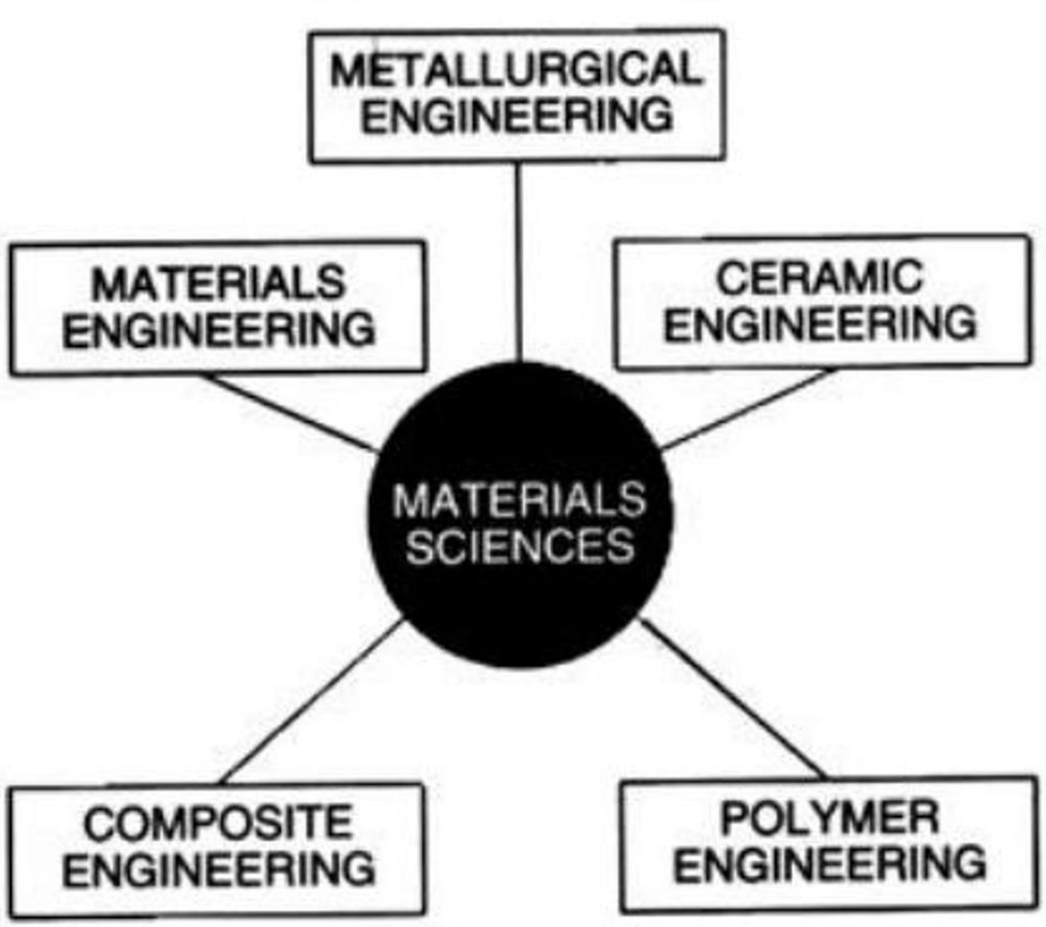
Metallurgy 1

Metallurgy is the science and technology of metal. It is the oldest of the sciences devoted to the study of engineering materials. Metallurgy has evolved into three separate groups: extractive, mechanical, and physical.

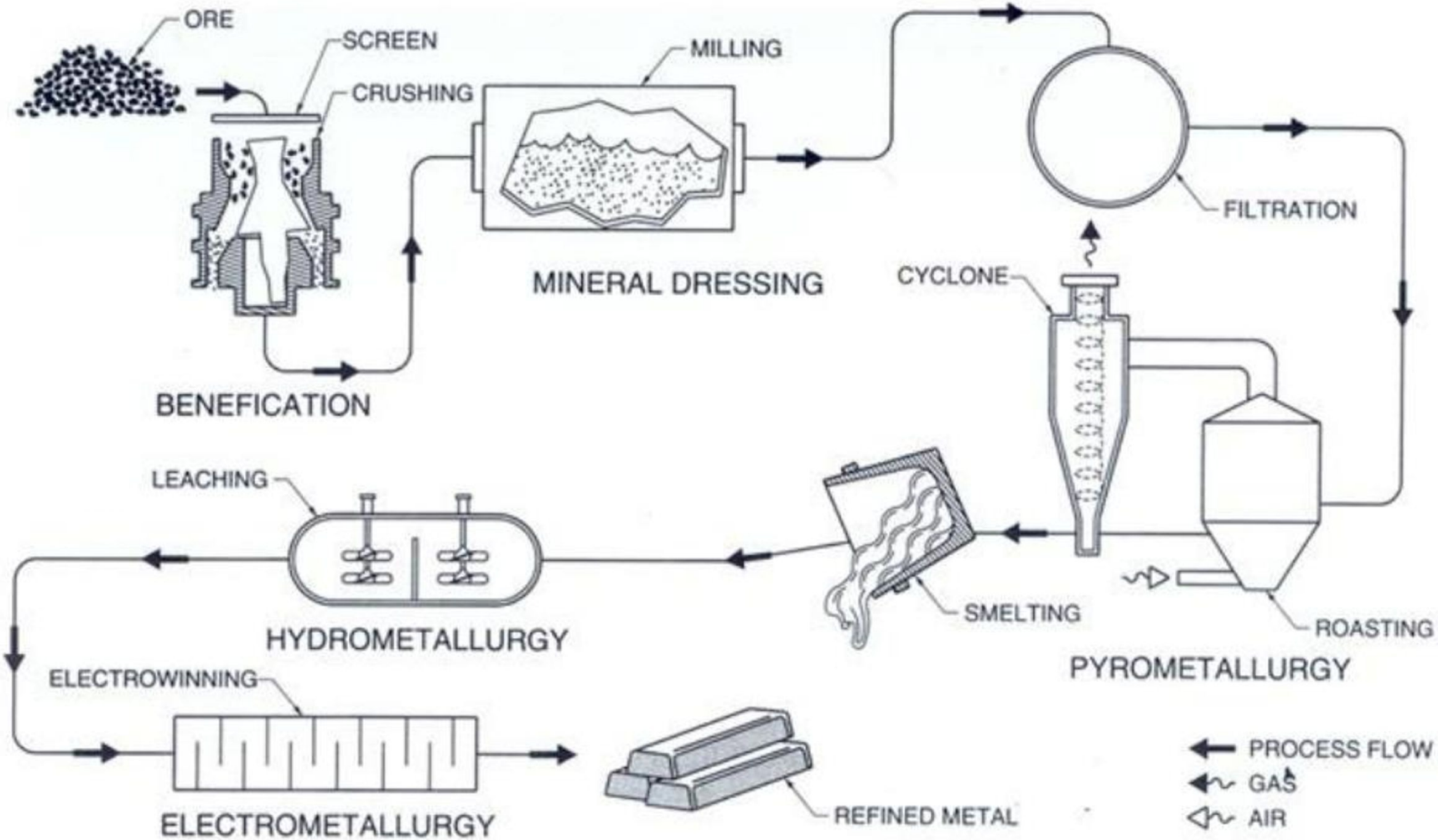
Metallurgical Engineering

Metallurgical engineering or metallurgy is the study of metals and is the oldest sciences devoted to the study of engineering materials.



Extractive Metallurgy

- Extractive metallurgy is the study of the extraction and purification of metals from their ores.
- Extracting a metal from its ore is conducted in several process steps.
- For example, the extraction route from ore to refined metal includes any or all of the following process steps.


ORE
SCREEN
CRUSHING
MILLING
MINERAL DRESSING
FILTRATION
CYCLONE
BENEFICATION
LEACHING
HYDROMETALLURGY
SMELTING
ROASTING
PYROMETALLURGY
ELECTROWINNING
ELECTROMETALLURGY
REFINED METAL
PROCESS FLOW
GAS
AIR

Extractive Metallurgy Cont.

- Benefication, mineral dressing, pyrometallurgy, gydrometalluryg, and electrometallurgy.

- See figure 1-2

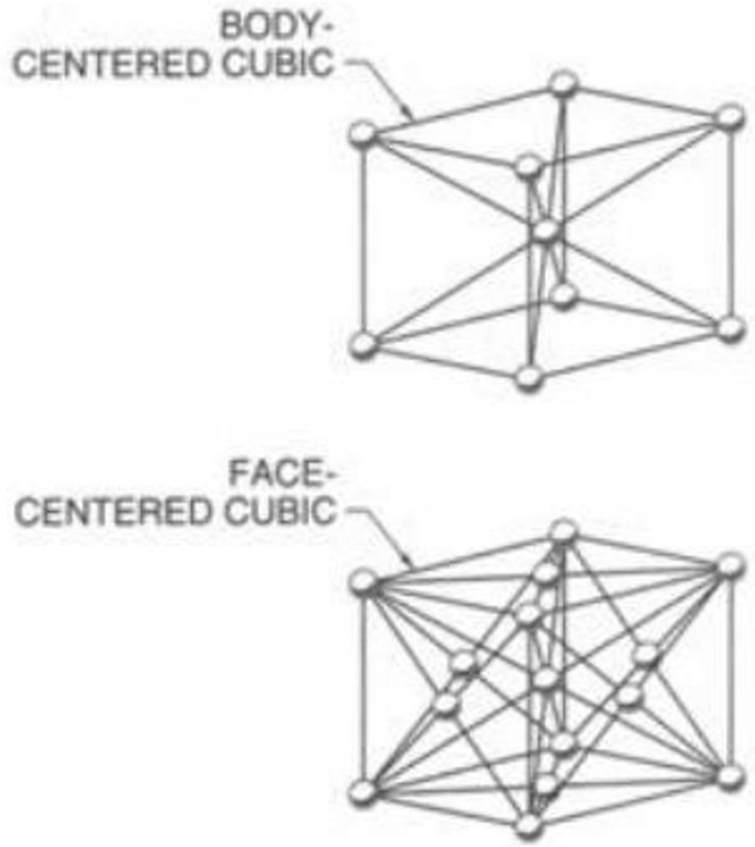
Mechanical Metallurgy

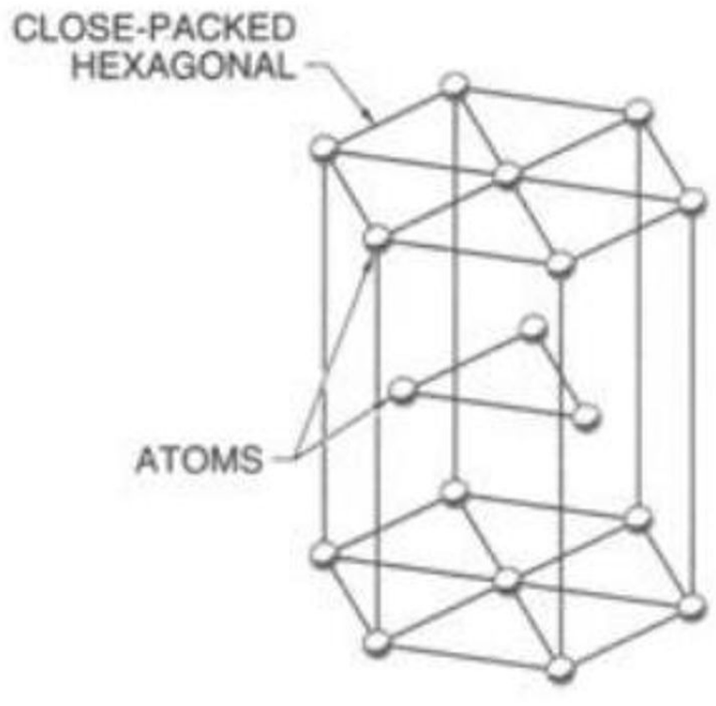
Mechanical metallurgy is the study of the techniques and mechanical forces that shape or make finished forms of metal.

SELECTED FACTORS STUDIED IN MECHANICAL METALLURGY
Stress
Time
Temperature
Rate of heating
Rate of cooling
Geometry of raw material
Geometry of desired finish product
Processing environment

Physical Metallurgy

- Physical metallurgy is the study of the effect of structure on the properties of metals.
- The two structures studied in physical metallurgy are the crystal structure and micro structure.
- See figure 1-4
- The *crystal structure* is the arrangement of atoms in the metal.
- An *atom* is the smallest building block of matter that can exist alone or in combination.
- It cannot be divided without changing its basic character.
- The crystal structure is shown through modeling.
- The *microstructure* is the microscopic arrangement of the components, or phases, within a metal.
- The technology of heat treatment of steels is based on a specific crystal structure and microstructure change that occurs when steel is rapidly cooled from a high temperature.
- These changes lead to hardening and strengthening of steels.





CRYSTAL STRUCTURES

Ceramic Engineering

Ceramic engineering, or *ceramics*, is the study of the development and production of products made from nonmetallic, inorganic materials by firing at high temperatures. Ceramic materials are divided into four groups:

Ceramic Engineering Cont.

- Clay-based materials
- Refractories
- Glasses
- Inorganic cements

Polymer Engineering

Polymer engineering or *polymer* is the study of the development and production of synthetic organic materials. Polymer are divided into two groups:

Polymer Engineering Cont.

- Thermoplatics
- Thermosets
- Polymer are used I applications such as adhesives, building products, fibers sporting goods, and automotive and aerospace components.

Composite Engineering

Composite engineering, or *composites*, is the study of the applicability of combinations of materials. Composites are used to strengthen metals, ceramics, or polymers and improve their structural usefulness.

Materials Engineering

Materials engineering, which crosses the boundaries of all the branches of materials sciences, is the study of the evaluation of the characteristic properties of all materials.

METAL IDENTIFICATION

Metal is performed by studying certain characteristics that metals exhibit. A metal is described as a pure metal or as an alloy and may be further divided into and identified as ferrous or nonferrous. Metals and all other materials exhibit three types of properties that help identify the materials.These properties are:

Physical properties

Mechanical properties

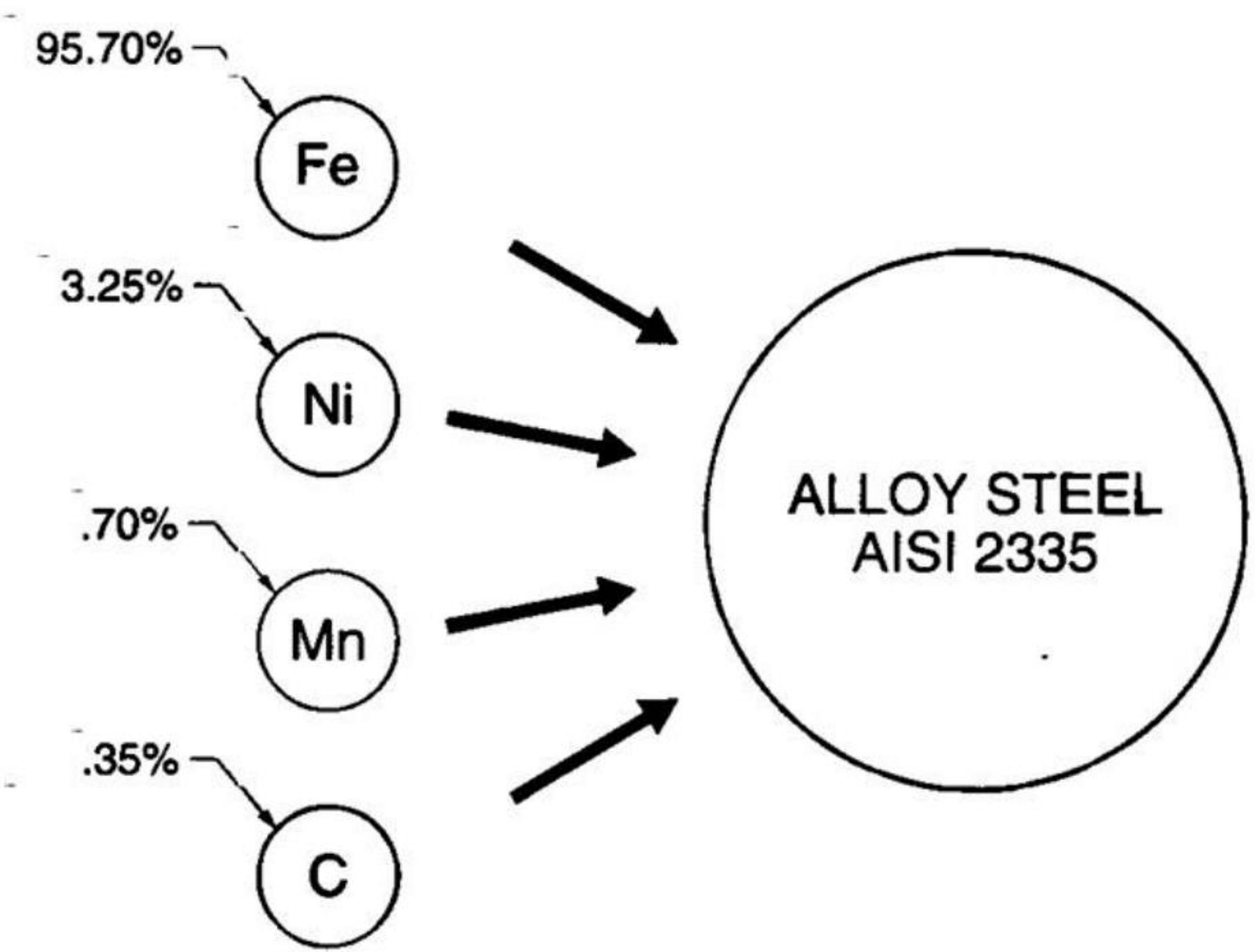
Chemical properties.

Metals and Alloys

Metals refer strictly to pure metals, which are also chemical elements.

For example, copper, iron, manganese, and zinc, are chemical elements and pure metals. Pure metals, which are usually soft and have low-strength, have extremely limited usage in engineering applications. *Alloys* are materials that have metallic properties and are composed of two or more chemical elements. At least one of the elements in an alloy is metal.

See figure 1-6


95.70%
Fe
3.25%
Ni
.70%
Mn
.35%
C
ALLOY STEEL
AISI 2335
ALLOYING ELEMENTS
ALLOY

Ferrous and Nonferrous

Metals and alloys are also described as ferrous or nonferrous. *Ferrous metallurgy* encompasses alloys based on iron, where the major alloying element is iron.

Nonferrous metallurgy encompasses all other pure metals and alloy systems.

Chemical Analysis

Chemical analysis is the key to the identification of alloys and is used to determine the weight percentages of all the elements that make up alloys.

COMPOSITION OF SELECTED STAINLESS STEELS

UNS	%C	%Mn	%Si	%Cr	%Ni	%P	%S	Others
S30200	.15	2.00	1.00	17.0 to 19.0	8.0 to 10.0	.045	.03	—
S30215	.15	2.00	2.0 to 3.0	17.0 to 19.0	8.0 to 10.0	.045	.03	—
S30300	.15	2.00	1.00	17.0 to 19.0	8.0 to 10.0	.20	.15 min	.6 Mo (optional)
S30310	.15	2.5 to 4.5	1.00	17.0 to 19.0	7.0 to 10.0	.20	.25 min	—
S30323	.15	2.00	1.00	17.0 to 19.0	8.0 to 10.0	.20	.06	15 min Se
S30345	.15	2.00	1.00	17.0 to 19.0	8.0 to 10.0	.05	.11 to .16	.40 to .60 Mo; .60 to 1.00 Al
S30400	.08	2.00	1.00	18.0 to 20.0	8.0 to 10.5	.045	.03	.10 N
S30403	.03	2.00	1.00	18.0 to 20.0	8.0 to 12.0	.045	.03	.10 N
S30409	.04 to .10	2.00	1.00	18.0 to 20.0	8.0 to 10.5	.045	.03	—

Properties

A *property* is a measurable or observable attribute of a material that is of a physical, mechanical, or chemical nature.

SELECTED PROPERTIES OF METALS		
Physical	**Mechanical**	**Chemical**
Coefficient of thermal expansion	Elongation	Chemical reactivity
Color	Fatigue limit	Corrosion resistance
Density	Hardness	Electrochemical potential
Electrical conductivity	Stiffness	Irradiation resistance
Lattice parameter	Shear strength	Resistance to acids
Magnetic permeability	Tensile strength	Resistance to alkalies
Weight	Toughness	Solubility

Physical Properties

Physical properties are the characteristic response of materials to forms of energy such as heat, light, electricity, and magnetism. Color, density, magnetic permeability, and weight of a material are physical properties.

Mechanical Properties

Mechanical properties are the characteristic dimensional changes in response to applied external or internal mechanical forces.

Chemical Properties

Chemical properties are the characteristic responses of materials in chemical environment. Corrosion resistance and resistance to acids and alkalies are examples of chemical properties.

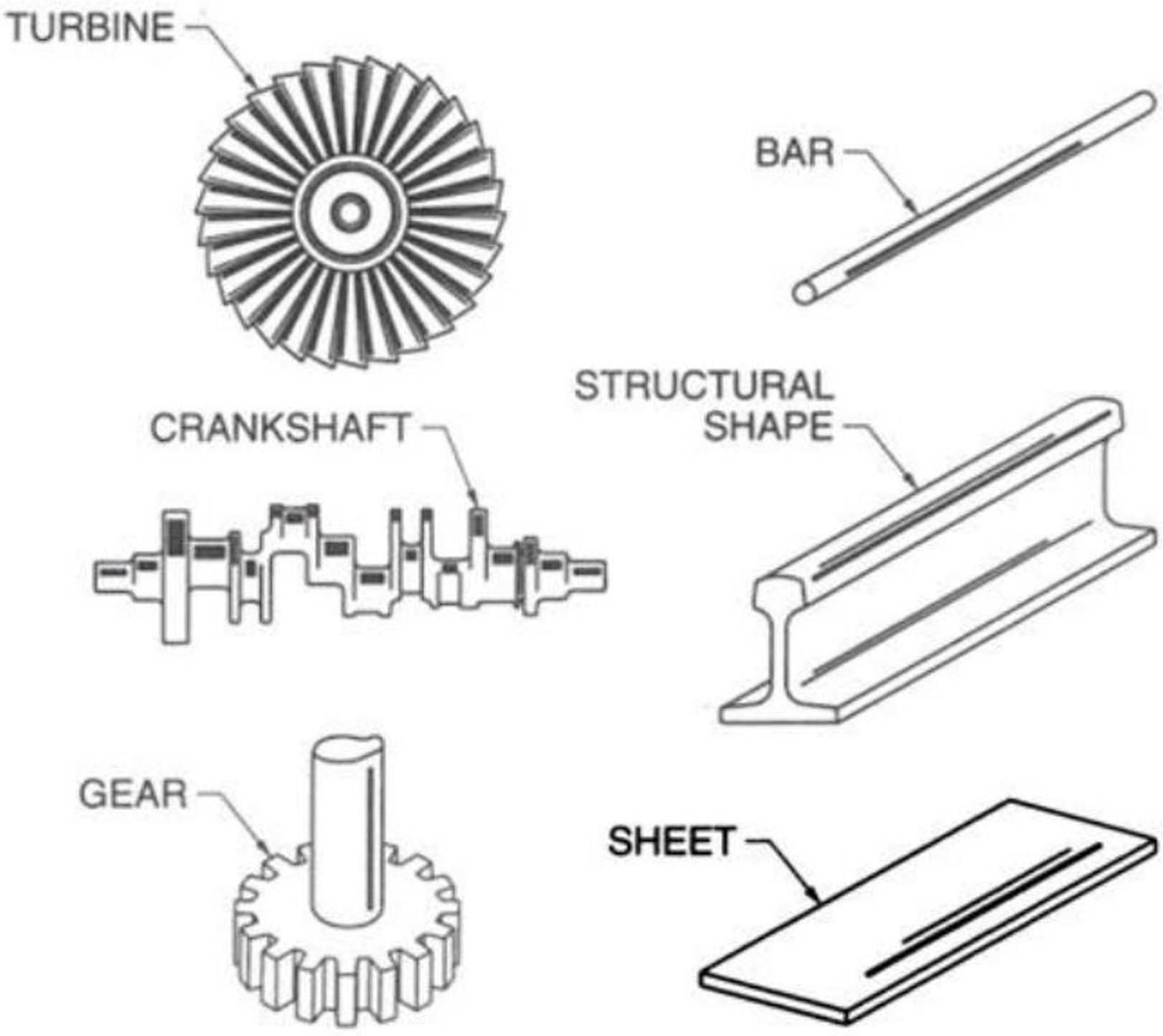
Process Condition

Metals may be supplied as cast, as wrought, or from powders.

See figure 1-9

The properties of cast and wrought metals any be substantially and identifiably different.

Cast metals are produced from molten metal solidifying in a mold cavity.


TURBINE
BAR
STRUCTURAL SHAPE
CRANKSHAFT
GEAR
SHEET