Engineering Software

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Engineering Assumptions

When dealing with energy conversion and considering ideal (isentropic) operation and the working fluid is air, the following assumptions are valid:

Power Cycle Components/Processes
Single species consideration
Basic equations hold (continuity and energy equations)
Specific heat is constant

Thermodynamic and Transport Properties
Single species consideration
Ideal gas approach is used (pv=RT)
Specific heat is not constant
Coefficients describing thermodynamic and transport properties were obtained from the NASA Glenn Research Center at Lewis Field in Cleveland, OH -- such coefficients conform with the standard reference temperature of 298.15 K (77 F) and the JANAF Tables

Thermodynamics Engineering Equations

1st Law

$$q - w = u_2 - u_1 \text{ [kJ/kg]}$$

2nd Law

$$s_2 - s_1 = q/T \text{ [kJ/kg*K]}$$

Basic Engineering Equations

Ideal Gas State Equation

$pv = RT$ [kJ/kg]

Perfect Gas

c_p = constant [kJ/kg*K]

Kappa

$\chi = c_p/c_v$ [/]

For air: $\chi = 1.4$ [/], $R = 0.2867$ [kJ/kg*K] and $c_p = 1.004$ [kJ/kg*K]

Thermodynamics Engineering Equations

1st Law

$$q - w = u_2 - u_1 \text{ [kJ/kg]}$$

or

$$q - pdv = du \text{ [kJ/kg]}$$

$$h = u + pv \text{ [kJ/kg]}$$

Thermodynamics Engineering Equations

$$dh = du + pdv + vdp$$

$$q = du + pdv$$

$$q = dh - vdp$$

When $q = 0$ (for isentropic compression and expansion), it follows:

$$dh = vdp$$

$$pv = RT$$

$$p = RT/v$$

$$v = RT/p$$

Thermodynamics Engineering Equations

$$c_p - c_v = R$$

$$X = c_p/c_v$$

$$1 - c_v/c_p = R/c_p$$

$$(X - 1)/X = R/c_p$$

$$h = c_p T$$

Thermodynamics Engineering Equations

Therefore,

$$dh = vdp$$

$$c_p dT = RTdp/p$$

$$c_p dT/T = Rdp/p$$

$$dT/T = (R/c_p)dp/p$$

$$dT/T = ((X - 1)/X)dp/p$$

$$\ln(T_2/T_1) = \ln(p_2/p_1)^{(X-1)/X}$$

$$T_2/T_1 = (p_2/p_1)^{(X-1)/X}$$

Thermodynamics Engineering Equations

Therefore,

$$T_2/T_1 = (p_2/p_1)^{(X-1)/X}$$

$$p_2/p_1 = (T_2/T_1)^{X/(X-1)}$$

Power Cycle Components/Processes Engineering Equations

Isentropic Compression

$$T_2/T_1 = (p_2/p_1)^{(X-1)/X} \; [/]$$

$$T_2/T_1 = (V_1/V_2)^{(X-1)} \; [/]$$

$$p_2/p_1 = (V_1/V_2)^{X} \; [/]$$

$$w_c = c_p(T_2 - T_1) \; [kJ/kg]$$

$$W_c = c_p(T_2 - T_1)m \; [kW]$$

Power Cycle Components/Processes Engineering Equations

Isentropic Expansion

$$T_1/T_2 = (p_1/p_2)^{(X-1)/X} \ [/]$$

$$T_1/T_2 = (V_2/V_1)^{(X-1)} \ [/]$$

$$p_1/p_2 = (V_2/V_1)^{X} \ [/]$$

$$w_e = c_p(T_1 - T_2) \ [kJ/kg]$$

$$W_e = c_p(T_1 - T_2)m \ [kW]$$

Thermodynamics Engineering Equations

2nd Law

$$s_2 - s_1 = q/T \text{ [kJ/kg*K]}$$

Thermodynamics Engineering Equations

$$s_2 - s_1 = q/T$$

$$q = du + pdv$$

$$q = dh - vdp$$

$$u = c_v T$$

$$h = c_p T$$

$$pv = RT$$

$$p = RT/v$$

$$v = RT/p$$

Thermodynamics Engineering Equations

Therefore,

$$ds = c_v dT/T + R dv/v$$

$$ds = c_p dT/T - R dp/p$$

$$s_2 - s_1 = c_v \ln(T_2/T_1) + R \ln(v_2/v_1)$$

$$s_2 - s_1 = c_p \ln(T_2/T_1) - R \ln(p_2/p_1)$$

Physical Properties