

“Process Dynamics and Control Laboratory Experiments Carried Out Over the Internet”

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Abstract

Process control experiments can provide students with valuable hands-on experience to supplement the theory learned in classroom lectures. Because many of the concepts of process control are abstract and difficult to fully comprehend, the opportunity to study the dynamics and design controllers of an actual laboratory process is a valuable experience that can reinforce important concepts. Combining such laboratories into a traditional lecture-based class is a desirable goal given the current pressure on reduced credit hours in the curriculum. Performing such experiments over the Internet is an efficient way for students to receive a laboratory experience.

1 Introduction

Because many process control concepts are abstract and not easy to fully comprehend, we identified a need for the students in the undergraduate process control class to connect theory and applications via a real process and its instrumentation and control components.

Two experiments that were used sporadically as special projects in a senior lab course at UT-Austin implemented process control with analog controllers and recorded experimental data with charts. The idea of this project was to modernize these experiments so that they could be used as demonstrations for the required undergraduate process control course. In addition to introducing data acquisition and PC-based computer control to the students, a second goal was to develop a web tool to run the experiments over the Internet.

2 Experimental Description

The two experiments, control of liquid level and temperature from a heated pipe, have been modified for digital data acquisition and control as discussed below.

Liquid Level

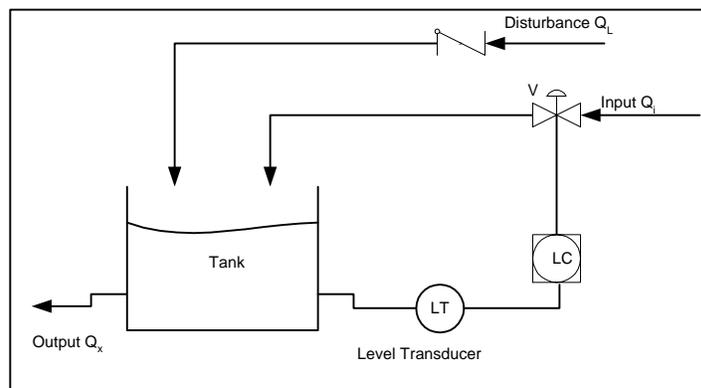


Figure 1. Liquid level experiment

The liquid level experiment is a linear first-order system which provides a suitable introduction to process control. The manipulated variable is the flow (Q_i) which enters the tank (T) (actually a large graduated cylinder) and is adjusted through the control valve (V). The disturbances are represented by the disturbance flow (Q_L). Other symbols in Figure 1 are Q_i : Input Flow, Q_x : Exit Flow, Q_L : Disturbance Flow, LT: Level Transmitter, LC: Level Controller. The level is sensed using a differential pressure transducer located at the bottom of the tank. The transducer output goes to a National Instruments data acquisition system connected to a PC. The PC is configured as a server where the students log on remotely to work on the experiments.

Control of Temperature from a Heated Pipe

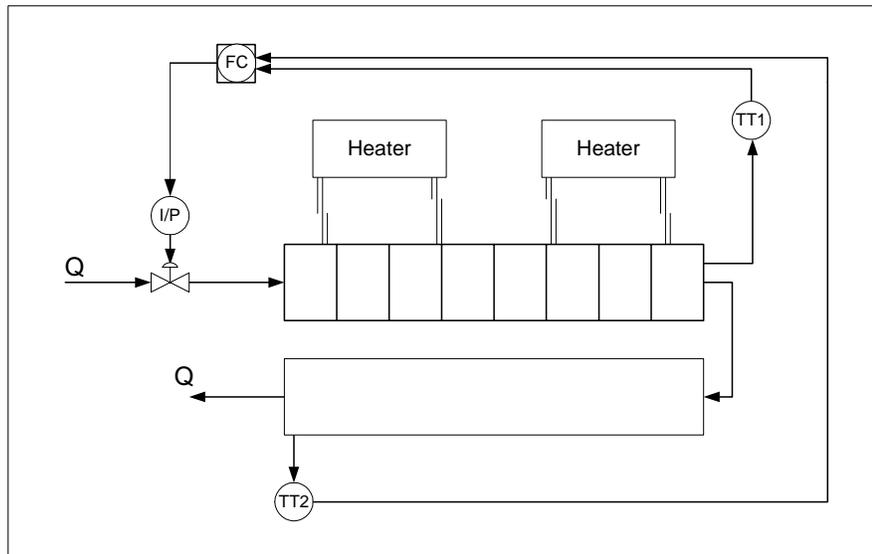


Figure 2. Heated Pipe experiment

Symbols in Figure 2 are FC: Flow Controller, TT: Temperature Transmitter, I/P: Current to Pressure Transducer, Q: Water Flow. In this experiment a control valve manipulates the flow of water (Q) through the heated pipe. This experiment senses exit temperature at two points (TT1 and TT2) and manipulates flow in. This process is more of a challenge to control because it is a nonlinear system with variable gain and time delay (as the flow rate changes), which is exacerbated by incorporating a transport delay before measurement TT2.

3 Remote Control

For both experiments the control algorithms implemented are PID control and ON-OFF control. The operation can be set to manual or automatic. In manual operation the user can select the position of the valve while in automatic operation it is adjusted by the controller. The set point and tuning parameters for the PID controller must be introduced via the computer for automatic operation.

The program has a graphical interface (Figure 3) which allows the student to follow the variations in the manipulated and controlled variables during the experiment and save the data in a text file that can be easily manipulated in a program like Excel. Other functions in the interface are highlighted in Figure 3.

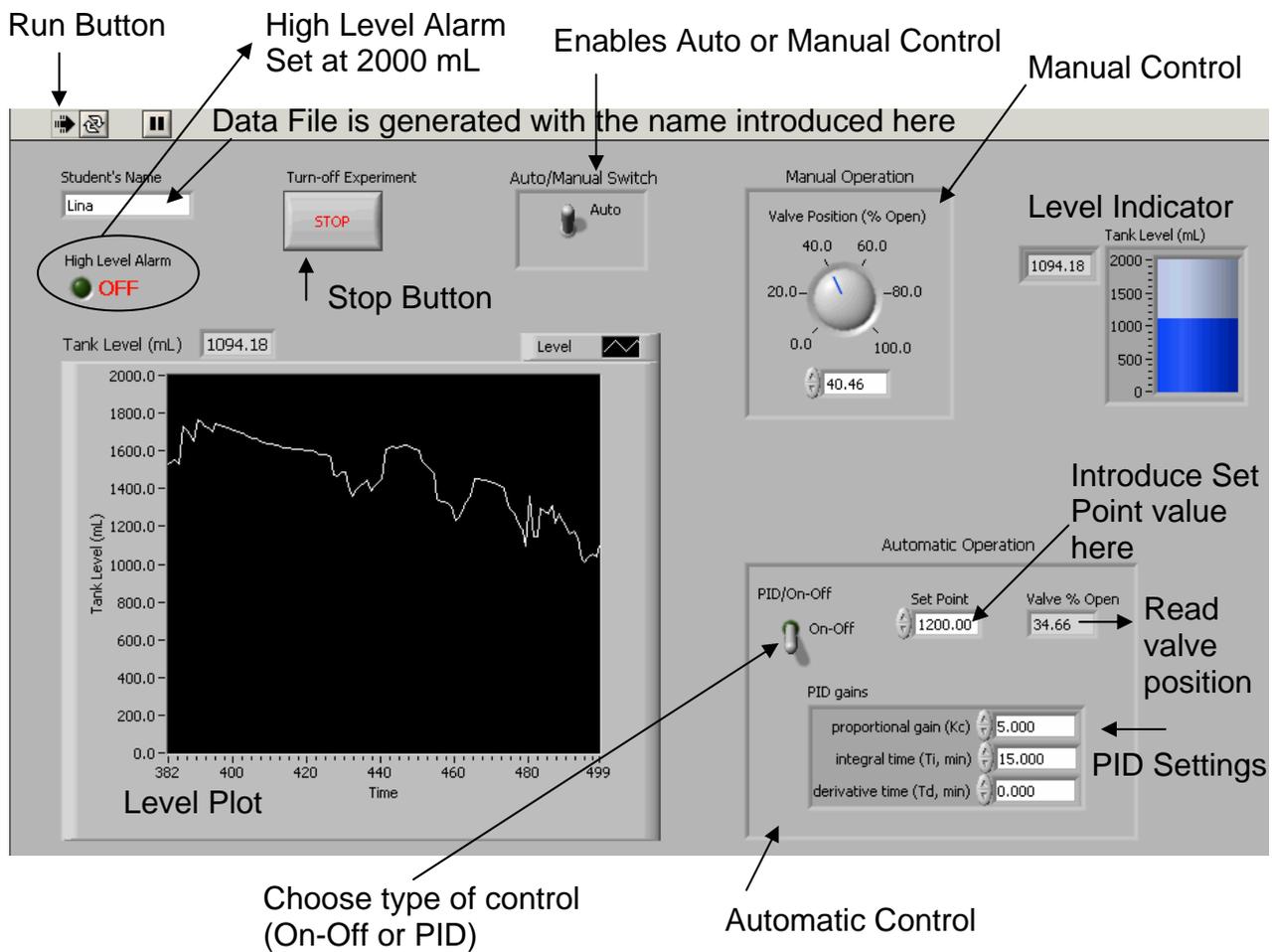


Figure 3. Liquid Level Experiment Interface

The remote control uses the same screen that can be seen from the server. The control is released from the server to the remote location by request and vice versa.

The experiments were implemented with Labview from National Instruments; the remote operation was configured with the Labview remote tool package which allows setting up the server and organizing the user's access to the experiment. For our case, the users were allowed to manipulate the experiment during one hour intervals; after a user reached the time limit control of the experiment was assigned to the next group in the queue. With a large class (~75 students) working in groups of two, managing the laboratory experience is a serious challenge.

3.1 The Laboratory Experience

The liquid level control was implemented in spring of 2003 in an undergraduate process control class with 75 senior chemical engineering students. Students performed the experiment in groups of two during a designated week, and about 80% of the groups accessed the experiment from the computer laboratories one floor above the laboratory. The rest accessed from different remote locations. Although the log-on process and the development of the experiment was a successful experience, some operational difficulties were faced during the first day of implementation. Student feedback (and patience) was a key consideration for improvement of the experiment.

4 Conclusions and Future work

This experience showed that implementation of practical experiments in the process control undergraduate course increased students' motivation towards learning the process control concepts. Studying the dynamics and optimizing the controller settings of an actual control system actually increased their understanding of the concepts, according to student feedback. The next step is to implement both experiments in the Fall, 2003 semester and use them to show different concepts. The heated pipe experiment presents challenges in modeling and control that can also be studied in graduate courses, where different types of advanced controllers can be configured.