Chapter 4 - Energy Analysis for a Control Volume

Lecture 26

Section 4.4

MEMS 0051 Introduction to Thermodynamics

Mechanical Engineering and Materials Science Department
University of Pittsburgh

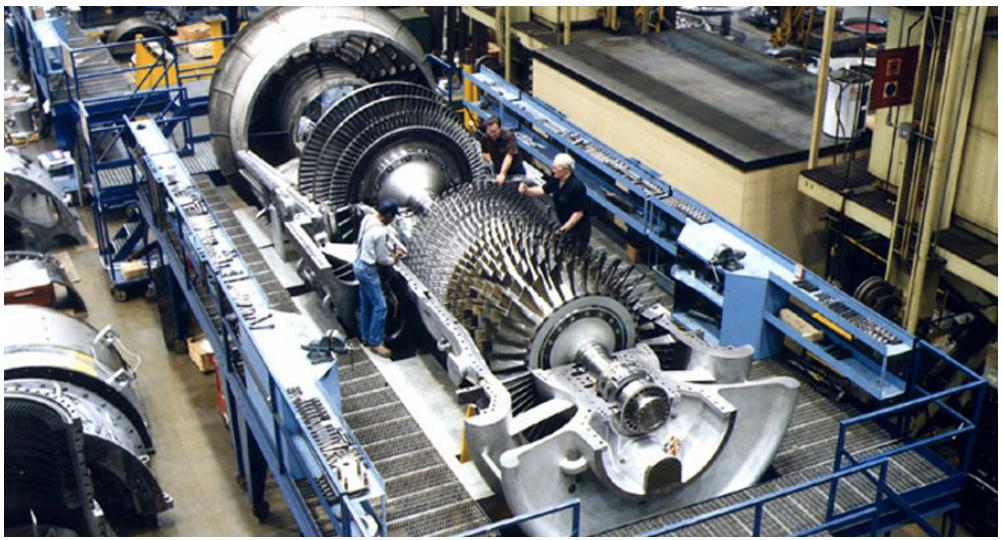
Student Learning Objectives

At the end of the lecture, students should be able to:

- Apply the Conservation of Energy and Conservation of Mass to steady state pumps, compressors and turbines

Turbines

- A turbine converts a high-energy thermal and pressure energies to mechanical energies to produce mechanical work



Example #1

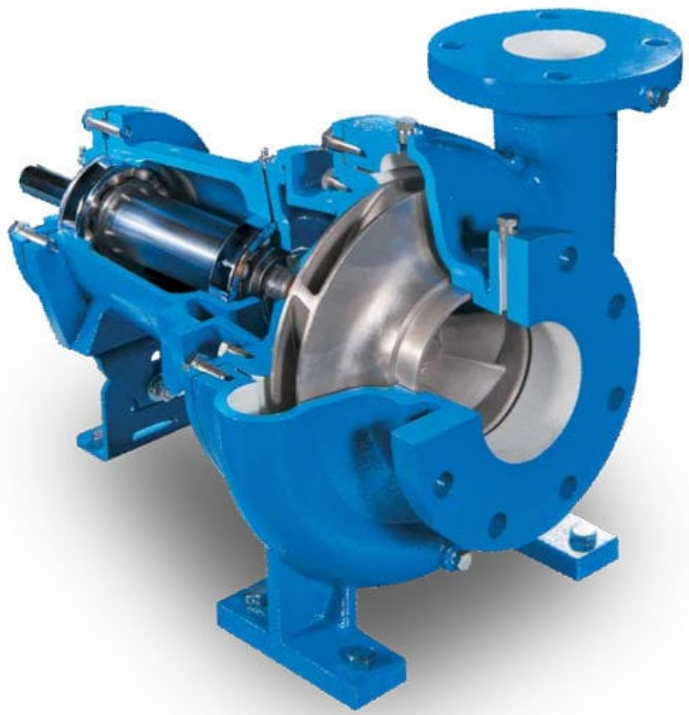
- Steam enters a turbine at 6,000 [kPa], 400 °C, 10 [m/s] at a rate of 4,600 [kg/hr]. The turbine produces 1,000 [kW] of mechanical power. The fluid then exits the turbine at 10 [kPa] at 50 [m/s] with a quality of 90%. Calculate the rate of heat transfer between the turbine and surrounding in [kW].

Example #1

Example #1

Pumps

- A pump converts mechanical energy to flow energy for a liquid
- A compressor converts mechanical energy to pres



Example #2

- An air compressor draws air at 100 [kPa] and 290 [K] through a 0.1 [m^2] opening at a velocity of 6 [m/s]. The air then exits the compressor at 700 [kPa] and a temperature of 450 [K] with a velocity of 2 [m/s]. The compressor rejects heat to the surroundings at a rate of 180 [kJ/min]. Calculate the necessary power input, in [kW].

Example #2

Example #2

Example #3

- A pump draws water with a mass flow rate of 9 [kg/s] through a piping network at a velocity of 3 [m/s]. The inlet of the pump is atmospheric (100 [kPa], 25 °C). At the exit of the network, the pressure is 140 [kPa], the temperature is the same as the inlet, and the exit velocity is 12 [m/s]. The exit is located 15 [m] above the inlet. Determine the power required by the pump.

Example #3

Example #3

Example #3

Student Learning Objectives

At the end of the lecture, students should be able to:

- Apply the Conservation of Energy and Conservation of Mass to steady state pumps, compressors and turbines
  - Turbines produce work by converting thermal and pressure energy to work, whereas pumps and compressors require work to move fluid and/or pressurize a fluid. The CoE must be constructed for each device on a per-case basis, to include things such as heat transfer, kinetic and potential energies.

Suggested Problems

- 4.40, 4.41, 4.42, 4.44, 4.45, 4.47, 4.50, 4.51, 4.52, 4.56, 4.61, 4.84, 4.85, 4.86, 4.87