The PG model: The PG (Perfect Gas) model simplifies the IG (Ideal Gas) model by assuming the specific heats to be constant (a material property). Although it is less accurate than the IG model, particularly if there is significant change in temperature, it is the simplest gas model and is ideally suitable for simplified analysis.

Assumptions:

(i) A perfect gas obeys the ideal gas equation of state:

$$pv = RT; \left[\text{kPa}\frac{\text{m}^3}{\text{kg}} = \frac{\text{kJ}}{\text{kg}}\right] \quad \text{where, } v = \frac{\bar{v}}{\bar{M}}; \left[\frac{\text{m}^3}{\text{kg}}\right] \quad \text{and } R \equiv \frac{\bar{R}}{\bar{M}}; \left[\frac{\text{kJ}}{\text{kg}\cdot\text{K}}\right] \qquad (1)$$

.

(ii) For both the IG and PG models, u is assumed to be a function of temperature only (it is actually a corollary to the first assumption.

(iii) For the PG model, c_v is also assumed to be a material property and, therefore, has a constant value for a given perfect gas.

PG model equations: (Constant value of R and c_p are read from tables

$$p = \rho RT = \frac{RT}{v} = \frac{m}{\cancel{V}}RT = \frac{m}{\cancel{V}}\frac{\bar{R}}{\bar{M}}T = \frac{m}{\bar{M}}\bar{R}\frac{T}{\cancel{V}} = n\bar{R}\frac{T}{\cancel{V}}, \qquad \text{where} \quad R \equiv \frac{\bar{R}}{\bar{M}} \qquad (2)$$

$$\Delta u \equiv u_2 - u_1 = c_v(T_2 - T_1), \quad \Delta h \equiv h_2 - h_1 = c_p(T_2 - T_1), \quad \text{where} \qquad c_p = (c_v + R) \qquad (3)$$

$$\Delta s = c_p \ln\frac{T_2}{T_1} - R\ln\frac{p_2}{p_1}; \;\; \Delta s = c_v \ln\frac{T_2}{T_1} + R\ln\frac{v_2}{v_1}; \text{ also, } k \equiv \frac{c_p}{c_v},\; c_p = \frac{kR}{k-1}; \;\; \text{and} \;\; c_v = \frac{R}{k-1} \qquad (4)$$

$$s = \text{con process: } \frac{p_2}{p_1} = \left(\frac{T_2}{T_1}\right)^{\frac{k}{k-1}} = \left(\frac{\rho_2}{\rho_1}\right)^k = \left(\frac{v_1}{v_2}\right)^k = \left(\frac{\cancel{V}_1}{\cancel{V}_2}\right)^k; \; \frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{k-1}{k}} = \left(\frac{v_1}{v_2}\right)^{k-1}; \frac{p_2}{p_1} = \left(\frac{v_1}{v_2}\right)^k; \;(5)$$

For polytropic process replace k with n

General state equations: (Applies to any substance)

$$m = \rho\cancel{V}; \; \rho = \frac{1}{v}; \; \text{ke} = \frac{V^2}{2000}; \; \text{pe} = \frac{gz}{1000}; \;\; e \equiv u + ke + pe; \; j \equiv h + ke + pe; \; h \equiv u + pv \qquad (6)$$

$$E = me; \;\; S = ms; \; KE = m(\text{ke}); \; PE = m(\text{pe}) \qquad (7)$$

$$\dot{m} = \rho AV; \;\; \dot{\cancel{V}} = AV; \; \dot{E} = \dot{m}e; \;\; \dot{S} = \dot{m}s \qquad (8)$$

$$Tds = du + pdv = dh - vdp; \quad c_v \equiv \left(\frac{\partial u}{\partial T}\right)_v; \; c_p \equiv \left(\frac{\partial h}{\partial T}\right)_p \qquad (9)$$

Reference: Chapter 1 introduces the concept of states and properties, Chapter 3 covers various material models and state evaluation, and Chapter 11 introduces advanced concepts on property evaluation. Read more about the PG model in Sec. 3.5.2.