Cascade control

In class activities

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Activities

1. Furnace temperature control:

   Draw a single loop feedback, and possible cascade control configuration for the furnace. Name the disturbances which can be handled by such cascade control configuration. Name the disturbances which cannot be removed by the cascade control configuration.

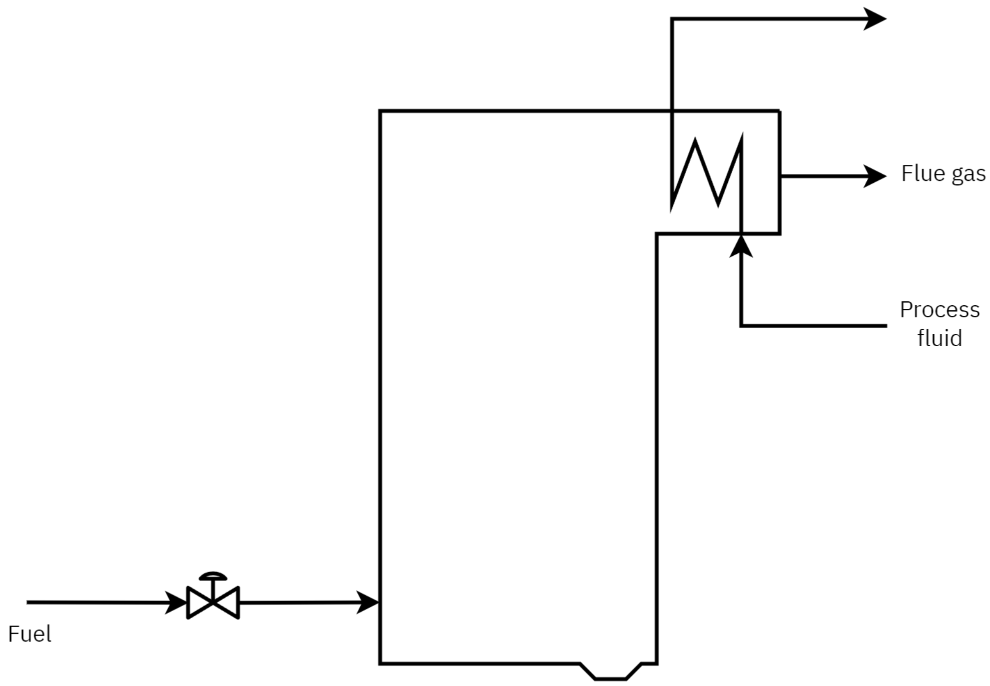

Figure 1: Furnace

2. Ammonia reactor

   Consider that you have been appointed by the plant manager to design a cascade control strategy for the Haber process that produces ammonia (NH_3) for fertilizer production. The Haber process is conducted in a multi-tubular catalytic reactor where reaction occurs in the tubes while cooling medium flowing in the shell outside the tubes. The reactor has a length of 10 meters and shell dimeter of 2.5 meters.

   Propose a cascade control strategy for this reactor. Give comments why you propose such a cascade control strategy

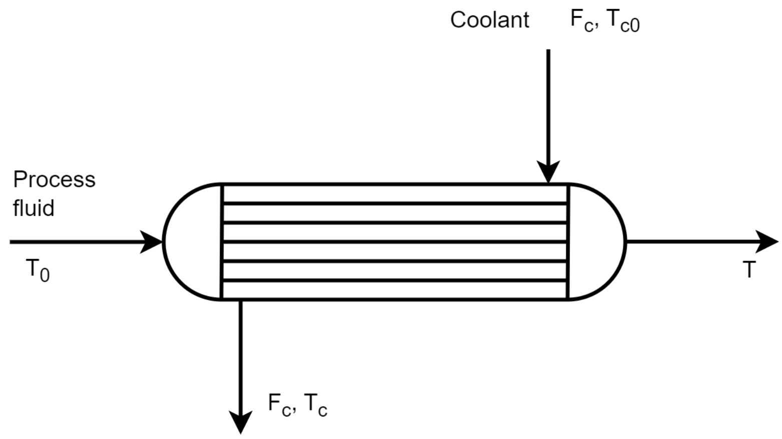

Figure 2: Ammonia reactor

3. Level control

   Draw a feedback system to control liquid level by using w1 as manipulated variable.

   Is it possible to improve the performance of the feedback system in the presence of disturbances in w1?

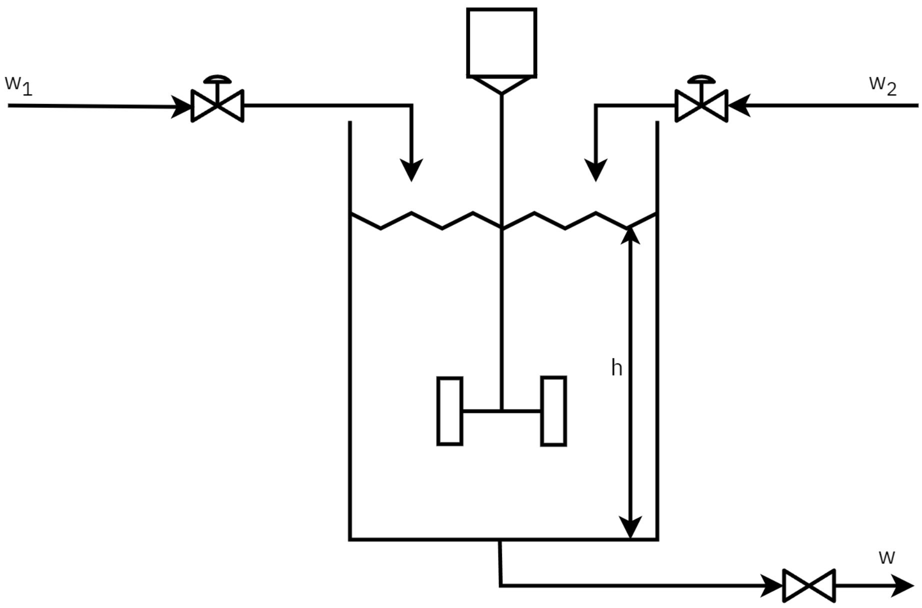

Figure 3: Level control

4. Exothermic reactor

   Consider a stirred chemical reactor where cooling water flows through the reactor jacket to regulate the reactor temperature.

   Draw a cascade control to regulate reactor temperature. What is the manipulate variable, what is the disturbance that is addressed by the cascade control?

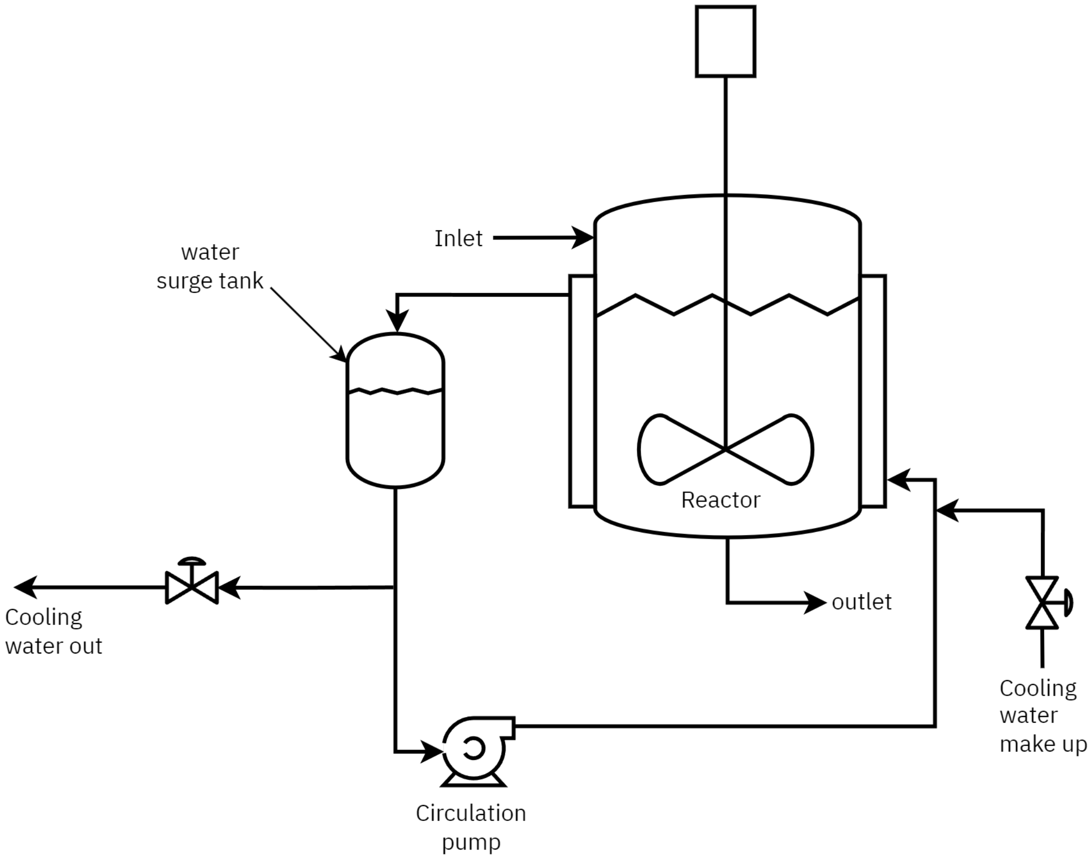

Figure 4: Exothermic reactor

5. For the processes and controllers below, analyze the stability of cascade control system

$$\text{Primary Process: } G_{p1} = \frac{1.0\exp(-4s)}{(10s+1)} \tag{1}$$

$$\text{Secondary Process: } G_{p2} = \frac{5\exp(-s)}{2s+1}$$

$$\text{Primary Controller: } G_{c1} = 2.5\left(1 + \frac{1.0}{5s}\right) \tag{2}$$

$$\text{Secondary Controller: } G_{c2} = 0.1$$

6. Simulate the system in 5 using simulink

7. For the processes and controllers below, analyze the stability of cascade control system

$$\text{Primary Process: } G_{p1} = \frac{\exp(-2s)}{(10s+1)} \tag{3}$$

$$\text{Secondary Process: } G_{p2} = \frac{\exp(-s)}{5s+1}$$

$$\text{Primary Controller: } G_{c1} = 3 \tag{4}$$

$$\text{Secondary Controller: } G_{c2} = 1$$

8. Simulate the system in 7 using simulink.

9. Distillation column Control Problems:

    a) Feed and composition temperature constantly change
    b) Reflux drum level constantly changes
    c) Vapor flow in the column constantly changes
    d) Distillate downstream pressure constantly changes
    e) Column pressure frequently fluctuates

   Suggest a suitable cascade control configuration to address the above mentioned issues.

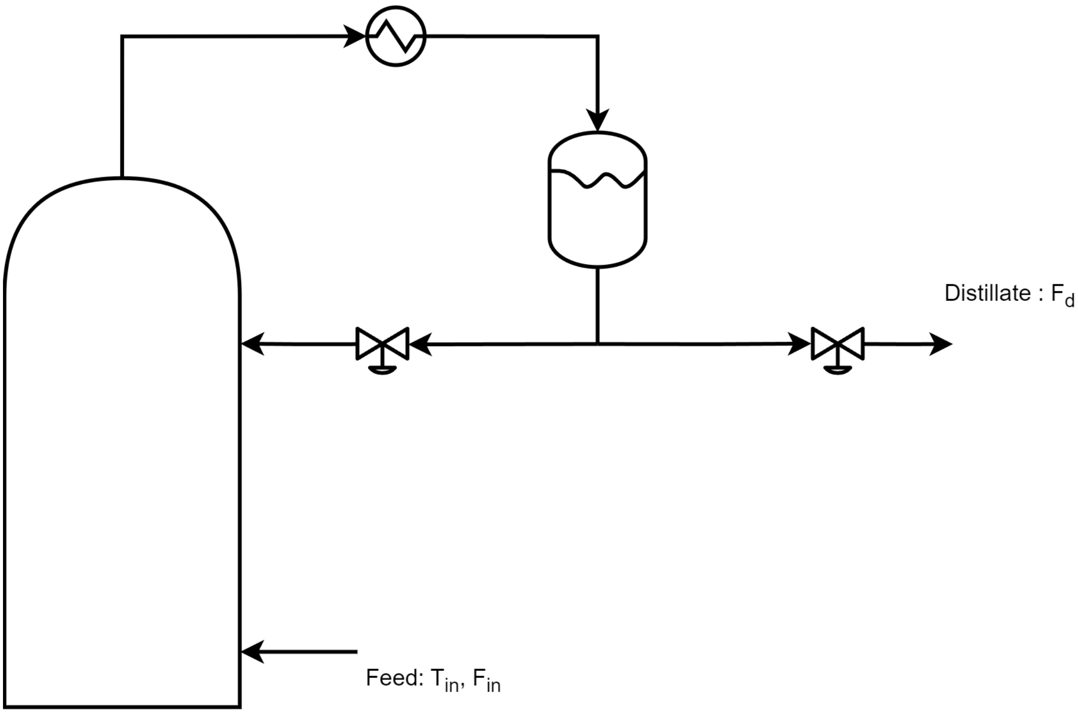

Figure 5: Distillation column top