ME -215 ENGINEERING MATERIALS AND PROCESES

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Lectures: F (Sec-007-1:00 pm-2:25 pm, GITC 1203; Sec-103- 5:45 pm- 7:40 pm GITC 5601)

Labs: Sec-007 W-10:00 am-12:10 pm ME232; Sec-103- F-7:45 pm- 9:45 pm ME 232;

Office Hours: Tuesday 11:30 m-12:30 pm, Friday 11:30 m-12:30 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.

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)

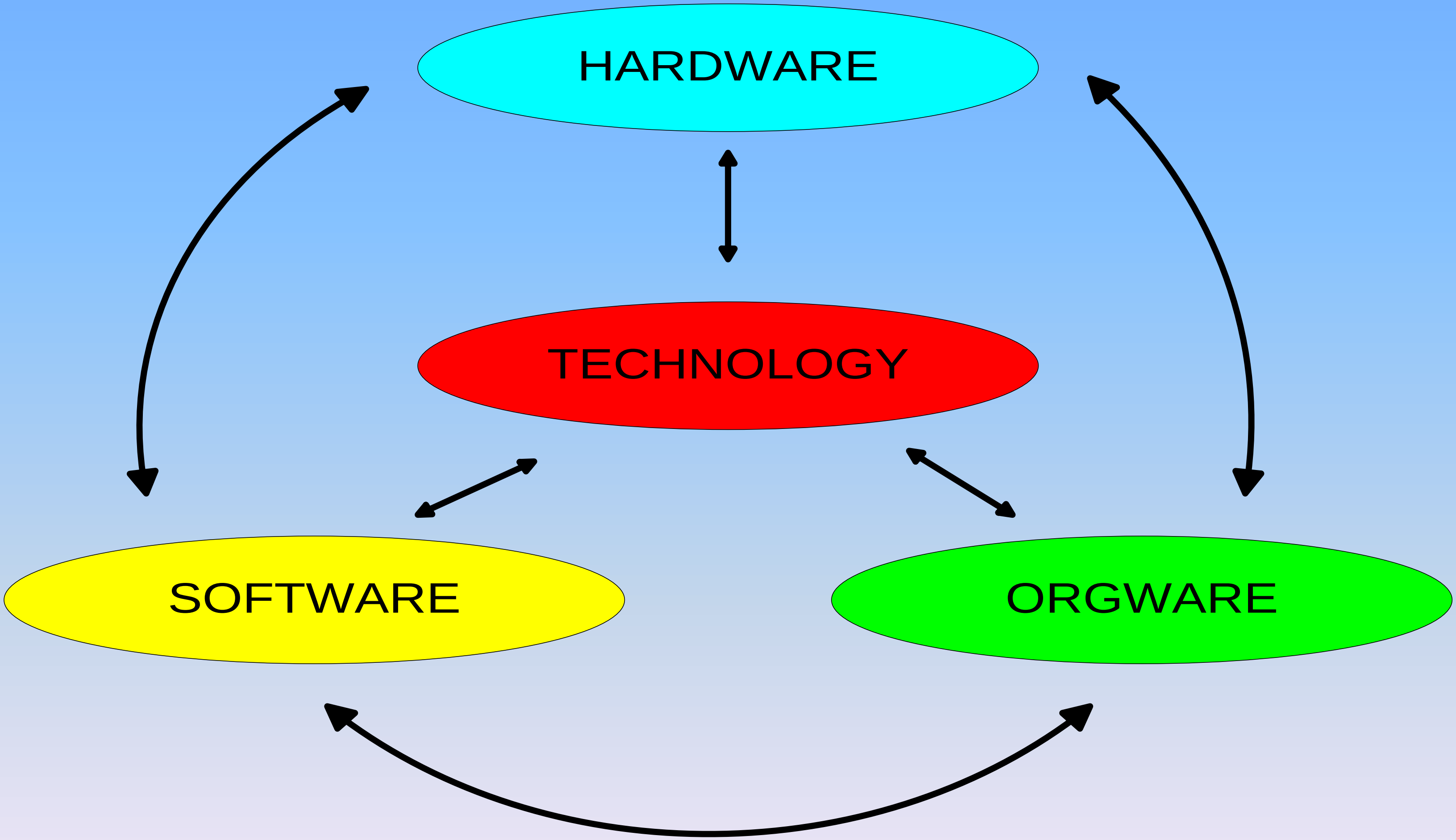
Impact on Societies

- 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.

Technology



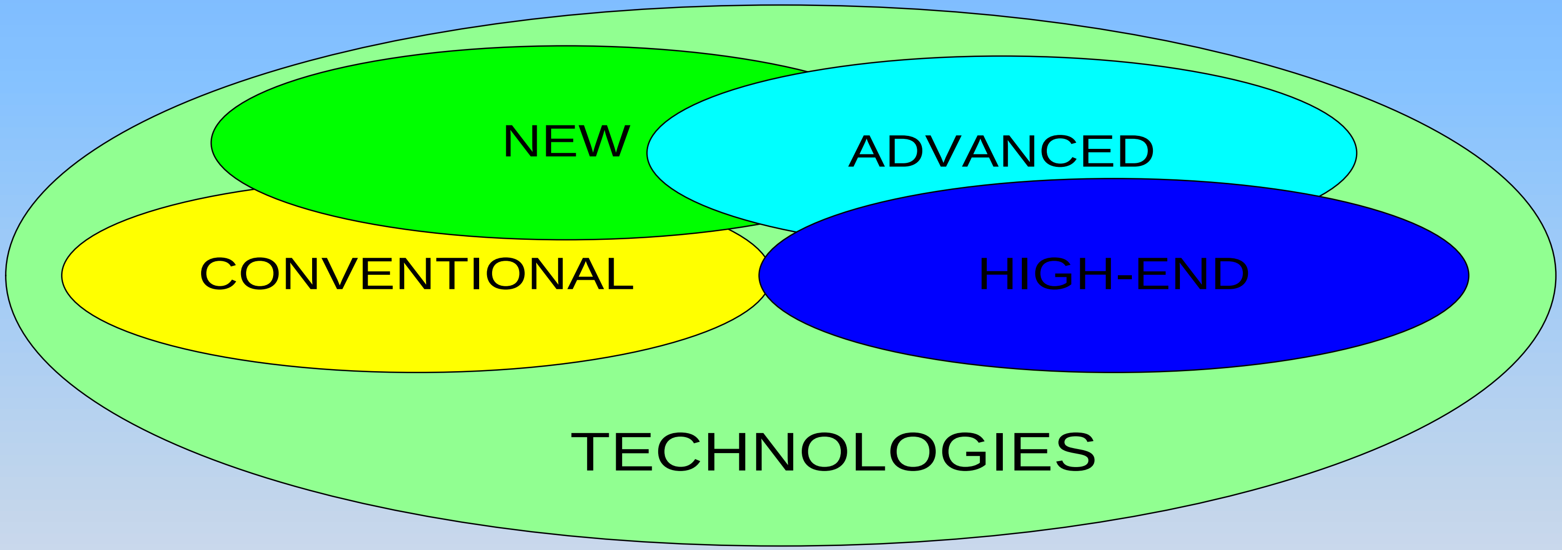
HARDWARE

TECHNOLOGY

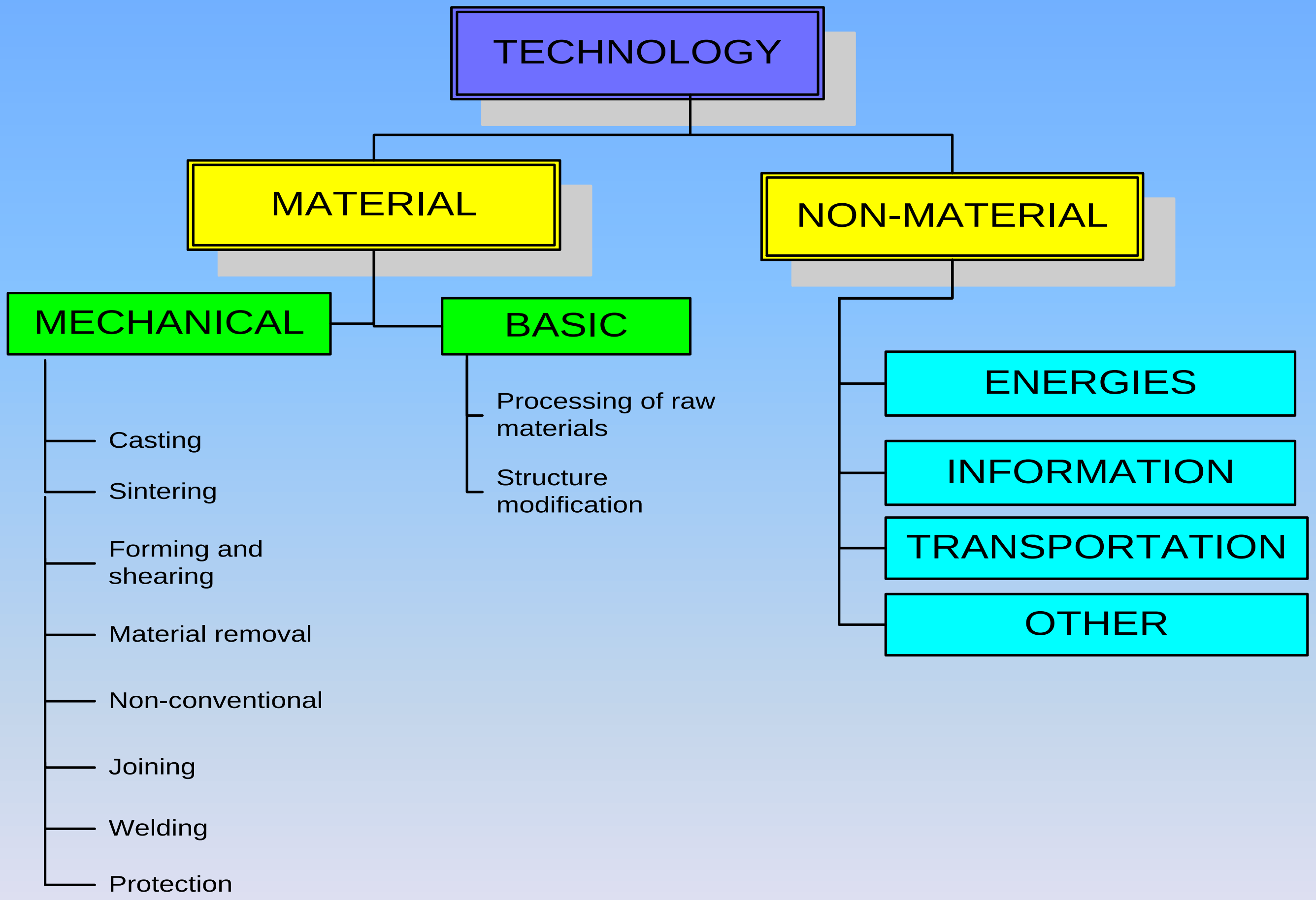
SOFTWARE

ORGWARE

Structural Development of Technologies



General Technology Classification



TECHNOLOGY

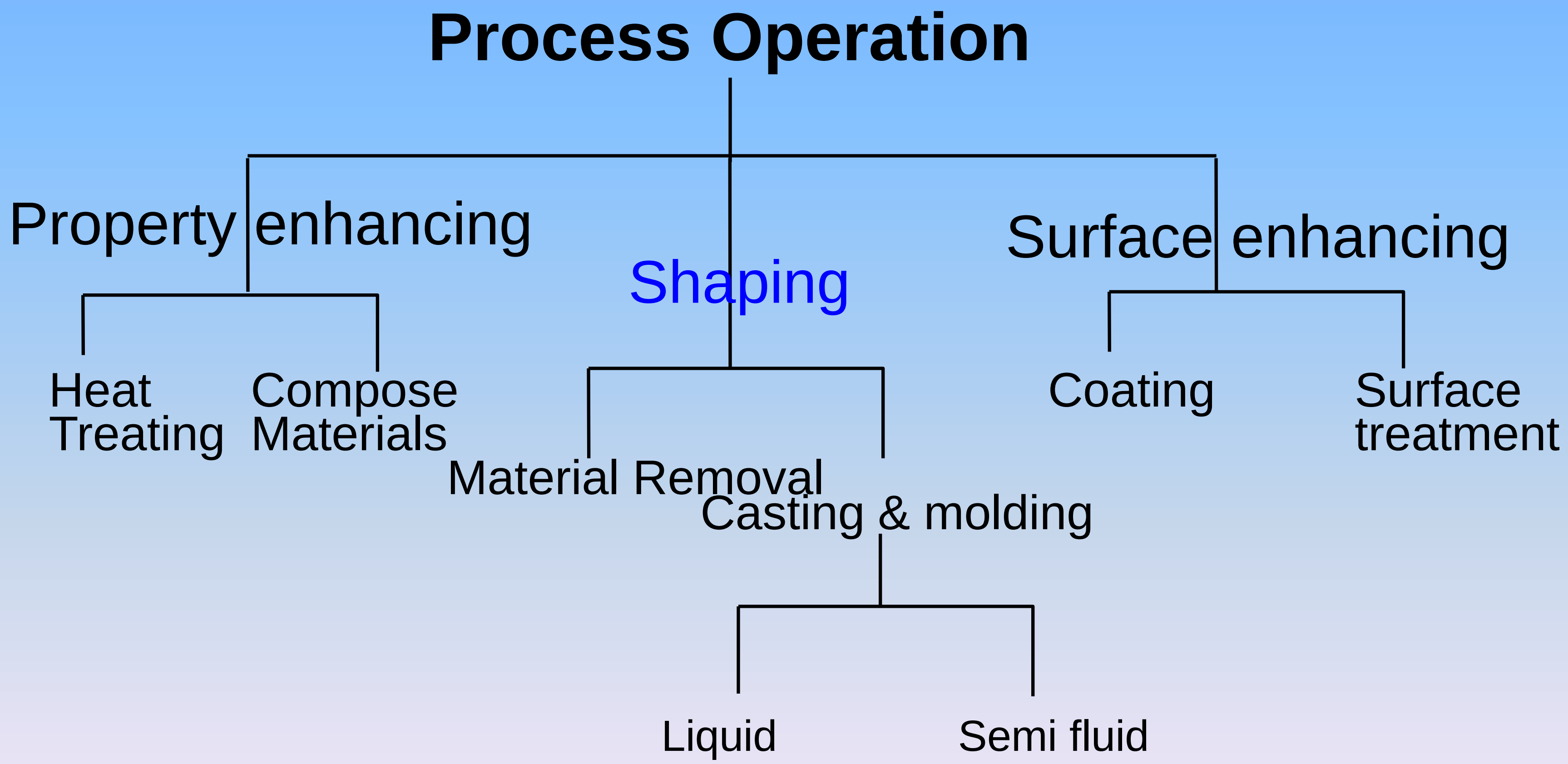
MATERIAL

- MECHANICAL
  - Casting
  - Sintering
  - Forming and shearing
  - Material removal
  - Non-conventional
  - Joining
  - Welding
  - Protection
- BASIC
  - Processing of raw materials
  - Structure modification

NON-MATERIAL

- ENERGIES
- INFORMATION
- TRANSPORTATION
- OTHER

Basic Manufacturing Processes



Process Operation

Property enhancing

- Heat Treating
- Compose Materials

Shaping

- Material Removal
- Casting & molding
  - Liquid
  - Semi fluid

Surface enhancing

- Coating
- Surface treatment

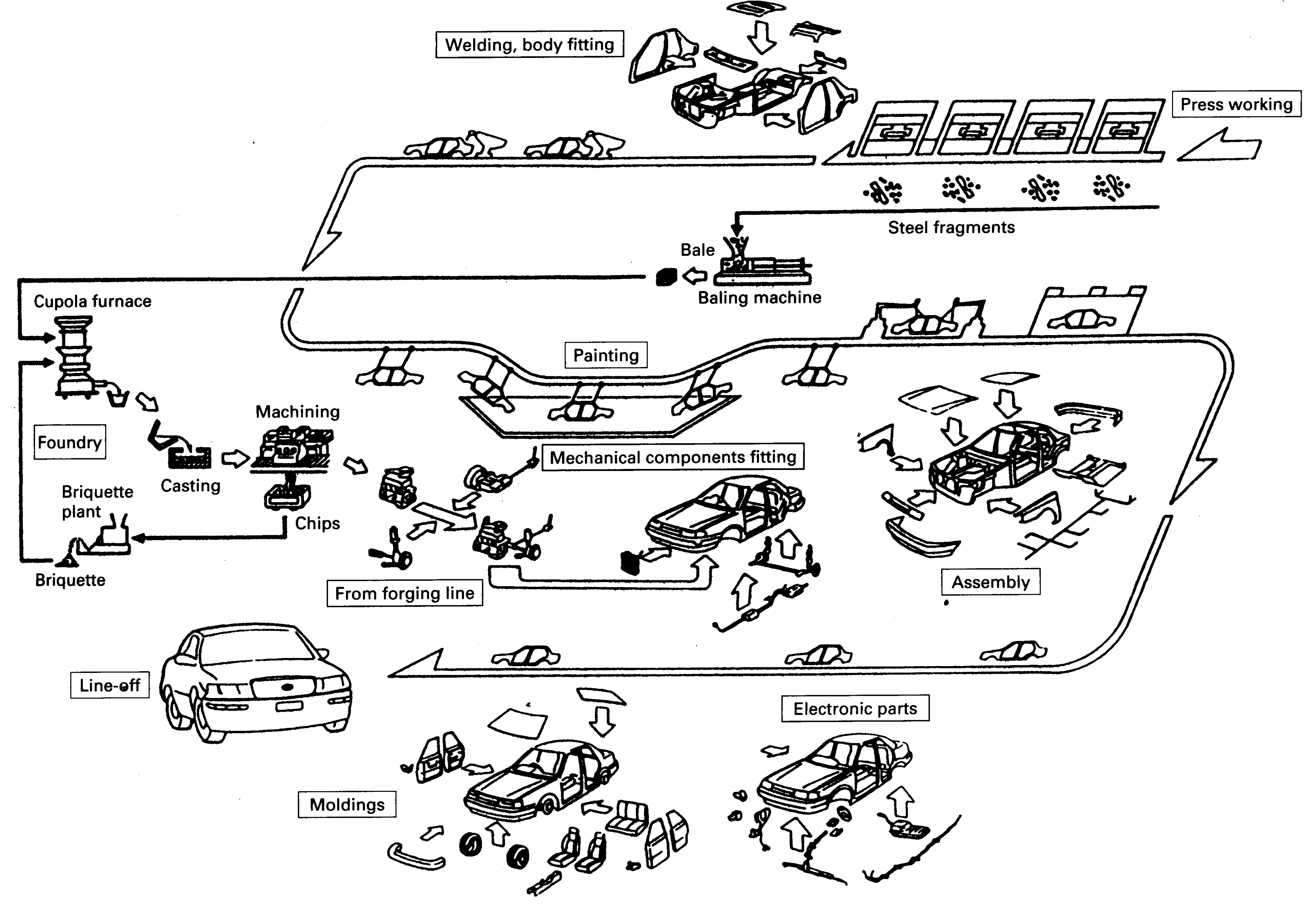
Manufacturing

- 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).

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);

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)
- 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.

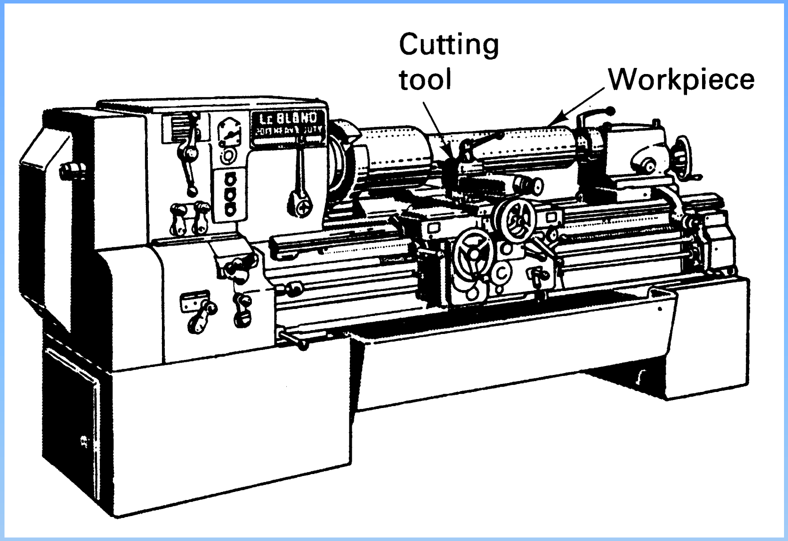
Manufacturing and Society

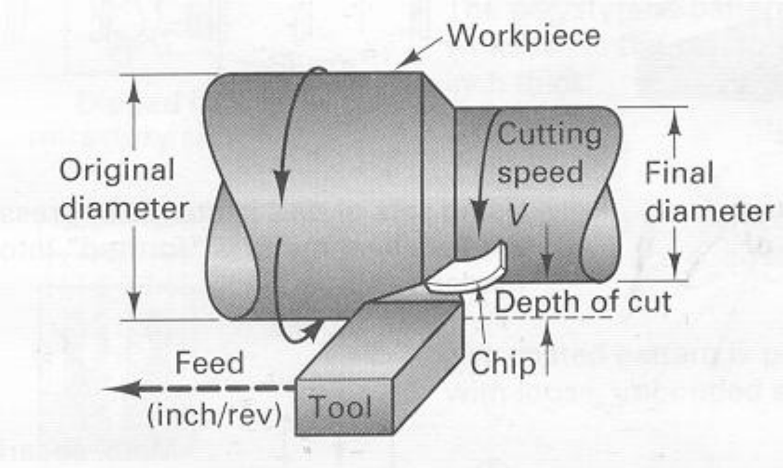
- Good natural resources as foundation for competitive manufacturing sector which together support a high standard of living.

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.

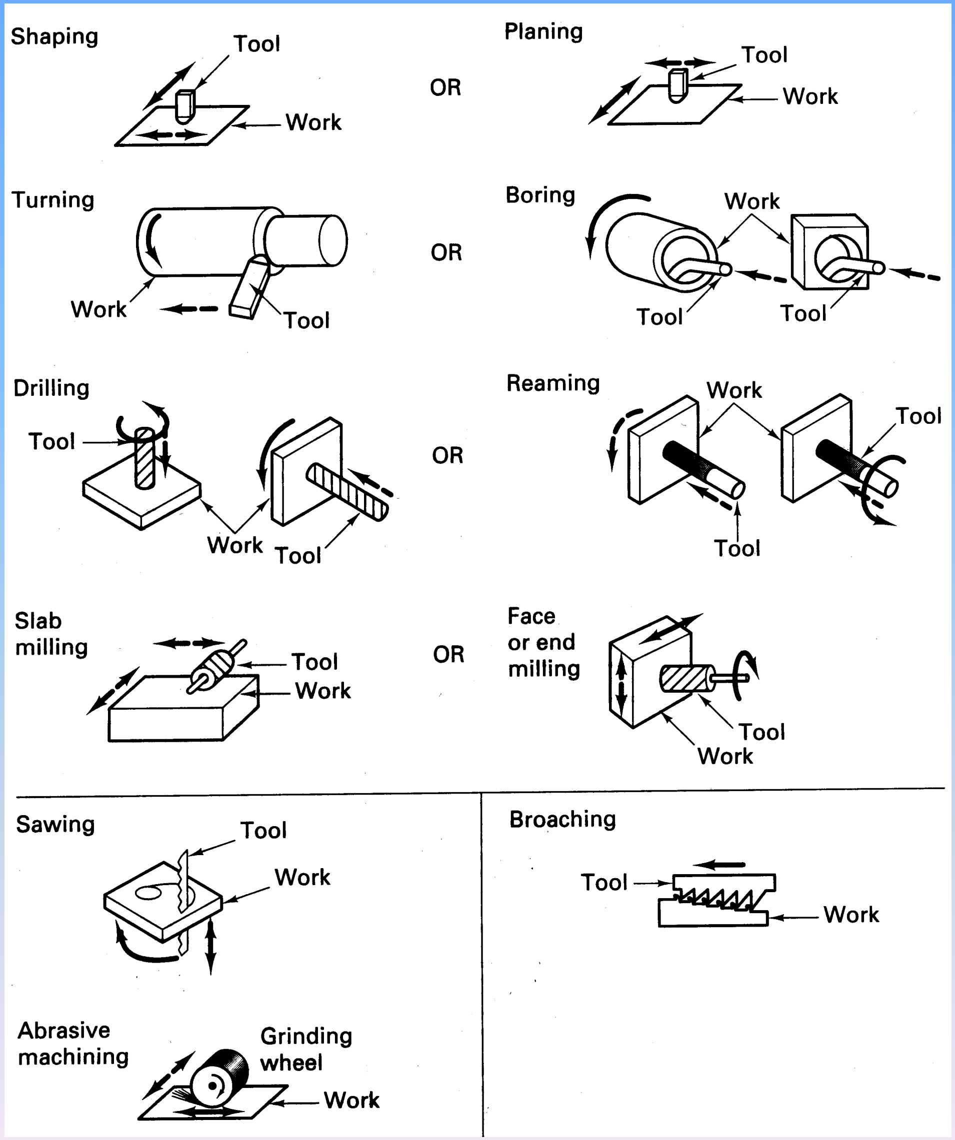
Turning on a Lathe



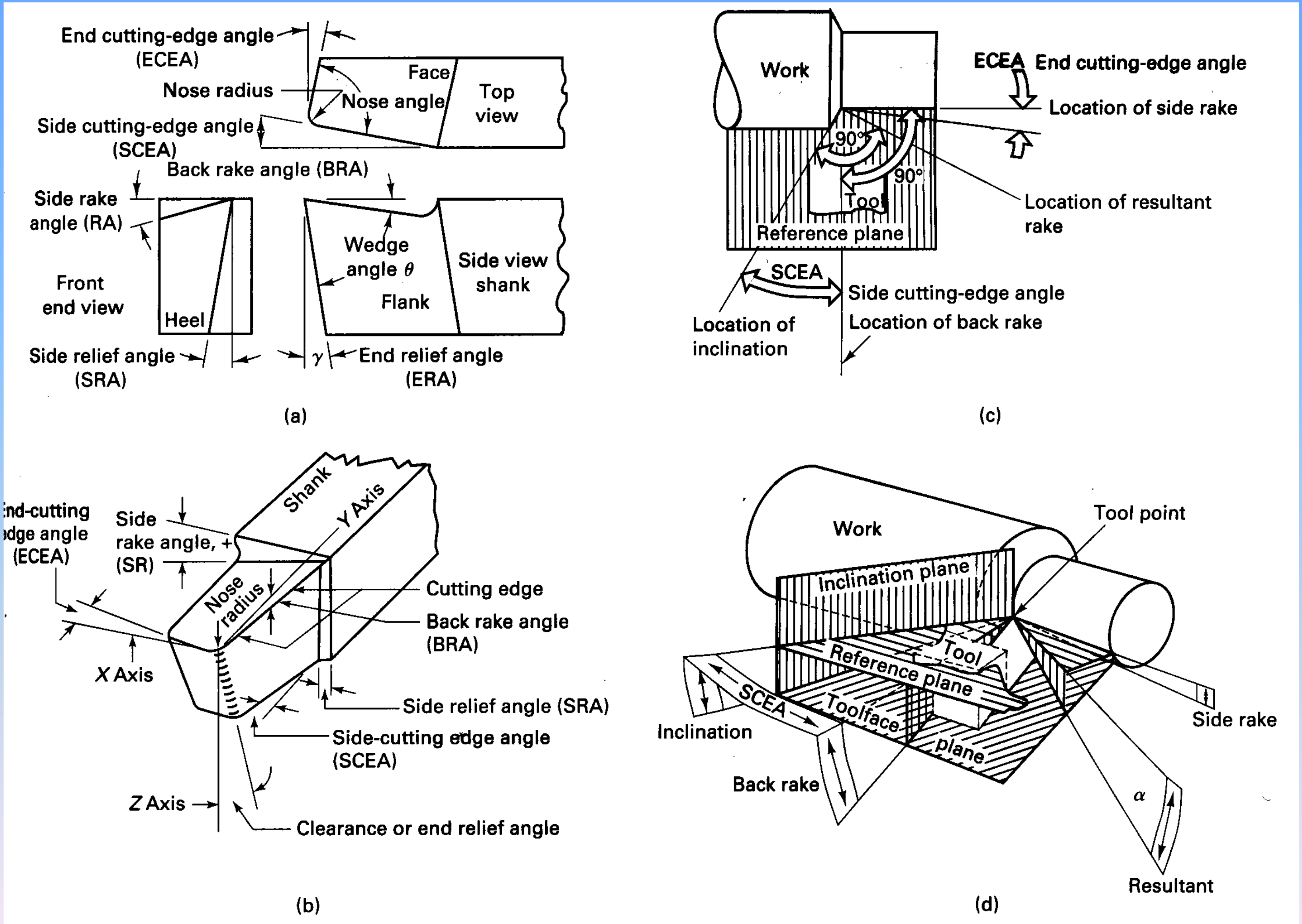


- The workpiece is mounted in a machine tool (lathe) with a cutting tool.
- The workpiece is rotated while the tool is fed at some feed rate (inches per revolution). The desired cutting speed V determines the rpm of the workpiece.

Material Removal



Tool Geometry



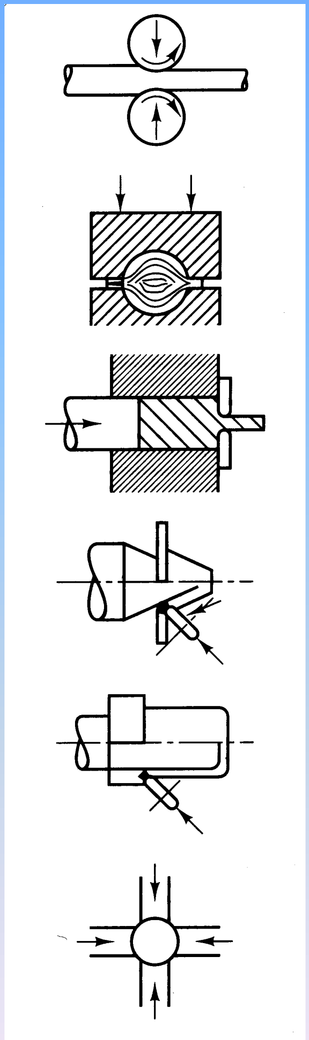
(a)

(c)

(b)

(d)

Forming operations



Rolling

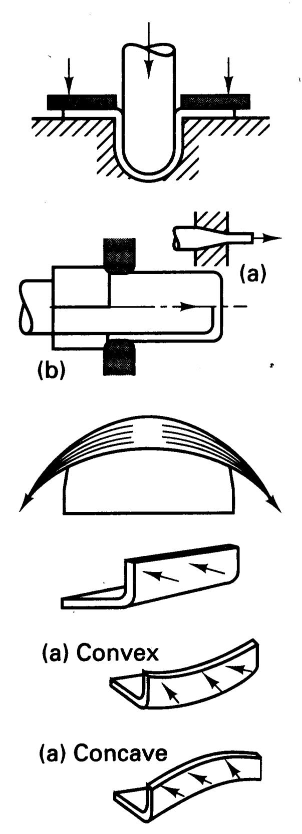
Forging

Extrusion

Shear spinning

Tube Spinning

Swaging and kneading



Deep drawing

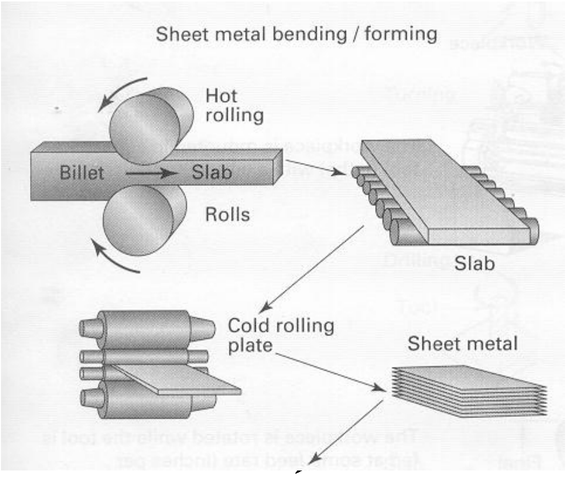
Wire and tube drawing

Stretching

Straight bending

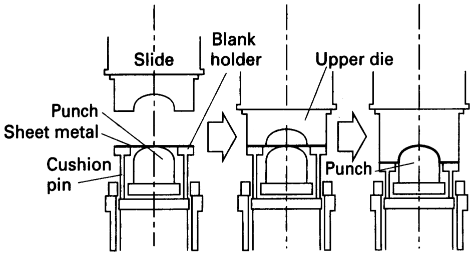
Contoured flanging

Forming and Shearing

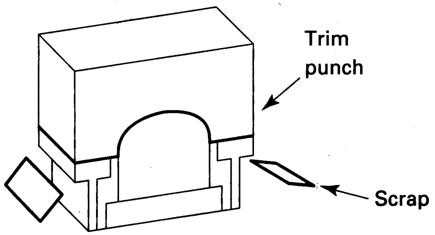


Cast billets of metal are passed through successive rollers to produce sheets of steel rolled stock.

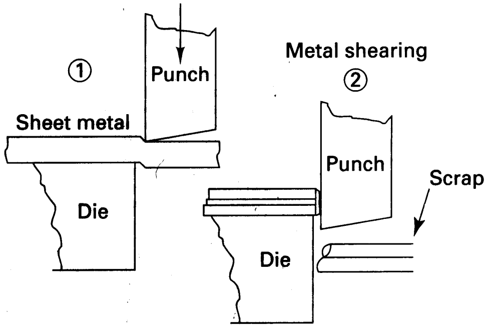
Single draw punch and die



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



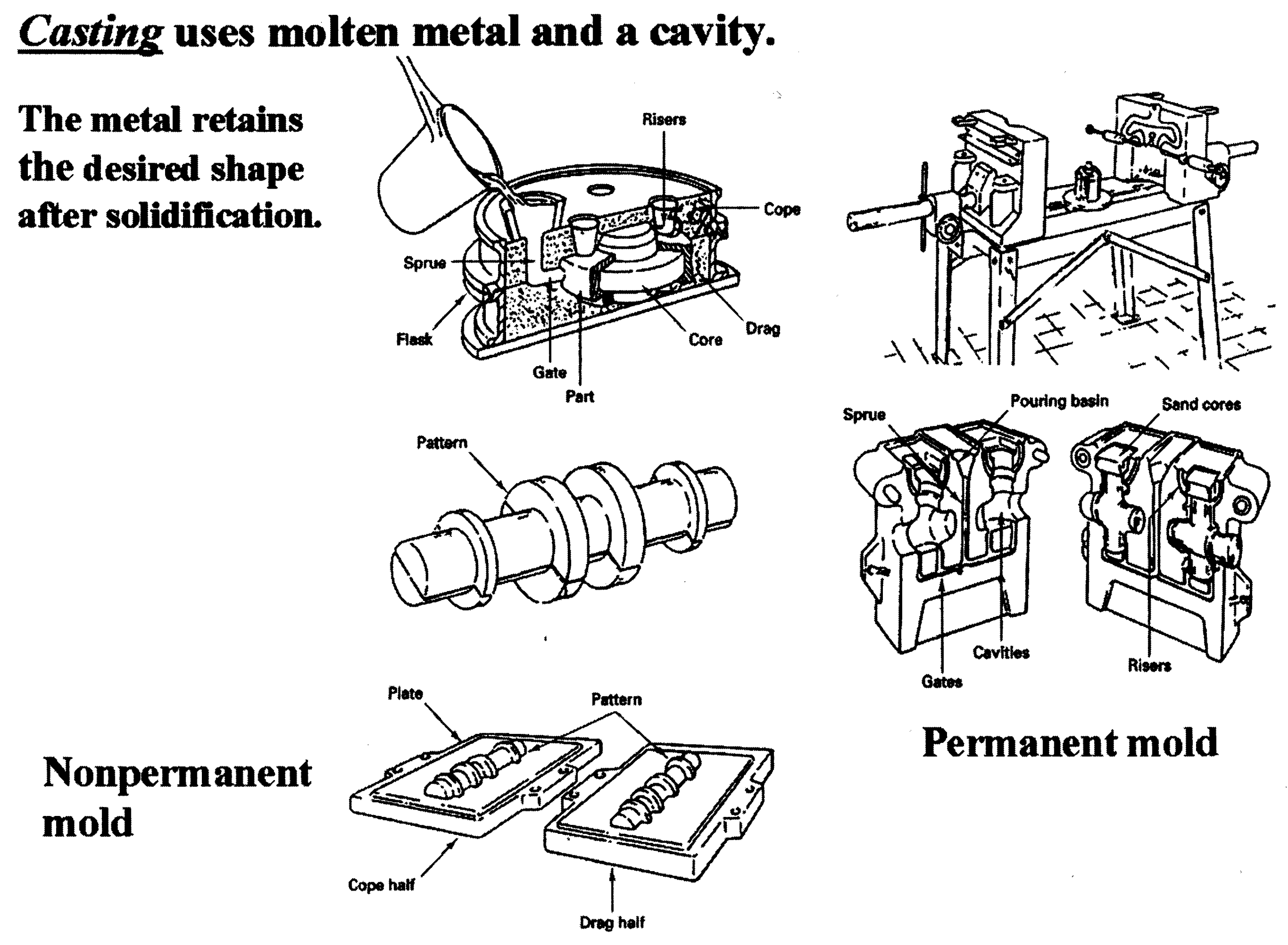
The fender is cut out of the sheet metal in the last stage using shearing processes.



Sheet metal shearing processes are like scissors cutting paper.

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

Casting and Molding



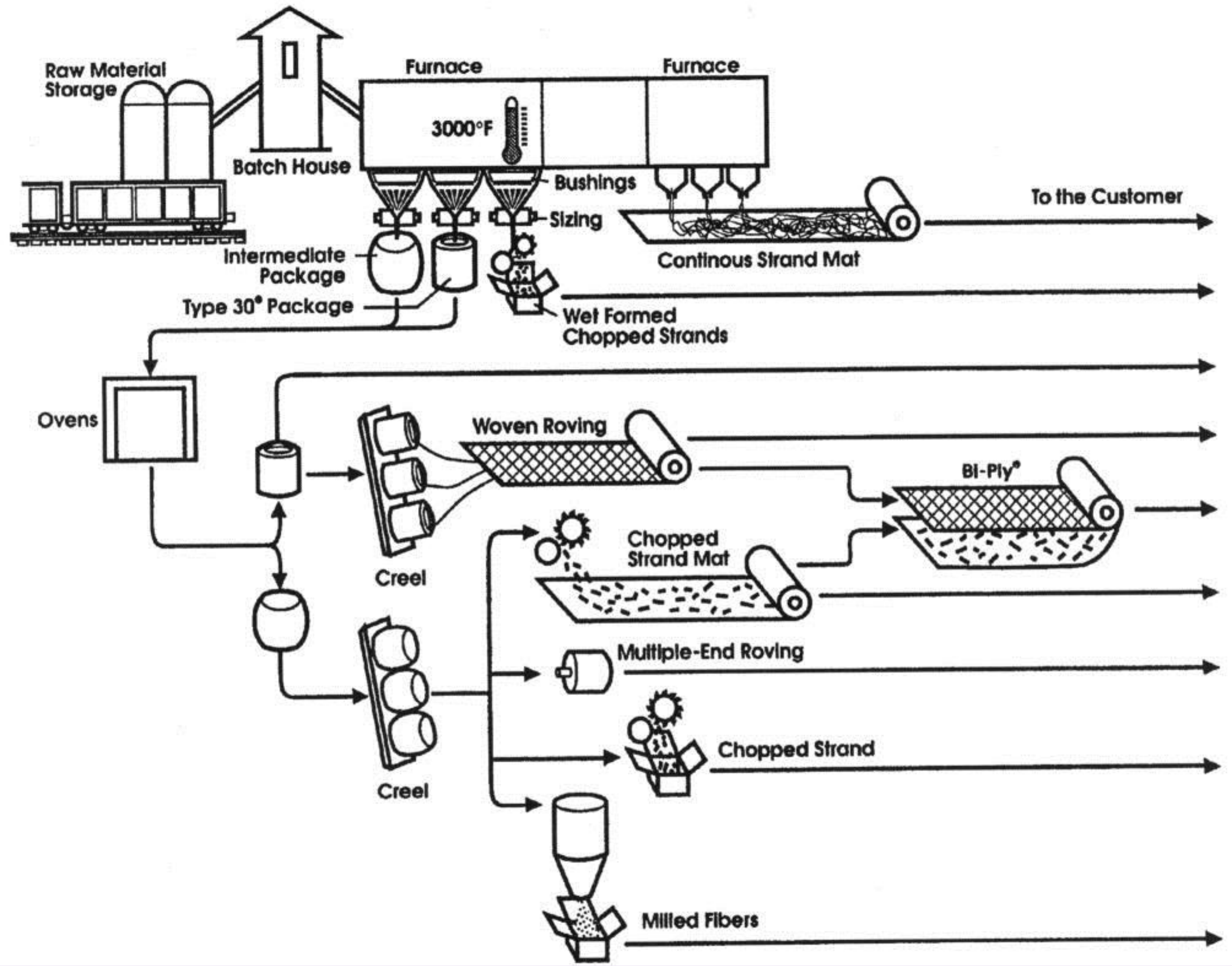
Casting **uses molten metal and a cavity.**

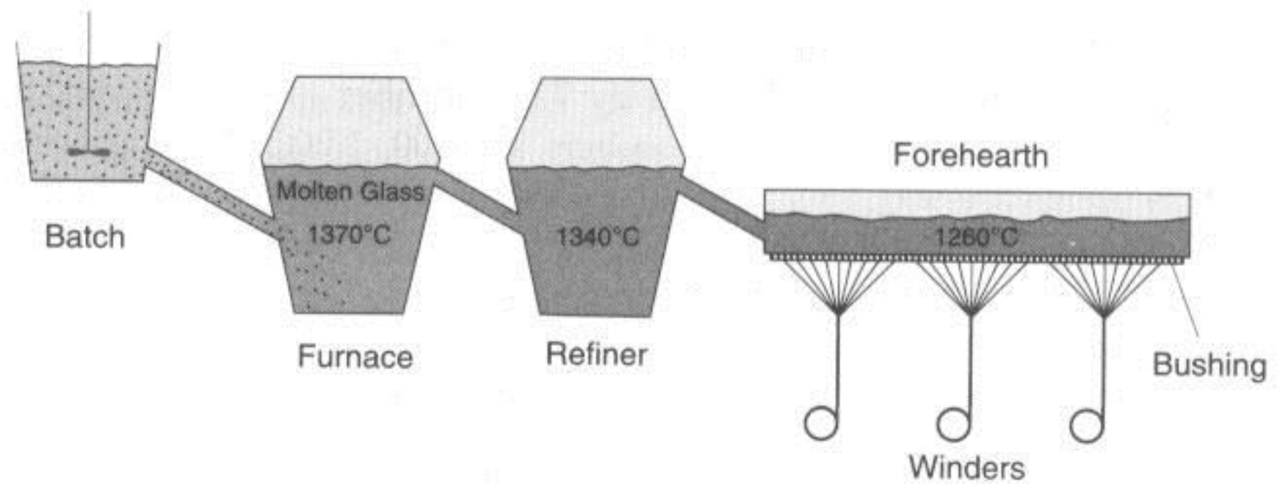
The metal retains the desired shape after solidification.

Nonpermanent mold

Permanent mold

Glass processing diagram





Schematic of glass fibre manufacturing process.

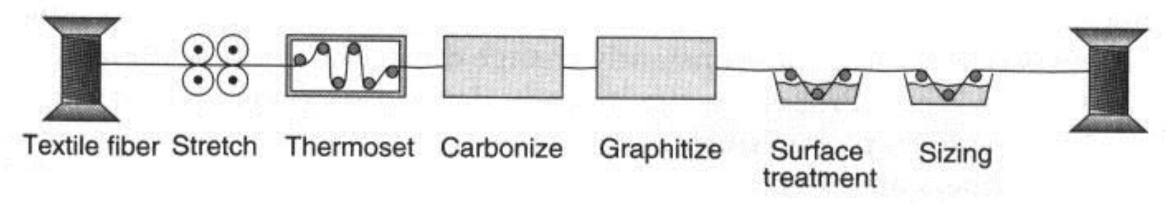
Aramid Fibre (Kevlar)

Aramids (short for aromatic polyamides) are TP polymers, which is extruded at 80^{o}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.

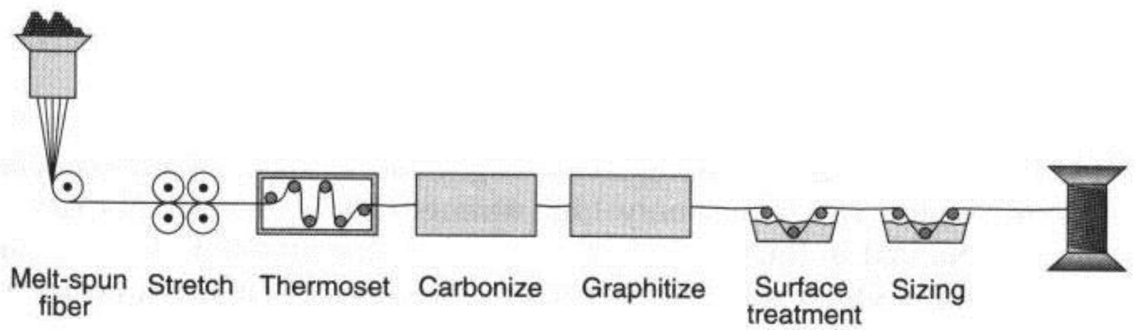
Carbon Fibre

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:



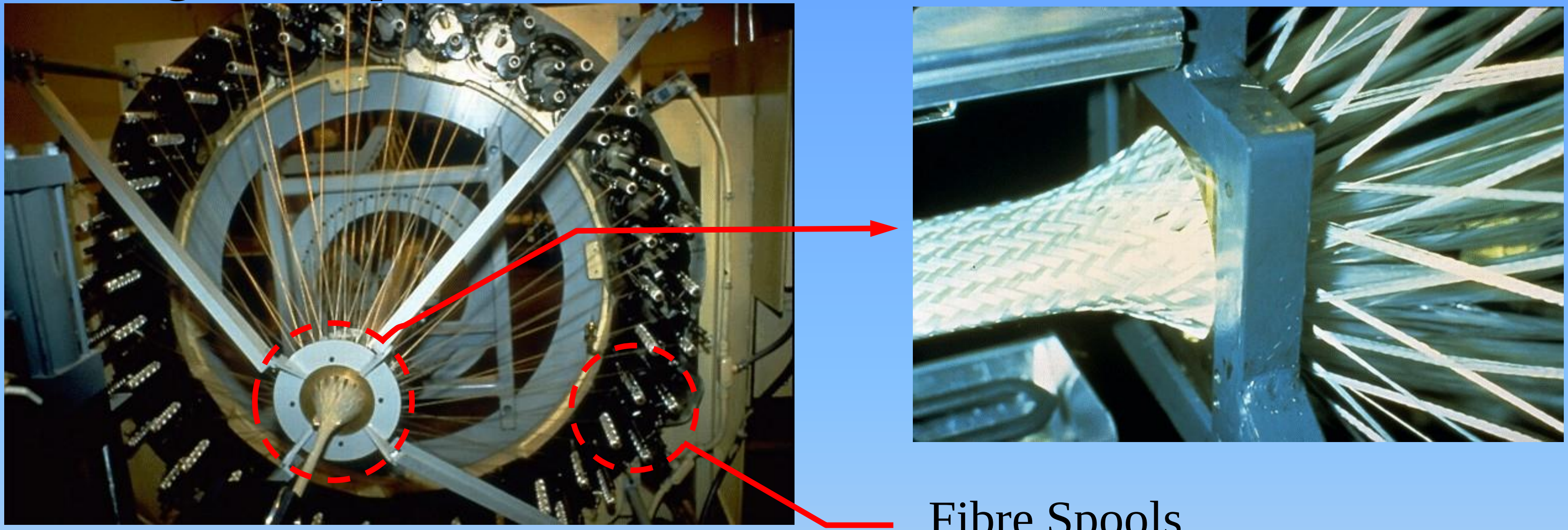
3. Pyrolytic Deposition

A variety of fibre grades are produced;

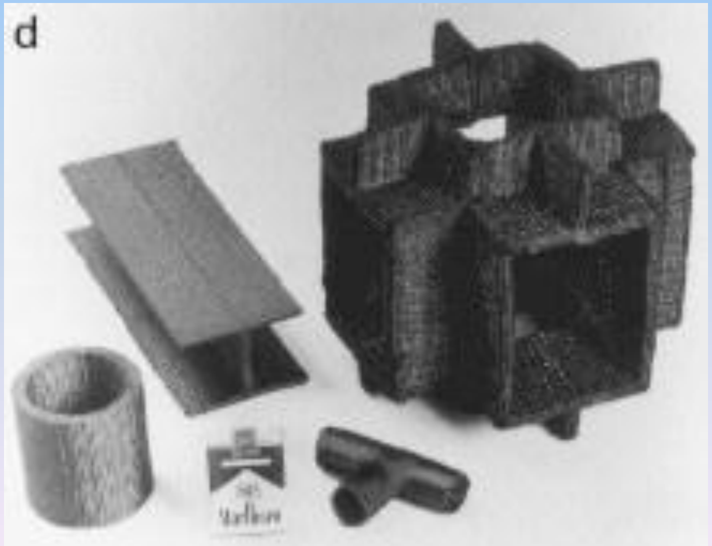
Carbon (IM)	Intermediate Modulus
Carbon (HM)	High Modulus
Carbon (UHM)	Ultra-high Modulus

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

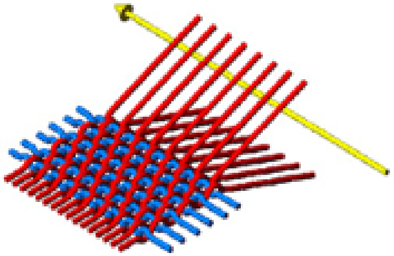
3D structures are formed using a variety of braiding, weaving, and knitting techniques:



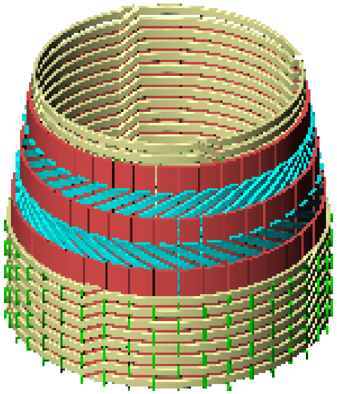
Examples of complex structures:



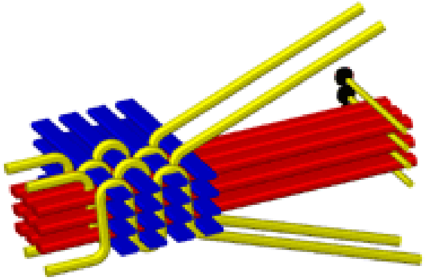
Examples of Fabrication Techniques



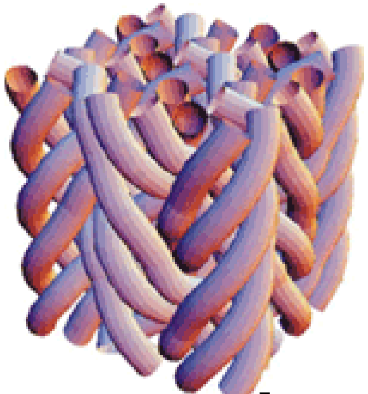
2-D Weave



3c Weave

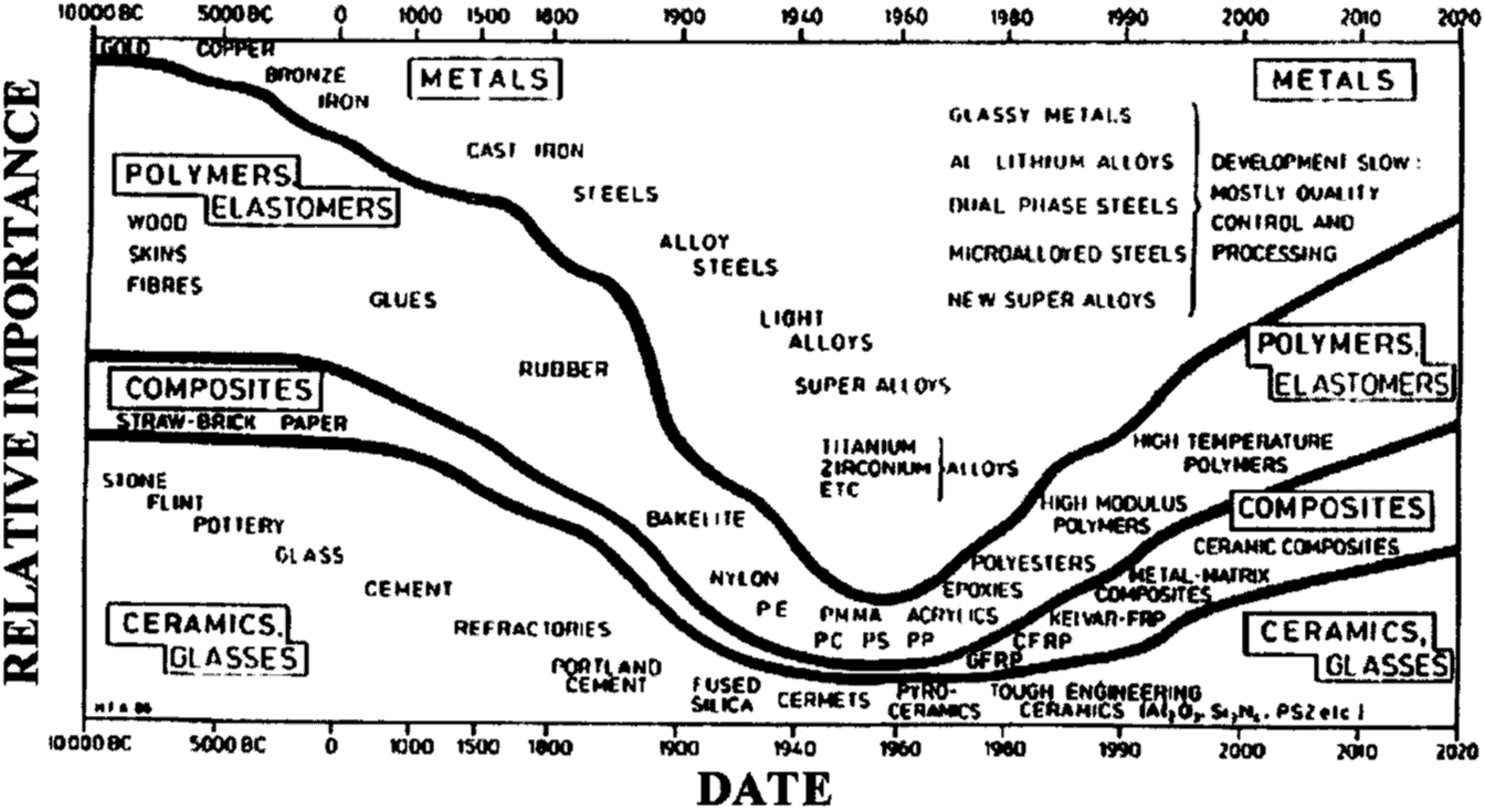


3-D Weave



Braid

Materials in Engineering



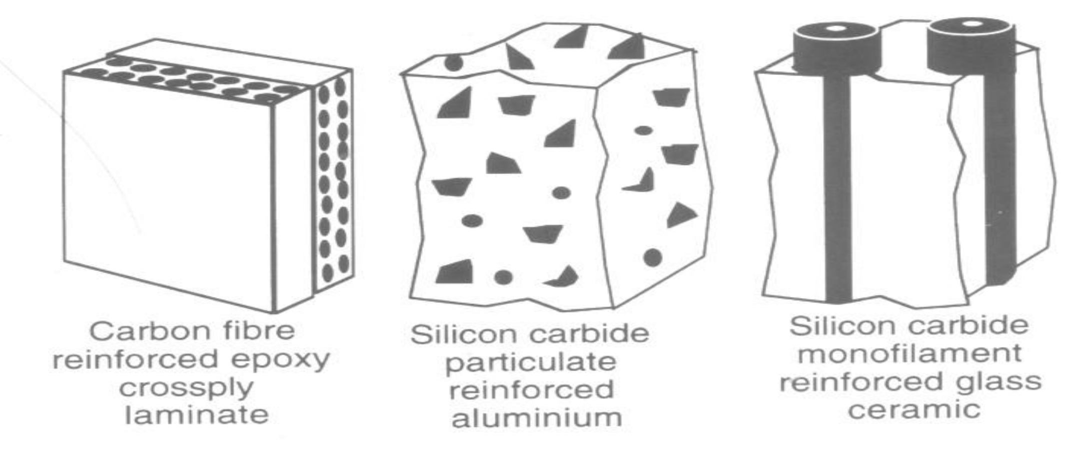
Material Selection

- 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?

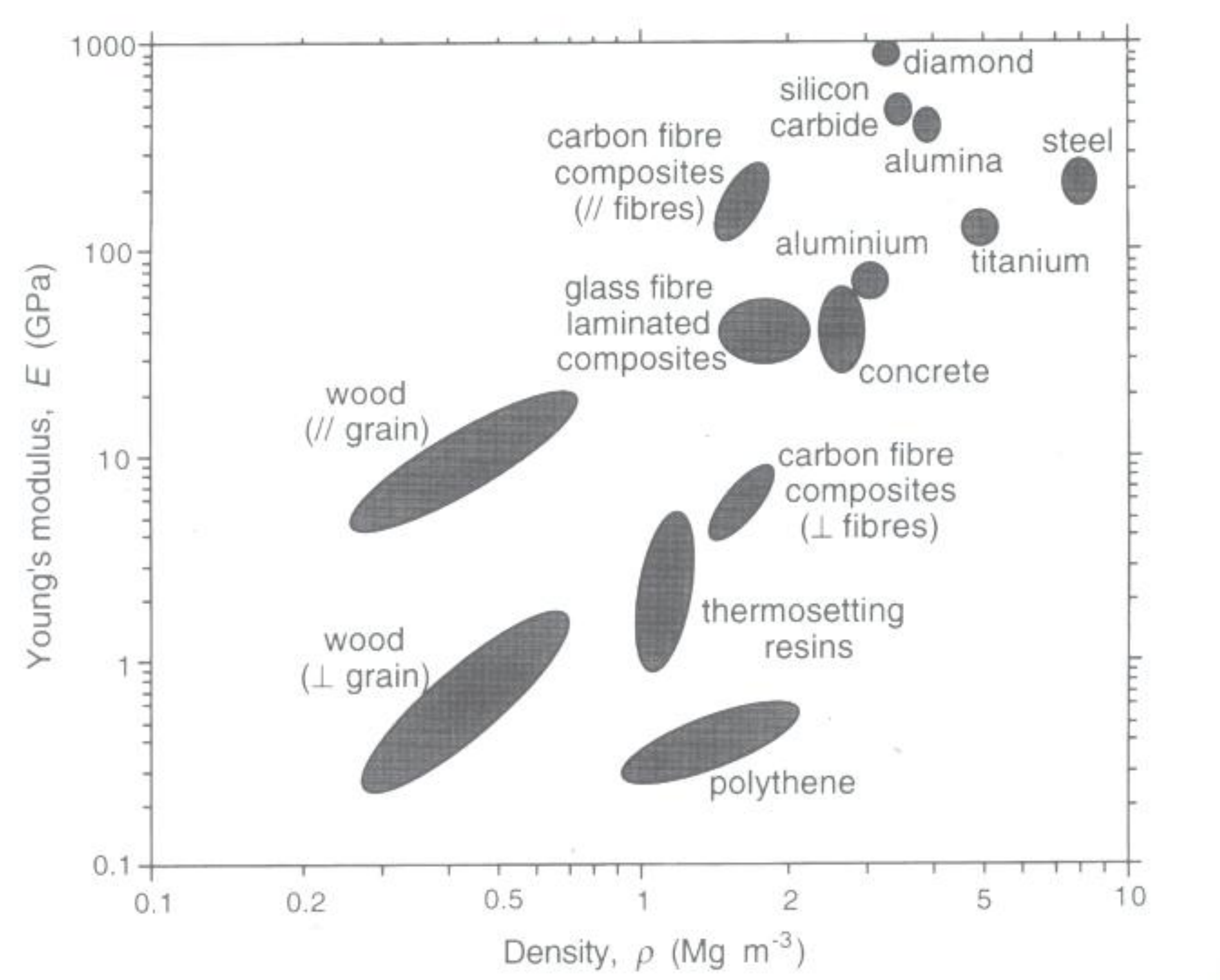
- A ***material system*** made by mixture or combination of 2 of micro or macro-constituents different in chemical composition and insoluble in each other.



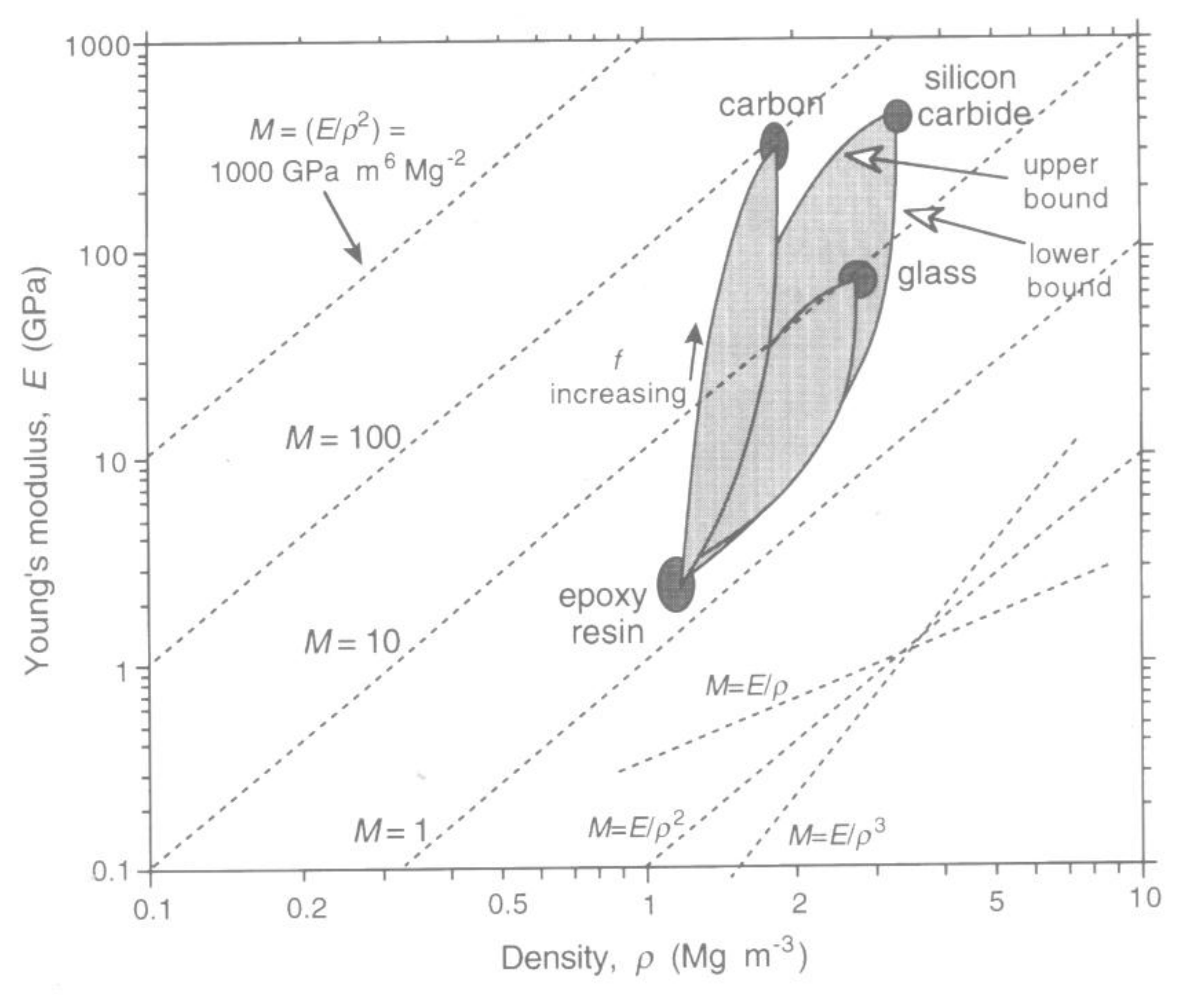
	Density ρ kg/m^3	Young’s Mod E_l GPa	Tensile Strength σ_l MPa	Strain to Failure ε_l %
E Glass	2570 – 2600	69 – 72	3.45 – 3.79	4.5 – 4. 9
S Glass	2460 – 2490	86 – 90	4.59 – 4.83	5.4 – 5.8
Kevlar 49	1440	131	3.6 – 4.1	2.8
Kevlar 149	1470	186	3.4	2.0
Carbon (IM)	1700 – 1830	276 – 317	2.34 – 7.07	0.8 – 1.9
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 ºC)

- When combined with polymer matrixes limit of use is above 200ºC