UNIFIED PROPULSION P7 SOLUTIONS — WAITZ 2001

a) $\frac{T_{T_3}}{T_0} = \frac{T_{T_3}}{T_{T_2}} \cdot \frac{T_{T_2}}{T_{T_1}} \cdot \frac{T_{T_1}}{T_0}$

$\frac{T_{T_3}}{T_{T_2}} = \tau_c$; $\frac{T_{T_2}}{T_{T_1}}$ assume inlet is isentropic $= 1$; $\frac{T_{T_1}}{T_0} = 1 + \frac{\gamma-1}{2} M_0^2$

COMPOSED OF TEMPERATURE RISE DUE TO RAM EFFECT + TEMPERATURE RISE DUE TO WORK ADDITION IN COMPRESSOR

ANY COMBINATION OF T_0 & M_0 SUCH THAT

$$T_0 \cdot \tau_c \cdot \left[1 + \frac{\gamma-1}{2} M_0^2\right] > 1000\,K$$ WILL EXCEED THE TEMPERATURE LIMIT.

$\tau_c = (\pi_c)^{\frac{\gamma-1}{\gamma}} = (25)^{\frac{\gamma-1}{\gamma}} = 2.508$

FOR

$T_0 = 300K$ LIMIT IS EXCEEDED FOR $M \gtrsim 1.3$

$T_0 = 216K$ LIMIT IS EXCEEDED FOR $M \gtrsim 2.1$

b) PLUGGING INTO EQNS:

$M = 1.2$, $T = 300K$, $\eta_0 = 0.367$, $\eta_{TH} = 0.69$, $\eta_p = 0.53$

$M = 1.2$, $T = 216K$, $\eta_0 = 0.298$, $\eta_{TH} = 0.69$, $\eta_p = 0.43$

- η_{TH} DOESN'T CHANGE $\eta_{TH} = 1 - \frac{T_0}{T_{T_3}} = 1 - \frac{1}{\tau_c\left[1 + \frac{\gamma-1}{2} M_0^2\right]}$ (from above)

  IS INDEPENDENT OF T_0

- η_p CHANGES BECAUSE AT CONSTANT M_0, $u_0 \downarrow$ AS $T_0 \downarrow$

c) $T_{T_4} = 1800K$, $F/\dot{m}a_0 = 3.16$, $\eta_0 = 0298$, $\eta_{TH} = 0.69$, $\eta_p = 043$

$T_{T_4} = 1400K$, $F/\dot{m}a_0 = 2.36$, $\eta_0 = 0.348$, $\eta_{TH} = 0.69$, $\eta_p = 0.54$

$\eta_0 \uparrow \Rightarrow$ IMPROVES RANGE & ENDURANCE

$F/\dot{m}a_0 \downarrow \Rightarrow$ REDUCED MANEUVERABILITY