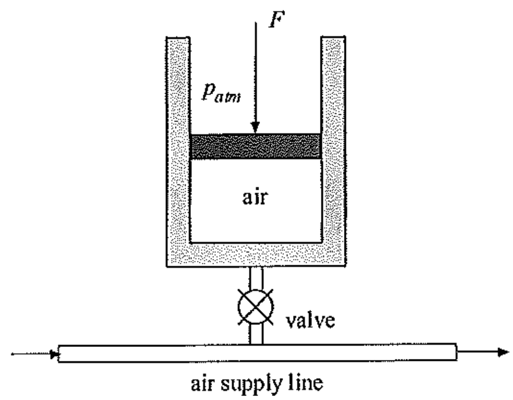
(1) A pneumatic lift uses a piston-cylinder assembly to raise a load F as shown in the figure. The well-insulated piston-cylinder assembly is connected by a valve to an air supply line that stays at a constant pressure and temperature of 8 bar and 300 K. The load is 10 kN, the piston diameter is 0.2 m, and the atmospheric pressure is 1 bar. Initially, the air in the cylinder is 300 K and the piston is located 0.4 m above the bottom of the cylinder. The valve is opened, air flows into the cylinder, the piston rises 20 cm (200 mm), and then the valve is closed. Determine the final mass and temperature of the air inside the cylinder. Neglect the weight of the piston and friction between the piston and cylinder. Assume that air behaves as an ideal gas with constant specific heats.



Use $R = 0.287$ kJ/(kg·K) and $c_p = 1.005$ kJ/(kg·K).

(2) You have been asked to evaluate a power cycle proposed for a distributed power generation facility aiming to meet a 100 kW_{elec} (electric) load-side demand. A superheated Rankine cycle has been selected for cost mitigation and ease of implementation. Due to safety concerns the maximum boiler pressure has been limited to 40bar (4MPa), and the superheat temperature is limited to 400°C. The efficiency of the steam turbine has been assessed at 70% for the expected operating point, and the efficiency of the feedwater pump is rated at 60%. Assume that the working fluid is expanded down to condensing temperature of 20°C, which is also the ambient temperature.

a. Determine the actual specific work output from the turbine.
b. Comment on the quality of the turbine exhaust.
c. Calculate the steam cycle efficiency
d. Compare the calculated efficiency against the maximum possible efficiency for a heat engine with the same maximum temperature.
e. Assuming that the efficiency of the generator is 80%, determine the required power rating for the feed-water pump.

(3) The experimental turbine shown in the figure is located inside a containment building. The turbine receives steam at 60 bar pressure and 280 °C temperature, at the rate of 500 kg/s. The turbine is not adiabatic, and the power output of the turbine is 80% of the output of a corresponding reversible and adiabatic turbine with the same inlet state and outlet pressure. The pressure at turbine exit is 0.1 bar. The system is in steady state. Heat is lost from the turbine to its surroundings inside the containment building through an average turbine surface temperature of 190 °C, at the rate of 10 MW. The fluid leaving the turbine is cooled to saturated liquid in a condenser. The condenser's secondary fluid is river water with an inlet temperature of 15 °C and an exit temperature of 22 °C.

a) Determine the turbine power and the flow rate of the river water that flows through the condenser
b) Using the turbine as the control volume, calculate the turbine entropy generation rate and exergy destruction rate.
c) Calculate the exergy destruction rate associated with the turbine, this time using the containment building as the control volume, and assuming that the containment building boundary is approximately at thermal equilibrium with the environment. Explain the difference between the exergy destruction rates in Parts (b) and (c)

Assume an ambient temperature of 25 °C. The specific heat of the river water is 4183 J/kg-K.