Energy in Food Processing

Outline

- Utilities need in a food processing facility
- Energy source and process for converting water to steam
- Boilers for steam generation
  - Fire tube boiler
  - Water tube boiler

Utilities Needed in Food Processing

- Electricity
  - Motor to convert electrical energy to mechanical energy for operating moving parts; lighting
- Compressed air
  - To operate machinery, valves
- Hot air
  - To dry food products
- Hot water
  - To heat food products (to inactivate microorganisms)
- Cold water or other coolant
  - To cool food products (to minimize quality losses)
- Refrigeration
  - To inhibit microbial growth
- Steam
  - To blanch or heat food products
Energy for Converting Water to Steam

- Combustion process (fuel source + oxygen) is the heart of energy generation
  - Fuel source: C + H     Oxygen: Air
- Combustion reaction
  \[0.853 \text{CH}_4 + 0.126 \text{C}_2\text{H}_6 + 0.001 \text{CO}_2 + 0.017 \text{N}_2 + 0.003 \氧 + 2.362 \text{O}_2 + 8.88 \text{N}_2 = 1.106 \text{CO}_2 + 0.218 \text{O}_2 + 2.084 \text{H}_2\text{O} + 8.897 \text{N}_2\]
- Dry basis composition of flue gases
  - 87.1% N₂, 10.8% CO₂, 2.1% O₂
- Heat of combustion: \(~36,750 \text{kJ/m}^3\)
- Loss in energy with flue gases: \(~5,715.2 \text{kJ/m}^3\)
- Thus, \(~84.4\%\) of total energy is available

Generation of Steam

- Water is converted to steam (in a boiler) using a basic source of energy
  - Fuel oil, natural gas, wood, coal, heating element
  - One of the above is used to generate hot gases which heat the metallic surface (usually steel) in contact with water to generate steam

Fire Tube Boiler

- Hot gases are inside tubes surrounded by water
- The heat vaporizes water and converts it to steam
- As needed, steam is released from the boiler
- Fire tubes boilers are well suited for applications where there are large fluctuations in demand for steam
**Fire Tube Boiler**

- Hot gases are outside tubes through which water flows.
- The heat vaporizes water and converts it to steam.
- As needed, steam is released from the boiler.
- Rate of heat transfer is higher in a water tube boiler.
  - This is due to turbulence of water in the tubes.

**Water Tube Boiler**

- Hot gases are outside tubes through which water flows.
- The heat vaporizes water and converts it to steam.
- As needed, steam is released from the boiler.
- Rate of heat transfer is higher in a water tube boiler.
  - This is due to turbulence of water in the tubes.
- Water tube boilers operate at larger capacities and higher pressures.
- They are more flexible and safer.
  - Safety relates to phase change taking place in small tubes and not in a large vessel.

**Water Tube Boiler**
Summary

• Utilities in a food processing facility
  – Electricity, compressed air, hot air, hot water, cold water (or other coolant), refrigeration, steam
• Energy source for generation of steam
  – Combustion of oil, natural gas, coal, wood
• Energy from combustion is utilized in a boiler
  – Fire tube
    • Hot gas in tube; water outside tube in vessel
    • Can handle larger fluctuations in steam demand
  – Water tube
    • Water in tube; hot gas outside tube in vessel
    • Larger capacity, higher pressure, higher heat transfer rate, safer