YOUR TASKS

I. Batch Process

First you need to design a control system for a batch process in which a liquid at room temperature (20ºC) is pumped into a tank until a given level is reached. The liquid is then heated and mixed, after which is evacuated. The system will work in five different states:

IDLE:

- Begins when the program is started or after a cycle is completed (when a low-level limit switch stops detecting the liquid).
- Ends when the START button is pressed or when alarm conditions trigger the FAULT state.
- Actuates the IDLING lamp for indicating purpose.

FILL:

- Begins when the START button is pressed in the IDLE state.
- The pump is on, at constant maximum speed.
- Ends when the liquid reaches the 80% level or when alarm conditions trigger the FAULT state.
- Actuates the FILLING lamp for indicating purpose.

HEAT & MIX:

- Begins when the 80% level is reached in the FILL state.
- The agitator is on.
- The servo-valve controlling the steam supply to a heater undergoes the following sequence of operations:
    - opens to 25%;
    - 5 seconds later opens to 50%;
    - 5 seconds later opens to 75%;
    - 5 seconds later opens to 100%;
    - remains fully open until the temperature of the liquid in the tank reaches 90ºC, at which point it shuts off.
- Ends when the temperature of the liquid in the tank reaches 90ºC or when alarm conditions trigger the FAULT state.
- Actuates the HEATING & MIXING lamp for indicating purpose.

EMPTY:

- Begins when the temperature of the liquid in the tank reaches 90ºC in the HEAT & MIX state or when alarm conditions are reset in the FAULT state.
- The solenoid drain valve is on.
- Ends when a low-level limit switch stops detecting the liquid or when alarm conditions trigger the FAULT state.
- Actuates the EMPTYING lamp for indicating purpose.

FAULT:

- Begins when a high-level limit switch is triggered or when the STOP button is pressed.
- Ends when the RESET button is pressed, and the system returns to the EMPTY state.
- Actuates the ALARM lamp for indicating purposes.

II. PID Level Control

You also need to design a closed-loop control system to control the water level in the Level Process Control System. The level process consists of:

- the variable speed pump,
- the cylinder, and
- an open drain valve, represented by:
    - the solenoid valve (Case A);
    - the manual valve (Case B).

The PID controller should be able to:

- track changes in the water level setpoint;
- correct variations in water level caused by disturbances represented by:
    - the opening of the manual valve in Case A;
    - a change in the opening of the manual valve in Case B.

	Your Task	Description
1	Mathematical modelling	Model mathematically the level dynamics: • in the FILL state of the batch process, • in the EMPTY state of the batch process, and • for the level process of the PID level control.
2	PLC programming for the batch process using mathematical models	Any industrial control system is first designed and validated on a model of the process, to avoid any risks and hazards involved in running the actual plant. Program the PLC in the UNITY PRO to run the batch process on the mathematical models of the level process. Assume a linear increase in temperature in the HEAT & MIX state, with the rate of increase proportional to the opening of the servo-valve.
3	PLC programming for PID level control using mathematical models	Perform a study for the PID control of the level process by using the root locus technique.