

Thermodynamic Process

Ideal Gas Law

$$pV = mR_sT$$

$$\frac{pV}{T} = mR_s = \text{constant} \quad (\text{For a closed system})$$

so

$$\boxed{\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}}$$

(1)

Further, a polytropic process follows

$$pV^k = \text{constant}$$

where

k = polytropic index

so

$$\boxed{p_1 V_1^k = p_2 V_2^k}$$

(2)

sub (1) into (2)

$$p \left(\frac{mR_sT}{p} \right)^k = \text{constant}$$

$$\frac{p}{p^k} T^k = \text{constant}$$

so

$$\boxed{p_1^{1-k} T_1^k = p_2^{1-k} T_2^k}$$

Thermodynamic Process Summary

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$$

Polytropic Process

$$pV^k = \text{constant}$$

polytropic index	polytropic relation	Work (w)	Heat transfer (q)	Process name
$K=0$	$p_1 = p_2$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$	$p(V_2 - V_1)$	$mC_p(T_2 - T_1)$	isobaric
$K=1$	$T_1 = T_2$ $p_1 V_1 = p_2 V_2$	$mR_s T \ln\left(\frac{V_2}{V_1}\right)$	$mR_s T \ln\left(\frac{V_2}{V_1}\right)$	isothermal
$K=\gamma$	$p_1 V_1^\gamma = p_2 V_2^\gamma$ $p_1^{1-\gamma} T_1^\gamma = p_2^{1-\gamma} T_2^\gamma$	$\frac{p_2 V_2 - p_1 V_1}{1-\gamma}$ $mC_v(T_1 - T_2)$	0	adiabatic
$K=\infty$	$V_1 = V_2$ $\frac{p_1}{T_1} = \frac{p_2}{T_2}$	0	$mC_v(T_2 - T_1)$	isometric