AA360 Propulsion
Spring 2008

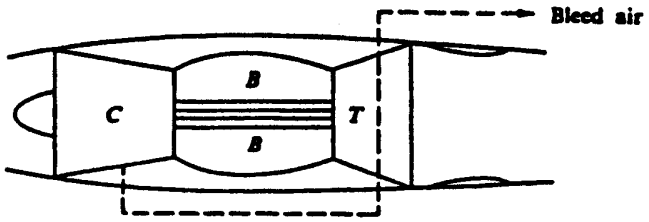
HOMEWORK #3

DUE: FRIDAY, April 25 at 5:00 pm at JH office (316E Gug)

1. (10 pts.) Problem 5-3 from *Mattingly's* book. It will be sufficient to calculate only the two cases of T_{t4} = 1800 K and T_{t4} = 2200 K. Based on those two cases, comment on the trends in specific thrust and specific fuel consumption with turbine inlet temperature and compressor pressure ratio.

2. (8 pts.) Problem 5-7 from *Mattingly*.

3. (10 pts.) Consider two versions of a jet engine. The first is a standard engine run with a turbine inlet temperature of T_{t4} = 1200 K. The second engine is identical, except that its turbine is cooled by bleeding air from the compressor, which allows the turbine inlet temperature to be raised to T_{t4} = 1600 K. The basic engine and the bleed air line are as sketched. To estimate the effect of the cooling-air modification on the engine performance, take the engine to be flying at Mach 2 at an altitude where the ambient temperature is T_a = 200 K, and take the compressor pressure ratio to be π_c = 9. In the modified engine, 10% of the compressor discharge air (at stagnation temperature T_{t3}) is diverted for turbine cooling. That air is then discharged with negligible velocity. Assume all components of both engines are ideal, and take γ = 1.4 and c_p = 1.0 kJ/kg-K.

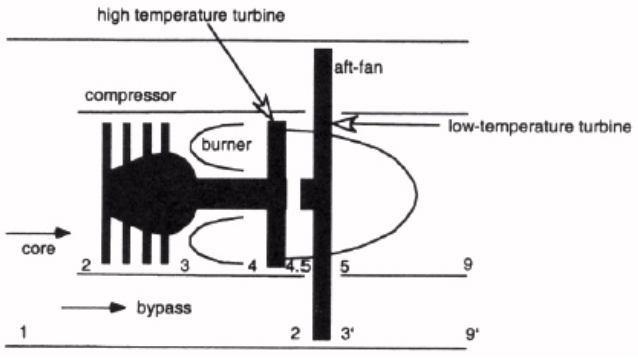


"B" = burner/combustor

   a) Determine the thrust of the two engines per unit mass flow entering the compressor (i.e., the specific thrust).

   b) What is the ratio of the thrust specific fuel consumption of the second engine to that of the first?

4. (8 pts.) Consider a turbojet fitted with an "aft fan," as shown in the sketch below. The compressor is driven by the high-pressure turbine only, and the aft fan is directly connected to, and driven by, the low-pressure turbine (this is a "work balance" problem). Take all components to be ideal.



   a) For the high-pressure turbine a total temperature ratio can be defined as $\tau_{tH} \equiv T_{t4.5}/T_{t4}$. Develop the expression for τ_{tH} in terms of τ_r, τ_λ, and τ_c.

   b) Similarly, a total temperature ratio for the low-pressure turbine can be defined as $\tau_{tL} \equiv T_{t5}/T_{t4.5}$. Develop the expression for τ_{tL} in terms of τ_r, τ_λ, τ_{tH}, the bypass ratio α, and $\tau_{c'} \equiv T_{t3'}/T_{t2}$ (note that the last quantity is based on point 3', downstream of the fan).

   c) State an advantage and a disadvantage of the "aft fan" approach compared to the more standard, front-mounted turbofan configuration.

(end)