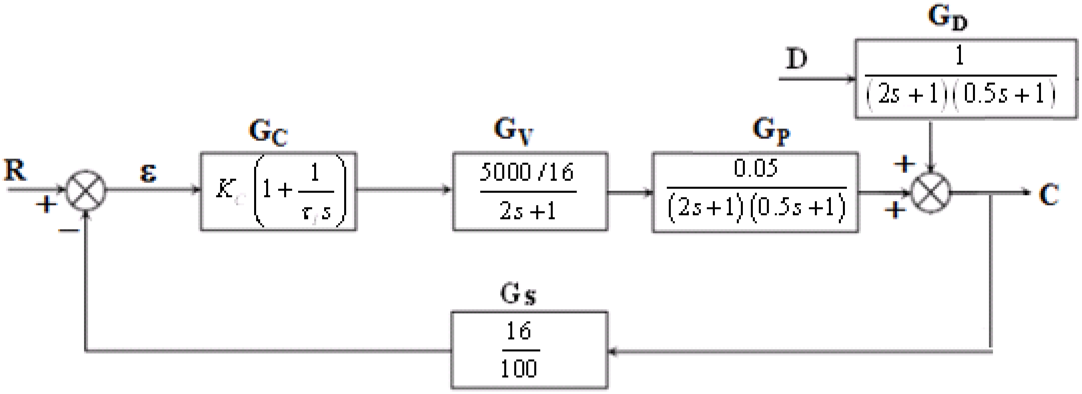
1.



a) What can be said about this control loop?

b) Provide the general transfer function of this control loop.

c) Calculate the optimum controller parameters for the best control performance in this control loop.

$[\,P = 2\pi/\omega$ (dak); $Kc = Kcu/2.2$; $\tau_I = P_U/1.2\,]$

d) With the optimum controller parameters calculated, does the control variable fit into the set value for a step change of 30 units in D?

2. In a chemical reactor it is desired to control the reaction temperature (T) at 90°C with PD (Proportional + derivative) controller, by manipulating the flow rate of cooling water (Fc). In the PD controller, the proportional band value is 50% and the derivative time constant (τD) is 5 min. The transfer function of the process, the transfer function of the disturbance, the transfer function of the thermocouple and the transfer function of the valve used are as follows;

$$G_p(s) = \frac{-0.2}{(4s+1)(5s+1)} \qquad G_d(s) = \frac{0.4}{(4s+1)(5s+1)} \text{ °C/°C,}$$

$$G_s(s) = \frac{16/200}{(s+1)} \qquad G_V(s) = \frac{-500}{16} \text{ lt/min/mA}$$

a) Is this system stable?

b) Is it oscillating?

c) If feed temperature increases by 30°C, does the response of the system fit to the set point?

d) How much offset value is seen?

e) What is the value of the temperature when the system becomes stable?

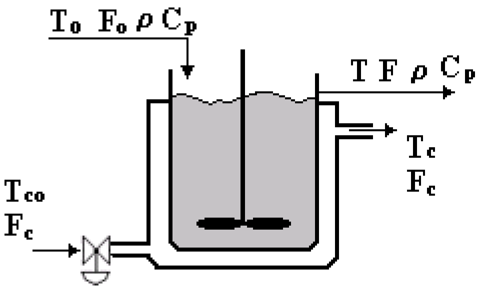
3 Feedback control loop with PID

$$G_p(s) = \frac{5 \cdot 10^{-4} \text{ °C/kcal/min}}{(4s+1)(2s+1)} \qquad G_d(s) = \frac{1\text{ °C/°C}}{4s+1} \qquad G_s(s) = \frac{16/100\, mA/°C}{s+1},$$

$$G_v(s) = \frac{600.000\ kcal/min}{16\text{ mA}}.$$

a) Find the optimum controller parameters to control this sysytem by using Tyreus-Luyben method

b) If the feed temperature, which is the disturbance variable, increases by 50 C , how much of an off-set is seen in the system?



The figure shows a system with a cooling jacket. Heat is transferred from the wall of the tank to the fluid in the jacket by convection. The heat transfer from the fluid in the tank to the fluid in the jacket is formulated as $\Theta = 2 \cdot F_c \cdot (T - Tco)$. The tank is mixed very well. The output temperature of the tank **T**,is desired to be kept at 30°C by adjusting the flow rate of the cooling water with a **P** controller. The volume of fluid in the inner tank is **V**=10 m^3; the density of the fluid is ρ=800 kg/m^3; the heat capacity of the fluid is **Cp**=1.4 kcal/kg°C. The feed flow rate of the fluid fed to the system is **F**=0.5 m^3/min and the feed temperature is **T$_0$**=80°C. The feed temperature of the cooling fluid **Tc$_0$**=20°C.

The transfer functions of thermocouple and pneumatic valve used in the proposed feedback control loop are given as $G_s(s) = \dfrac{16/100\ mA/°C}{(s+1)}$ and $G_v(s) = \dfrac{\dfrac{-500}{16}\dfrac{kcal/dk}{mA}}{(s+1)}$, respectively.

a) Derive the transfer function of the system (without control loop).
b) Calculate the **P** controller parameters in order to hold the output temperature of fluid at 30°C.
c) On the tank controlled with **P**, if the temperature of T$_0$ decreases to 50°C, find the last temperature of the fluid and flow rate of the cooling fluid.