National University of Singapore
Department of Mechanical Engineering

ME5309 Aircraft Engines and Rocket Propulsion

Assignment 2: Ideal and Non-Ideal Cycle Analysis

Due Date: 27 March 2025 (Thursday of Week 10)

Part (a)

Obtain plots to depict how the (i) specific thrust; (ii) thrust specific fuel consumption (*TSFC*); (iii) thermal efficiency; (iv) propulsive efficiency and (v) overall efficiency of a turbojet engine vary with altitude z for $z = 0$ (sea level) to $z = 15$ km. Assume a flight Mach number of $M_0 = 0.85$, a compressor stagnation pressure ratio of $\pi_c = 15$ and an allowable turbine inlet total temperature of $T_{t4} = 1900$ K. Assume that the gas is a perfect gas with $\gamma = 1.4$ and $R = 0.287$ kJ/(kg·K). Assume a heating value of $Q_R = 43$ MJ/kg. Assume the engine to be ideal.

Repeat the above analysis for a flight Mach number of $M_0 = 2.1$ with all other factors remaining constant.

Part (b)

Repeat the analysis in Part (a) above using the optimum compressor pressure ratio π_c which maximizes the specific thrust. In addition, plot the variation with altitude z for the optimum compressor ratio π_c for both $M_0 = 0.85$ and $M_0 = 2.1$.

Part (c)

Now, assume that the turbojet engine analyzed in Part (a) is non-ideal. Repeat the analysis in Part (a) with the additional assumptions that $\pi_d = 0.98$; $e_c = 0.85$; $\pi_b = 0.95$; $\eta_b = 0.98$; $e_t = 0.85$, $\eta_m = 0.98$; $\pi_n = 0.97$, $\gamma_c = 1.4$, $C_{pc} = 1.004$ kJ/(kg·K), $\gamma_t = 1.33$, $C_{pt} = 1.156$ kJ/(kg·K) and $P_9 = P_0$.

Part (d)

Perform a sensitivity analysis. Provide plots for how the specific thrust varies with altitude corresponding to (i) ±2% variation in e_c and (ii) ±2% variation in e_t corresponding to the baseline engine parameters provided in Part (c). Is the specific thrust more sensitive to variations in values of e_c or e_t?

Part (e)

Perform an optimization analysis. Consider a fixed operating altitude of $z = 10$ km. For a turbojet engine with the parameters provided in Part (c) (with the exception of varying the compressor pressure ratio π_c), determine the optimum compressor pressure ratio π_c which maximizes the specific thrust for both free stream Mach numbers of $M_0 = 0.85$ and $M_0 = 2.1$. Compare these optimum values of π_c with those corresponding to the ideal-cycle analysis which you have obtained in Part (b).