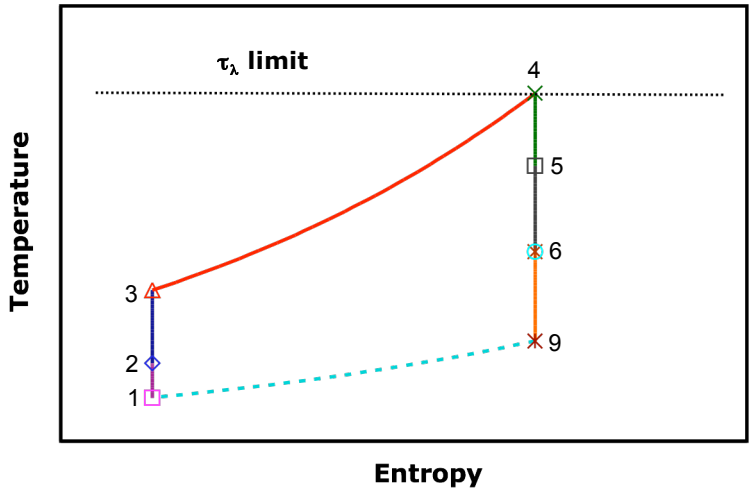
AME 436	Assigned: Thursday 4/16/09
Problem Set #6	• Due Friday 4/24/09 at 4:30 pm in OHE 430J • Email to the grader (Thada Suksila, suksila@usc.edu) or fax to 213-740-8071 if you're off campus • DEN students submit through the usual channels

Problem #1 (from last year's final exam) (25 points)

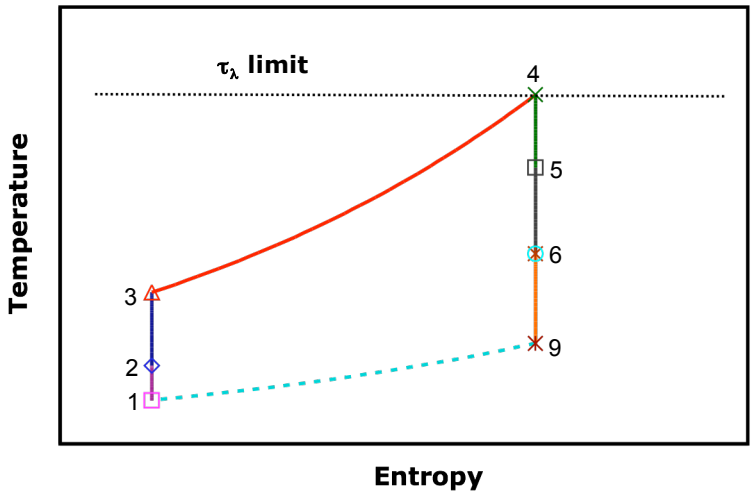
In an ideal τ_λ-limited turbofan, how would the T-s diagram be affected if the following changes are made. In some cases there may be no change to the cycle. Assume that the compressor pressure ratio is the same for all cycles. When useful, add statements like "this ΔT = that ΔT," "this area = that area," etc. *Please make your modifications clear; cycles that look like random scribbles and have no explanations don't get much credit!*

a)



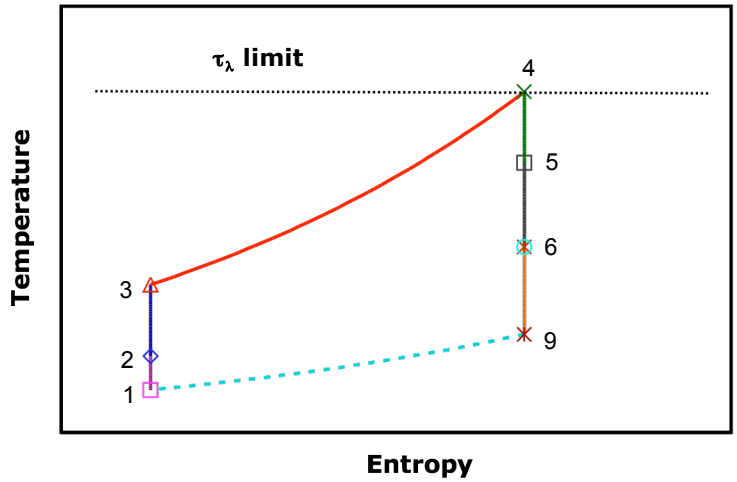
The fan is removed, but the redesigned turbine that supplies power to the compressor is irreversible

b)



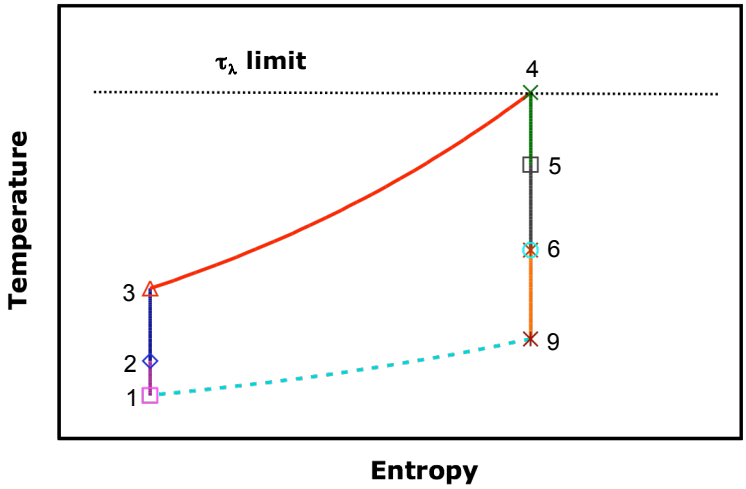
A **constant-area** afterburner is added, with the maximum possible heat addition (no τ_λ limit for the afterburner, but the main combustor still has the same τ_λ limit as always.)

c)



The flight Mach number is increased

d)



The ambient air **temperature** increases, but the ambient air **pressure** does not change

Problem #2 (from last year's final exam) (15 points)

- Engine A is a premixed-charge reciprocating-piston engine with a volume compression ratio of 10 that burns a lean ($\phi = 0.7$) octane-air mixture.
- Engine B is a stationary (Mach number = 0) gas turbine engine with a compressor pressure ratio of 10 that uses a non-premixed octane-air flame and has a turbine inlet temperature limit of 1200K. **Engine B is sized such that it has the same air mass flow rate as engine A** (which obviously means it's smaller and lighter.)

Both engines are being considered for producing shaft power to drive an electrical generator, not for ground vehicle or aircraft propulsion. Which engine, A or B, would have

a) Higher thermal efficiency

b) More power

c) Higher engine RPM

Problem #3 (20 points)

For a turbofan with bypass ratio (α) = 8, γ = 1.35 for all processes, compressor pressure ratio (π_c) = 30, fan pressure ratio (π_c') = 1.8, flight Mach number 0.8, turbine inlet temperature = 1800K, ambient pressure 0.25 atm, ambient temperature 225 K, and the following component efficiencies:

a) For the ideal cycle (all component efficiencies = 1), determine the temperature, pressure and Mach number at each station 1, 2, 3, 4, 5, 6 and 9. Assume FAR << 1. You can use aircycles4recips.xls to check your results, but you need to show the calculations that led to your results.
b) From these results, determine the specific thrust, thrust specific fuel consumption, thermal efficiency, propulsive efficiency, and overall efficiency.

Problem #4 (20 points)

Repeat problem #3 for a non-ideal cycle with no heat losses but the following component efficiencies:

Component	Component efficiency
Diffuser	0.97
Compressor	0.85
Burner	0.99
Turbine	0.90
Nozzle	0.98
Fan	0.85

For the non-ideal cycle your results will be slightly (but only slightly) different than those of aircycles4recips.xls due to the way the spreadsheet breaks the compression and expansion processes up into 25 smaller parts.

Problem #5 (20 points)

For turbofan of Problems #3 and #4, using aircycles4propulsion.xls, determine what combination of bypass ratio (α) and fan pressure ratio (π_c') (changing **nothing else)** gives the minimum thrust specific fuel consumption under the following 3 conditions:

a) Ideal cycle (all component efficiencies = 1) as in Problem #3
b) Component efficiencies as in Problem #4 with drag coefficient = 0
c) Component efficiencies as in Problem #4, part (b), with drag coefficient = 0.1

You don't have to show any calculations as you did in Problems 3 and 4, just use the spreadsheet to find the optima under these conditions, but answer the following questions:

1) Why was the answer to (a) $\alpha \rightarrow \infty$, $\pi_c' \rightarrow 1$?
2) Why was the optimum α smaller for part (c) than (b)?