Time delay system

1. Pure Time delay system

Time delay : there is a time interval (short or long)during which no effect is observed on the outputs (response)of the system when an input variable of a system changed. This time interval is called time delay , or transportation lag or pure delay , or distance velocity lag. The delay time known as transportation time is basically the time required for a material to move a specific distant. However, time delay is an inherent property of any chemical process.

Sources:

- The use of chromatography to measure composition of liquids or gases is another source of dead time.
- Flow in a long pipe.
- Time lag produced from staged processes.

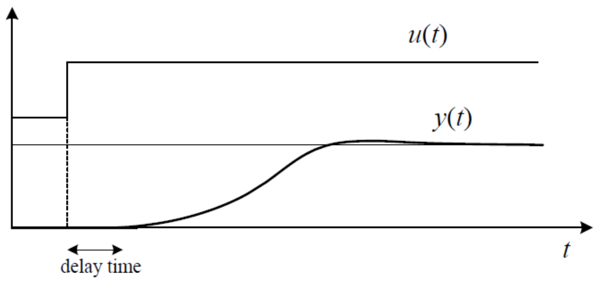

Fig.21 The response of time delay system to step change

$$\tau_D = \frac{volume\ of\ pipe}{volume\ flow\ rate} = \frac{A.L}{A.u_{av}} = \frac{L}{u_{av}}$$

Initially Water pure is flow in the pipe

Time delay $\tau_D = \frac{L}{u}$

$$C_o(t) = C_i(t - \tau_D)$$

Laplace Transformation

$$C_o(s) = C_i(s)e^{-\tau_D s}$$

$$G(s) = \frac{C_o(s)}{C_i(s)} = e^{-\tau_D s} \quad steady\ state\ gain\ k = 1$$

Conveyor belt :

Assume change is flow rate of mass form hopper . what response in mass flow rate in the end of the belt .

$\tau_D = \frac{L}{u}$, $\quad G(s) = \frac{m_2(s)}{m_1(s)} = e^{-\tau_d s} = e^{-\frac{L}{u}s}$

At t=0 $\quad m_1 = m_1^o$

Step change =$0.2m_1^o$

$$m_2(s) = \frac{0.2m_1^o}{s} e^{-\frac{L}{U}s}$$

$$m_2(t) = 0.2m_1^o U(t-\tau_D)$$

Screw conveyer

$$\tau_D = \frac{L}{u}$$

$$\theta = \frac{l}{R}, \omega = \frac{\theta}{t}, \theta = \omega t$$

$$u = \frac{l}{t}, u = \frac{\theta R}{t}$$

$$\tau_D = \frac{L}{u} = \frac{L}{2\pi NR}$$

Transfer function of pure time delay :

$$G(s) = \frac{y(s)}{f(s)} = \frac{\pounds(t-\tau_D)}{\pounds(t)}$$

Expressing $\pounds(t-\tau_D)$ in terms of Taylor series:

$$f(t-\tau_D) = f(t) + \frac{\tau_D f'(t)}{1!} + \frac{\tau_D{}^2 f''(t)}{2!} + \cdots, \qquad t = 0$$

L.T $\quad \pounds(t-\tau_D) = f(s) + \frac{\tau_D s}{1!} + \frac{\tau_D{}^2 s^2}{2!} + \frac{\tau_D{}^3 s^3}{3!} + \cdots,$

$$= f(s)e^{-\tau_D s}$$

$$G(s) = \frac{y(s)}{f(s)} = \frac{f(s)e^{-\tau_D s}}{f(s)} = e^{-\tau_D s}$$