Heat Engines

Heat Engines - Possibility of easing human labor by utilizing heat sources. Any device that can take energy from a warm source and convert the heat to mechanical energy.

Examples:
- Coal-fired steam boiler, combustion chamber of an automobile engine and more…
Energy Content of Fuels

• Heat derived from Fuels:

  Simple reactions:
  
  C + O₂ → CO₂ + Heat
  
  H₂ + O → H₂O + Heat

  Heptane Reaction: colorless liquid from gasoline
  
  C₇H₁₆ + 11O₂ → 7CO₂ + 8H₂O + Heat
This shows the general pathways by which we utilize energy from fossil fuels.
Carnot Efficiency

-A percentage less then 100%, which is taken from a heat source and is converted into mechanical work. Usually compared to an ideal engine.

Equation:
Efficiency(Carnot) = (1 - (Q_{cold}/Q_{hot})) \times 100\%
Heat Engine

Figure 3.2:
A thermodynamic diagram of a heat engine operating between a heat source and a heat sink at a lower temperature. The work output, because of conservation of energy, must equal the difference between the heat energy extracted from the source and that rejected to the sink.
Example:

- A coal fired electric power plant has a boiler temperature of 825K ($T_{\text{hot}}$). And the cooling tower has a temperature around 300K ($T_{\text{cold}}$). What is the Carnot Efficiency of this power plant?

Efficiency(Carnot) = (1-(Q(cold)/Q(hot)))x100%

What other ways could we use the waste heat?
Generation of Electricity

• **Electric Induction:** Founded by Michael Faraday (1791-1867), is the production of voltage across a conductor situated in a changing magnetic field or a conductor moving through a stationary magnetic field.

Electric Induction lead to…

**Electric Generators:** (Basic) A loop of copper wire that has a magnet pass through creating current. And many other devices!
Generators

Current Generator

- A loop of wire is forced to rotate in a magnetic field. The induced alternating current enters the external circuit through contacts (Carbon brushes) that rub against rotating metal rings, slip rings, attached to the coil. The current created, I, reverses in direction as the coil rotates.
Electric Power Transmission

• Electric power has to be transported from factories to homes and other areas that need electricity.
• Energy is lost during the transportation of electricity… To reduce transmission losses we must increase Voltage (V).
• What causes transmission losses?
• Power plants can be hundreds of miles apart, how can we reduce energy losses?
• What common voltages are brought into our homes?
Interesting Facts:

• 1) North American grid has more than 200,000 miles of high-voltage transmission lines.
  2) There are more than 3,000 power plants.
  3) Power plant’s electricity can span for hundreds of miles (Four Corners Power Plant in New Mexico to Los Angeles-over 500 mi)
Steam Engines

Interesting Fact: Steam engines were used over 300 years!

• Operating Steam Engines: Water is boiled to steam at atmospheric pressure and it is confined in a small compartment. As the pressure builds up, the steam expands and tries to escape with great force. This force can be exerted against a piston and go against the blades of a turbine and rotate a shaft creating

• [http://science.howstuffworks.com/steam1.htm](http://science.howstuffworks.com/steam1.htm)
Gasoline Engines

- In contrast from steam engines, gasoline engines are internal combustion engines.
- [http://www.youtube.com/watch?v=_y6PS-2j2Ug&feature=related](http://www.youtube.com/watch?v=_y6PS-2j2Ug&feature=related)
Diesel Engines

• Very similar to gasoline engine
• Differences:
  1. No electric spark ignition
  2. Fuel and air are not mixed before combustion
  3. Larger, heavier, bulky
  4. More efficient than gasoline engines
Interesting fact with diesel fuel

- Diesel engines can handle different types of fuel including different grades of diesel fuel, distilled liquor, and even certain kinds of cooking oils.
Gas Turbines

- Powers things like jet engines
- http://www.youtube.com/watch?v=7LTtjwlregM
Heat Pumps

• Opposite of a heat engine where it goes from cold to hot instead of hot to cold.

• Energy is needed to make this situation happen.

![Diagram of heat pump](image.png)

Figure 3.11 Energy and the Environment 2e © 2006 John Wiley & Sons, Inc.
Coefficient of Performance

$$\text{COP} = \frac{T_{\text{hot}}}{T_{\text{cold}} - T_{\text{hot}}}$$

Applies to an ideal heat pump
Cogeneration

- A small cogeneration plant that uses the combustion of natural gas to drive a gas turbine coupled to an electric generator. The hot exhaust gases boil water to steam for use in space heating and cooling.
The End
Heat source $T_{\text{hot}}$

HEAT ENGINE

Heat sink $T_{\text{cold}}$

$Q_{\text{hot}}$

$Q_{\text{cold}}$

Work output

$W = Q_{\text{hot}} - Q_{\text{cold}}$

Figure 3-2 Energy and the Environment 2e
© 2006 John Wiley & Sons, Inc.
Figure 3-10 Energy and the Environment 2e
© 2006 John Wiley & Sons, Inc.
Figure 3-11 Energy and the Environment 2e
© 2006 John Wiley & Sons, Inc.
Figure 3-13 Energy and the Environment 2e
© 2006 John Wiley & Sons, Inc.