C.01.01.Z1 – Biblioteca Simplificada de Gás Ideal

Aplicação em FTHA – Finite Time Heat Addition Otto Engine Model

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https://github.com/CNThermSci/ApplThermSci

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Equação de Estado (EoS): Comportamento $P-T-v$

$$Pv = RT \qquad P\bar{v} = \bar{R}T \qquad \rightharpoondown$$

$$P = \frac{RT}{v} \qquad P = \frac{\bar{R}T}{\bar{v}} \qquad \rightharpoondown$$

$$T = \frac{Pv}{R} \qquad T = \frac{P\bar{v}}{\bar{R}} \qquad \rightharpoondown$$

$$v = \frac{RT}{P} \qquad \bar{v} = \frac{\bar{R}T}{P} \qquad \therefore$$

Cada equação com forma nas bases **mássica**, e **molar**, com $R = \bar{R}/M$ — armazenar $\bar{R}$ e M!

Modelo de $\bar{c}_p(T)$ Polinomial:

$$\bar{c}_p(T) = \sum_{i=1}^{4} a_i T^{i-1}, \qquad T_{min} \leqslant T \leqslant T_{max} \qquad \rightharpoondown$$

$$\bar{c}_p(T) = a_1 + a_2 T + a_3 T^2 + a_4 T^3, \qquad T_{min} \leqslant T \leqslant T_{max} \qquad \rightharpoondown$$

$$\bar{c}_v(T) = \bar{c}_p(T) - \bar{R} = \sum_{i=1}^{4} b_i T^{i-1}, \qquad T_{min} \leqslant T \leqslant T_{max} \qquad \rightharpoondown$$

$$b_1 = a_1 - \bar{R}, \qquad b_{i>1} = a_{i>1} \qquad \therefore$$

Armazenar a_i, T_{min} e T_{max} e saber as **conversões** (i) $a_i \to b_i$ e (ii) $\bar{c}_{p,v}(T) \to c_{p,v}(T)$.

Modelo de $\bar{c}_p(T)$ Polinomial: $\bar{u}(T)$

$$\bar{u}(T) = \int_{T_{ref}}^{T} \bar{c}_v(T)\,dT = \int_{T_{ref}}^{T} \sum_{i=1}^{4} b_i T^{i-1}\,dT, \qquad T_{min} \leqslant T \leqslant T_{max} \qquad \rightharpoondown$$

$$\bar{u}(T) = \left(b_1 T + \frac{b_2 T^2}{2} + \frac{b_3 T^3}{3} + \frac{b_4 T^4}{4} \right)_{T_{ref}}^{T}, \qquad T_{min} \leqslant T \leqslant T_{max} \qquad \therefore$$

- Armazenar T_{ref},
- Compor **eficientemente** a soma de produtos, e
- Saber as **conversões** $\bar{u}(T) \to u(T)$.

Modelo de $\bar{c}_p(T)$ Polinomial: $\bar{h}(T) = \bar{u}(T) + \bar{R}T$

$$\bar{h}(T) = \int_{T_{ref}}^{T} \bar{c}_p(T)\,dT + \bar{R}T_{ref} = \int_{T_{ref}}^{T} \sum_{i=1}^{4} a_i T^{i-1}\,dT + \bar{R}T_{ref}, \quad T_{min} \leqslant T \leqslant T_{max} \quad \rightharpoondown$$

$$\bar{h}(T) = \left(a_1 T + \frac{a_2 T^2}{2} + \frac{a_3 T^3}{3} + \frac{a_4 T^4}{4} \right)_{T_{ref}}^{T} + \bar{R}T_{ref}, \quad T_{min} \leqslant T \leqslant T_{max} \quad \therefore$$

- Compor **eficientemente** a soma de produtos, e
- Saber as **conversões** $\bar{h}(T) \to h(T)$.

Modelo de $\bar{c}_p(T)$ Polinomial: $\bar{s}^\circ(T)$

$$\bar{s}^\circ(T) = \int_0^T \frac{\bar{c}_p(T)}{T}\,dT = \int_0^{T_{ref}} \frac{\bar{c}_p(T)}{T}\,dT + \int_{T_{ref}}^{T} \frac{\bar{c}_p(T)}{T}\,dT, \quad T_{min} \leqslant T \leqslant T_{max} \quad \rightharpoondown$$

$$\bar{s}^\circ(T) = \bar{s}^\circ_{ref} + \int_{T_{ref}}^{T} \sum_{i=1}^{4} a_i T^{i-2}\,dT \quad T_{min} \leqslant T \leqslant T_{max} \quad \rightharpoondown$$

$$\bar{s}^\circ(T) = \bar{s}^\circ_{ref} + \left(a_1 \ln(T) + a_2 T + \frac{a_3 T^2}{2} + \frac{a_4 T^3}{3} \right)_{T_{ref}}^{T}, \quad T_{min} \leqslant T \leqslant T_{max} \quad \therefore$$

- Armazenar $\bar{s}^\circ_{ref}$, compor **eficientemente** a soma de produtos, e
- Saber as **conversões** $\bar{s}^\circ(T) \to s^\circ(T)$.

Modelo de $\bar{c}_p(T)$ Polinomial: $P_r(T)$ e $v_r(T)$

$$\left(\frac{P_2}{P_1}\right)_s = \frac{P_{r2}}{P_{r1}} \qquad \left(\frac{v_2}{v_1}\right)_s = \frac{v_{r2}}{v_{r1}} \quad \rightharpoondown$$

$$P_r(T) \equiv e^{\bar{s}^\circ(T)/\bar{R}} \qquad P_r(T) = e^{s^\circ(T)/R}$$

$$v_r(T) \equiv \frac{T}{P_r(T)}.$$

- **Sem requisitos adicionais** de armazenamento!
- **Sem conversões** de base!

Padrões nos Cálculos:

$$\bar{c}_p(T) = a_1 + a_2 T + a_3 T^2 + a_4 T^3, \quad T_{min} \leqslant T \leqslant T_{max} \quad \rightharpoondown$$

$$\bar{c}_v(T) = b_1 + b_2 T + b_3 T^2 + b_4 T^3, \quad T_{min} \leqslant T \leqslant T_{max} \quad \rightharpoondown$$

$$\bar{u}(T) = \left(b_1 T + \frac{b_2 T^2}{2} + \frac{b_3 T^3}{3} + \frac{b_4 T^4}{4} \right)_{T_{ref}}^{T}, \quad T_{min} \leqslant T \leqslant T_{max} \quad \rightharpoondown$$

$$\bar{h}(T) = \left(a_1 T + \frac{a_2 T^2}{2} + \frac{a_3 T^3}{3} + \frac{a_4 T^4}{4} \right)_{T_{ref}}^{T} + \bar{R}T_{ref}, \quad T_{min} \leqslant T \leqslant T_{max} \quad \rightharpoondown$$

$$\bar{s}^\circ(T) = \left(a_1 \ln(T) + a_2 T + \frac{a_3 T^2}{2} + \frac{a_4 T^3}{3} \right)_{T_{ref}}^{T} + \bar{s}^\circ_{ref}, \quad T_{min} \leqslant T \leqslant T_{max} \quad \therefore$$

- Verificação de **limites**;
- Coef./func. **próprios**; e
- Produtos **matriciais**.

```julia
# Universal gas constant
R̄() = 8.314472 # ± 0.000015 # kJ/kmol·K

# Standard Tref
Tref() = 298.15 # K

# IG (Ideal Gas) structure: values for each gas instance
struct IG
    MW                  # Molecular "Weight", kg/kmol
    CP::Ntuple{4}       # Exactly 4 c̄p(T) coefficients
    Tmin                # T_min, K
    Tmax                # T_max, K
    sref                # s̄°ref, kJ/kmol·K
end
```