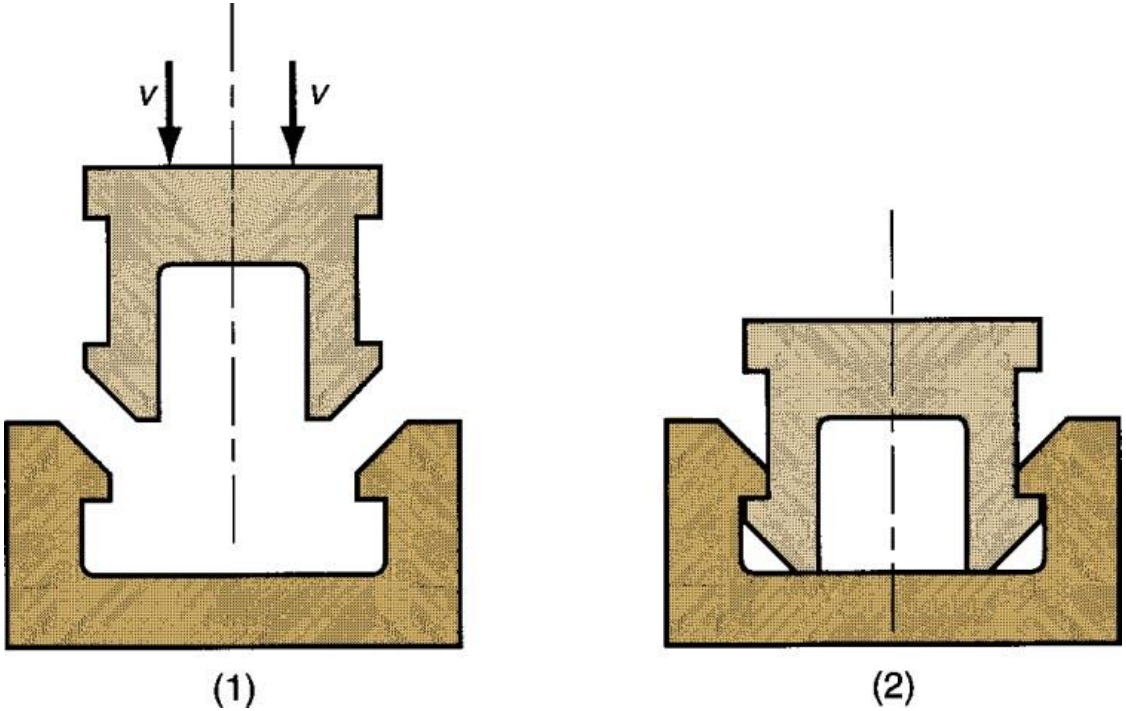


Snap Fits

- Joining 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 the temporary interference
  - Originally conceived as a method ideally suited for industrial robots
    - It’s easier for humans too

Snap Fit Assembly

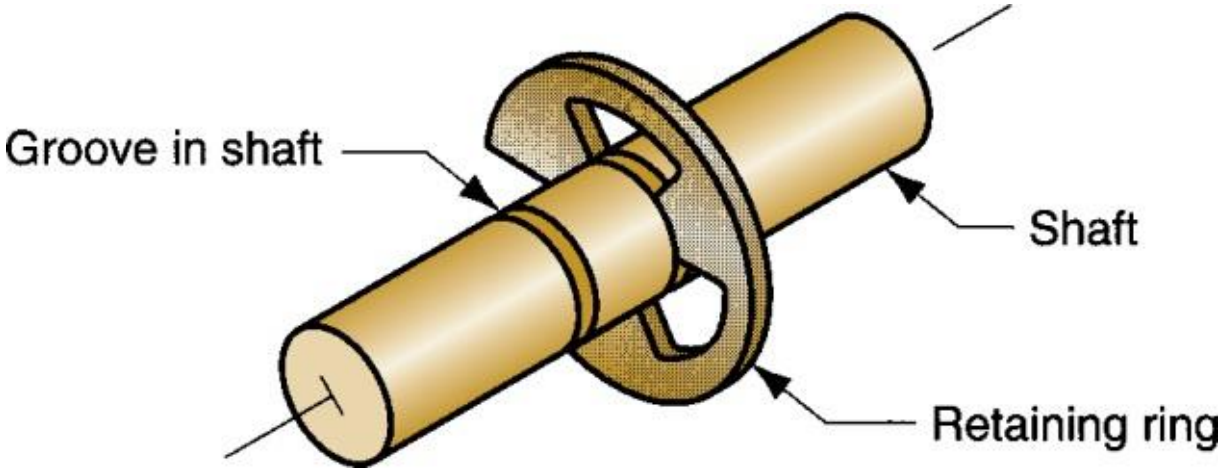
(1) Before assembly and (2) parts snapped together



Retaining Ring

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

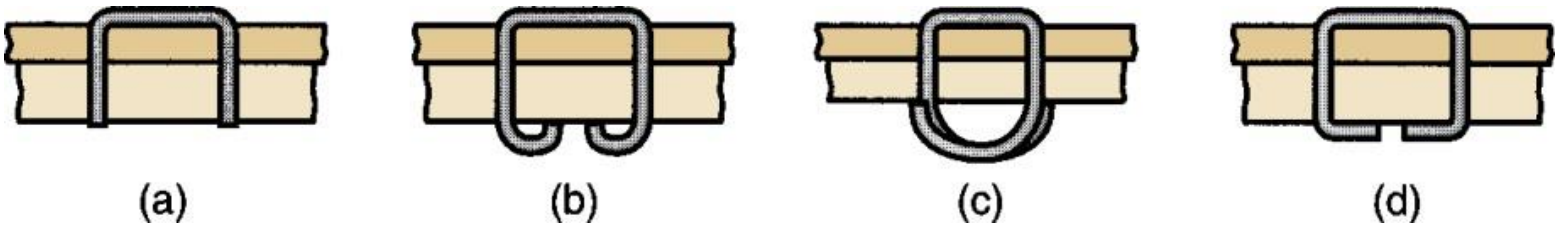
- Used to locate or restrict movement of parts on a shaft

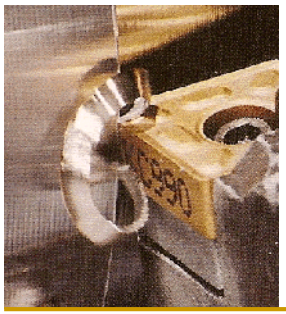


Stitching

U-shaped stitches formed one-at-a-time from steel wire and immediately driven through parts (a) unclinched, (b) standard loop, (c) bypass loop, and (d) flat clinch

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





Stapling

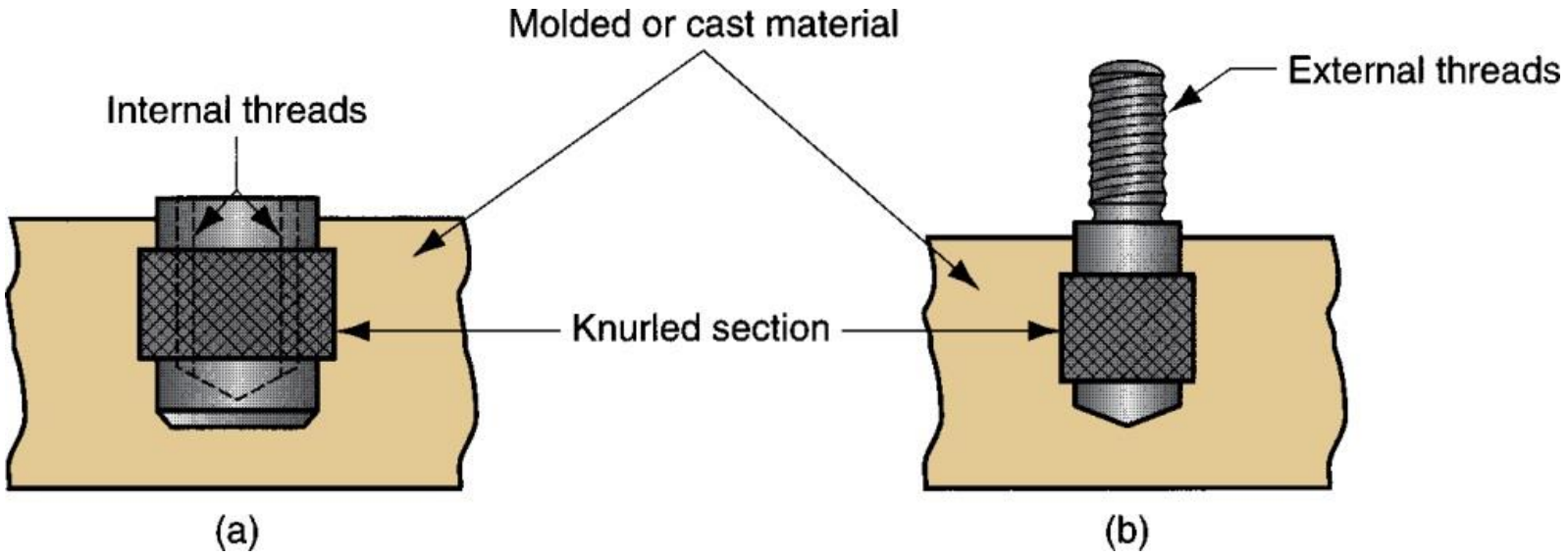
- Preformed U-shaped staples are punched through the two parts to be attached
  - Supplied in convenient strips
  - Usually applied by portable pneumatic guns
  - Applications: furniture and upholstery, car seats, various light-gage sheet-metal and plastic assembly jobs, and paper documents

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

Molding Inserts

Placement of a component into mold prior to plastic molding or metal casting, so that it becomes a permanent and integral part of the molding or casting: (a) threaded bushing, and (b) threaded stud

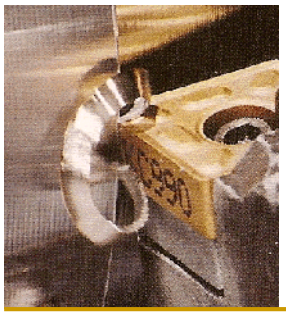


Why Use Molding Inserts?

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

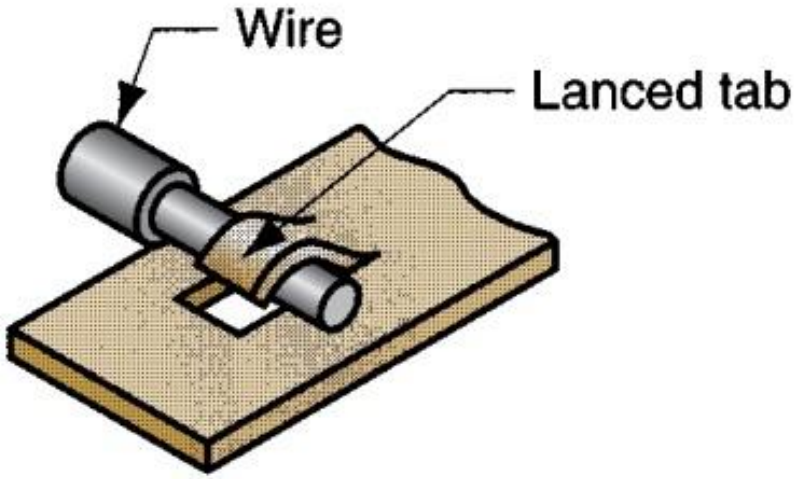
Integral Fasteners

- Components are deformed so they interlock as a mechanically fastened joint
  - Methods include:
    - Lanced tabs
    - Seaming



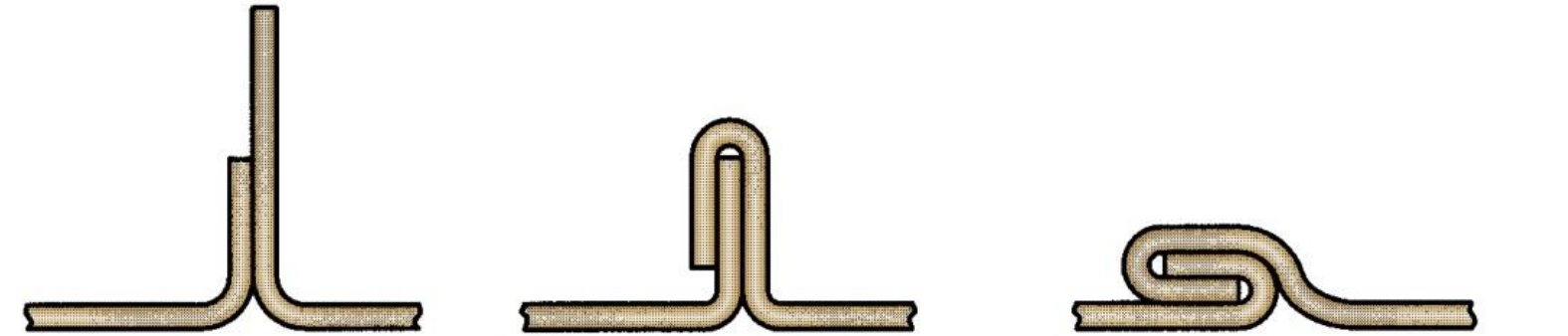
Lanced Tabs

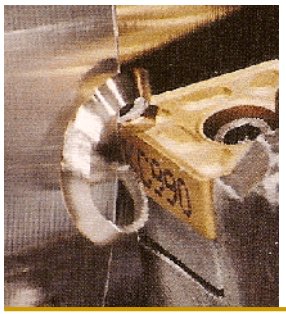
Lanced tabs to attach wires or shafts to sheet metal



Seaming

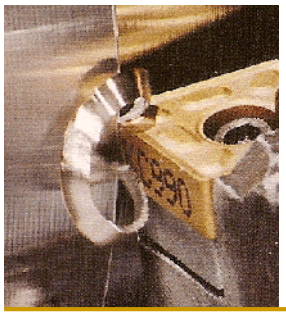
Edges of two separate sheet-metal parts or the opposite edges of the same part are bent over to form the fastening seam





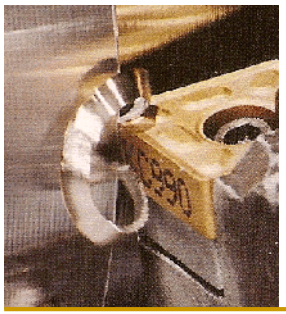
Design for Assembly (DFA): General Guidelines

- Keys to successful DFA:
  1. Design product with as few parts as possible
  2. Design 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 to reduce assembly costs



Design Guidelines for Automated Assembly

- 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

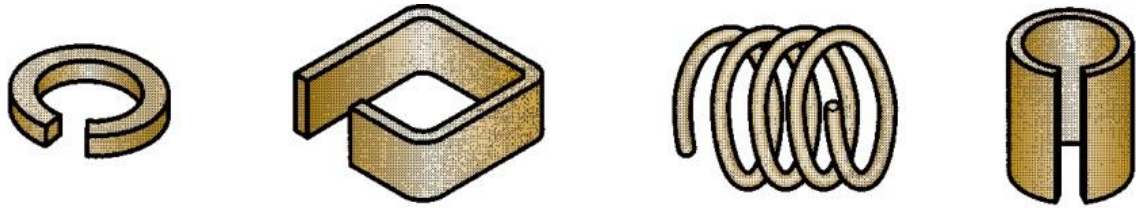


Design Guidelines for Automated Assembly

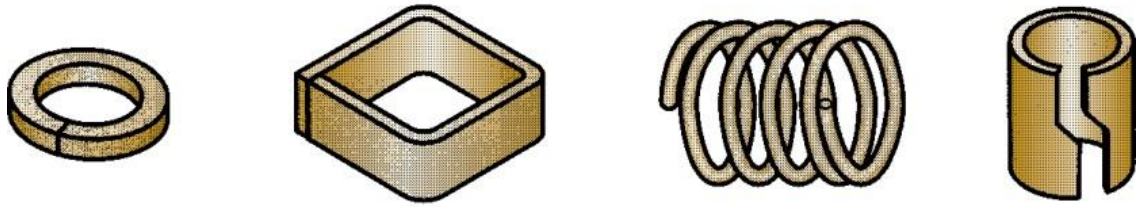
- Limit the required directions of access
  - Adding all components vertically from above is the ideal
- Use high quality components
  - Poor quality parts jams feeding and assembly mechanisms
- Minimize threaded fasteners
- Use snap fit assembly

Design Guidelines for Automated Assembly

Avoid parts that tangle: (a) Parts that tend to tangle, and (b) parts designed to avoid tangling



(a)



(b)