

ME -215 ENGINEERING MATERIALS AND PROCESSES

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Lectures: F (Sec-002-1:00 pm-2:25 pm, MEC224
Sec-104- T- 5:45 pm- 7:40 pm MEC 224)

Labs: Sec-002 F-9:15 am-11:25 am MEC232;
Sec-104- T-7:45 pm- 9:45 pm ME 232;

Office Hours: Tuesday 3:00 pm-4:00 pm

Objectives of the of Course

- To combine lectures and laboratory practice as introduction to: Engineering Materials and Manufacturing Processes
- Key objectives:
 - Introduction to engineering materials and alloy design;
 - Introduction to microstructure-properties relations;
 - Introduction to manufacturing processes;
 - Laboratory report writing practice.
- Textbook: E. Paul De Garmo, J.T.Black, R.A. Kohser, Materials and Processes in Manufacturing, 10th edition, NY, 2009

More specifically

- Establish foundation of engineering thinking;
- Expand engineering communication means;
- Expand foundation of engineering knowledge;
- Practice new problem solving techniques;
- Preparation for advanced ME courses;

Tests & home assignments

- Three closed book tests will be given (5th week, 11th week and final exam);
- Homework is due first 5 minutes of next lecture;
- Laboratory report due one week after completion of lab practice at the beginning of next lab session;

Grading and performance

- Homework-5%, Laboratory reports& performance-30%, Test 1-20%, Test 2-20%, Final exam-25%.
- Detailed explanation of lab manual, lab rules and requirements posted at: ME home page-undergraduate-ME 215. Print it and have it ready for next class;
- Be ready for the lecture and lab practice (read assigned material prior to class) and bring with you printed material to the class;
- Submit homework and lab reports on time or you loose;
- HW assignments posted on ME 215 syllabus.

1.1 Materials, Manufacturing, and the Standard of Living

- Standard of living of a society is determined by the goods and services that are available to its people
- Manufactured goods
 - Producer goods:
 - Intermediate goods used to manufacture either producer or consumer goods
 - Consumer goods:
 - Purchased directly by the consumer

History of Materials

- The development of materials and man's ability to process them is linked to the history of man
 - Stone Age
 - Copper and Bronze Age
 - Iron Age
 - Steel Age
- The current age is that of plastics, composite materials, and exotic alloys

Important Dates in Technologies Development

- B. Pascal- Mechanical calculator, France, 1642
- Industrial revolution, England, 1760
- Vertical lathe machine, USA, 1840
- H. Ford- Conveyer assembly line, USA, 1913
- J. von Newman- Principles of computer programming, USA, 1945
- Industrial robot (cylindrical config.), USA, 1959
- EXAPT- Programming language, W. Germany, 1966
- Microprocessors, CNC, CIM, 1970
- Intelligent automation, automatic production cells, PC, USA, 1980
- Engineering revolution, 1997 (ongoing)

Impact on Societies

- From Stone age until nowadays tools design and development controlled the pace of engineering advancement;
- Bronze age led to rise of empires;
- Printing press (1450) led to expansion of literacy, knowledge;
- Industrial revolution, 1760, led to the fastest advances of all aspects of human existence;
- Engineering revolution, 1997, computer based means for simulation and optimization shortened the time from the concept and sellable product.

Wheel Evolution



- Dated around 2700 B.C. this ancient wooden wheel is one of the oldest known wheels in Europe.

Product Development

- Sustaining technology:
 - Innovations bring more value to the consumer
 - Improvements in materials, processes, and design
- Product growth normally follows the “S” curve

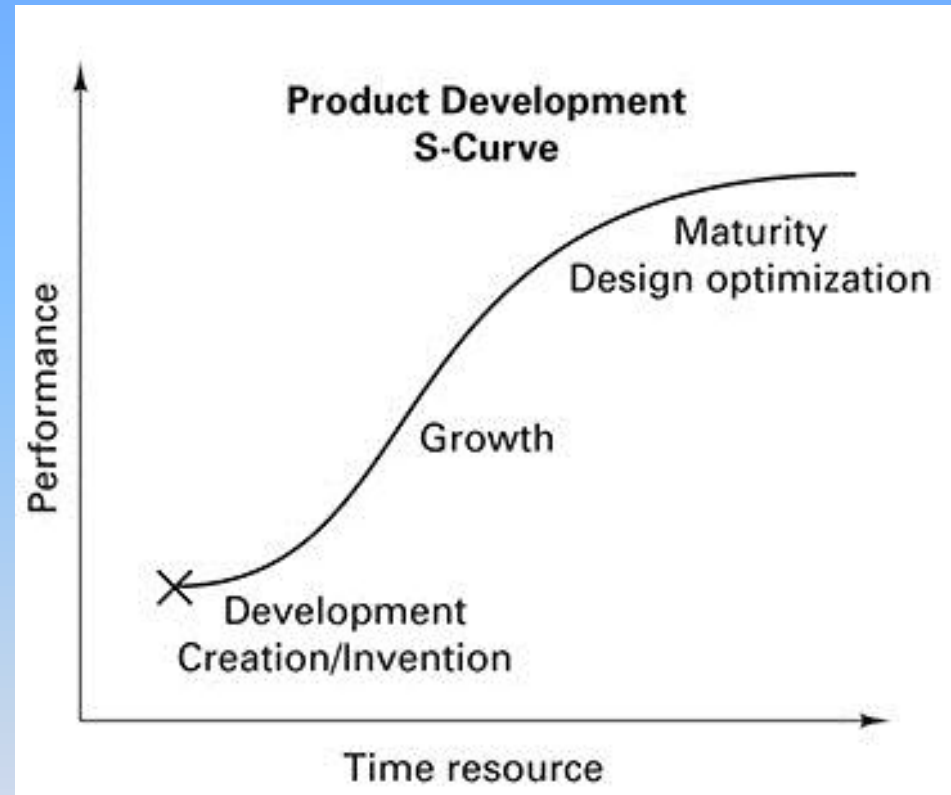
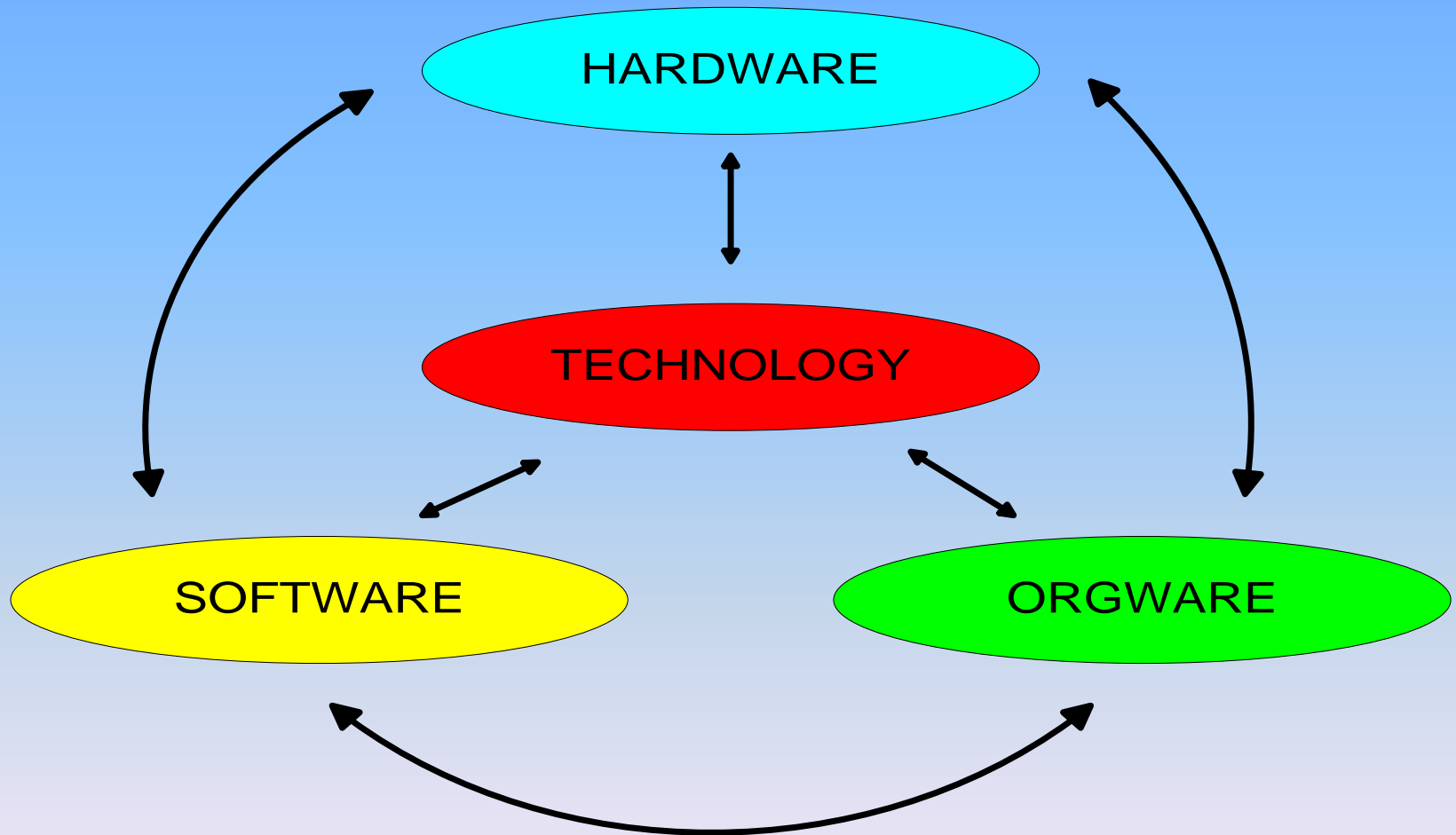
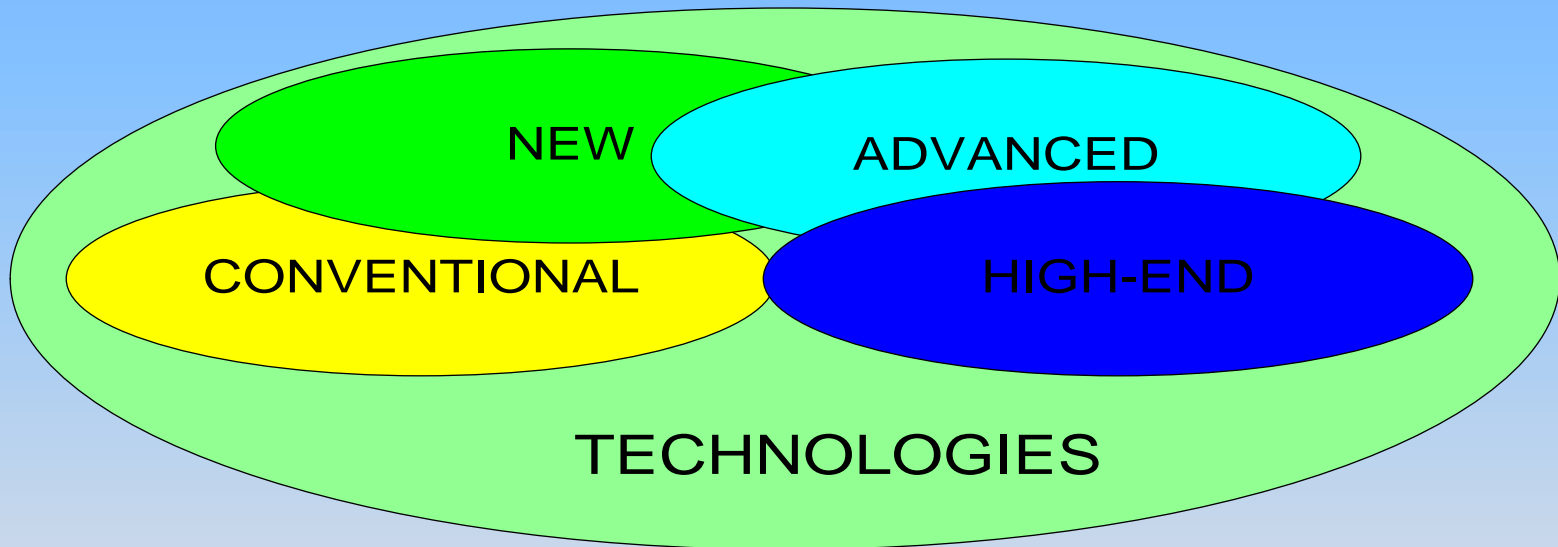


Figure 1-1a) A product development curve

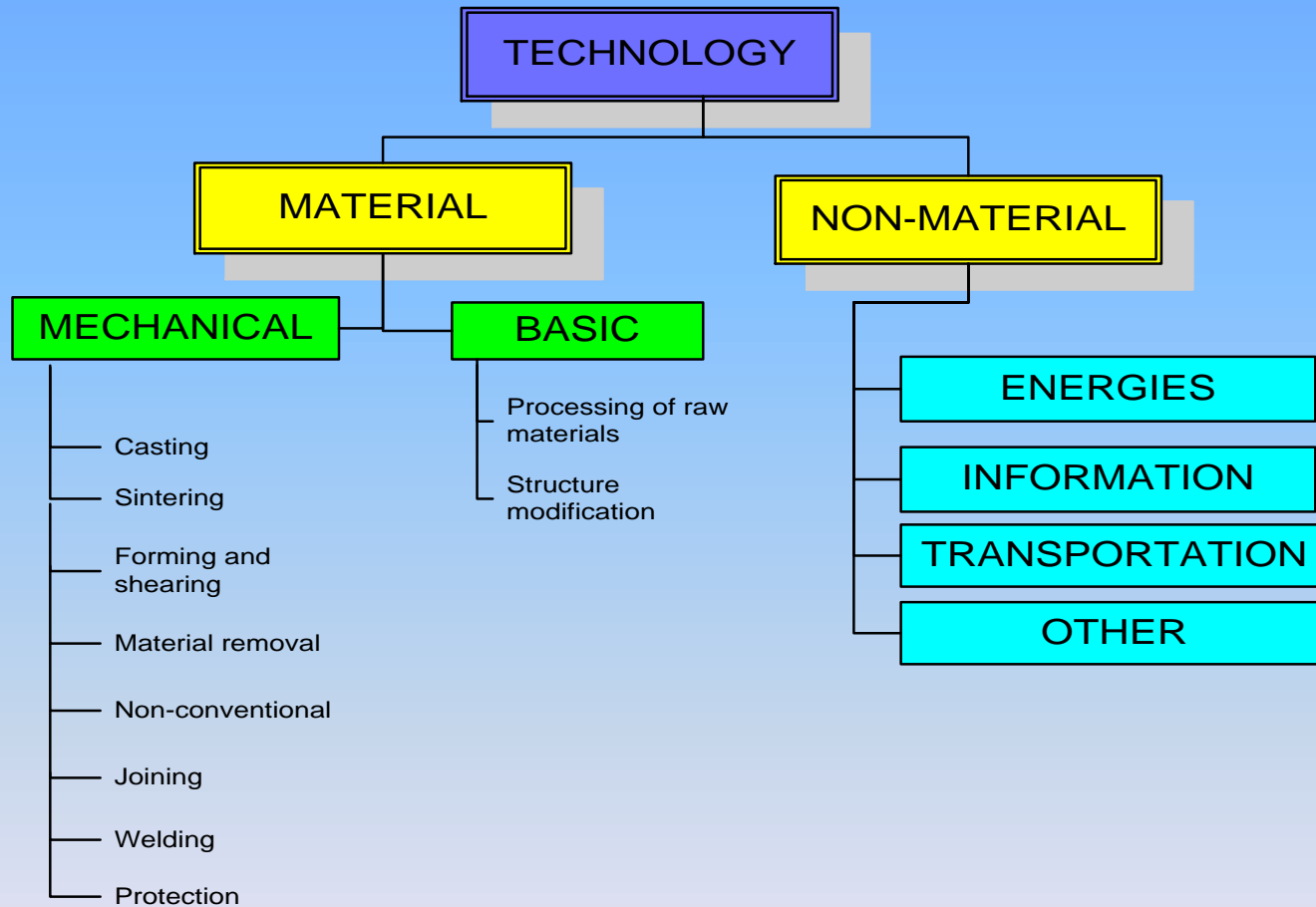
Technology



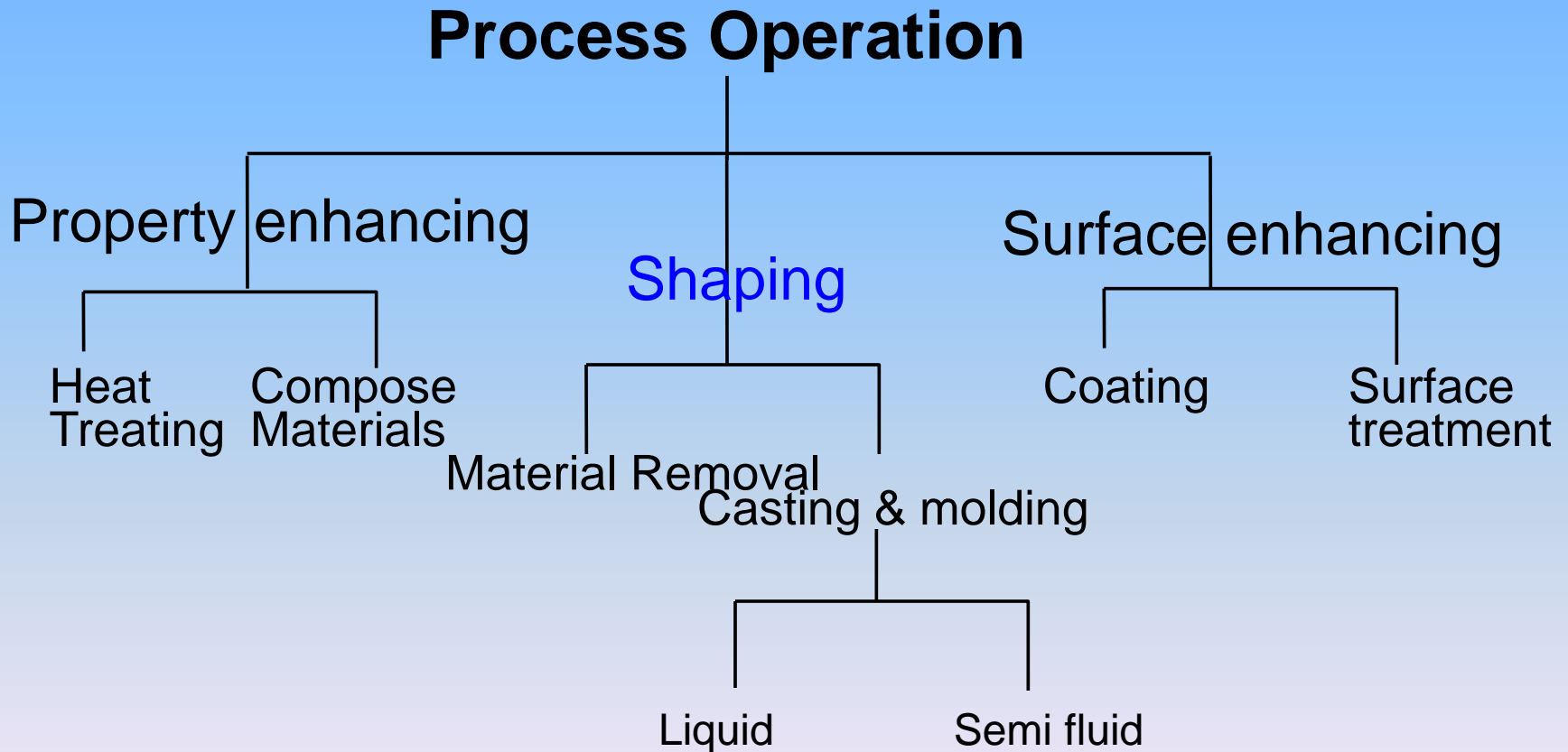
Structural Development of Technologies



General Technology Classification



Basic Manufacturing Processes

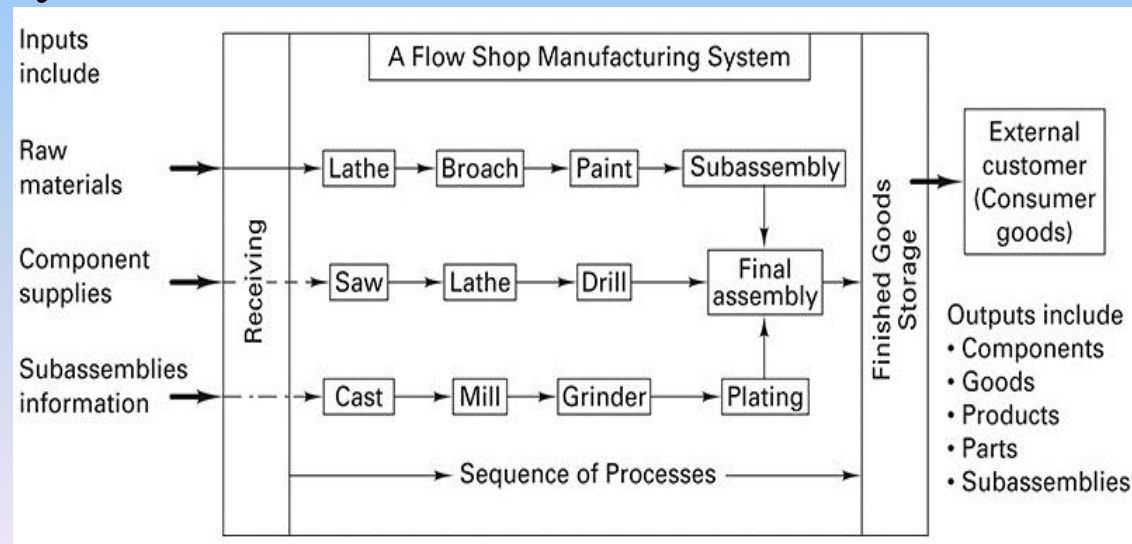


1.2 Manufacturing and Production Systems

- Manufacturing is the ability to make goods and services to satisfy societal needs
 - Manufacturing processes are strung together to create a manufacturing system (MS)
- Production system is the total company and includes manufacturing systems

Figure 1-3

The manufacturing system converts inputs to outputs using processes to add value to the goods for the external customer.



Manufacturing

- Making goods to satisfy human needs.
- MS-manufacturing system formed by integration of manufacturing processes;
- PS- production system unifies manufacturing system and other areas of the plant for information , design, analysis and control;
- SPS-Service production system(transportation, banking, finance, savings & loan, insurance, health care, utilities, education, communication, entertainment, sporting events, etc).

Common Aspects of Manufacturing

- Job and station
 - Job is a group of related operations generally done at one station
 - Station is the location or area where production is done
- Operations
 - Distinct action to produce a desired result or effect
 - Categories of operations
 - Materials handling and transport
 - Processing
 - Packaging
 - Inspecting and testing
 - Storing

Common Aspects of Manufacturing

- Treatments operate continuously on a workpiece
 - Heat treating, curing, galvanizing, plating, finishing, chemical cleaning, painting
- Tools, tooling and workholders
 - Lowest mechanism in the production is a tool
 - Used to hold, shape or form the unfinished product
- Tooling for measurement and inspection
 - Rulers, calipers, micrometers, and gages
 - Precision devices are laser optics or vision systems that utilize electronics to interpret results

Manufacturing Systems

- The **job shop**: machines situated by function and parts circulated in containers between them;
- The **linked cell shop**: fluently connected manufacturing cells by special information control;
- The **project shop**: product built on the spot of use (bridge, etc);
- The **flow shop**: mass production designated shop with specific manufacturing orientation;
- The **continuous process**: liquid and gasses production systems (oil refineries);

Job Shop

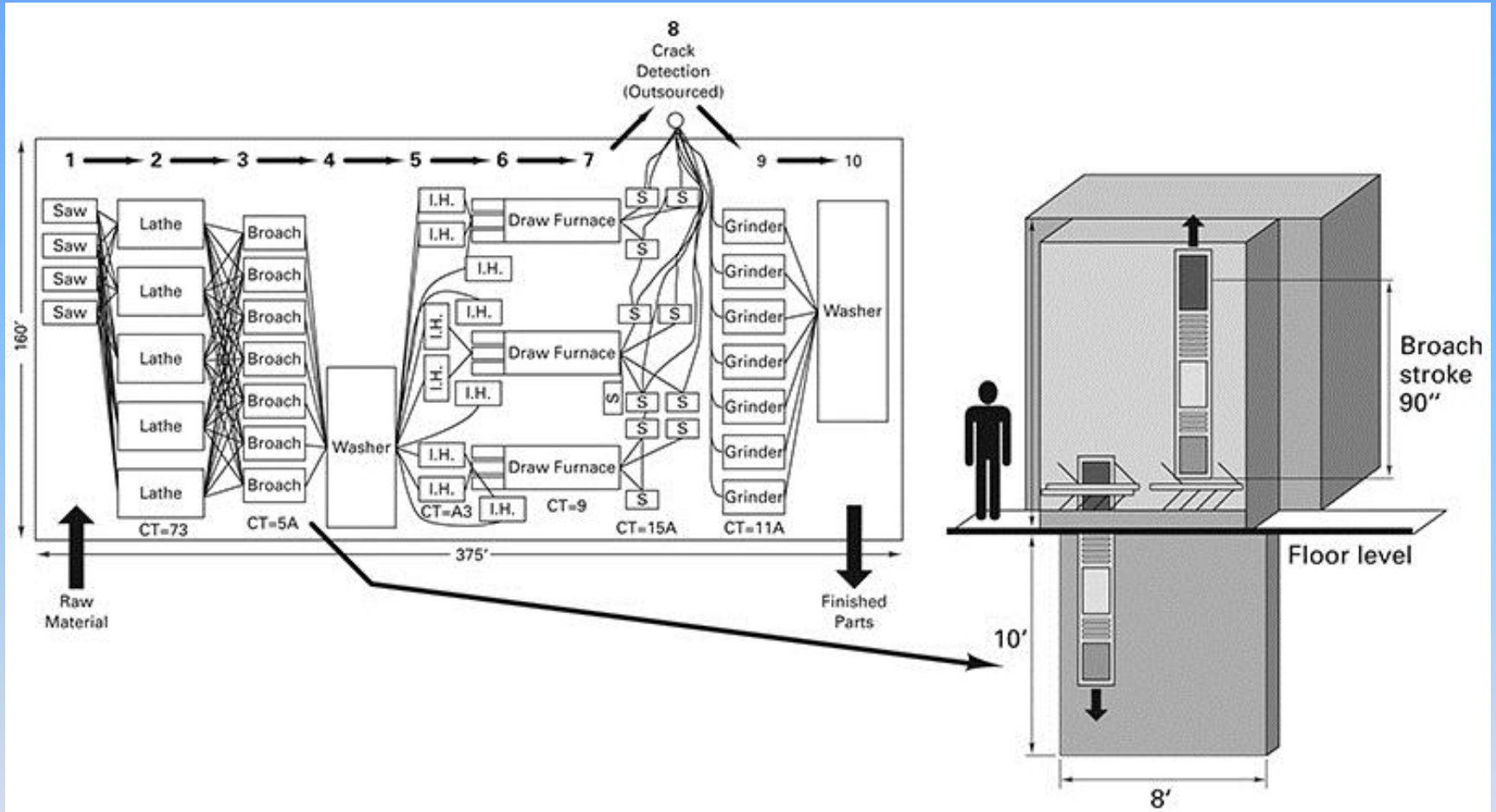
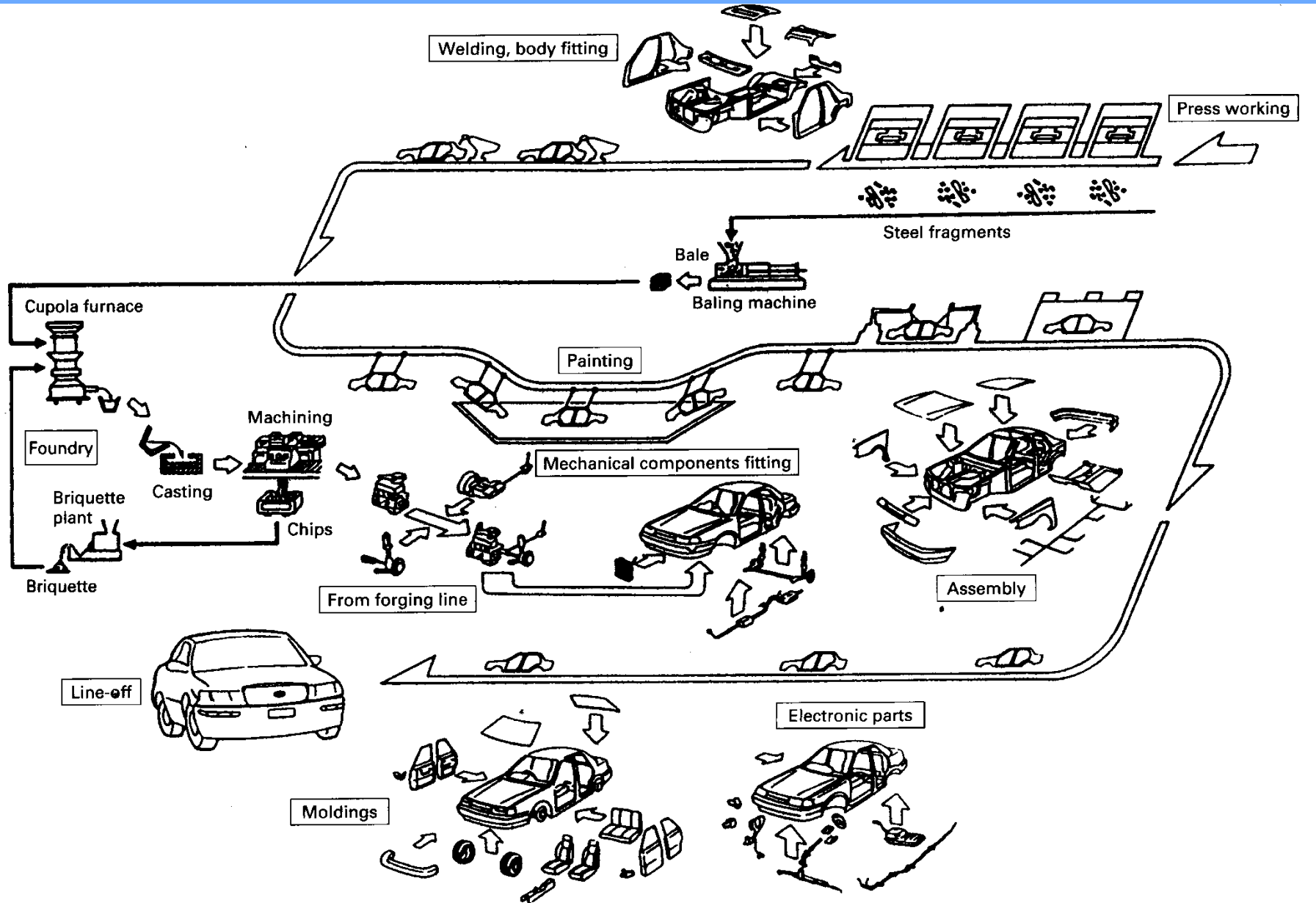


Figure 1-8 This rack bar machining area is functionally designed so it operates like a job shop, with lathes, broaches, and grinders lined up.

Flow Shop Assembly Line



Manufacturing and Society

- Contributes by 20 % to GNP;
- Employs about 18 % of workforce;
- Accounts for 40 % of the exports of the US;

- Producer goods and Consumer goods;
- Converting materials adds value to them (high manufacturing efficiency, high quality, better living standard of employees);

The Manufacturing Process

- Raw material/components are subjected to Manufacturing process (involving machinery, tooling, power, labor and cost) providing con.
- Transformed materials have higher value.
- Raw materials are transformed into: finished goods and/or components.
- Components are transformed into: components and/or finished goods.

Basic Manufacturing Processes

- Surface Processes
 - Coating (electro plating, plasma, thermal spray);
 - Cleaning (chemical agent, water jet, ice jet, etc)
 - Surface treatment (carburizing);

Work piece & it's Configuration

- By manufacturing goods of prescribed geometry, size& finish are produced.
- Types of surfaces:
 - Plane or flat;
 - Cylindrical (Int./Ext.);
 - Conical (Int./Ext.);
 - Irregular (curved/warped)



Assembly operations

- Mechanical fastening
- Soldering & brazing
- Welding
- Press, shrink, or snap fittings
- Adhesive bonding



Basic Manufacturing Processes

- Shaping Processes
 - Casting (molten metals) or molding (plastic);
 - Materials removal: turning, drilling, milling, grinding and new techniques;
 - Particulate processes: pressing and sintering of metal powder and ceramics;
 - Deformation processes: forging, extrusion, rolling, bending etc.

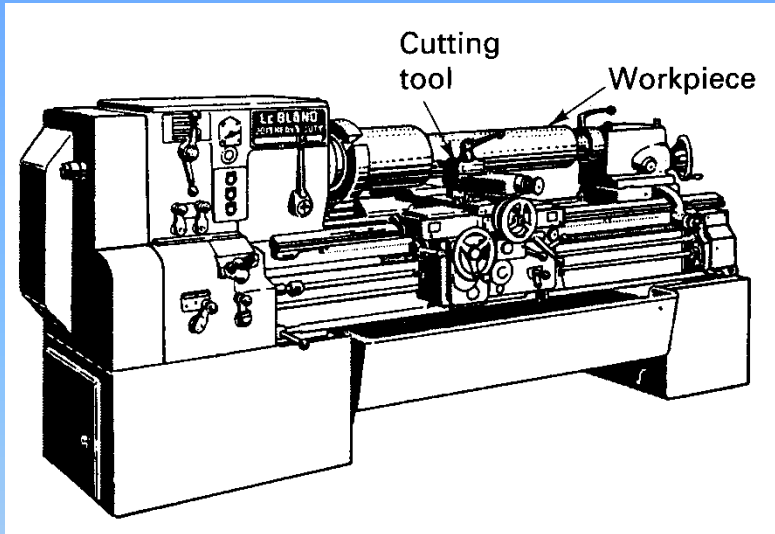
Manufacturing and Society

- Good natural resources as foundation for competitive manufacturing sector which together support a high standard of living.

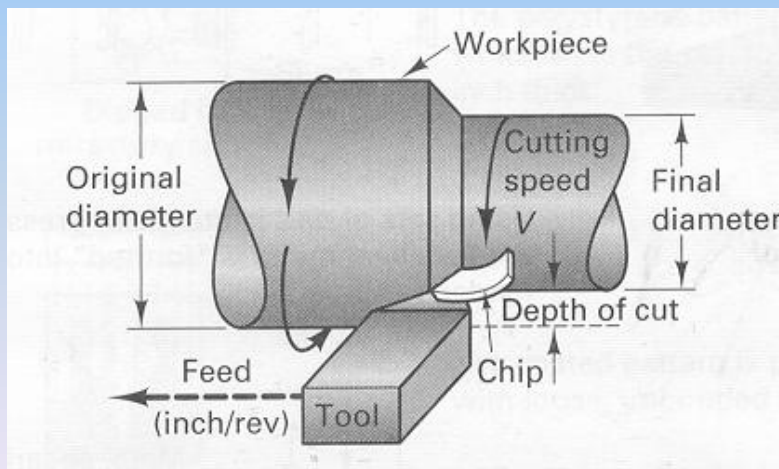
Material Removal

- The best way to create flat surfaces, sharp corners, external and internal profiles and process brittle and surface properties altered materials;
- High accuracy and high quality surface finish process;
- In most cases economically superior to concurrent processes.

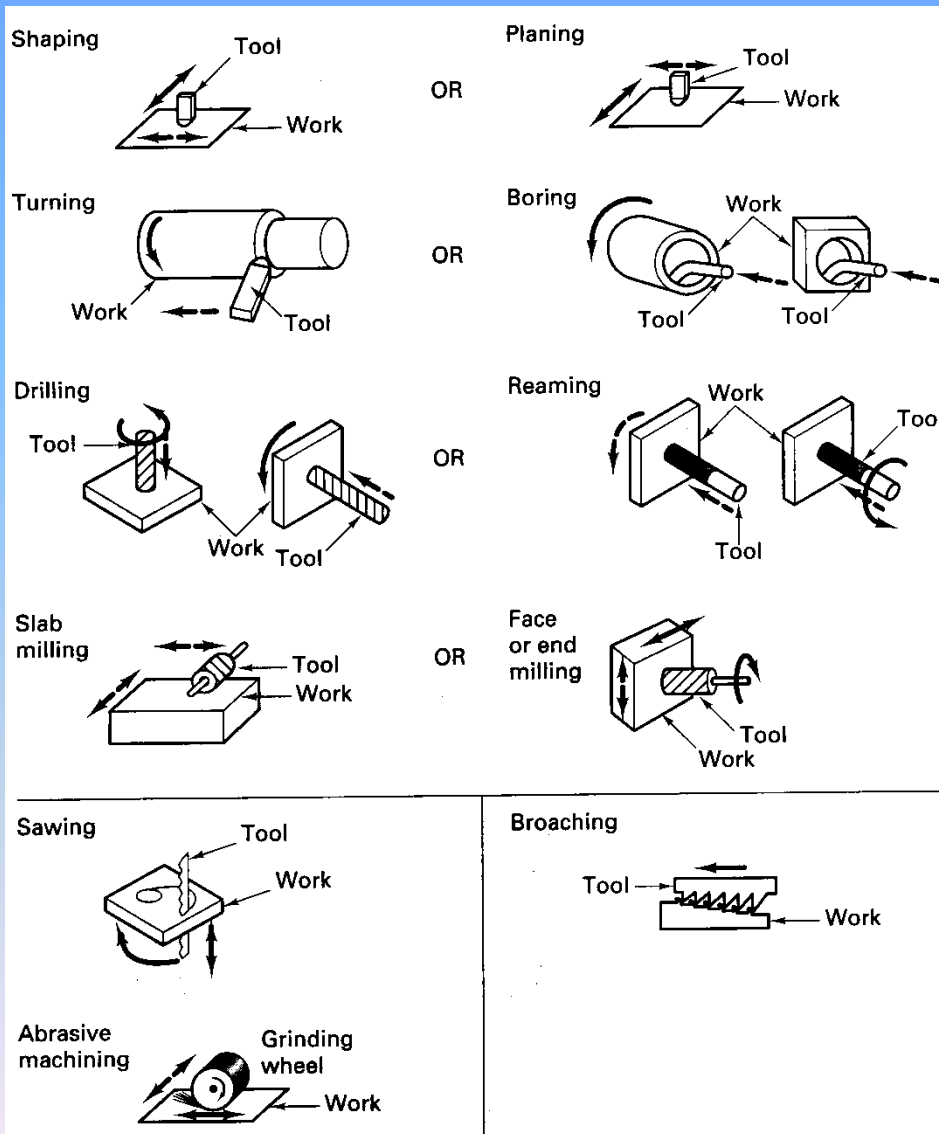
Turning on a Lathe



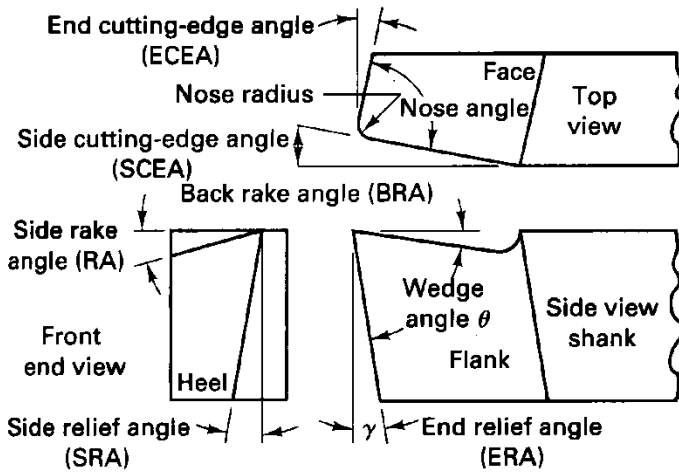
- The workpiece is mounted in a machine tool (lathe) with a cutting tool.
- The workpiece is rotated while the tool is fed at some feed rate (inches per revolution). The desired cutting speed V determines the rpm of the workpiece.



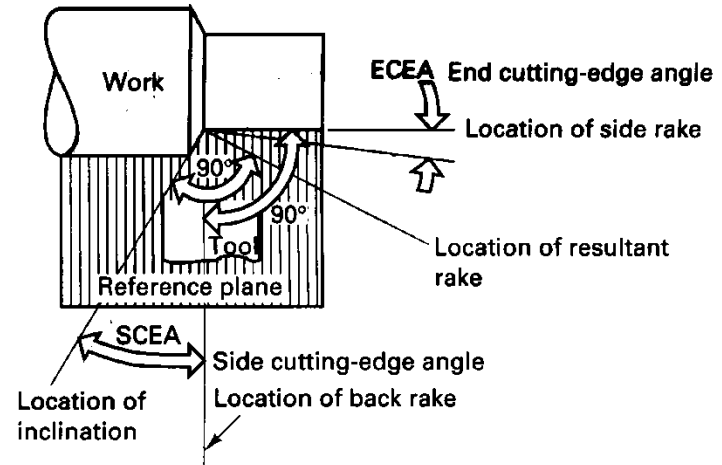
Material Removal



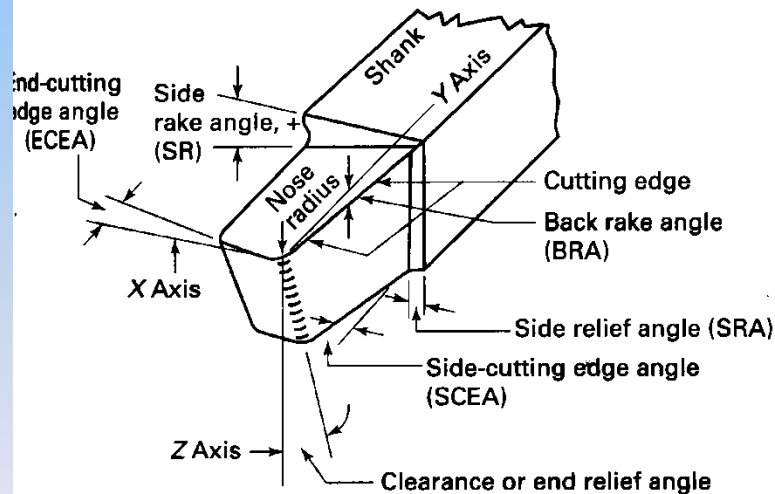
Tool Geometry



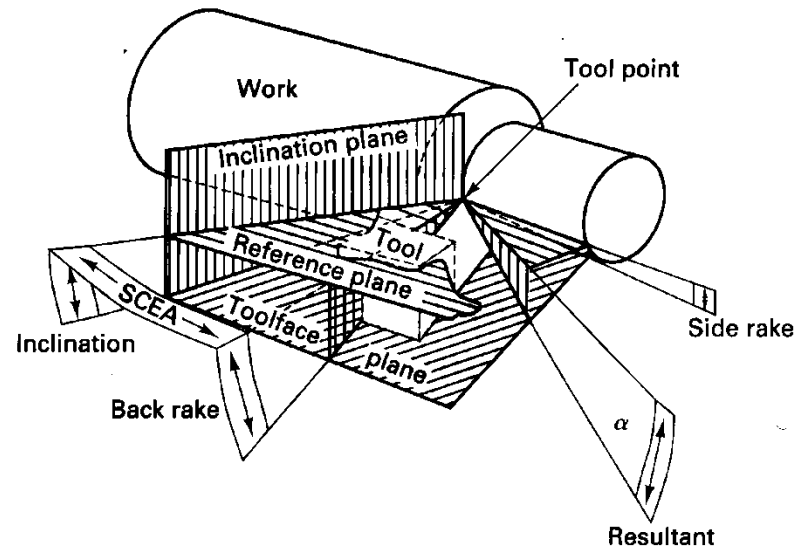
(a)



(c)

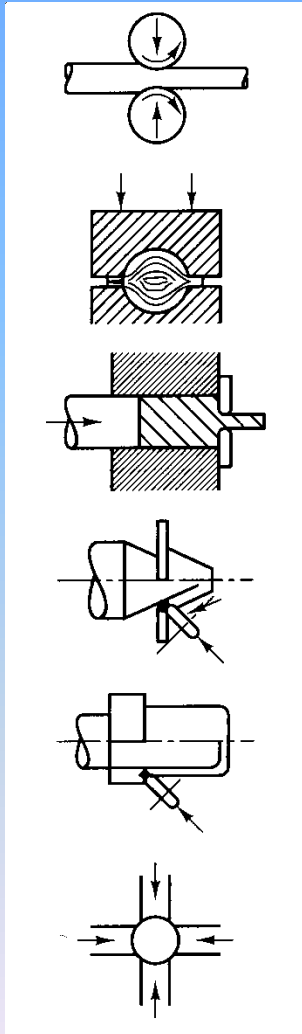


(b)



(d)

Forming operations



Rolling

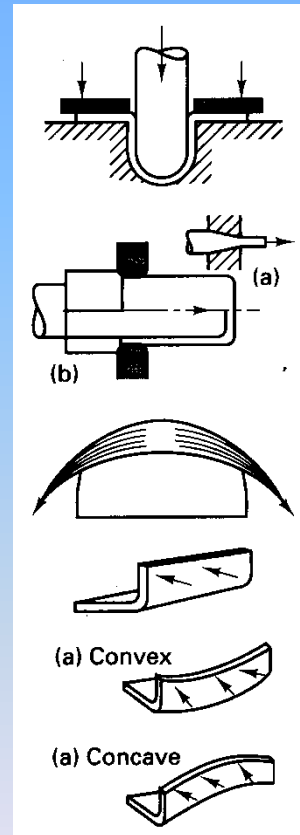
Forging

Extrusion

Shear spinning

Tube Spinning

Swaging and kneading



Deep drawing

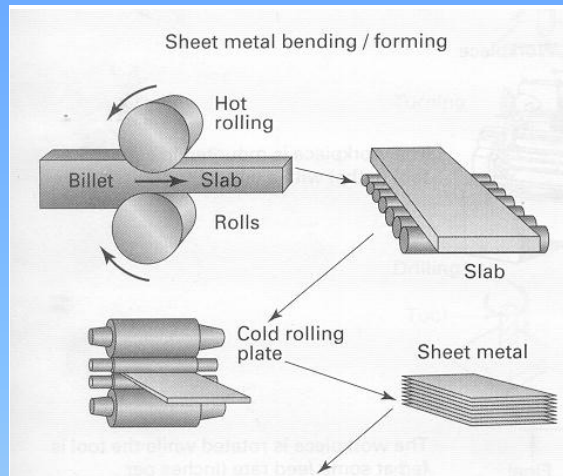
Wire and tube drawing

Stretching

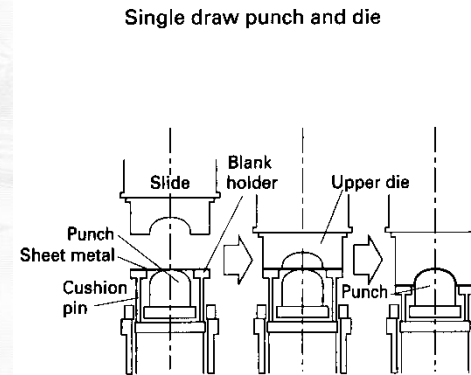
Straight bending

Contoured flanging

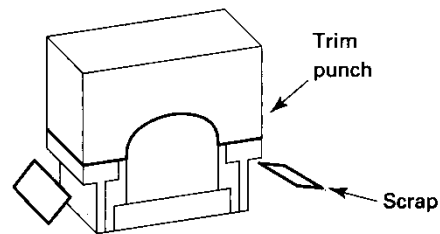
Forming and Shearing



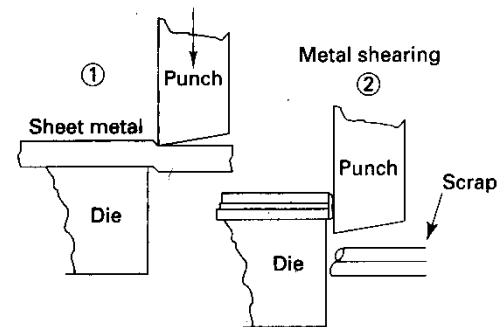
Cast billets of metal are passed through successive rollers to produce sheets of steel rolled stock.



Using sets of dies in stands of presses, the flat sheet metal is "formed" into a fender.



The fender is cut out of the sheet metal in the last stage using shearing processes.



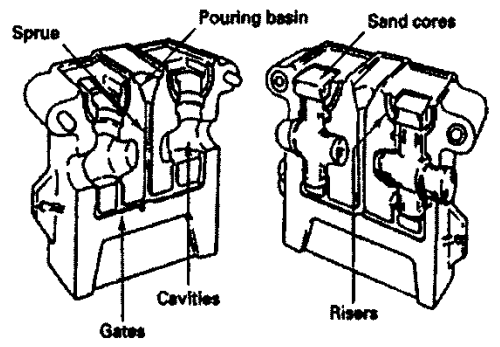
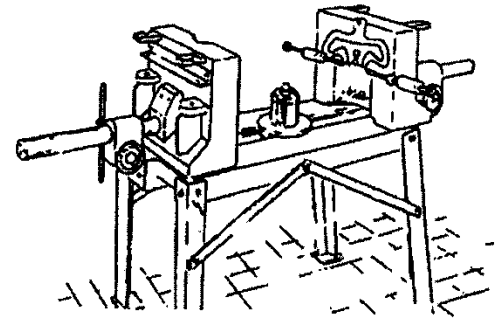
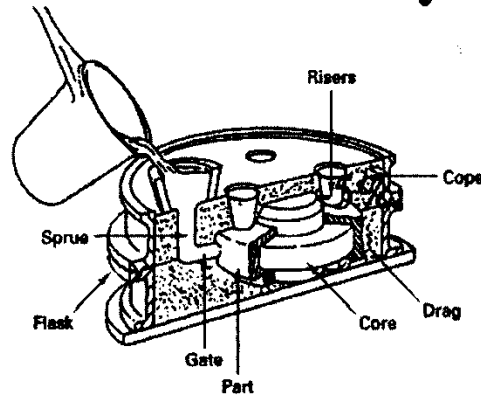
Sheet metal shearing processes are like scissors cutting paper.

The sheet metal parts are welded into the body of the car.

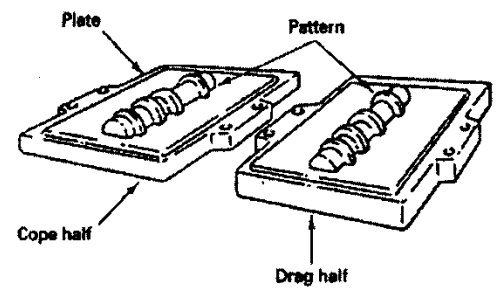
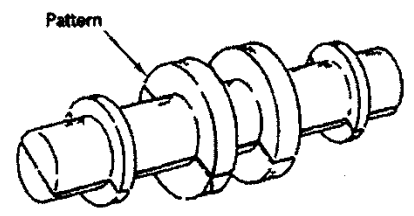
Casting and Molding

Casting uses molten metal and a cavity.

The metal retains the desired shape after solidification.



Permanent mold

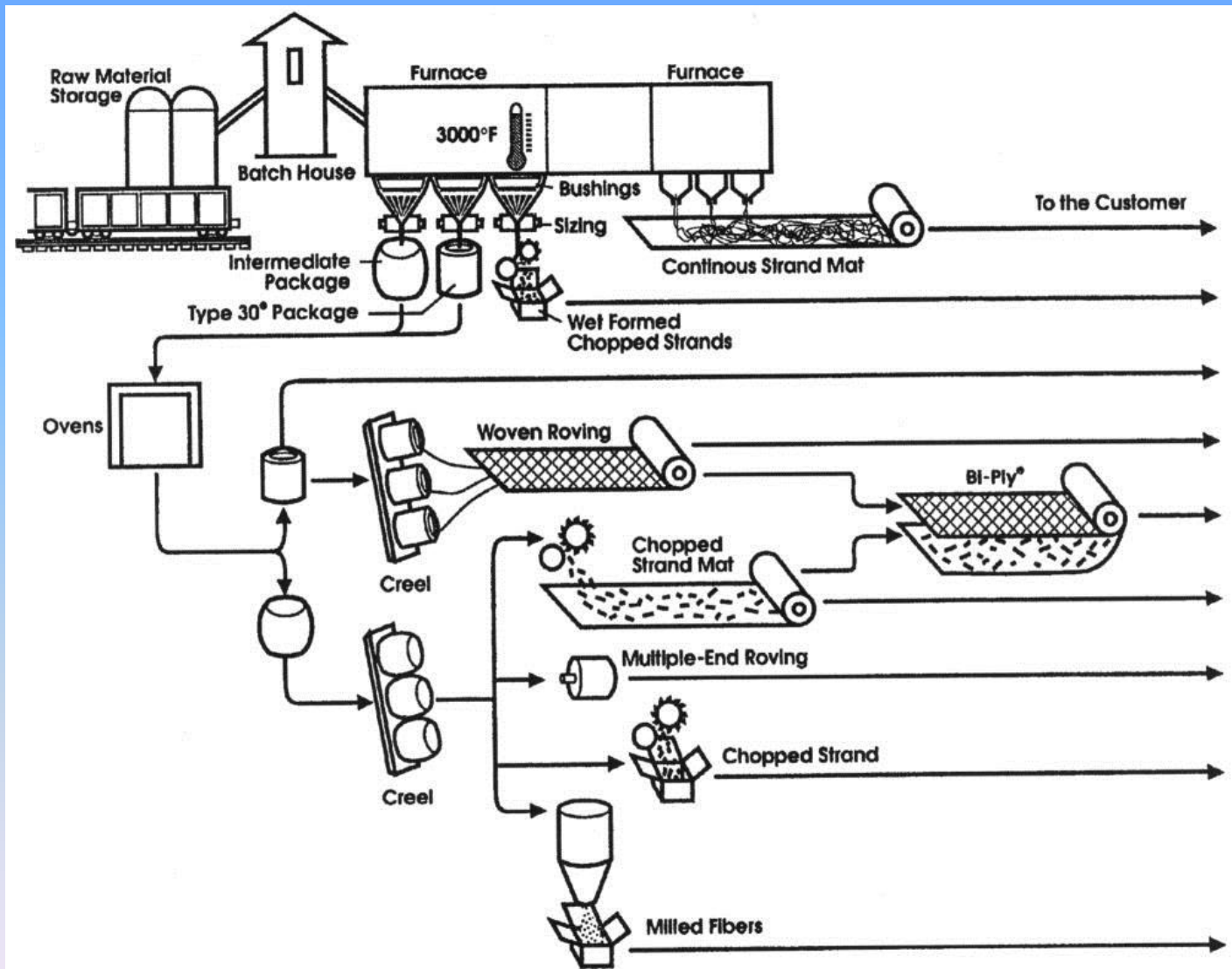


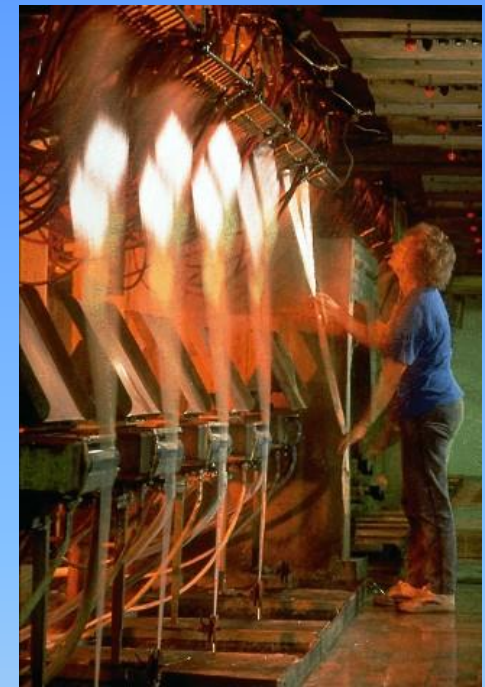
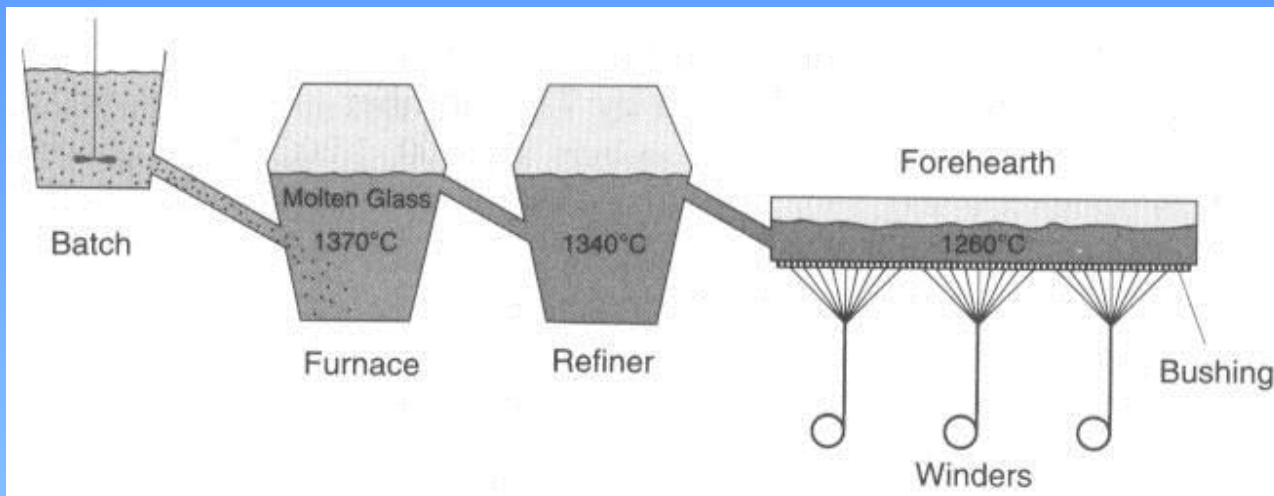
Nonpermanent mold

Joining Processes

- Mechanical fastening
- Soldering and brazing
- Welding
- Press, shrink, or snap fittings
- Adhesive bonding
- Assembly processes

Glass processing diagram





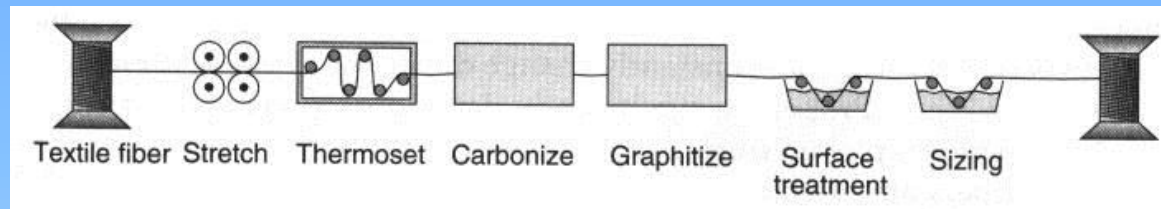
Schematic of glass fibre manufacturing process.

Aramid Fibre (Kevlar)

Aramids (short for aromatic polyamides) are TP polymers, which is extruded at 80°C from very small holes to form fibres. Aramid fibres offer significant improvements in stiffness over glass, but it is their outstanding toughness and damage tolerance that are most important. This reinforcement is applied in applications requiring high impact energy absorption.

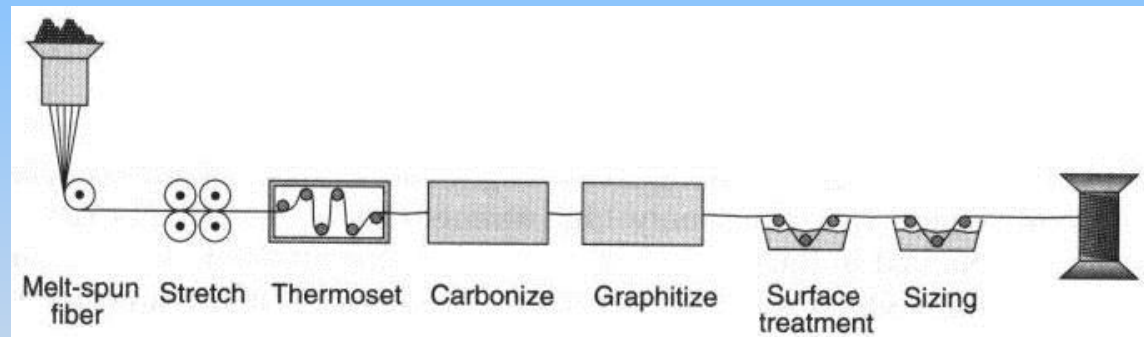
Carbon Fibre

Carbon fibres have the highest strength and stiffness of any fibrous composite reinforcement, being applied in applications where these properties are crucial. The fibres are manufactured from rayon, polyacrylonitrile (PAN), and petroleum pitch.



1. PAN
manufacturing
process:

2. Pitch
manufacturing
process:



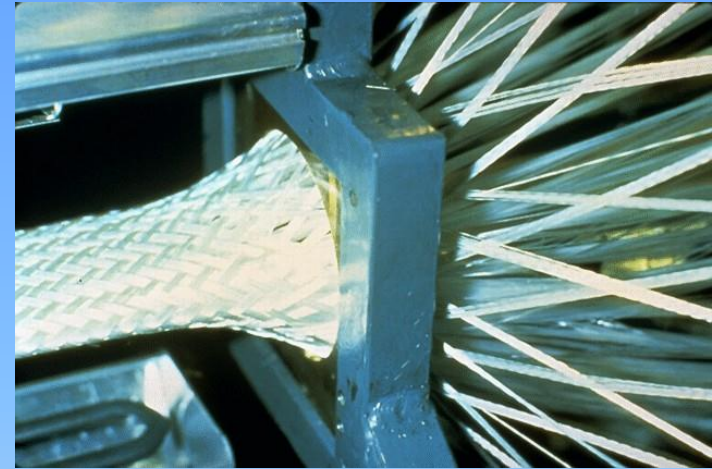
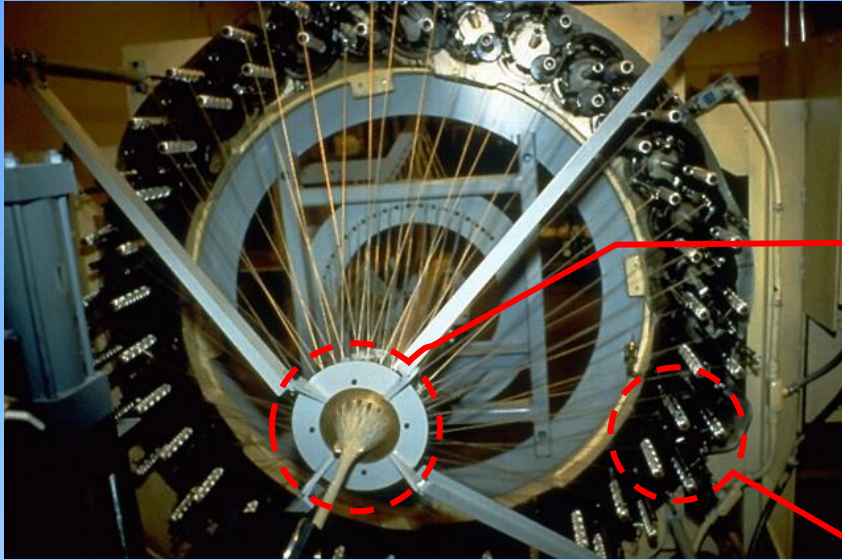
**3. Pyrolytic
Deposition**

A variety of fibre grades are produced;

Carbon (IM)	Intermediate Modulus
Carbon (HM)	High Modulus
Carbon (UHM)	Ultra-high Modulus

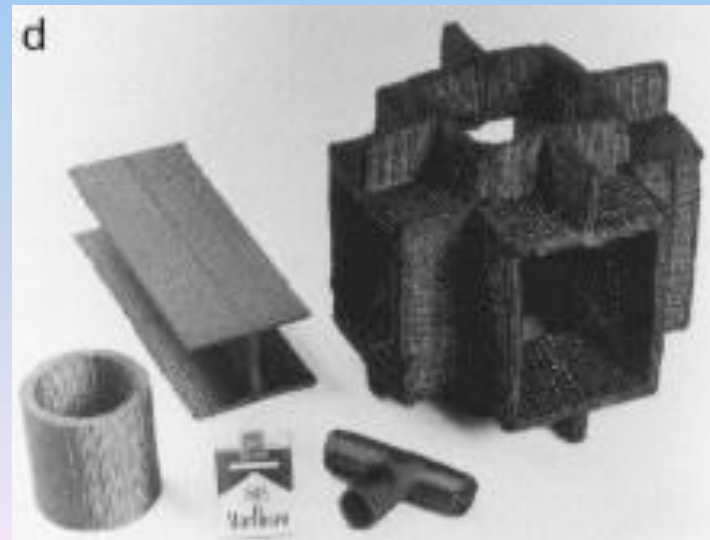
Typically, the **stiffer** the fibre, the lower the **strength** and **strain to failure**.

3D structures are formed using a variety of braiding, weaving, and knitting techniques:

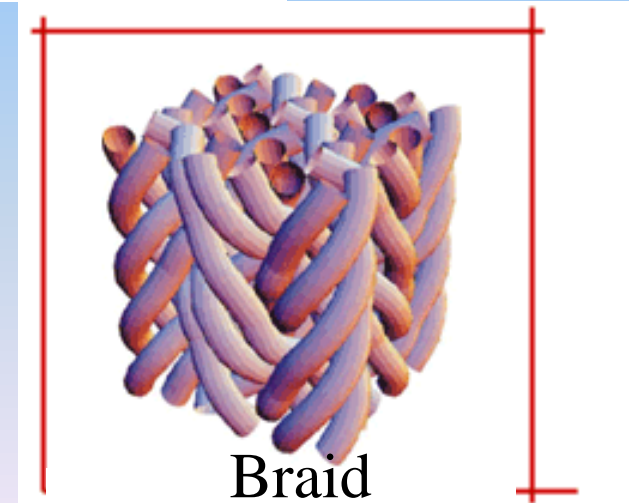
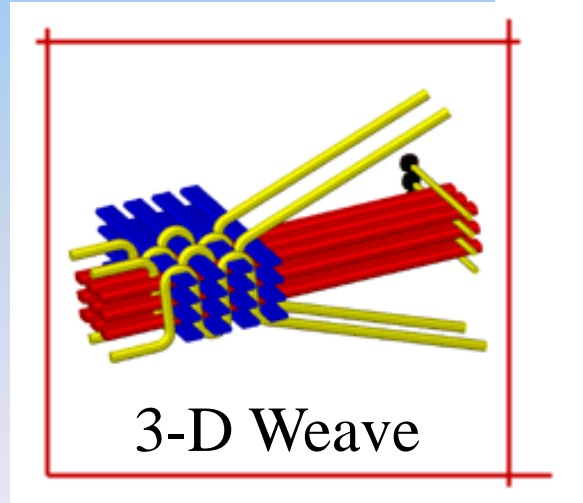
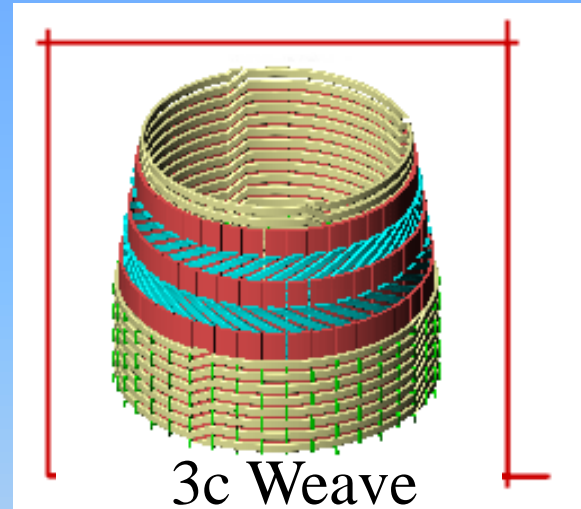
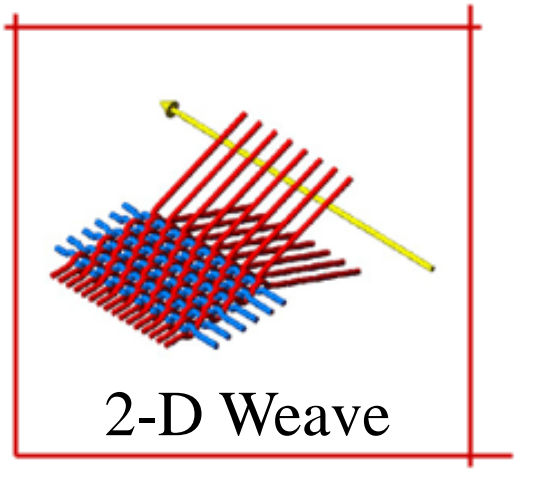


Fibre Spools

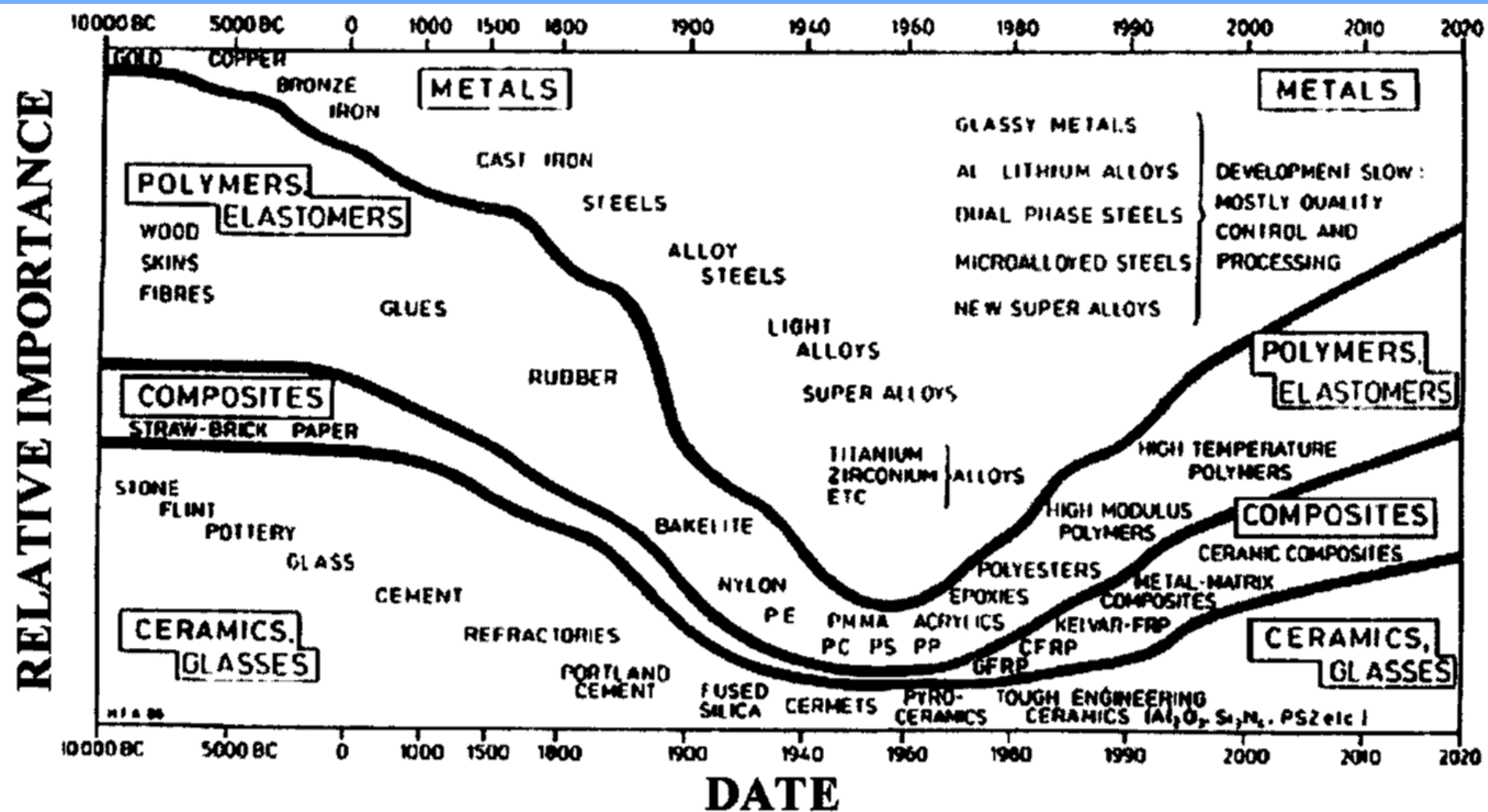
Examples of complex structures:



Examples of Fabrication Techniques



Materials in Engineering

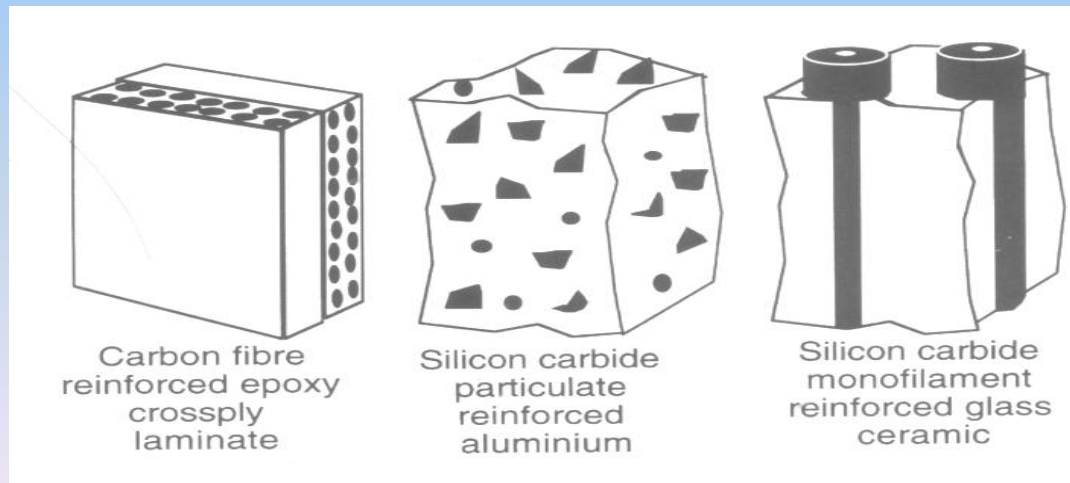


Material Selection

- Optimal combination of properties (strength, ductility, hardness, etc.);
- Selected material meets processing requirements;
- Selected material meets operational requirements;
- Lower range price of selected material.

What is the Composite Material?

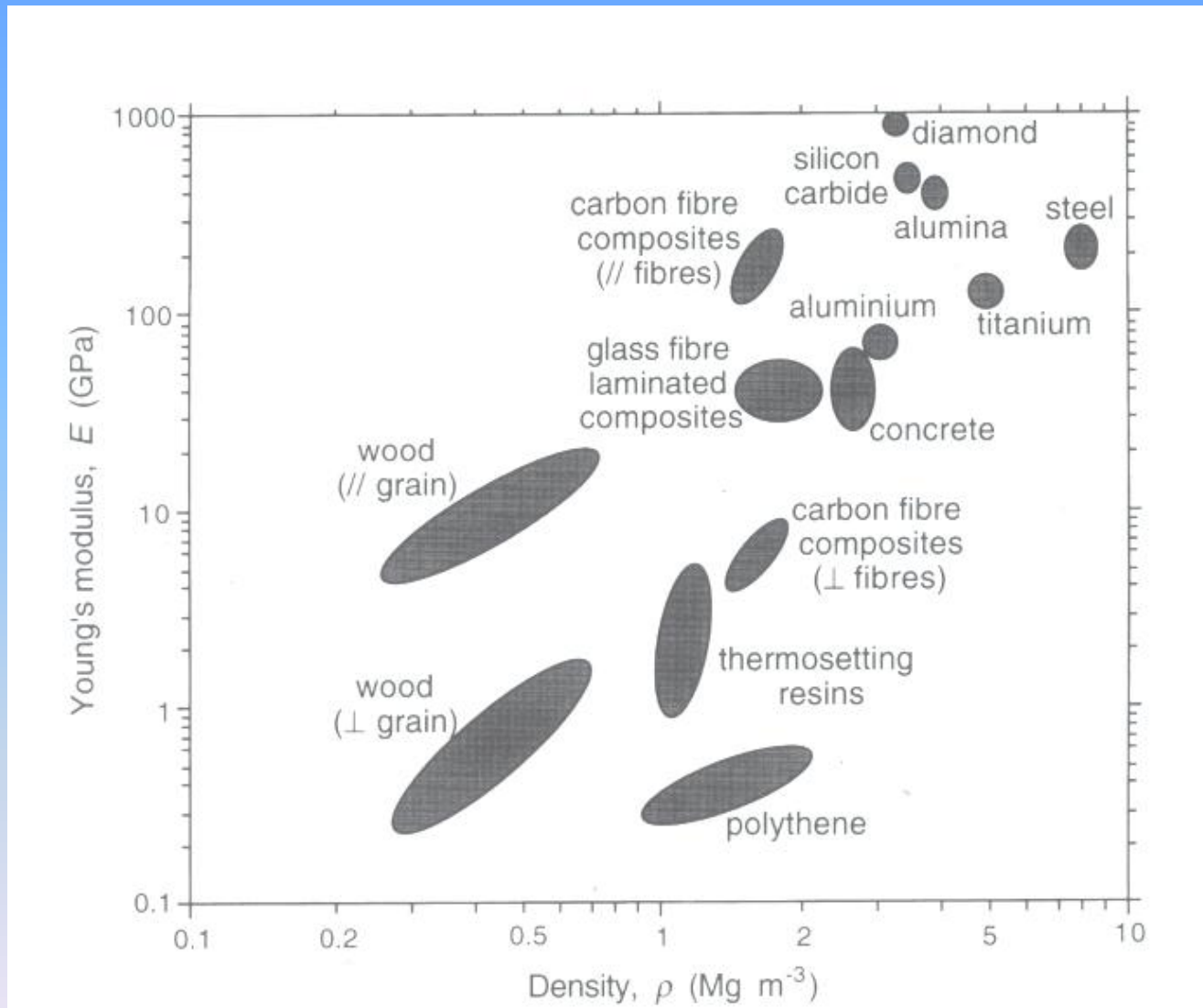
- A *material system* made by mixture or combination of 2 of micro or macro-constituents different in chemical composition and insoluble in each other.



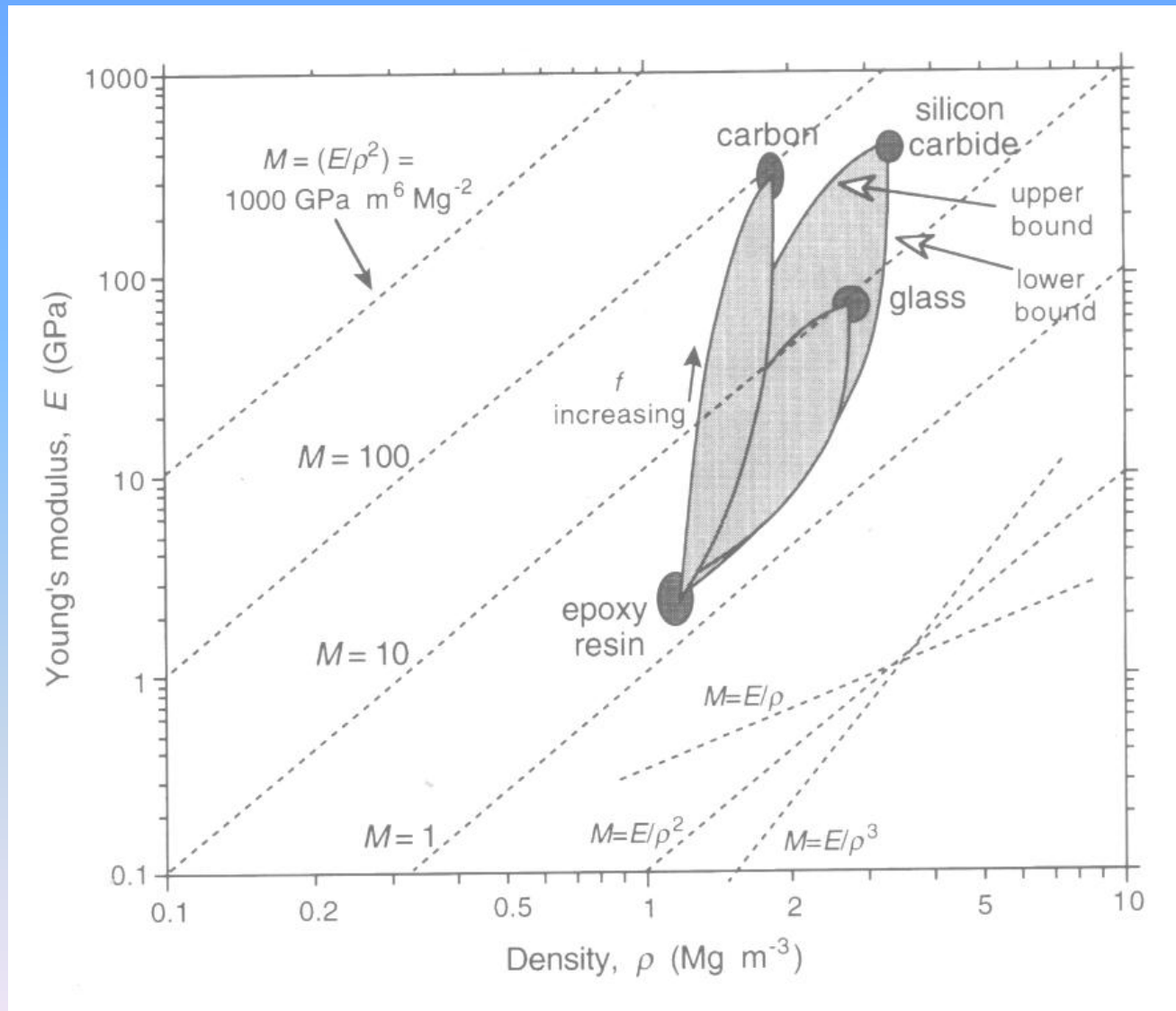
	Density ρ kg/m ³	Young's Mod E_l GPa	Tensile Strength σ_l MPa	Strain to Failure ϵ_l %
E Glass	2570 – 2600	69 – 72	3.45 – 3.79	4.5 – 4.9
S Glass	2460 – 2490	86 – 90	4.59 – 4.83	5.4 – 5.8
Kevlar 49	1440	131	3.6 – 4.1	2.8
Kevlar 149	1470	186	3.4	2.0
Carbon (IM)	1700 – 1830	276 – 317	2.34 – 7.07	0.8 – 1.9
Carbon (HM)	1750 – 2000	338 – 436	1.9 – 5.52	0.5 – 1.4
Carbon (UHM)	1870 – 2000	440 – 827	1.86 – 3.45	0.4 – 0.5
Spectra 900 (PE)	970	117	2.6	3.5
Spectra 1000 (PE)	970	172	2.9 – 3.3	0.7

* At room temperature

Property map 1

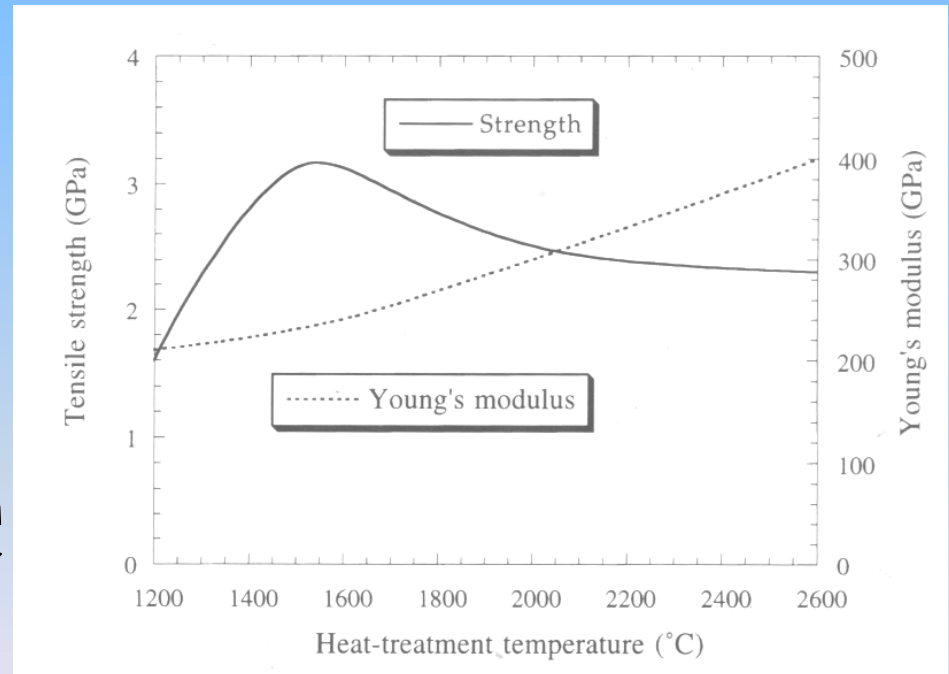


Property map 2



Thermal Stability of Carbon Fibres

- Good high-temperature properties (far above 2000 °C)
- When combined with polymer matrixes limit of use is above 200°C



Summary

- Economical and successful manufacturing requires knowledge of the relationships between labor, materials, and capital
- Design a manufacturing system that everyone understands
- Engineers must possess a knowledge of design, metallurgy, processing, economics, accounting, and human relations