Unified Engineering Spring 2008
Thermodynamics & Propulsion Z. S. Spakovszky

(Add a short summary of the concepts you are using to solve the problem)

Problem T7

A turbojet and a ramjet are being considered for flight at M = 1.5 and 50,000 ft altitude (ambient pressure and temperature: 11.6 kPa and 205 K, respectively). The turbojet pressure ratio is 12 and the maximum allowable temperature is 1400 K. For the ramjet the maximum temperature is 2500 K. For simplicity ignore aerodynamic losses in both engines. Conventional hydrocarbon fuels are to be used with a heating value of 45 MJ/kg). Assume $\gamma = 1.4$ and R = 287 J/kg-K for both air and combustion gas.

a) Sketch both the turbojet and ramjet cycles in h-s coordinates.

b) Compare the specific fuel consumption of the turbojet and ramjet.

c) Comment on your results for part b), why is one better than the other?

d) How does the answer to part b) change if M = 3? Why?

(Add a short summary of the concepts you are using to solve the problem)

Problem T8

A ramjet engine is to propel an object at an air speed of 914 m/s at an altitude of 12.8 km (Pa=0.2 bar, Ta=-51 C). We assume that there are no losses. The pressure at the nozzle exit is 0.2 bar and the heating value of fuel is 43 MJ/kg. The stagnation temperature of the gases as they enter the nozzle is 2230 C and the propulsive power at the specified flight speed is 7.5 MW. Assume air with γ = 1.4 and R = 287 J/kg-K to be the working fluid, neglecting the effects of fuel.

a) Draw the ramjet cycle in a T-s diagram.

b) Find the stagnation temperature and pressure at the exit of the diffuser.

c) Determine the nozzle exit velocity.

d) Calculate the engine mass flow.

e) Find the specific mechanical work done on the working fluid.

f) Determine the fuel-to-air ratio and the fuel mass flow.

g) Compute the propulsive efficiency.

h) Determine the TSFC.

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Problem T9

By accident, a scuba diver drops his compressed air bottle to the ground. The valve breaks off such that compressed air rushes out through a 1 cm diameter hole at the end of the bottle. The 20 cm diameter, 20 kg heavy bottle is pressurized at 150 bar and at an ambient temperature of 15 deg C. The ambient pressure at sea level is 1 bar. During the time period of interest here, the flow can be assumed steady. Air can be modeled as an ideal gas with $\gamma = 1.4$ and $R = 287$ J/kg-K.

a) Assuming sonic conditions at the hole (M=1), what are the static temperature and the static pressure of the air at the exit?

b) What is the air mass flow out of the bottle?

c) Determine the steady-state velocity at which the bottle is propelled. You can assume a drag coefficient of 1.5 and a friction coefficient of 1.0 between aluminum and concrete.