

2. Integral mode, (I .controller)

$$P(t) = K_I \int_0^t E(t) dt$$

$$P'(t) = K_I \int_0^t E'(t) dt + P_0$$

Steady state : $P^o = P_0$ *bais*

$$P(s) = \frac{K_I}{s} E(s)$$

$$G_c(s) = \frac{P(s)}{E(s)} = \frac{K_I}{s}$$

$$G_c(s) = \frac{P(s)}{E(s)} = \frac{1}{\tau_I s}$$

τ_I =integral time constant(min.)

1. Proportional Plus integral action (PI) controller

2. Steady state : $P^o = P_0$ *bais*

At unsteady state:...

$$P'(t) = P_0 + K_c E(t) + \frac{K_I}{\tau_I} \int_0^t E'(t) dt$$

In deviation variable:

$$P(t) = K_c E(t) + K_I \int_0^t E(t) dt$$

$$P(t) = K_c \left(E(t) + \frac{1}{\tau_I} \int_0^t E(t) dt \right)$$

$$P(s) = K_c \left(E(s) + \frac{1}{\tau_I s} E(s) \right)$$

$$G_{cPI}(s) = \frac{P(s)}{E(s)} = K_c \left(1 + \frac{1}{\tau_I s} \right)$$

$$G_c(s) = \frac{P(s)}{E(s)} = \frac{100}{P.B} \left(1 + \frac{1}{\tau_I s} \right)$$

3. Proportional -Derivative action (PD controller)

Derivative action

Controller output

$$P(t) \propto \frac{dE(t)}{dt}$$

For PD controller:

$$\begin{aligned} P(t) &= K_c E(t) + K_d \frac{dE(t)}{dt} \\ &= K_c \left(E(t) + \frac{K_d}{K_c} \frac{dE(t)}{dt} \right) \end{aligned}$$

$$P(t) = K_c \left(E(t) + \tau_D \frac{dE(t)}{dt} \right)$$

$$\tau_D = \frac{K_d}{K_c} \text{ , derivative time (min.)}$$

$$G_{cPD}(s) = \frac{P(s)}{E(s)} = K_c (1 + \tau_D s)$$

4. Three mode control action (P+I+D)

$$P(t) = K_c E(t) + \frac{K_c}{\tau_I} \int_0^t E(t) dt + K_c \tau_D \frac{dE(t)}{dt}$$

$$G_c(s) = \frac{P(s)}{E(s)} = K_c \left(1 + \frac{1}{\tau_I s} + \tau_D s \right)$$

This controller combines the benefits of PI controller with the derivative mode.

- The derivative mode provides anticipatory "look ahead" behavior, which helps to counteract the destabilizing effect of the I-mode, thus providing stability.
- The amount of anticipation is decided by the parameter τ_d .
- The PID is suitable for processes with long time constant such as temperature and composition control.
- The PID is not recommended for processes with short time constant and/or noisy systems such as flow and pressure control.
- *Derivative kick.*
- *Reset windup*