Lect 6 – Thermo I – Work and Heat Introduction

1. Able to identify forces and displacements in energy systems
2. Able to distinguish between work or energy and power
3. Able to explain why work and heat are path functions as opposed to pt functions
4. Able to calculate work know a functional or graphical relationship of P vs. V or F vs. x

Class MMap

Bottom line – getting the most heat exchange or work done is our goal with cost, quality, timing, environment impact in mind

Examples
- In words
- In math

From Physics and this course

How can we summarize energy so far?

Graphical Integration

How do we calculate work?
Thermo Engineer in a Nutshell

“The biggest bang for the buck.”

“Most work or heat for the least cost.”

“Cost is complicated.”

Drip, drip, drip – The efficiency story
Work and Heat Overview
Is this fan assembly doing work?
Is this NEW system doing work?

Types of Work

- Assumption
  - Not quasi-equilibrium
  - Quasi-equilibrium

- Electrical
  - Batteries
  - Magnetics
  - aligning dipoles

- Tension / Torsion
  - Films
  - Stretching
  - Springs
  - Solid Bar
  - Shafts
  - Turbines
  - Compressors
  - Drive trains

- Moving Boundary
  - Compression
  - Expansion

- Flow
  - Pump
  - Compressors
  - Fans

- Viscous
  - Fluid - water interactions
Work…graphically shown

Three Quasi-Equilibrium Paths…is the work equivalent?
Spring Work – Garage Door

\[ f + \Delta f \]

Spring Work – Garage Door

\[ W = F \cdot d \]
Lect 7 – Thermo I – Work and Heat

Introduction

1. Able to calculate work for polytropic process
2. Able to distinguish between an quasi equilibrium process and a nonequilibrium process (equilibrium process doesn't make sense to me)
3. Able to identify and explain the three different modes of heat transfer
4. Able to calculate heat transfer by conduction using Fourier's law

Compression or Expansion work

\[
P \quad 2 \\
\begin{array}{c}
h \\
\text{2} \\
\end{array} \\
\begin{array}{c}
\text{1} \\
\end{array} \\
V \\
\begin{array}{c}
a \\
\text{1} \\
\end{array} \\
\begin{array}{c}
b \\
\text{2} \\
\end{array} \\
\end{array}
\]

\[dV \]

\[ (+) \]

\[ (-) \]
Example Problem

PROBLEM STATEMENT:
A piston-cylinder device contains 50 kg of water at 150 kPa and 25°C. The cross-sectional area of the piston is 0.1 m². Heat is now transferred to the water, causing part of it to evaporate and expand. When the volume reaches 0.2 m³, the piston reaches a linear spring whose spring constant is 100 kN/m. More heat is transferred to the water until the piston rises 20 cm more.
Work Done - Graphical

Class MMap

Lect 7
Work and Heat
Part B
Polytropic Processes - EXPANSION

\[ n = 0 \]

\[ n = \pm \infty \]

\[ n = 1 \]

\[ n = 1.3 \]

http://www.ac.wwu.edu/~vawter/PhysicsNet/Topics/Thermal/ImportantThermalProcess.html#Isobaric
Polytropic Processes at Work – Adiabatic Compression

Fire Piston

Adiabatic process

Isotherms

Work done
Work MMap

Types of Work

Torsion Work

\[ F \, dx \, d\theta \]
Two chambers separated by a membrane

\[ \text{P}_1 \quad \text{P}_2 \]

**Work Done?**

1. If entire interior is system – no boundary work
2. If green = system – no resistance at system boundary

**Quasi-Equilibrium process?**

[http://jersey.uoregon.edu/vlab/Thermodynamics/therm1d.html](http://jersey.uoregon.edu/vlab/Thermodynamics/therm1d.html)

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**Expert Comments**


2. “This assumption [quasi-equilibrium] is valid in the vast majority of cases encountered in engineering applications.” Schmidt et al. Thermodynamics an Integrated Learning System".
Modes of Heat Transfer

Conduction

Convection

Radiant

Modes of Heat Transfer