Automobile

- Body
- Suspension / Chassis
- Engine / Exhaust
- Transmission
- Interior

Body - In - White

- Roof
- Quarter Panels
- Fenders
- Floor Pan
- Pillars

- Closures
  - Doors
  - Deck Lid
  - Hood
Where Do Metals Come From?

- Earth’s Crust: Igneous Rocks
  - 98.3% of crust is composed of only 8 elements:
    - Oxygen -- O
    - Silicon -- Si
    - Aluminum -- Al
    - Iron -- Fe
    - Calcium -- Ca
    - Sodium -- Na
    - Potassium -- K
    - Magnesium -- Mg
  - Some metals occur naturally as an element:
    - Gold -- Au; Silver -- Ag; Platinum -- Pt; Copper -- Cu
  - However most metals occur in compounds as oxides or sulfides

RAW MATERIALS: ORE

- Naturally occurring aggregate of minerals from which a metal can be extracted at a profit.
  - Mixture of:
    - Primary valuable mineral (usually as compound)
    - Greatly predominate worthless "gangue"
    - Valuable by-products
    - Detrimental impurities
**Important Ores for Steel & Aluminum**

- **Hematite**
  - iron oxide (Fe₂O₃)
  - Metal Content: 69.9% Fe
  - Normal Ore Grade 20-70% Fe
  - Russia, USA, France, Australia, Canada, China, Sweden, Brazil, India

- **Magnetite**
  - iron oxide (Fe₃O₄)
  - Metal Content: 72.4% Fe
  - Normal Ore Grade 20-70% Fe
  - Russia, USA, France, Australia, Canada, China, Sweden, Brazil, India

- **Bauxite**
  - Hydrous aluminum & iron oxides
  - Metal content: 25-39% Al
  - Normal Ore Grade 25-39% Al
  - Australia, Guinea, Jamaica, Surinam, Russia, Guyana
RAW MATERIALS FOR PRODUCING STEEL

- ORE
- COAL
- LIMESTONE

ORE BENEFICIATION

(for iron ore or limestone)

Mining

0.1 - 1 meter size

Coarse Crushing

0.2 - 0.5 kWh / ton ore

Fine Crushing

0.5 - 2 kWh / ton ore

Coarse Grinding

1 - 10 kWh / ton ore

0.0001 m size (0.1 mm)

Micronizing

> 100 kWh / ton ore

Screening

homogeneous size
ORE BENEFICIATION-continued

- concentration
  - gravity separation
  - flotation
  - magnetic separation

- liquid / solid separation
  - thickening
  - filtration

- drying & calcination
  - removal of H₂O
  - removal of CO₂

- agglomeration
  - sintering
  - pelletizing

- concentrated ore

RAW MATERIALS: CARBON BASED FUELS

 Contains: Carbon, Hydrogen, Nitrogen, Sulfur, Oxygen, Oxides, Silicates

- Wood >40% Oxygen ~30% Carbon
- Peat ~30% Oxygen ~ % Carbon
- Lignite ~20% Oxygen ~ % Carbon
- Bituminous Coal ~ 5% Oxygen >90% Carbon
- Anthracite Coal ~ 2% Oxygen >95% Carbon

- High Calorific Efficiency means low ash content and low sulfur content

- Therefore coal is treated before its use in reducing ore to metal
**High Temperature Coking**

- Coal heated (1000 C) in atmosphere of low oxygen to:
  - impart improved properties for metallurgical processing
  - expel volatiles (to avoid contaminating iron/steel)
  - volatiles are rich in hydrogen and methane (CH4)
  - other off-gases: CO, CO₂, H₂O, VOCs, SO₂, NH₃, NOx, particulates (cyanides -hazardous sludges from scubbers, emission leaks)
  - 1-2% volatiles remain in coke
  - 67% of initial sulfur remains in coke

**IRONMAKING: BLAST FURNACE**

- Reducing Atmosphere
- Carbothermic Reduction Reaction
  - 2 FeO + C --- CO₂ + 2 Fe
- ~0.5 ton C used for every ton pig iron
- Produces 1.8 tons CO₂
- Other emissions: SO₂, NOx

- Pig Iron:
  - 4% Carbon
  - 0.5-1% Silicon
  - 0.5-1% Manganese
  - 0.05% Sulfur
  - 0.05% Phosphorus

- Capacity: 10,000 Ton / Day
STEELMAKING: BASIC OXYGEN FURNACE

- Charge
  - pig iron 70-80%
  - scrap 20-30%
  - lime
  - Fluorspar

- Oxygen Gas Jet through top lance

- Oxidize carbon and other impurities to slag

- Produce Plain Carbon Steel
  - 0.2% Carbon
  - 0.5% Manganese
  - 0.05% Sulfur max
  - 0.04% Phosphorus max

ORE BENEFICIATION- Bayer Process

45-65% Al₂O₃
10% FeO
3% TiO₂
<5% SiO₂

Goal: to dissolve as much alumina without impurity
Al₂O₃ + 2 NaOH = 2(NaAlO₂) + H₂O

Filter out RED MUD

NaAlO₂ + H₂O = NaOH + Al(OH)₃

Al₂O₃
ALUMINUM PRODUCTION: HALL CELL

- Electrochemical Processing  -- US Capacity 4 million tons per year
  - cathode
  - anode
  - electrolyte
  - produces metal and gases

- Feed: Aluminum Oxide (Alumina) from Bayer process
  - dissolved in Na₃AlF₆ - AlF₃ - CaF₂

- Anode: Manufacture of Carbon Prebakes from coal, tar, pitch
  - 0.5 lb C needed to produce 1 lb Al

- Cathode: Carbon Liners

ENERGY!!  Electricity drives the reaction
  -- Primary Smelting consumes 2% of total US power

Emissions from Aluminum Smelting

- Fugitive Emissions from Hall Cell
  - CO₂
  - Fluorides
  - particulates

- Anode Prebake Operation
  - SO₂
  - VOCs
  - PNAs
  - particulates

- Spent Potliners (150,000 ton/year disposed)
  - Fluorides
  - Cyanides
Alloy Designation System for Aluminum Alloys

**WROUGHT ALLOYS**
- 1XXX aluminum of 99% minimum purity or higher
- 2XXX copper (2-6%)
- 3XXX manganese (1-1.5%)
- 4XXX silicon (3-13%)
- 5XXX magnesium (0.5-5%)
- 6XXX magnesium & silicon (0.35-1.5% Mg & 0.2-1.8% Si)
- 7XXX zinc (4-8%)
- 8XXX other element
- 9XXX unused

**CAST ALLOYS**
- 1XX.X aluminum of 99% minimum purity
- 2XX.X copper (3.5-5%)
- 3XX.X silicon + (copper or magnesium) (5-18%)
- 4XX.X silicon (5-13%)
- 5XX.X magnesium (4-8%)
- 6XX.X unused
- 7XX.X zinc
- 8XX.X tin
- 9XXX other element

Metal Fabrication Techniques

- Forming Operations
  - Forging
  - Rolling
  - Extrusion
  - Drawing
- Casting
- Miscellaneous
  - Sand
  - Die
  - Investment
  - Welding
  - Powder Metallurgy
Materials Choices

- Affect Manufacturing
- Affect Fabrication
- Affect Product Use
- Affect Disposal