**Puddling Furnace**

- Low Arched Roof With Two Chambers
- Molten Iron & Combustion Chamber Are Separated

**Bessemer Process**

- Sir Henry Bessemer
  - Inventions
    - Stump, That, Could, Not, Be, Forged
    - Improved, Land, Penet 11., T. Pattern, E, Type
    - Bes., Way, Of, Melting, Bronze, Powder
    - Machinery, For, Crushing, Sugar, Cone
    - Melting, Plate, Glass
    - Guns, Fur, England
- Bessemer Process (Beginning 1855)
  - Worked, Beginning, Of, Steel Age

**Bessemer Process (Continued)**

- Very Simple Idea
  - Dismissed At First By All So-Called Experts
  - Observation
    - Walls, Iron, Reacted, On, the, Surface, With, Air
- Process
  - Recall, To Convert Molten "Cast" Iron To Wrought Iron, The Carbon Must Be Removed
  - Bessemer Blew Cold Air Through The Molten Iron
  - Though He Produced Wrought Iron
  - However, He Produced Malleable Iron "Steel"
    - What We, Call, Mild, Steel.

**Bessemer Process (Continued)**

- Numerous Patents (1855 To 1856)
- Experimental Setup
  - 770 lb Iron (1/3 Ton) & Required 30 Minutes
    - Converted To 550 lb In, Puddling Furnace. For, 2, hrs
  - Ordinary Air - 21% Oxygen
  - Converter (Pear) Tilted For Charging & Pouring
- Produced Mild Steel
  - Could Be Bent & Formed Without Heat
- Process Difficulties
  - Bessemer Licensed Process
  - Licensees Could Reproduce Quality Of Steel

**Bessemer Process (Continued)**

- Iron Gets Hotter As Cold Air Passes Through It
  - Experts Thought It Would Cool Iron
  - Like A Volcano
  - Most Spectacular Sight In Iron & Steel Industry
  - Clear Flame Finally From Converter
  - Shown - 25 Ton

**Bessemer Process (Continued)**

- Experimental Plant At St. Pancras
  - Ore Mined At Blaenavon, Gwent (No Phosphorous)
- Bessemer Plant At Sheffield (1905)
  - Made A Fortune
  - Steam Boilers (1860)
  - Railway Rails (1863)
# Thomas Process

- P.G. Thomas, Police-Court Clerk & Scientist
- Removed Phosphorous Problem
  - Lined Converter With Dolomite
    - Chemically Basic
    - Used With Phosphorous
    - West Away, Mull slag
    - Sold As Agricultural Fertilizer
- Thomas Process Spread Quickly To Regions With Phosphorous Iron Ores (Most Abundant)

# Basic Oxygen Process

- Advancement Of Bessemer & Thomas Process
- Air Is Replaced With High Pressure Stream
  - Pure Oxygen
  - Oxygen Lance (Water-Cooled Tip)
  - Supersonic Speed
- 275 tons Per hour

# Siemens Process

- C.W. Siemens, Germany
  - Improving Furnaces For Glass Making
    - By 1857, Saved 75% Of Fuel Need To Make Glass
    - Waste Gases Used To Heat Air Needed To Burn Fuel
  - First Applied To Steel Making In France
    - Emile Pierre Martin (1855)
    - Siemens Set Up Iron Works In Birmingham (1865)
    - Company At Savannah, Producing 75 Tons A Week
- Siemens Process
  - Phosphorous & Non-Phosphorous Molten Iron
  - Cost
    - Bessemer Was Cheaper (No Fuel) But Required Molten Iron
    - Siemens Required Fuel
  - Speed
    - Bessemer - 30 min
    - Siemens - 10 hours
- Could Melt Scrap Iron

# Siemens Process (Continued)

- Phosphorous & Non-Phosphorous Molten Iron
  - Cost
    - Bessemer Was Cheaper (No Fuel) But Required Molten Iron
      - Located Near Blast Furnace
    - Siemens Required Fuel
  - Speed
    - Bessemer - 30 min
    - Siemens - 10 hours
  - Could Melt Scrap Iron

# Open-Hearth Furnace

- Process Of Producing Steel
  - Furnace Can Be Charged With
    - Pig Iron (Molten Or Cold)
    - Scrap Steel
    - Iron Dross
  - Carbon Content Is Lowered By
    - Silicon
  - Impurities Combine With Limestone As Slag
    - Silicon, Phosphorous, Magnesia, & Sulfur

# Open-Hearth Process

- Derived From Siemens’s Process
- Components
  - Rectangular Brick Hearth (20’x30’x8’)
  - Regenerative Preheating
- Operates At 3000°F
  - Steel Melts At 2500°F
- Produces 100 tons Per hour
Open-Hearth Furnace

Electric Furnaces
- Electric Arc Or Electric Induction
- Primary Use Is Alloy & Specialty Steels
  - Charge Is Usually Scrap
  - Limestone & Iron Ore Are Added In Small Amounts
  - No Contamination From Fuel
  - Alloying Elements Are Added In Charge Or Later
- Electric Arc
  - Refractory Lined Vessel Of Drum Shape
  - Heat Is Generated By Electric Arc
- Electric Induction
  - Electric Current Induces Secondary Current In Vessel

Electric-Arc Furnace

Classifications Of Steels
- Carbon Steels
- Alloy Steels
- High-Strength Low-Alloy Steels
- Stainless Steels
- Tool Steels

Carbon Steels
- 90% Of All Steels
- Composition
  - Varying Amounts Of Carbon
  - Less Than 1.65% Manganese
  - Less Than 0.60% Silicon
  - Less Than 0.60% Copper
- Uses
  - Auto Bodies, Machines, Structural Steel For Buildings, Ship Hulls, Etc.

Alloy Steels
- Composition
  - Certain Percentages Of Vanadium, Molybdenum, Or Other Elements
  - Larger Amounts Of Manganese, Silicon, & Copper Than Carbon Steels
- Uses
  - Auto Gears & Axles, Knives
### High-Strength Low-Alloy Steels
- Called HSLA
- Combination Between Carbon Steels & Alloy Steels
- Cost Less Than Alloy Steels
- Stronger Than Carbon Steels

### Stainless Steels
- Composition
  - Chromium
  - Nickel
  - Other Alloying Elements
- Properties
  - Corrosion Resistance
  - Hard & Strong

### Tool Steels
- Composition
  - Tungsten
  - Molybdenum
  - Cobalt
  - Other Alloying Elements
- Properties
  - Hardness