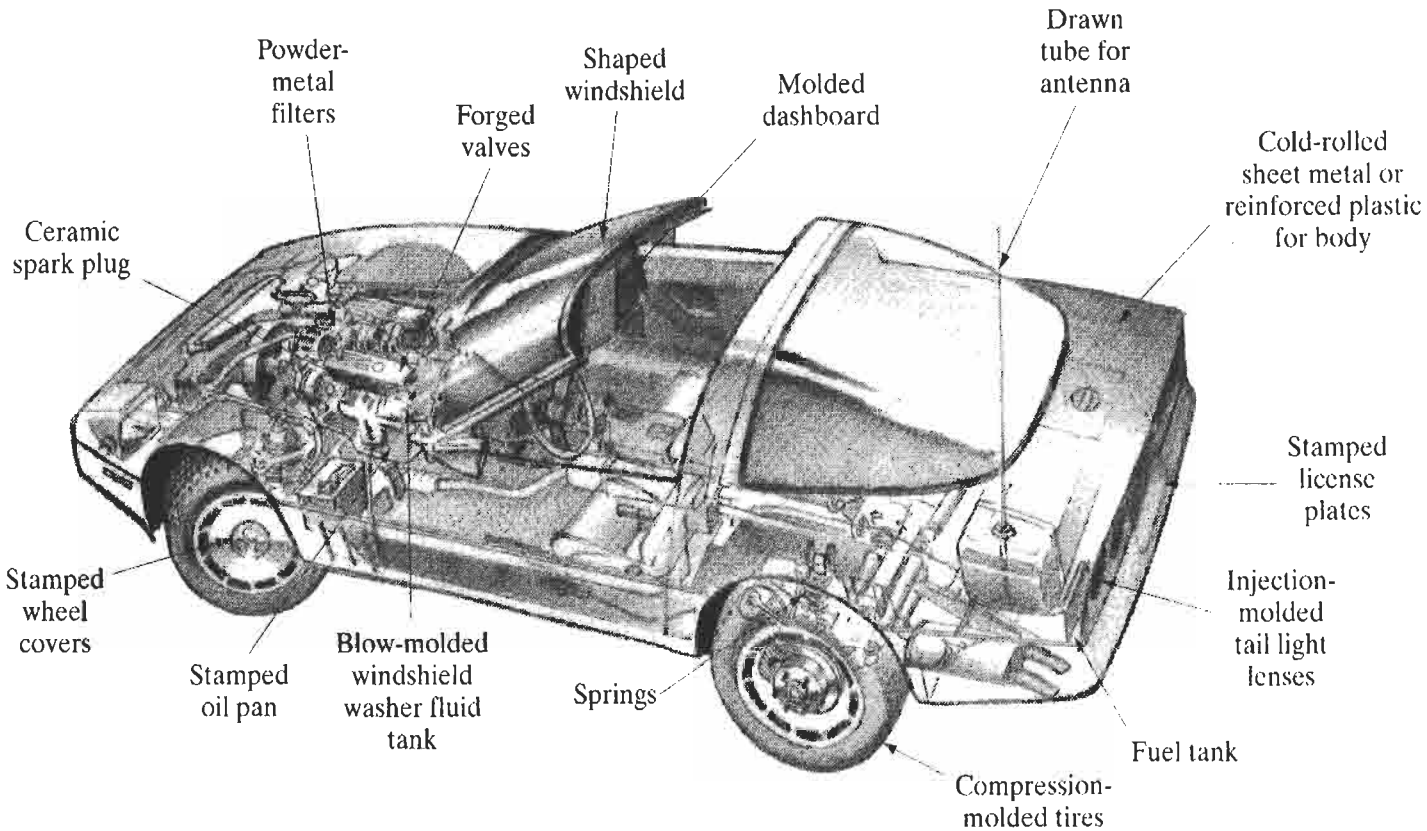
FREDERICK INSTITUTE OF TECHNOLOGY
Mechanical Engineering Department

3. FORMING AND SHAPING PROCESSES

Forming and Shaping

- Rolling
- Forging
- Extrusion
- Drawing
- Sheet
- Forming
- Powder metallurgy
- Molding
- Rabid prototyping

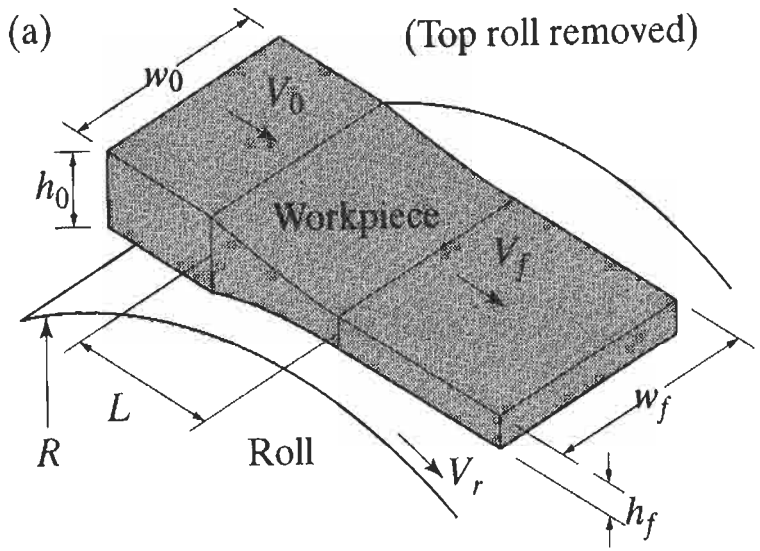
Formed and shaped parts in a typical automobile.



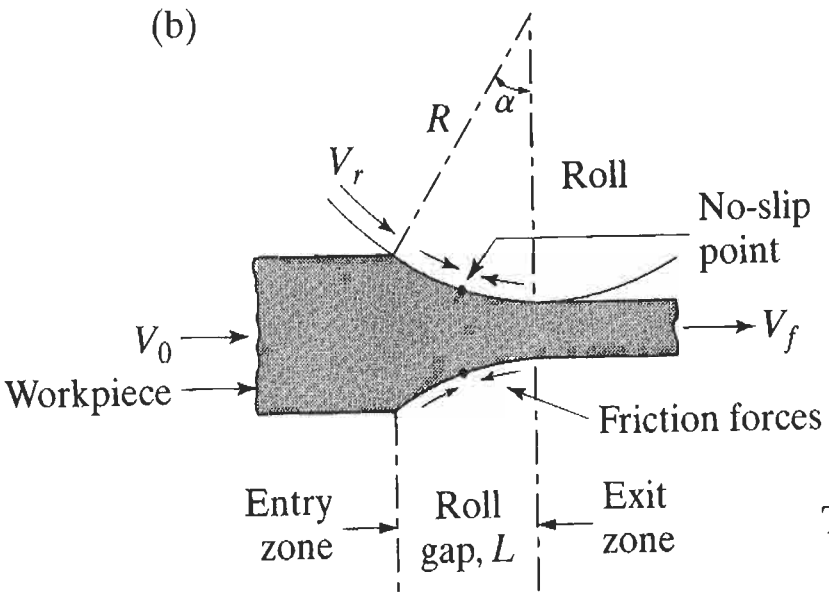
FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Forming and shaping processes**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 1-a**

Process	Characteristics
Rolling	
Flat	Production of flat plate, sheet, and foil in long lengths, at high speeds, and with good surface finish, especially in cold rolling; requires high capital investment; low to moderate labor cost.
Shape	Production of various structural shapes, such as I-beams, at high speeds; includes thread rolling; requires shaped rolls and expensive equipment; low to moderate labor cost; moderate operator skill.
Forging	Production of discrete parts with a set of dies; some finishing operations usually required; similar parts can be made by casting and powder-metallurgy techniques; usually performed at elevated temperatures; die and equipment costs are high; moderate to high labor cost; moderate to high operator skill.
Extrusion	Production of long lengths of solid or hollow products with constant cross-section; usually performed at elevated temperatures; product is then cut into desired lengths; can be competitive with roll forming; cold extrusion has similarities to forging and is used to make discrete products; moderate to high die and equipment cost; low to moderate labor cost; low to moderate operator skill.
Drawing	Production of long rod and wire, with round or various cross-sections; smaller cross-sections than extrusions; good surface finish; low to moderate die, equipment, and labor costs; low to moderate operator skill.
Sheet-metal forming	Production of a wide variety of shapes with thin walls and simple or complex geometries; generally low to moderate die, equipment, and labor costs; low to moderate operator skill.
Powder metallurgy	Production of simple or complex shapes by compacting and sintering metal powders; can be competitive with casting, forging, and machining processes; moderate die and equipment cost; low labor cost and skill.
Processing of plastics and composite materials	Production of a variety of continuous or discrete products by extrusion, molding, casting, and fabricating processes; can be competitive with sheet-metal parts; moderate die and equipment costs; high operator skill in processing of composite materials.
Forming and shaping of ceramics	Production of discrete ceramic products by a variety of shaping, drying, and firing processes; low to moderate die and equipment cost; moderate to high operator skill.

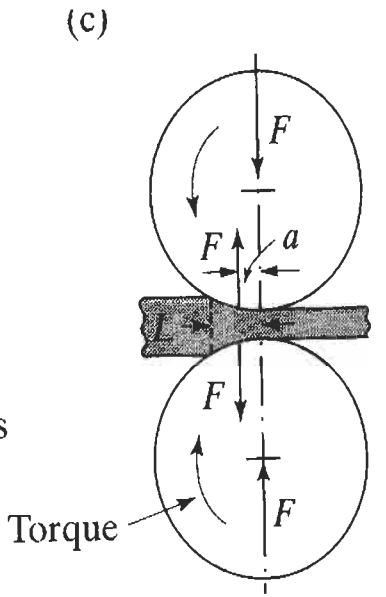
Flat rolling process



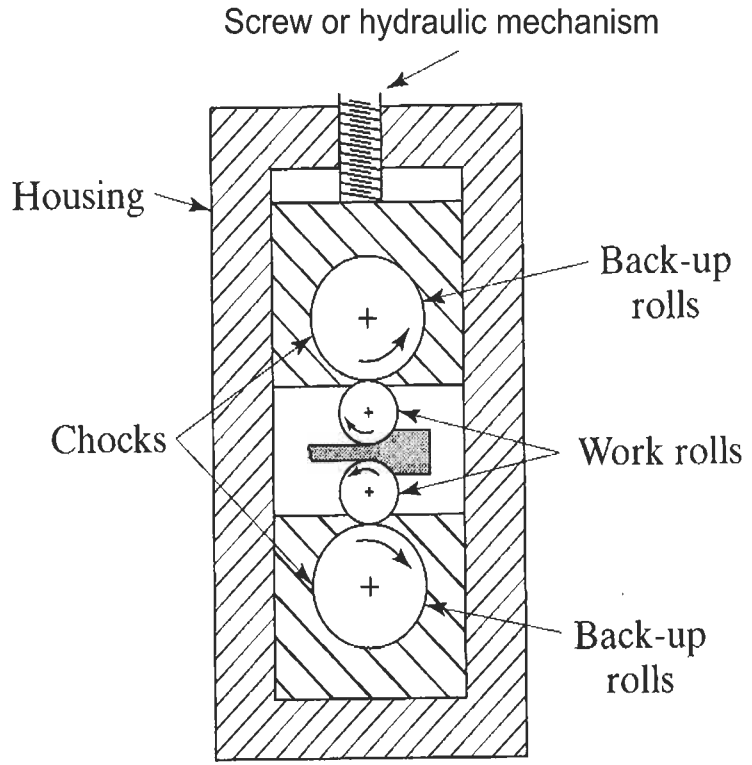
Friction Forces acting on strip surfaces

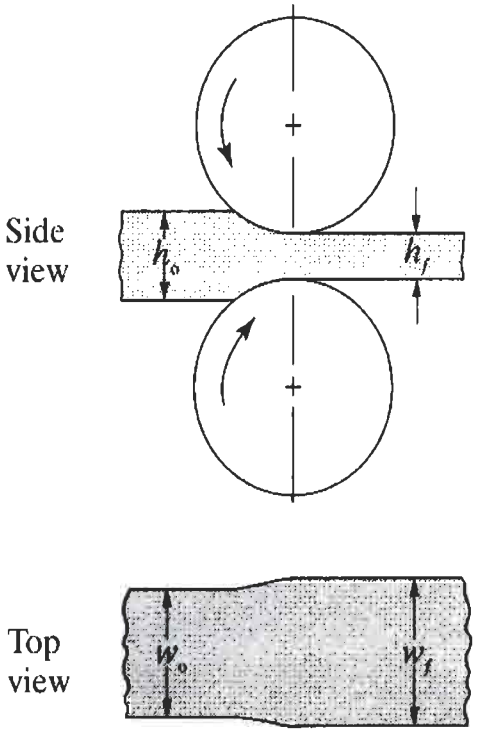


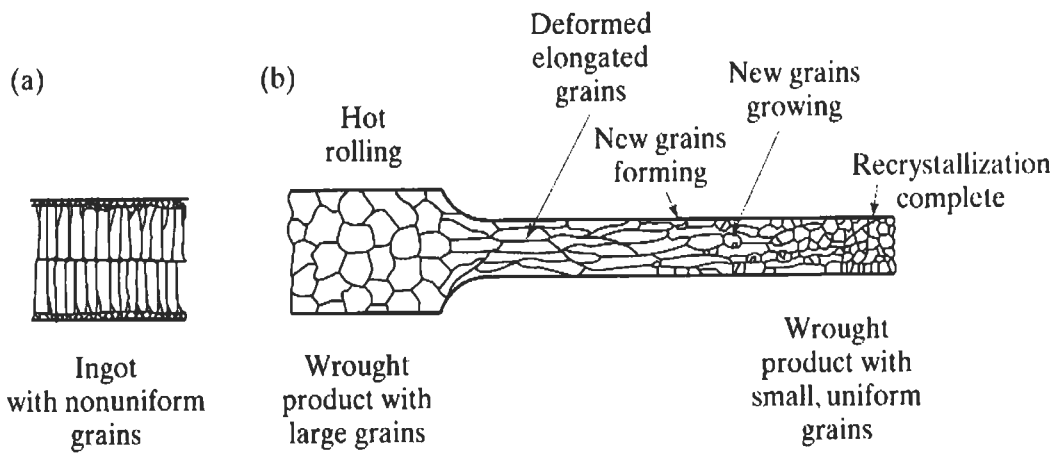
Roll force and torque



FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Flat rolling**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 2-a**

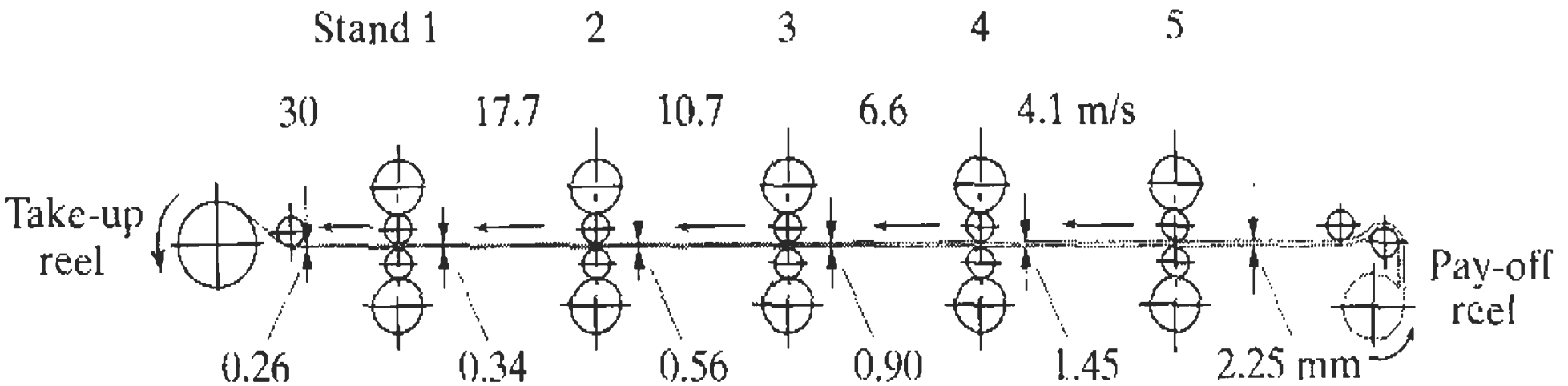






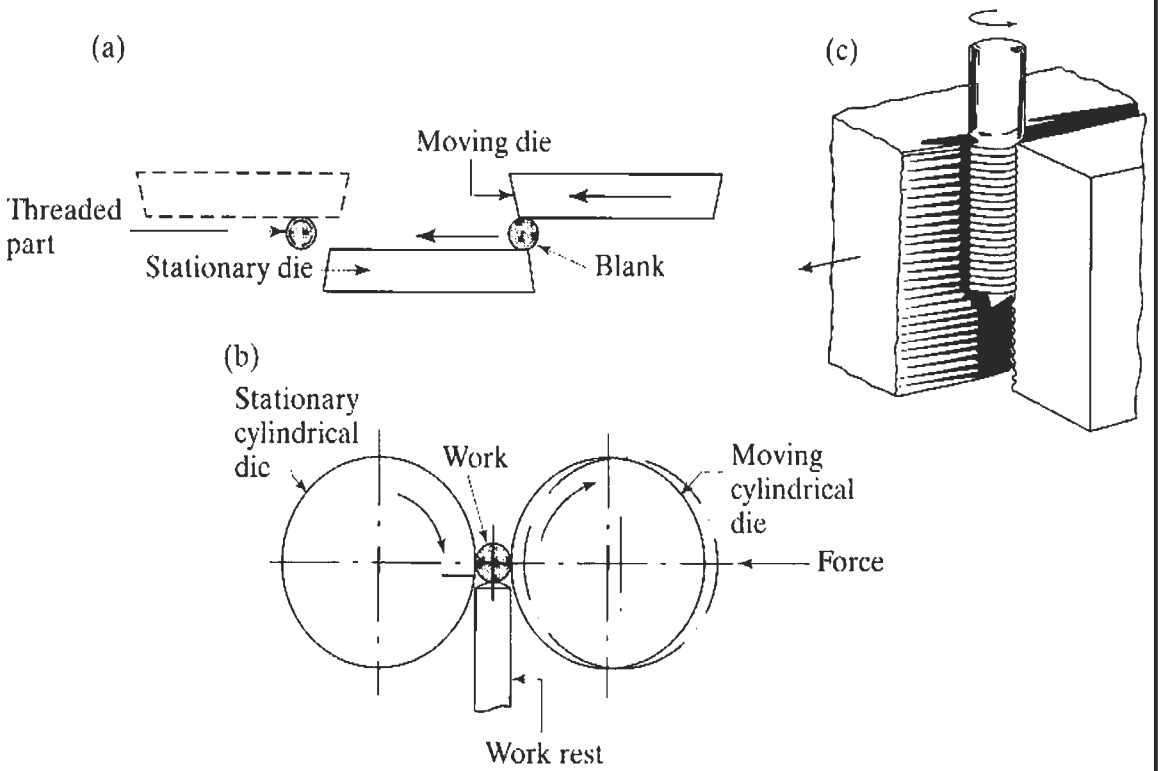
Changes in the grain structure.
Hot rolling for reduce grain size.
Better strength and ductility.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Flat rolling**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 3-a**



A tandem rolling operation.

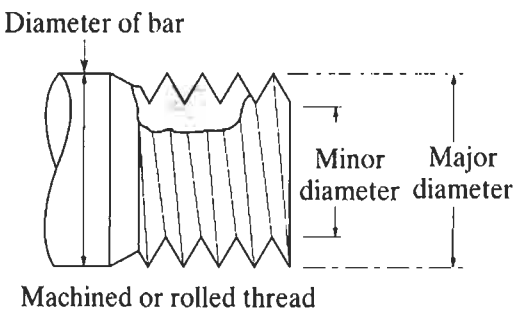
FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* Tandem rolling		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	Mechanical Engineering Department	File:	Figure 4-a

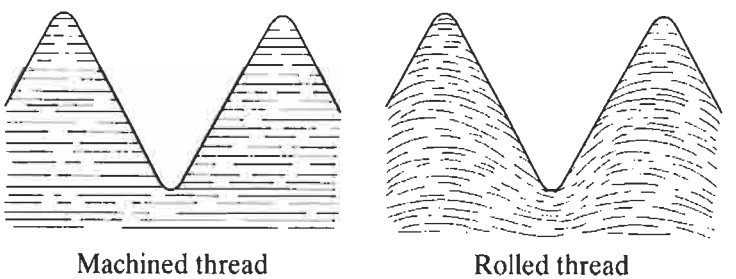


Thread-rolling processes:
(a) and (c) reciprocating flat dies (b) two-roller dies
Economically processes at high rates of production

(a) Features of a machined or rolled thread
(b) Grain flow in machined and rolled threads

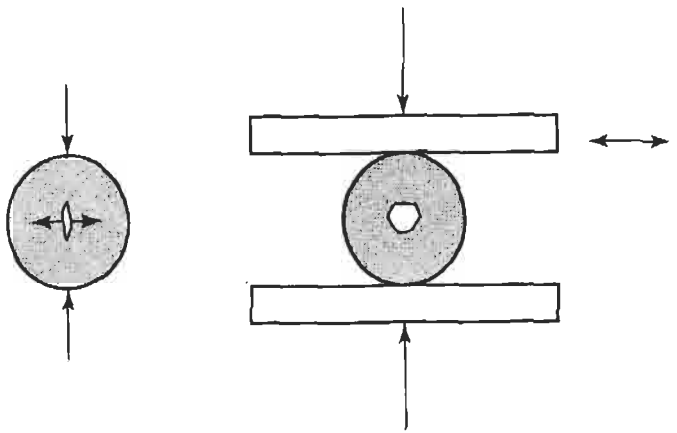
Unlike machining, which cuts through the grains of the metal, the rolling of threads causes improved strength, because of cold working and favorable grain flow.

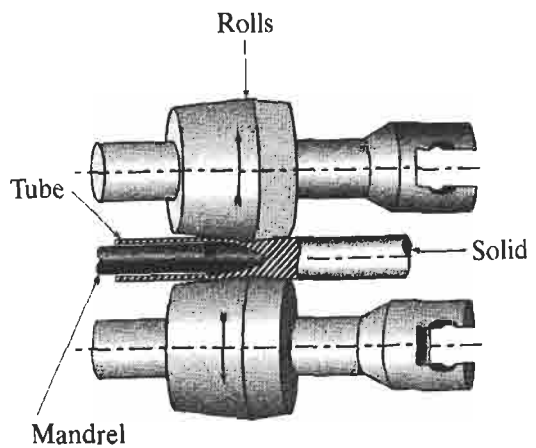


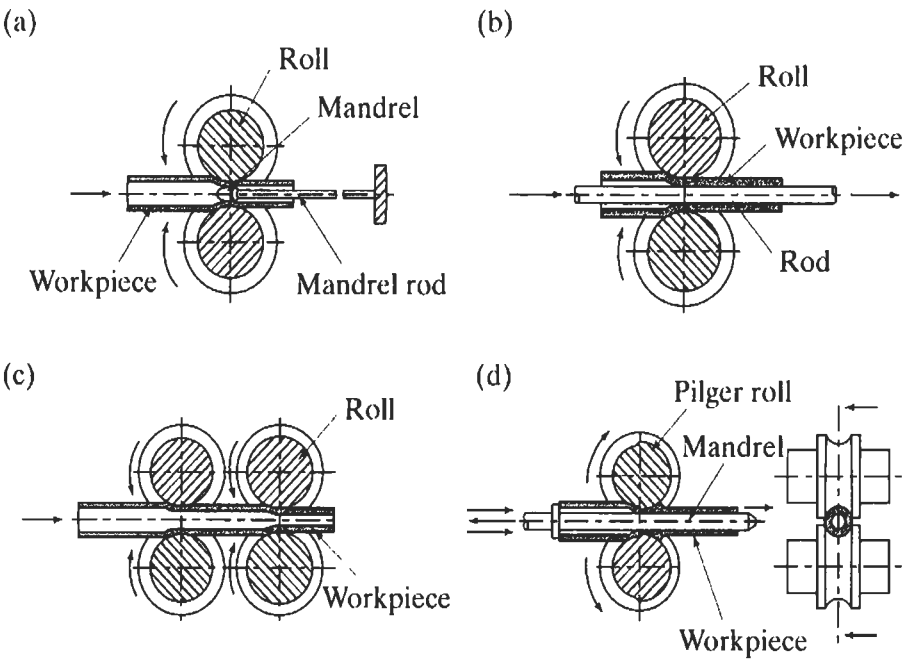


FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Thread rolling processes**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 5-a**

Cavity formation in a solid round bar and its utilization in the rotary tube piercing process for making seamless pipe and tubing



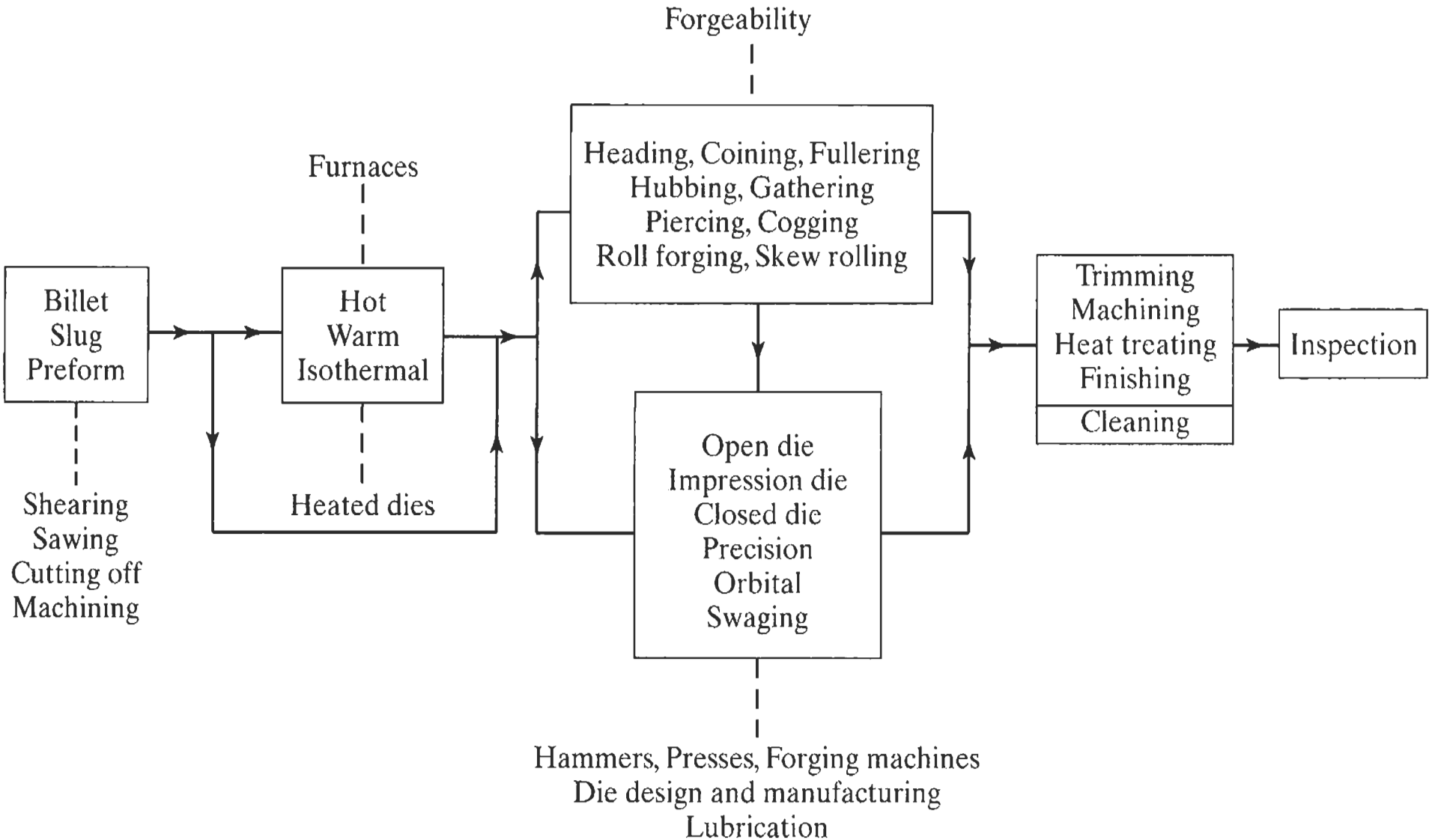




Various tube-rolling processes:
(a) With fixed mandrel
(b) With moving mandrel
(c) Without mandrel
(d) Pilger rolling over a mandrel and a pair of shaped rolls

Tube diameters and thicknesses can also be changed by other processes, such as drawing, extrusion, and spinning.

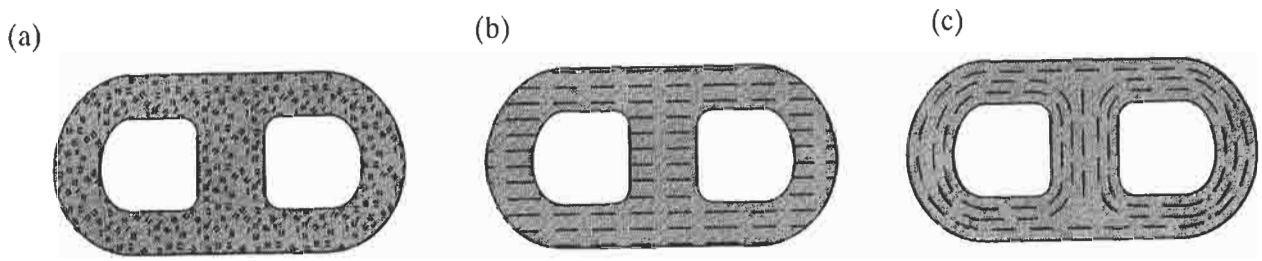
FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Tube rolling processes**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 6-a**



FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Forging and related operations**	
	SUBJECT: Manufacturing Processes	
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:** **Figure 7-a**

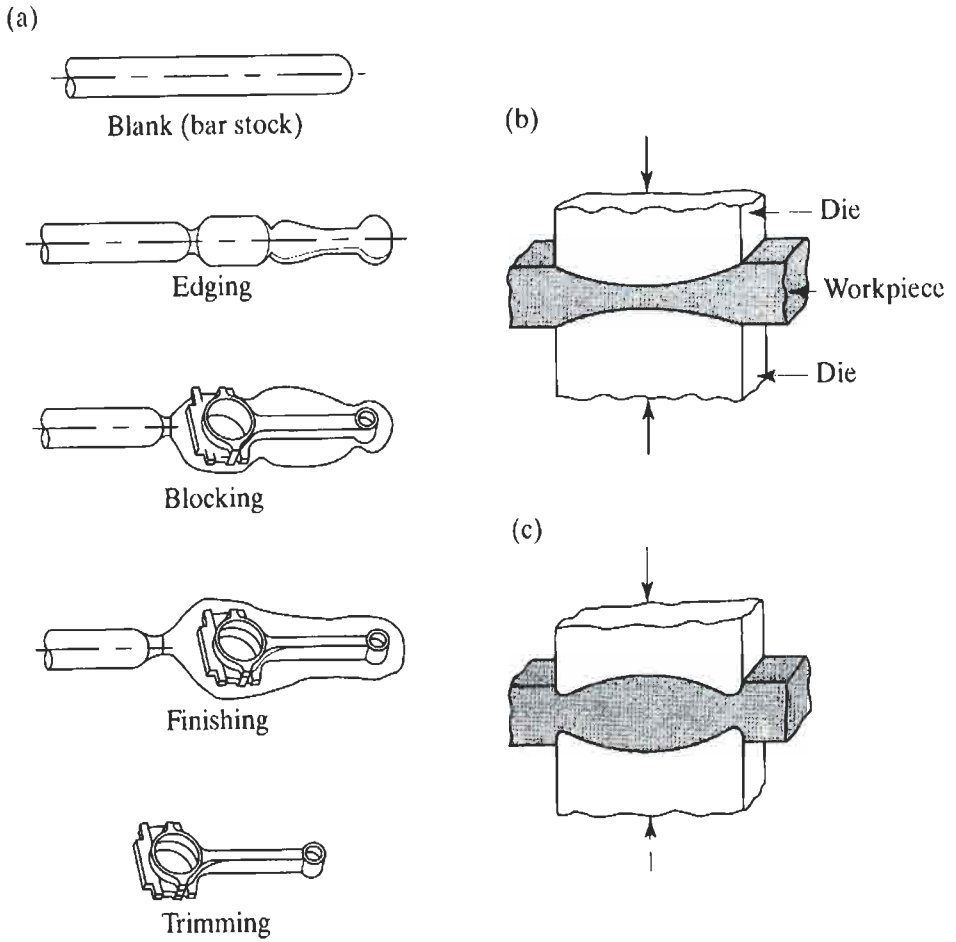
Characteristics of Forging Processes

Process	Advantages	Limitations
Open die	Simple, inexpensive dies; useful for small quantities; wide range of sizes available; good strength characteristics	Limited to simple shapes; difficult to hold close tolerances; machining to final shape necessary; low production rate; relatively poor utilization of material; high degree of skill required
Closed die	Relatively good utilization of material; generally better properties than open-die forgings; good dimensional accuracy; high production rates; good reproducibility	High die cost for small quantities; machining often necessary
Blocker type	Low die costs; high production rates	Machining to final shape necessary; thick webs and large fillets necessary
Conventional type	Requires much less machining than blocker type; high production rates; good utilization of material	Somewhat higher die cost than blocker type
Precision type	Close tolerances; machining often unnecessary; very good material utilization; very thin webs and flanges possible	Requires high forces, intricate dies, and provision for removing forging from dies

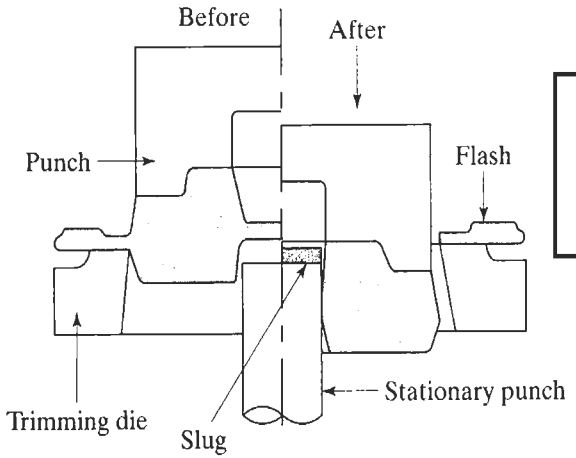


A part made by three different processes, showing grain flow.
(a) casting, (b) machining, (c) forging

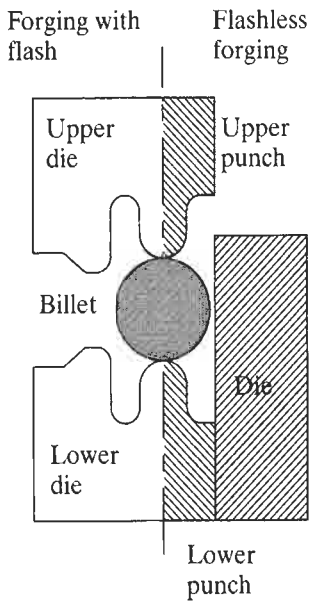
FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Characteristic of forging processes**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 8-a**



(a) Stages in forging a connecting rod for an internal combustion engine. The amount of flash required to ensure proper filling of the die cavities
(b) Fullering
(c) Edging operations to distribute the material when preshaping the blank for forging

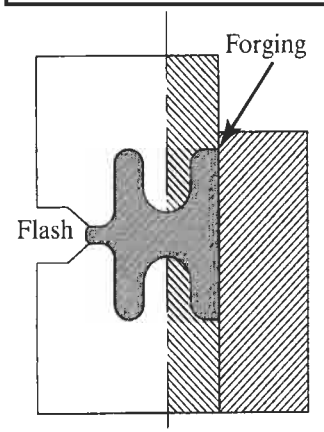


Trimming flash from a forged part. The thin material at the center is removed by punching



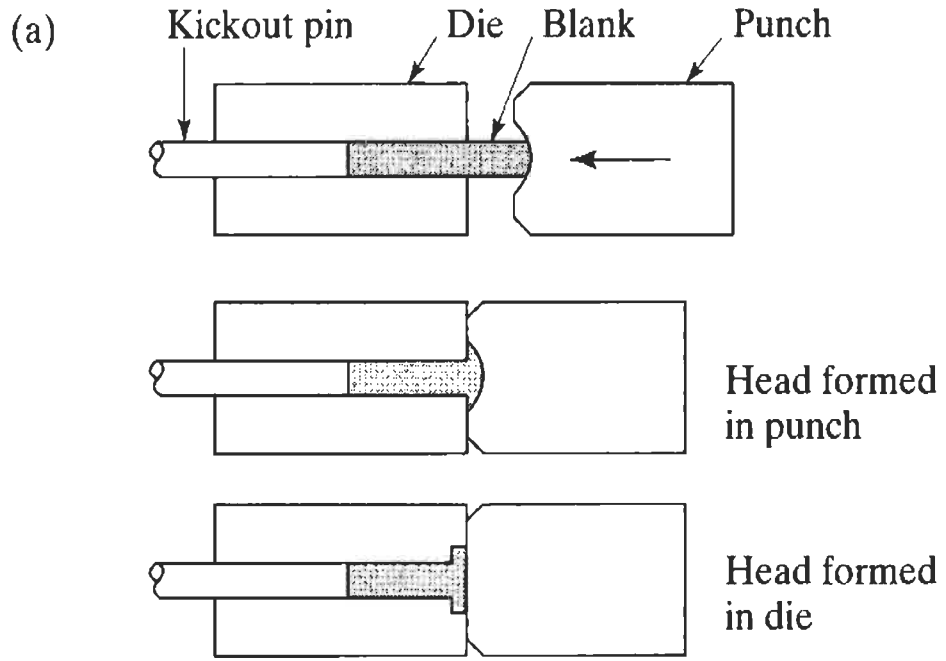
(a) Start of stroke

Comparison of closed-die forging to precision or flashless forging of a cylindrical billet.

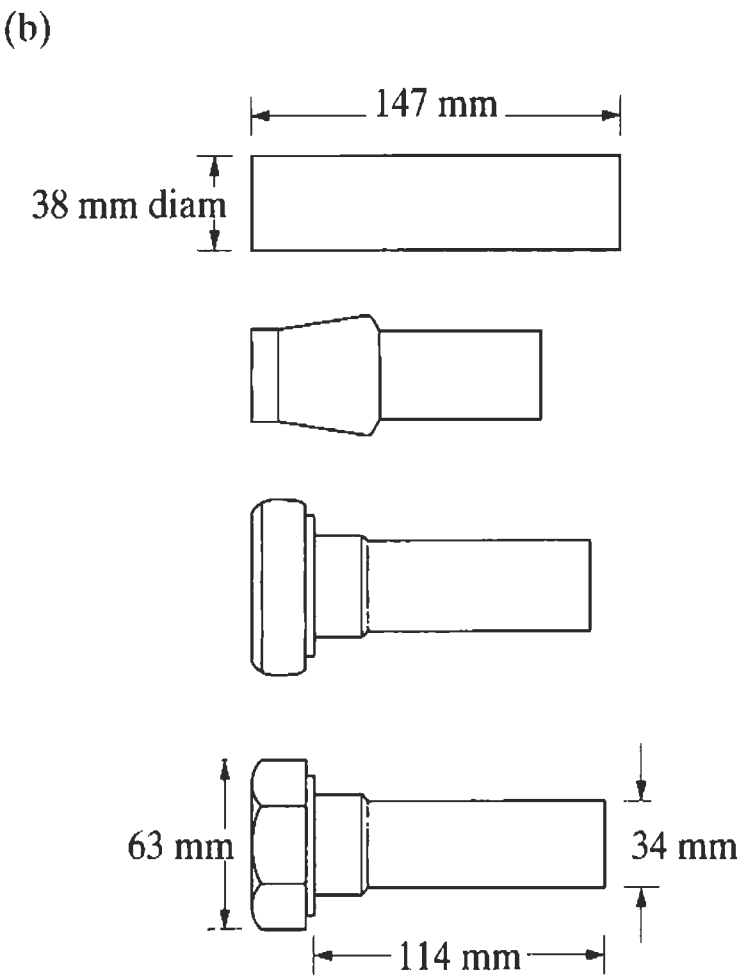


(b) End of stroke

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Forging processes**	
	SUBJECT: Manufacturing Processes	
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:** **Figure 9-a**

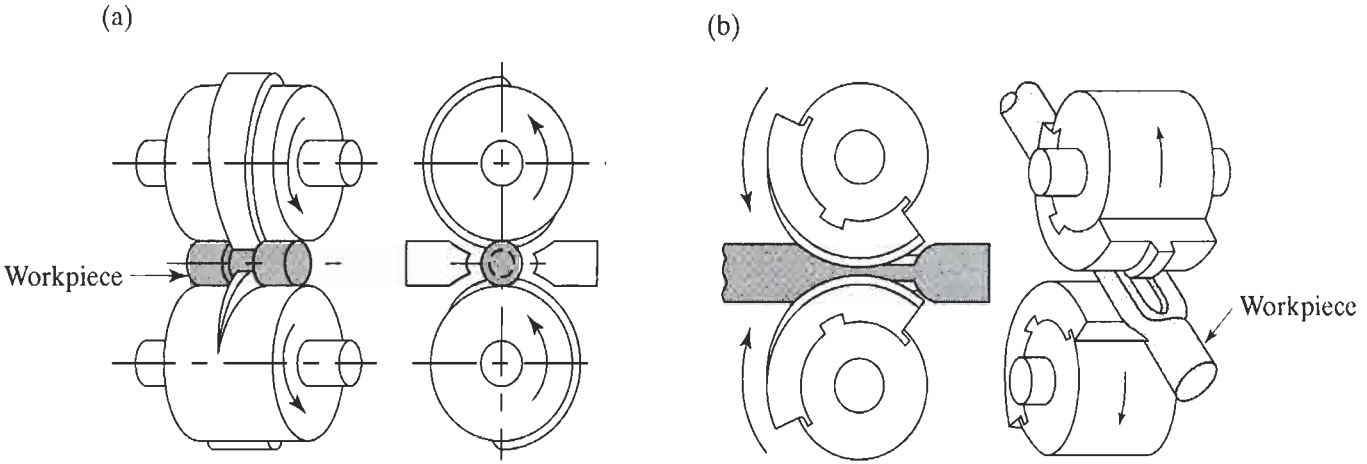


(a) Heading operation, to form heads on fasteners such as mails and rivets

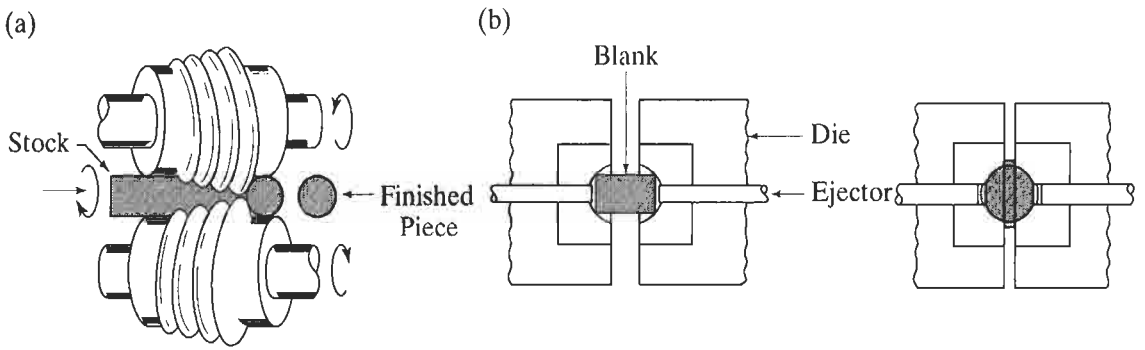


(b) Sequence of operations to produce a bolt head by heading

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* Heading operation and production of a bolt head	
	SUBJECT: Manufacturing Processes	
Instructor: Dr. A. Lontos	Mechanical Engineering Department	File: Figure 10-a

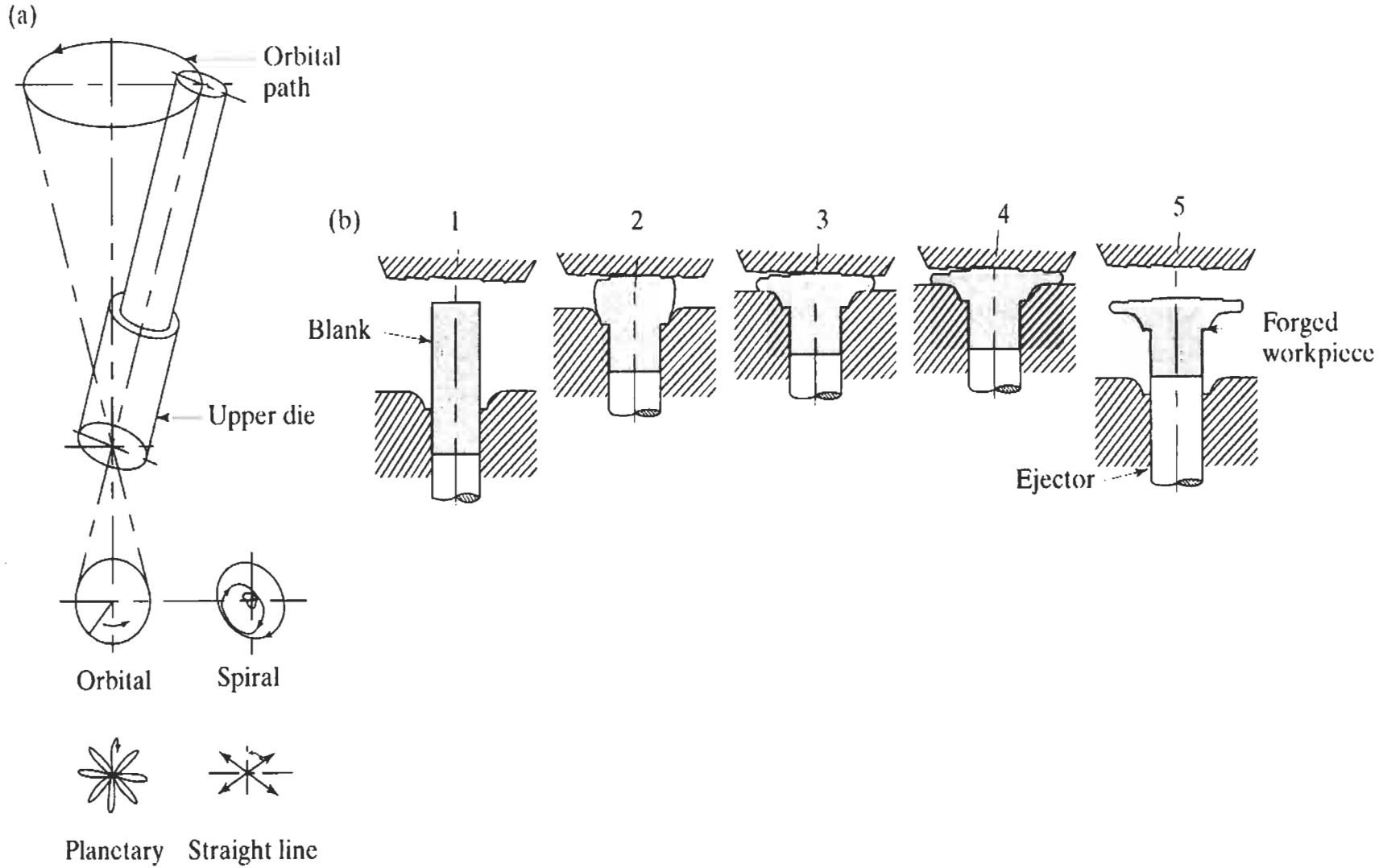


Two examples of the roll-forging operation, also known as *cross-rolling*. Tapered leaf springs and knives can be made by this process.



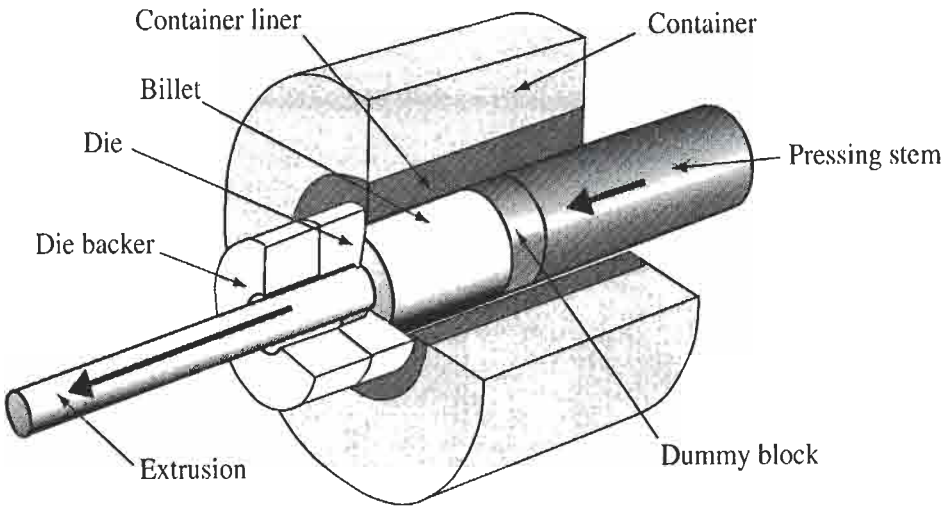
(a) Production of steel balls by the skew-rolling process. (b) Production of steel balls by upsetting a cylindrical blank. Note the formation of flash. The balls made by these processes are subsequently ground and polished for use in ball bearings

FREDERICK INSTITUTE OF TECHNOLOGY	***Title:*** **Cross and skew rolling process**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 11-a**



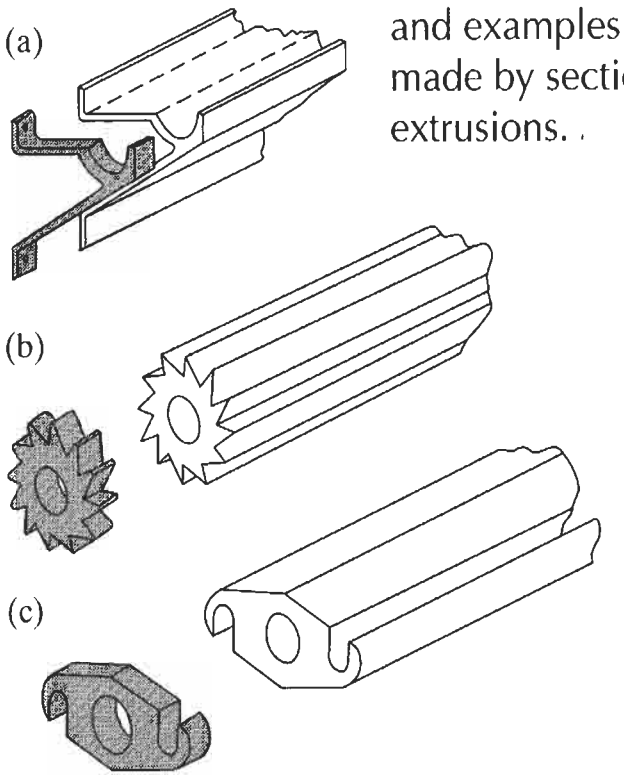
(a) Various movements of the upper die in orbital forging (also called rotary, swing, or rocking-die forging); the process is similar to the action of a mortar and pestle. (b) An example of orbital forging. Bevel gears, wheels, and rings for bearings can be made by this process.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Movements during forging**	
	SUBJECT: Manufacturing Processes	
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:** **Figure 12-a**

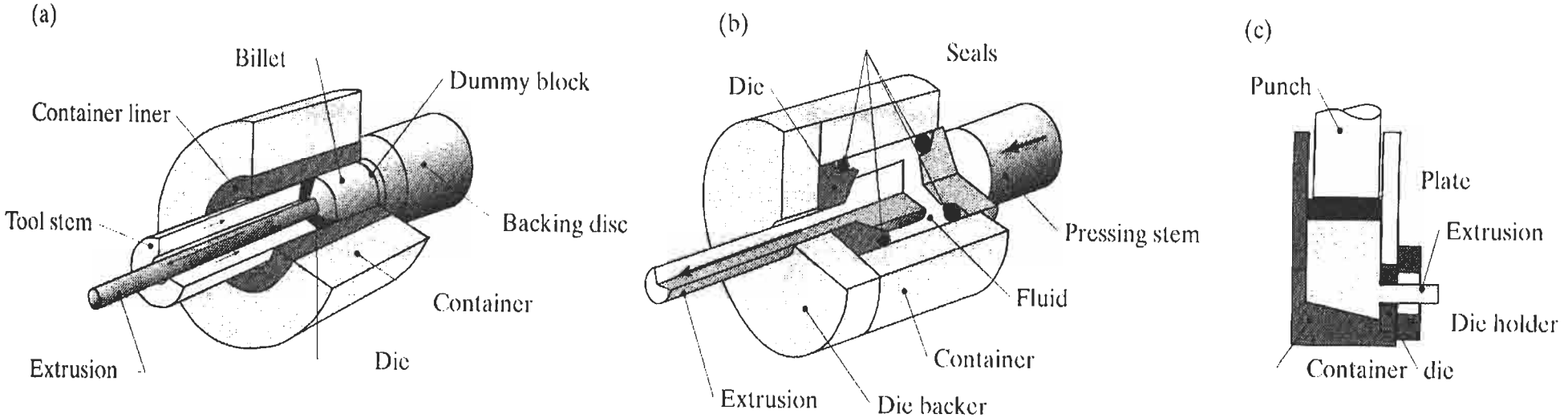


Schematic illustration of the direct extrusion process.

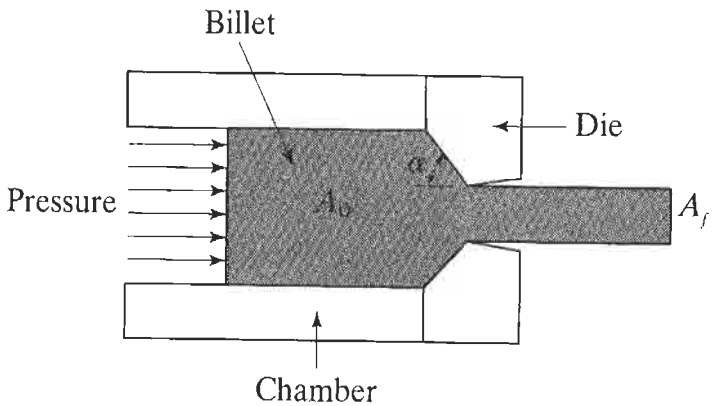
Extrusions, and examples of products made by sectioning off extrusions. .



FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Extrusion processes**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 13-a**

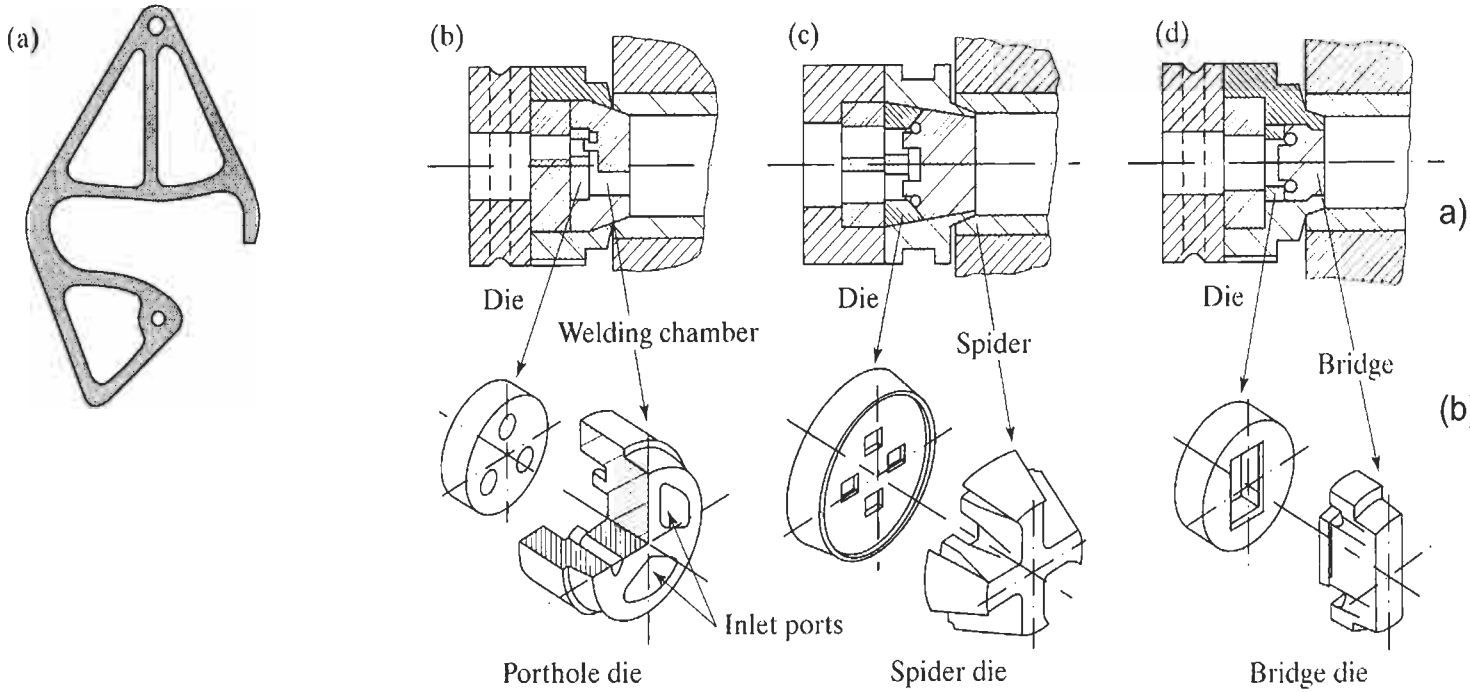


Types of extrusion: (a) indirect; (b) hydrostatic; (c) lateral.



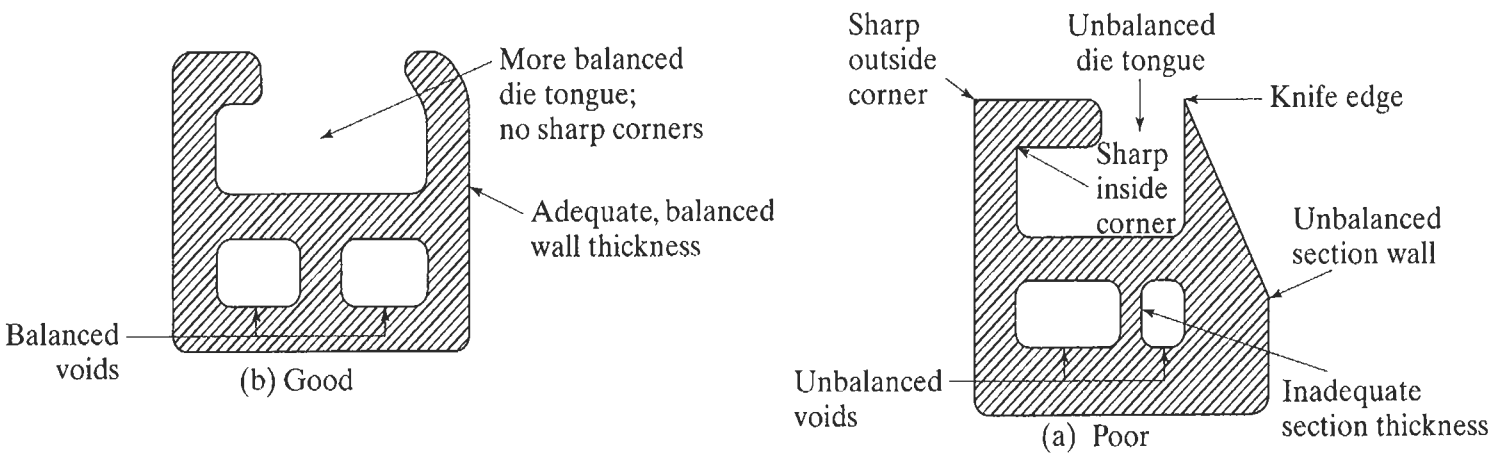
Process variables in direct extrusion. The die angle, reduction in cross-section, extrusion speed, billet temperature, and lubrication all affect the extrusion pressure.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Various types of extrusion**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 14-a**



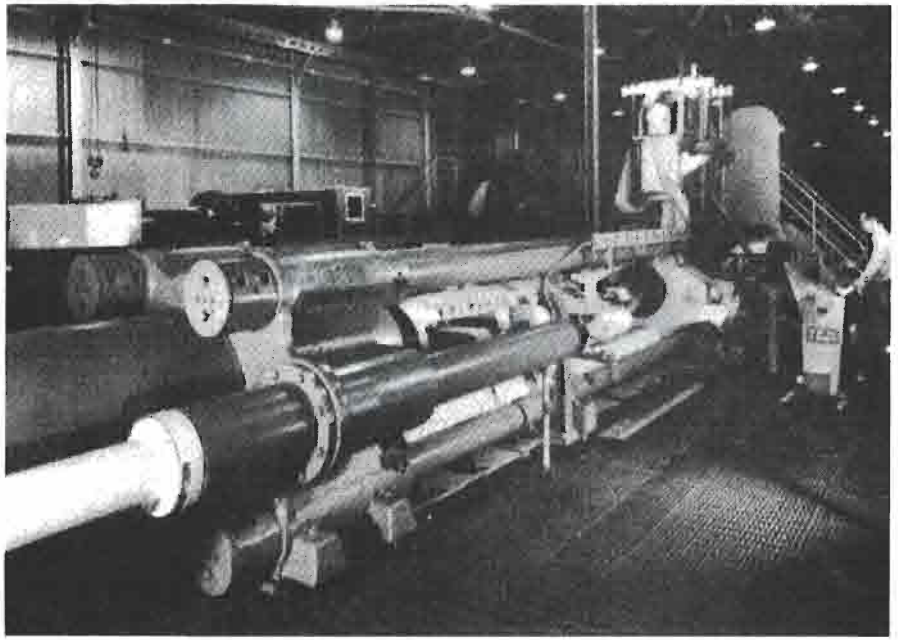
a) An extruded 6063 aluminum lock adder lock for aluminum extension ladders. This part is 8 mm thick and is sawed from the extrusion

(b)-(d) Components of various dies for extruding intricate hollow shapes.

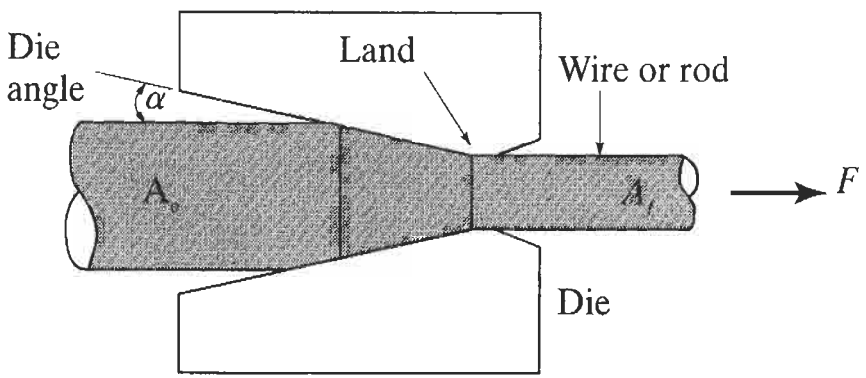


Poor and good examples of cross-sections to be extruded. Note the importance of eliminating sharp corners and of keeping section thicknesses uniform

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Extrusion of aluminum**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 15-a**

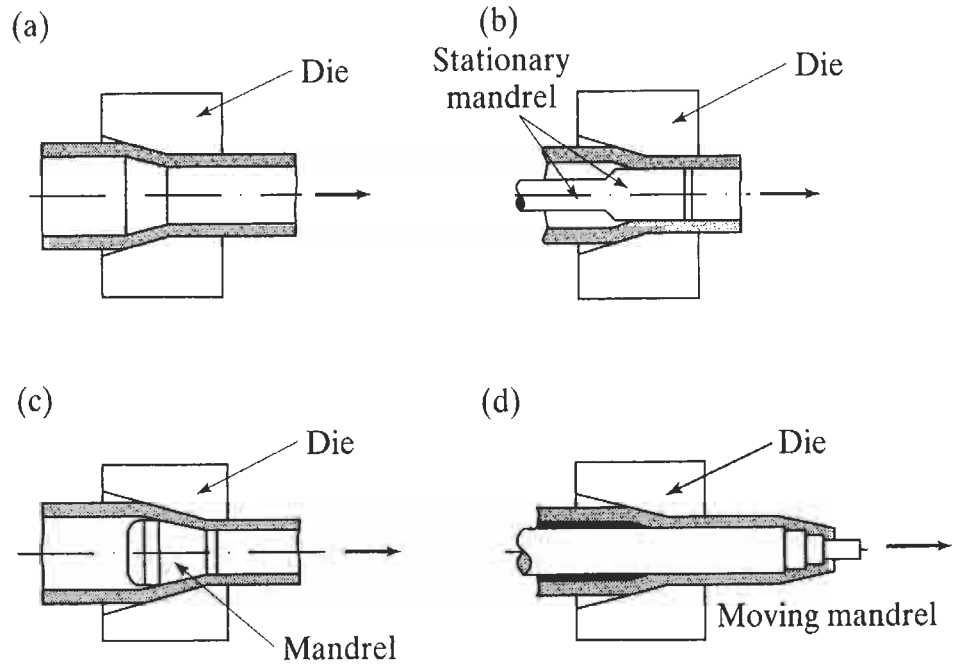


General view of a 9-MN (1000-ton) hydraulic-extrusion press.

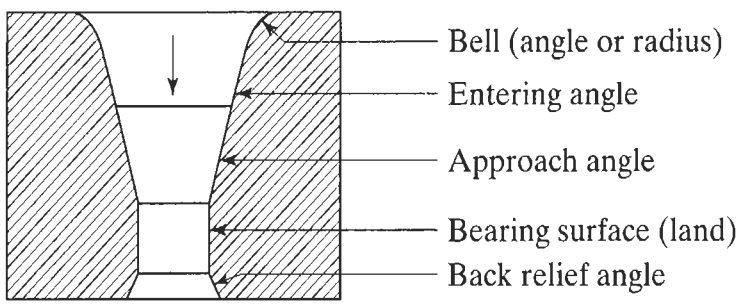


Process variables in wire drawing. The die angle, the reduction in cross-sectional area per pass, the speed of drawing, the temperature, and the lubrication all affect the drawing force, F.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Extrusion equipment - Wire drawing**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 16-a**



Examples of tube-drawing operations, with and without an internal mandrel.
Note that a variety of diameters and wall thicknesses can be produced from the same initial tube stock (which has been made by other processes).



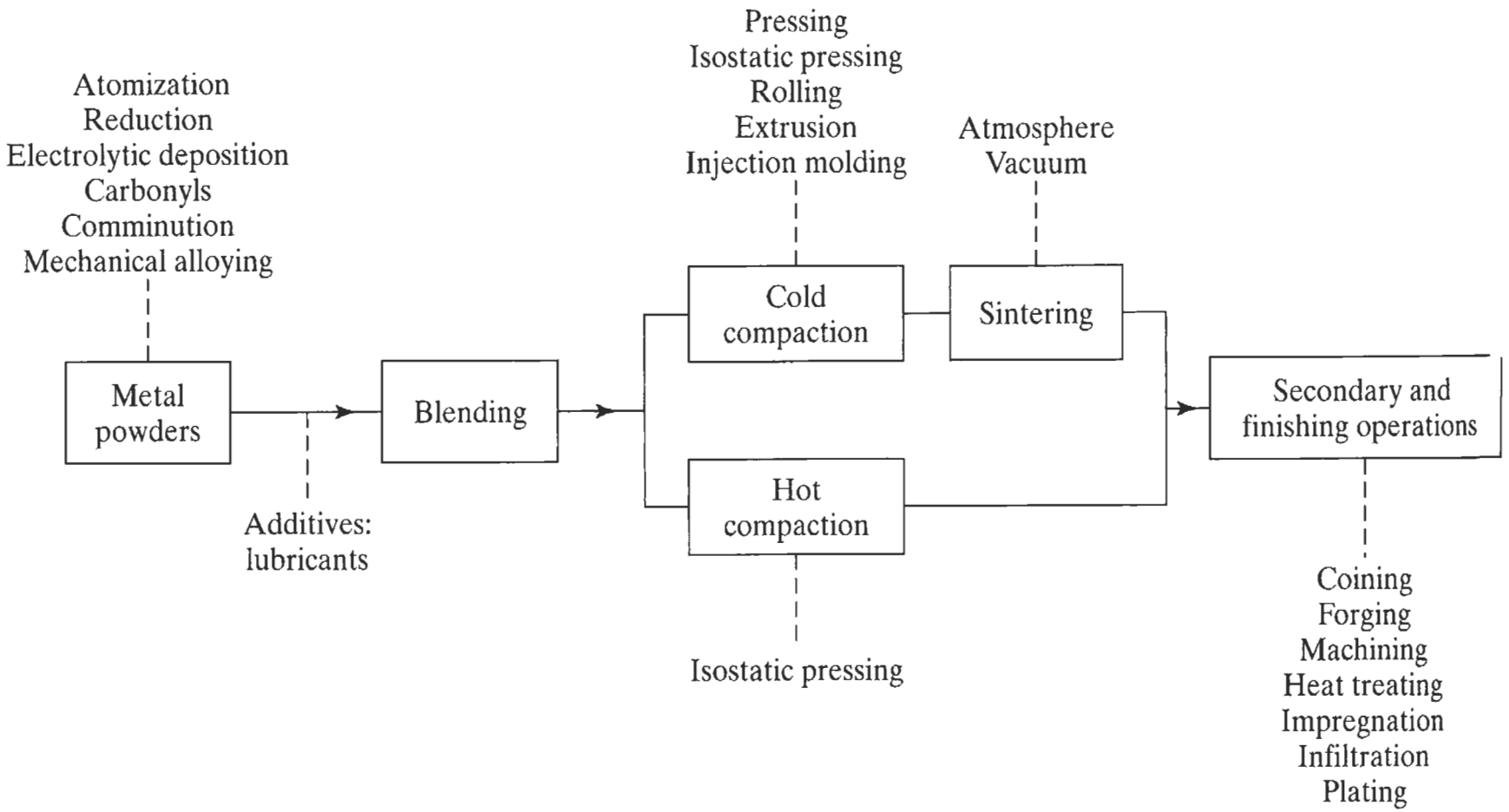
Terminology of a typical die used for drawing round rod or wire.

The wires produced can be as small as 4 μm in diameter. They can be made from such materials as stainless steels, titanium, and high-temperature alloys.

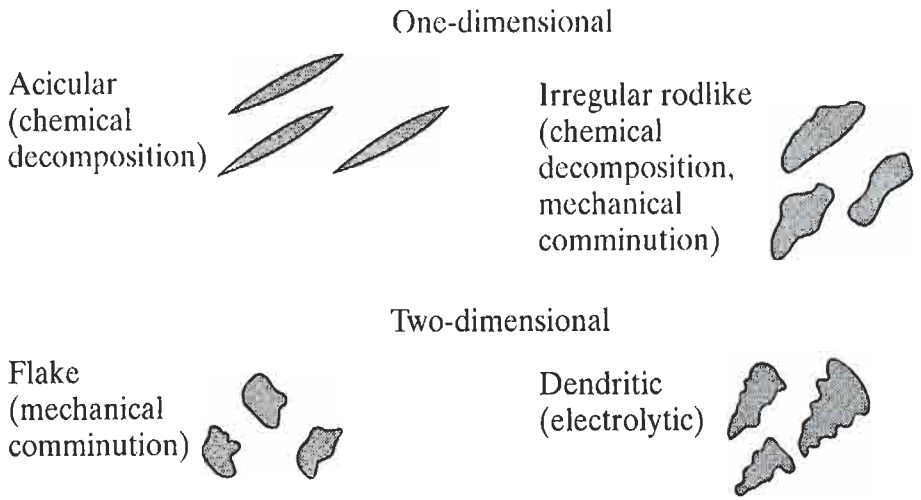
Die angles usually range from 6° to 15°.

FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Extrusion equipment - Wire drawing**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 17-a**

Outline of processes and operations involved in making powder-metallurgy parts.



FREDERICK INSTITUTE OF TECHNOLOGY	*Title:* **Production of powder metallurgy-parts**	
	SUBJECT: Manufacturing Processes	
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:** **Figure 18-a**



Methods of Powder Production

Particle sizes range from 0.1 μm 1000 μm. Metal sources are generally bulk metals and alloys, ores, salts, and other compounds.

The shape, the size distribution, the porosity, the chemical purity, and the bulk and surface characteristics of the particles depend on the particular process used.

FREDERICK INSTITUTE OF TECHNOLOGY	***Title:*** **Particle shapes of metal powders - Production method**		
	SUBJECT: Manufacturing Processes		
Instructor: Dr. A. Lontos	**Mechanical Engineering Department**	**File:**	**Figure 19-a**