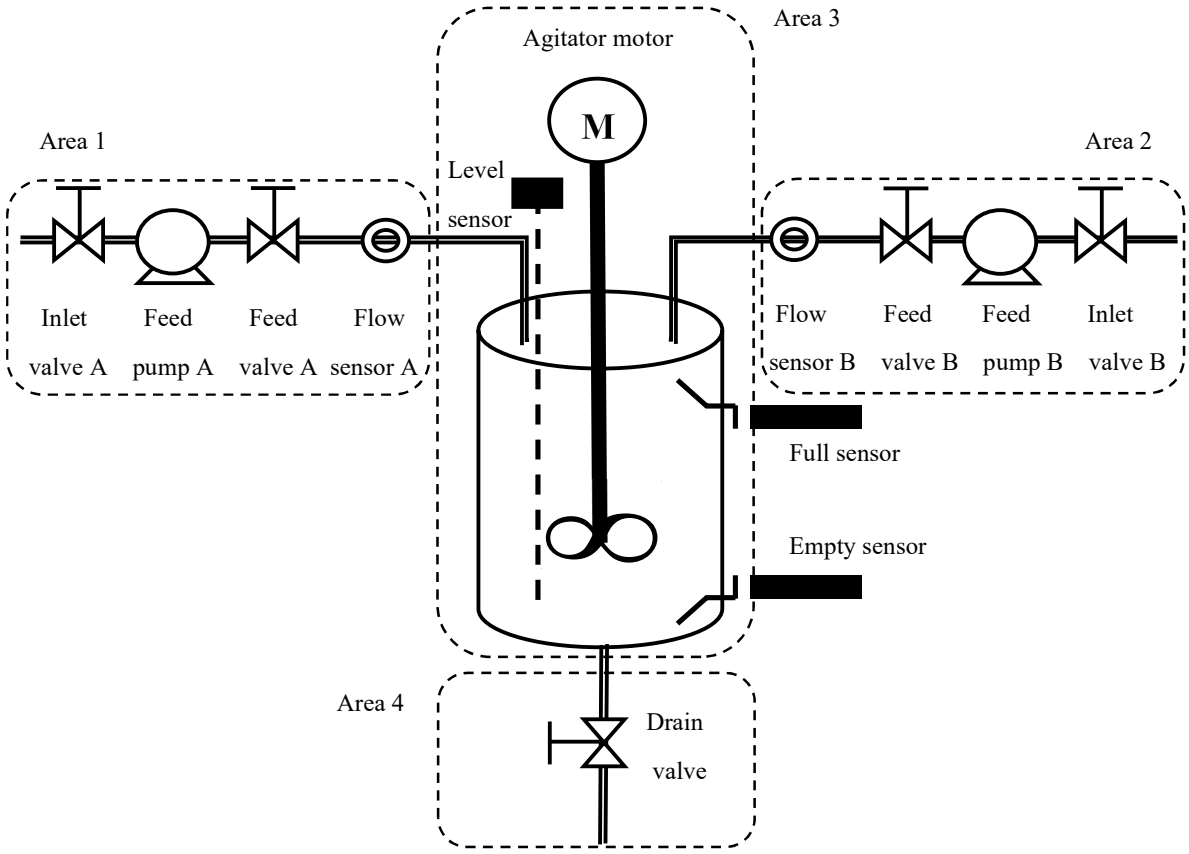
Industrial Blending Process

Define the task



Area 1 and 2:

- The pipe is equipped with an inlet and a feed valve, feed pump and flow sensor.
- Turning on the feed pump must be interlocked when the tank full sensor indicates that the tank is full and the drain valve is open.
- The inlet and feed valves must be opened at the earliest 1 second after starting the feed pump.

- The valves must be closed immediately after the feed pump stop (signal from the flow sensor) to prevent ingredients leaking from the pump.
- The activation of the feed pump is combined with a time monitoring function, in other words, within 7 seconds after the pumps start, the flow sensor must report a flow.
- The feed pump must be turned off as quickly as possible if the flow sensor no longer signals a flow while the feed pumps are running.
- The number of times that the feed pump are started must be counted (maintenance interval).
- The feed pump A opens until level equals to 2.5m.
- The feed pump B opens until full sensor detects full tank.

Area 3:

- The activation of the agitator motor must be interlocked when the tank empty sensor indicates that the tank is empty or the drain valve is open.
- The agitator motor must reach the rated speed (1500 RPM) within 20 seconds after the motor is activated; if not, the motor must be turned off.
- The agitator motor is controlled by a drive with analog input from 0 - 10V. This input is connected with analog output of PLC. The analog output must be linearly increased from 0 to 10V in 5 seconds, (10V → 1500RPM).
- The number of times that the agitator motor starts must be counted (maintenance interval).
- Three sensors must be installed in the mixing tank:

- Full sensor: a normally closed contact. When the maximum tank level is reached, the contact is opened.
- Empty sensor: a normally open contact. If the tank is not empty, the contact is closed.
- Level sensor: analog sensor has range from 0 – 5m.

Area 4:

- Drainage of the tank is controlled by a solenoid valve.
- The solenoid valve is controlled by the operator, but must be closed again when the "Empty sensor" signal is generated.
- Opening the drain valve is interlocked when:
  - the agitator motor is running
  - the tank is empty.

Operator Station:

The operator station is equipped with the following:

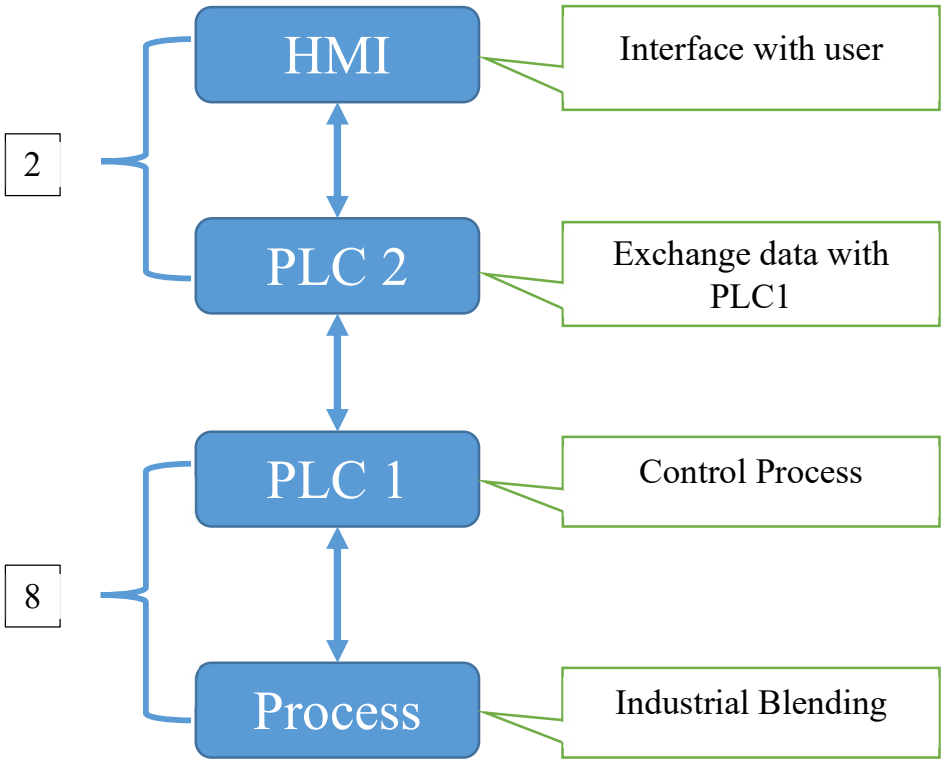
- Pushbuttons to:
  - Start, stop feed pump.
  - Start, stop agitator.
  - Open, close drain.
  - Turn off the maintenance display lamps for the motors due for maintenance and reset the corresponding counters for the maintenance interval to 0.
- Display lamps to indicate the status of the process:
  - Start, stop feed pump.
  - Start, stop agitator.
  - Open, close drain
  - Maintain feed pump, agitator.
  - Tank full and empty sensor.

- Display numbers to indicate the value of the process:
  - Level of tank
  - Speed of motor
- The emergency stop switch.

Operation Mode (optional):

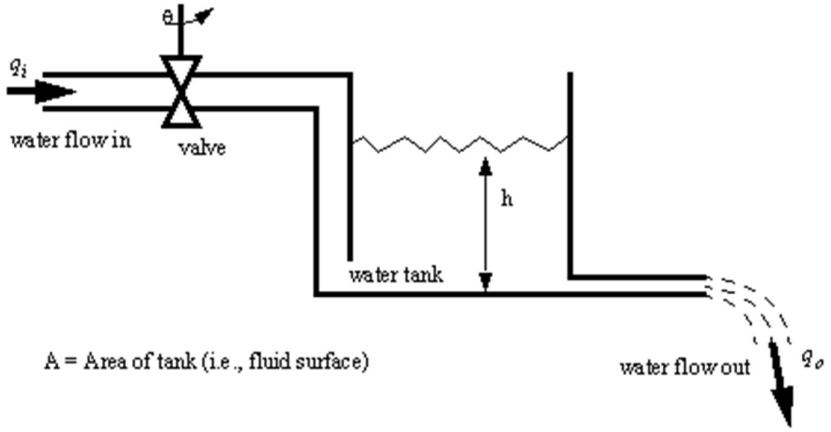
- Manual
- Auto

Divide problem into subtasks using FC and FB.



Appendix:

- **Tank model**



ODE:

$$\frac{dh(t)}{dt} = \frac{q_i - q_o}{A} = \frac{q_i - k\sqrt{h(t)}}{A}$$

With:

h(t): level (m)

q_i : input flow rate (lit/min)

q_o : output flow rate (lit/min)

A : Area of tank (m^2)

k : coefficient

Numeric values: A = 3, k = 0.01, q_i = 1000 when the valve opens.

- **Motor model**

$$\omega(k) = A * \omega(k-1) + B * u(k-1)$$

With: $A = e^{\frac{-Ts}{\tau}}, B = \omega_{max}(1 - A)$

Numeric values: $\tau = 1\ sec, \omega_{max} = 1500\ RPM,$

T_s: $sampling\ time,$

u: $power, \omega$: $speed$