Tuning of controller

Ziegler-Nichols closed loop tuning method

1. Close integral and derivative modes and leave only proportional mode.
2. Select a law value of k_c(high % P.B)and run the system to reach steady state operation $\theta_0 = \theta_{set} = \theta_m$.
3. Introduce small step change to system via set point or load and observe the response .
4. Increase k_c and go back to step 2,3.
5. Continuo increasing k_c until we reach the hunting case and record the ultimate period, (Tu) and maximum gain, (k_{max}).

Ziegler-Nichols optimum settings

Control mode	k_c	τ_I	τ_D
P	$\frac{1}{2}k_{cmax}$	-	-
PI	$0.45k_{cmax}$	$\frac{T_u}{2}$	-
PD	$0.6k_{cmax}$	-	$\frac{T_u}{8}$
PID	$0.6k_{cmax}$	$\frac{T_u}{2}$	$\frac{T_u}{8}$

Open loop tuning method

Controller setting based on process reaction curve (open –loop step test data)

$$G(s) = \frac{e^{-T_D s}}{\tau s + 1}$$

Table2 : Tuning of controller's parameters

Cohen and coon	**Ziegler-Nichols**	
$k_c k_p = \left(\frac{\tau}{T_D} + \frac{1}{12}\right)$	$k_c k_p = \frac{\tau}{T_D}$	P
$k_c k_p = \left(0.9\frac{\tau}{T_D} + \frac{1}{12}\right)$ $\tau_I = T_D\left(\frac{30+3\left(\frac{\tau}{T_D}\right)}{9+20\left(\frac{\tau}{T_D}\right)}\right)$	$k_c k_p = 0.9\frac{\tau}{T_D}$ $\tau_I = 3.3T_d$	PI
$k_c k_p = \left(\frac{4}{3}\frac{\tau}{T_D} + \frac{1}{4}\right)$ $\tau_I = T\left(\frac{32+8\left(\frac{T}{\tau}\right)}{13+8\left(\frac{T_D}{\tau}\right)}\right)$ $\tau_D = \tau_I\left(\frac{4}{11+2\left(\frac{T}{\tau}\right)}\right)$	$k_c k_p = 1.2\frac{\tau}{T_D}$ $\tau_I = 2T_D$ $\tau_D = 0.5\tau_I$	PID