

Equipping a Process Control Lab via Department Sponsored Senior Projects

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Abstract

This paper discusses the equipping of a Process Control Lab with realistic process simulators by having the ECE department sponsor student teams to build the apparatus as their capstone design project. This sponsorship involves having the department specify the behavior of the apparatus, specify the Input / Output connections between the apparatus and the Programmable Logic Controller (PLC I/O), and pay for all the materials.

I. Introduction

At Lawrence Tech we teach a senior elective course “Process Control” in which students learn how to control various processes with a PLC using ladder logic. One of the biggest challenges of teaching the associated laboratory is getting the students to visualize the process they are trying to simulate. This is complicated by the fact that the only inputs our simulator panels make available to the PLC are toggle switches, and the only output from the PLC consists of lamps. (There is one switch and lamp simulator per student group in the lab.) For example to simulate filling a tank, a switch is chosen to represent the on / off selector, another switch is chosen to represent the low-level float switch, a third switch is chosen to represent the high-level float switch, and a lamp is chosen to represent the tank input valve. The student writes a ladder that opens the tank input valve whenever the low-level float switch is not actuated, and closes the valve only when the high-level float switch is actuated. The ladder program is tested by having the instructor actuate the low-level switch, then activate the on / off switch, and by observing that the valve lamp is not lit until the low-level switch is deactivated, and remains lit until the high-level switch is activated (regardless of the subsequent condition of the low-level switch). While the above example is readily visualized by most students, more complicated simulations are not. In addition, the simulation by switches and lamps lacks the “hands-on” experience students need to maintain their interest and to help them relate the theoretical material to the real world.

To alleviate these short-comings of our process control lab, we have commissioned several student teams to build various process simulators. We currently have two intermediate level process simulators (the temperature controlled chamber and the fluid mixing tank) and one

advanced level simulator (the four story elevator), all of which will be discussed in detail in subsequent sections. We introduce the temperature chamber and the mixing tank after the students have had sufficient experience doing simple tasks with the switch and lamp simulation panel. Since we have only one of each simulator and 4 - 6 student groups in the lab, the students take turns with the temperature chamber, the mixing tank, and the elevator.. Since the students typically finish the introductory material at different rates, there is rarely a conflict over who is to use a process simulator at any given time. After the intermediate level process simulators, there follows several weeks of more advanced work with the switch and panel simulator before the four story elevator simulator is programmed as a final laboratory exercise.

The capstone design experience (called the senior project at LTU) is a two course sequence, each course receiving two semester hours credit. The student teams who build the process simulators are responsible not only for building the process simulator, but for providing a technical manual (their final project report), for providing a user manual, for hard-wiring the inputs and outputs to a lab PLC, and for writing a ladder program to test their device. The senior project sequence includes the usual written and oral proposals and reports.

II. The Temperature Controlled Chamber

The temperature controlled chamber is simply a styrofoam insulated plywood box (with a lid), divided into three chambers as shown from the top in figure 1.

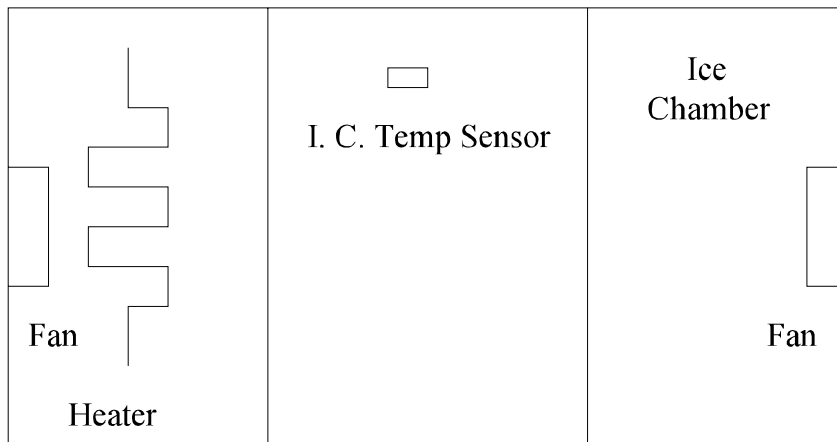


Figure 1 Temperature Controlled Chamber

The center chamber is the chamber whose temperature is to be controlled. The two fans in the outer chambers can be operated to force air in either direction through the center chamber by way of holes drilled in both interior bulkheads. The student using the process simulator has an analog input corresponding to the temperature, and digital outputs for the heater, and for each fan. (Each fan can be turned off, inward, and outward.) The student is asked to maintain (and

display) the temperature in the center chamber at several set-point temperatures.

III. The Fluid Mixing Tank

The fluid mixing tank simulator (see figure 2) consists of two reservoir tanks, a mixing tank (with a stirrer), and a collection tank into which the contents of the mixing tank is transferred after the stirring is accomplished.

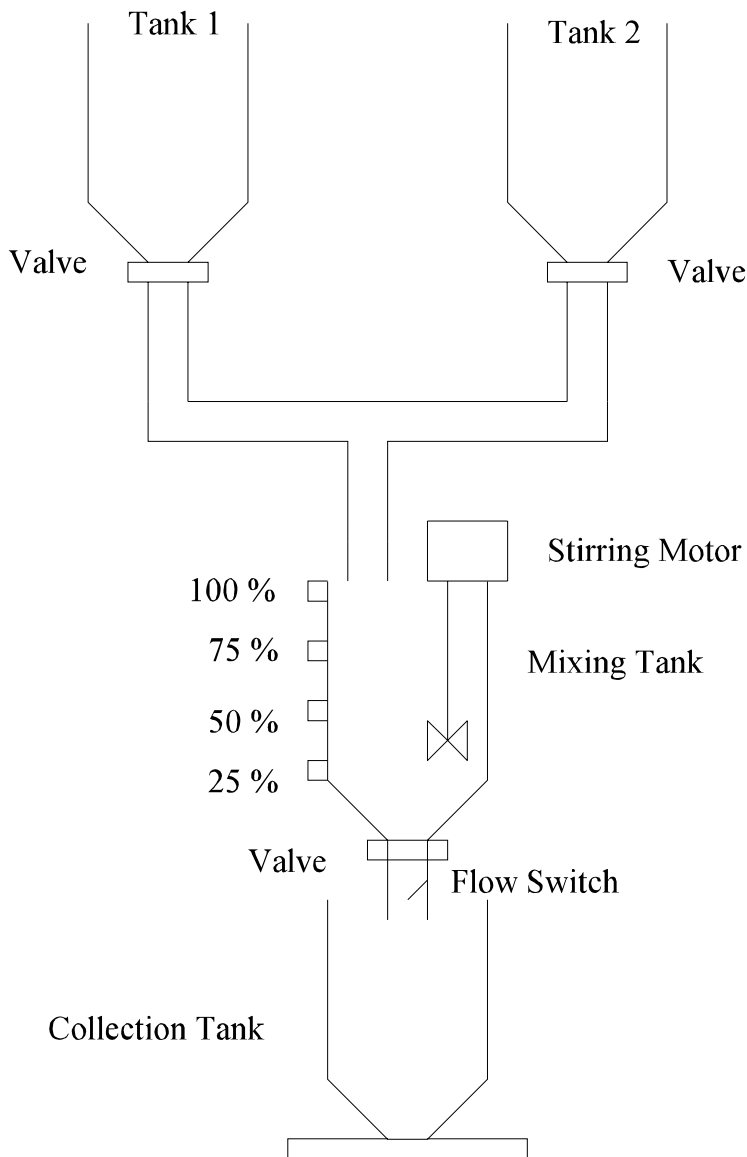


Figure 2 Fluid Mixing Tank

The mixing tank is equipped with four float switches that actuate when the mixing tank fluid level is at the indicated percentage full. The usual task is to ask the student to provide a selector switch that determines the percentage fill of each fluid, provide an indication of the selected mix

(the switches and lamps are on the switch and lamp simulator panel), have the machine fill the mixing tank according to the selected mix, stir for some predetermined time, transfer the mixed fluids to the collection tank, and light a done lamp when the transfer is complete. The fluids are usually water, colored with food coloring; blue and yellow seem to work well.

IV. Four Story Elevator

The four story elevator simulator is six feet high with a concrete base. Each floor has an up call button and a down call button with associated lights. (Except, of course, for the top floor and the bottom floor which each have only one call button.) The car has a door that opens and closes (the car door mechanically opens the outer door at each floor), and four lighted buttons for choosing the desired floor. There is an input to the elevator to engage the motor in the upward direction, and another input to engage the motor in the downward direction. There are micro-switches at each floor and micro-switches that actuate when the door is fully open and fully closed. All lamps and motors are directly controlled by the PLC and all buttons and switches are directly read by the PLC. This means that the PLC ladder program must, for example, turn on the door open motor, sense when the door is fully open, and turn the motor off. In addition, there are limit switches that deenergize all motors on over travel. If any of these limit switches is activated, all power is disconnected from the elevator and a fault lamp is lit. After the student fixes his or her ladder program, the elevator must be manually reset before operation can continue.

V. Conclusion

The simulators have increased student interest in the lab, as judged by their comments to the instructors. The simulators have also improved the students' ability to visualize the switch and lamp panel simulations, as evidenced by fewer student question concerning these simulations.

Bibliography

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Richard Johnston spent eight years as a technician (including three years in the U. S. Navy) before completing his BSEE from Wayne State Univ. He was employed as an electronic engineer by Motorola and by the Gulbransen Organ Co. before completing the MSEE and Ph.D also at WSU. He is currently Associate Professor at LTU, and his interests include electronic musical instruments, power electronics, and computational engineering.