Lecture #6

Environmentally Responsible Design and Manufacturing

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Recapping

Process

Examples:
* Mfg Process
* Product Usage
* Transportation

Resources
Energy

Wastes

Process Benefit:
* Product
* Material
* Utility of Product
* Service

Environment
Lecture Objectives

- While it is not the preferred approach, we must study pollution control.

- To summarize important classes of pollution control technology
Pollution Prevention Hierarchy

- Waste Avoidance
- Waste Reduction
- Recycle/Reclaim
- Treat
- Dispose

Preferred Strategies
Pollution Based on Form

❖ Airborne pollution
  o Combustion products (stationary, mobile)
  o Volatile chemicals (stationary, mobile)

❖ Waterborne pollution
  o Point sources (municipalities, industrial plants)
  o Non-point sources (urban runoff, agricultural runoff)

❖ Solid wastes
Criteria Air Pollutants

- Carbon monoxide (CO)
- Sulfur dioxide (SO2)
- Oxides of nitrogen (NOx)
- Volatile Organic Compounds (VOC)
- Photochemical Oxidants (O3, Smog)
- Lead (Pb)
- Particulates
Particulate Removal

- Settling chambers
- Cyclones
- Filters (e.g., baghouse)
- Scrubbers
- Electrostatic precipitators
Cyclone separator
Baghouse Collector
Gas Removal

- **wet scrubbers**
  - dissolve gas in water

- **adsorption systems**
  - gas molecules attach to surface

- **incineration**
  - gas molecules are oxidized to H2O, CO2, and other oxides
Air Scrubber

- used where
  - air is wet
  - corrosive
  - hot
  - baghouses cannot be used
  - in combination with cyclone

Diagram:
- Dirty air enters and clean air exits.
- Dirty water enters and clean water exits.
- Water spray within the air scrubber to clean the air.
Typical Water Pollutants

- Suspended solids, particles
- Heavy metals (e.g., Hg, Cd, Cr)
- Dissolved organic compounds (e.g., pesticides, solvents, gasoline)
- Plant nutrients (e.g., N, P)
- Pathogens (e.g., bacteria, viruses)
Particle Removal

- Settling tanks, flotation units
- Chemical addition, coagulation, flocculation, and settling
- Filters
Settling Tank

Diagram showing a settling tank with various zones:
- Inlet Zone
- Target Baffle
- Perforated Baffle
- Settling Zone
- Sludge Zone
- Outlet Zone
- Effluent Weir
Heavy Metal Removal

- Chemical addition, precipitation, settling tank
- Ion exchange
- Oxidation, precipitation
Organic Compound Removal

- Some removed as particulates
- Biological waste treatment
  - assimilation
  - metabolism
- Activated carbon adsorption
Biological Treatment System

- Wastewater enters the biological reactor, where additives are added.
- The treated wastewater moves to the settling tank for further processing.
- Recycled water from the settling tank returns to the biological reactor.
- Waste sludge is removed from the system.
- The effluent is the clean water that leaves the system.
Carbon Adsorption System
Nutrient Removal

- Biological waste treatment
- Chemical addition
Solid Waste Management

- Collection
- Transport/transfer
- Treatment
- Disposal
Major Sources of Solid Waste

- Mining: 75%
- Agriculture: 12%
- Industry: 9%
- Municipalities: 3%
- Sewage Sludge: 1%

Total: 100%
Incineration

- Burns waste, though usually not completely
- Residual is about 10-20% of original material and is landfilled
- Can cause odors, soot, and other air pollutants
- May emit dioxin, which is highly toxic ("Love Canal")
- Can be used to produce energy
Sanitary Landfills

- Approximately 61% of solid wastes go to sanitary landfills
- Sanitary landfills are not open dumps, but are engineered systems
- Waste is deposited in compacted layers and covered with earth daily
- Have impermeable liner, leachate, and gas collection systems
Resource Recovery

Can involve

- fairly simple methods like manual sorting
- very complex automated material sorting and recovery facilities
- reduces amount of disposable waste to about 1/3
Fate of Solid Wastes

- Germany: Recycled 20%, Incinerated 10%, Landfilled 70%
- Japan: Recycled 30%, Incinerated 50%, Landfilled 20%
- United States: Recycled 10%, Incinerated 50%, Landfilled 40%
- United Kingdom: Recycled 5%, Incinerated 10%, Landfilled 85%

Percentages are approximate and subject to change based on updated data.
Summary

- Almost every industrial production facility generates wastes — airborne, waterborne, solid — usually all forms
- Technology exists to deal with most wastes, some can be expensive
- Best to not to generate waste in the first place