

LITERATURE REVIEW

Interacting Tank Process

Since most industries use the tanks to produce many products, the tanks are often coupled together to be suitable production. There are many researchers studying in this topic in order to control system for obtaining a better product quality. Therefore, we will focus on the previous works in order to study the trends of researches.

Ko *et al.* (2001) presented the implementation of a web-based laboratory experiment on a couple tank apparatus, a Multi-Input-Multi-Output (MIMO) system. The web-based laboratory has been developed to serve students and staff in the Department of Electrical Engineering at the National University of Singapore (NUS). The laboratory is an educational tool for teaching students the basic principles and methodology in performing a series of the experiments on a coupled tank apparatus at any time and from any location through the internet. With a capability to implement strategies for manual, proportional integral derivative (PID), general state-space and fuzzy logic control, the laboratory also provides a platform for research staff to set control algorithms. Video conference has been used to provide audio and video feedback, with a camera mounted on a movable platform so that the user can control and viewing angle. The laboratory can be accessed at <http://vlab.ee.nus.edu.sg/vlab/control/>.

Henry and Nuttall (2004) discussed the implementation of several laboratory systems used for remote experimentation via the internet. They discussed the equipment and software developments for four systems used in teaching and research in controls systems and unit operation laboratories:

- A three-tank level control system (UNM)
- A twelve-tray distillation column (UTC)
- A shell-and-tube heat exchanger (UTC)
- A gas-fired water heater (UTC)

Each lab equipment system is connected to a dedicated control computer that allowing real-time operation and control manipulation of that equipment via the internet. The interaction is with web browsers with a LabVIEW plug-in. The computers collect all the data from the experiment. The experiment control panel can remotely be viewed (by any number of students) as they proceed and after the experiment are finished.

They discuss how the remote experiments are used for teaching and research. They present the pattern of student use of the equipment and the experiences of the students in developing and using the systems.

Join *et al.* (2005) provide fast and on-line methods for failure detection and isolation of uncertain non-linear system operating in closed-loop. They were based on accurate values of the derivatives of a time-signal, which are obtained via new algebraic estimation techniques. The applicability and efficiency of whose approach are illustrated by numerical simulations for a most popular case-study, namely the three-tank system.

Tunyasrirut *et al.* (2006) present the approach to design the auto-tuning PID controller for interactive water level process using integral step response. The integral step response (ISR) is the method to model a dynamic process which can be done easily, conveniently and efficiently. Therefore this method is advantage for designing the auto tune PID controller. Whose scheme is used for the root locus for modeling and testing of the control system. The experimental results of the interacting water level process can be satisfactory illustrated the transient response and the steady state response.

Two interacting tank is used for study in theory of process control. Furthermore, this system applies many strategies to control process. Then, internet is used to support the control at any place. Controlling throughout internet must have some program to implement.

LabVIEW is used in this work because it supports to a signal conditioning block connected between equipment and computer. Therefore, LabVIEW will be discussed in the next topic.

Laboratory Virtual Instrument Engineering Workbench (LabVIEW)

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming language that uses icons instead of lines of text to create applications. LabVIEW uses dataflow programming, where the flow of data through the nodes on the block diagram determines the execution order of the virtual instruments (VIs) and functions. VI is LabVIEW programs that imitate physical instruments. In LabVIEW, the user interface is built by using a set of tools and objects.

The graphic user interface is known as the front panel. The program can add code using graphical representations of functions to control the front panel objects. This graphical source code is also known as G code or block diagram code. The block diagram contains this code. In some ways, the block diagram resembles a flowchart. The user can purchase several add-on software toolkits for developing specialized applications. Since these advantages, there are researchers applied this program for control as follow

Toran *et al.* (2001) designed virtual instrument for water quality monitoring across the internet that enhance with powerful internet capabilities. The signal conditioning block has been simplified through the use of software routines. The system offers a wide variety of internet capabilities such as e-mail alarm notification, automatic storage of measured data in a remote machine via the FTP protocol, dynamic generation of HTML report, real time graph and indicators visible from a remote web browser, etc.

Mohammad *et al.* (2004) studied a closed loop temperature control by using LabVIEW that simulated PID algorithm to control system. Sub VI was used as a controller in a close loop which controls an oven temperature. The results of

experiment show a high degree of convergence with the results obtained when an electronic hard-wired controller was utilized.

LabVIEW is a popular control program. It is used to implement in many processes. Moreover, LabVIEW can control throughout internet which is very useful in control.

However, only LabVIEW is not enough for study because the control loop must have controller to approach to zero. In this work, there are four strategies used for controlling process. They will be discussed as follows.

Proportional Integral Derivative (PID)

Ingenious feedback control systems for water-level control were used by the Greeks as early as 250 B.C. (Mayr, 1970), with their mode of operation being very similar to that of the level regulator in the modern flush toilet. The fly-ball governor, which was first applied by James Watt to the steam engine in 1788, played a key role in the development of steam power. Feedback control was essential for the development in the 1930s of high-gain, operational amplifiers that are widely used in electronic equipment.

During the 1930s, three-mode controllers with proportional, integral, and derivative (PID) feedback control action became commercially available (Ziegler, 1975). The first theoretical papers on process control were published during this same period. Pneumatic PID controllers gained widespread industrial acceptance during 1940s, and their electronic counterparts entered the market in the late 1950s and early 1960s. Since the 1980s, digital hardware has been used on a routine basis and has had a tremendous impact on process control.

The literature contains a number of these tuning rules; possibly the best known are the Ziegler-Nichols rules proposed in 1942. Given the wide used of the first-order lag/lead time model for chemical process, tuning rules for PID control of this structure

have received wide attention in the literature. Most common are the rules proposed by Cohen and Coon (1953), Smith (1972) contains a good summary of efforts in this area.

Internal Model Control (IMC)

A more comprehensive model-based design method, Internal Model Control (IMC), was developed by Morari and coworkers (Garcia and Morari, 1982; Rivera et al., 1986). The IMC method is based on an assumed process model and leads to analytical expression for the controller settings. These two design methods are closely related and produced identical controller if the design parameter are specified in a consistent manner. Moreover, the IMC approach has the advantage that it allows model uncertainties and tradeoff between performance and robustness to be considered in a more systematic fashion.

The IMC method gives the control engineer a different perspective on the controller design problem. The basic idea of IMC is to use a model of the open loop process transfer function in such a way that the selection of the specified close loop response yields a physically realizable feedback controller.

Morari *et al.* (1986) developed the IMC controller which base on accurate model of the process. It leads to the design of a control system that is stable and robust. IMC design procedure is shown to lead to PID controller. The PID controllers have as their only tuning parameter the closed loop time constant or, equivalently, the closed loop bandwidth.

Skogestad (2003) presented analytic rule for PID controller tuning that are simple and still result in good closed loop behavior. The starting point has been the IMC-PID tuning rule that have achieved widespread industrial acceptance. The rule for the integral term has been modified to improve disturbance rejection for integrating processes.

Generic Model Control (GMC)

GMC is based on the principle of using the best available process model as the means of developing a control strategy. This process model is derived from fundamental conservation and constitutive relations. This type of model will fully describe the process nonlinearities and interactions that occur between process variables.

Lee and Sullivan (1988) need to implement the control performance of chemical process which is nonlinear. They presented the general framework for process controllers that rely upon a model to approximate plant behaviors. Nonlinear process models can be imbedded directly into the controller without resorting to linearization.

Cott and Macchietto (1989) used GMC to control temperature in exothermic batch reactors which is nonlinear. It also allows the use of the same control algorithm for both heat up and temperature maintenance, therefore eliminating the need to switch between two separate control algorithms as is the case with today's commonly used strategies. A deterministic on-line estimator is used to determine the amount and rate of heat released by the reaction. This information is utilized to determine the change in jacket temperature set point in order to keep the reaction temperature on its desired trajectory.

Arpornwichanop *et al.* (2004) purposed on-line dynamic optimization and control strategy for improving the performance of batch reactors by using Extended Kalman Filter (EKF). GMC controller is used for tracking the profile of the new updated setpoint in order to maximize the yield of product and minimize the batch time. The result of work can be satisfyingly illustrated the good optimum temperature progression and calculated the heat release of process.

Fuzzy Logic Control (FLC)

Fuzzy logic control (FLC) is a general feedback control technique that utilizes qualitative information (Rhinehart et al., 1996; Passino and Yurkovich, 1998). FLC has been used in consumer products such as washing machines, vacuum cleaners, and camcorders. It has also been applied to industrial control problems using commercial FLC software.

The most interesting in this work will integrate all of these researches to control the two-interacting tank process. All strategies, PID, IMC, GMC, and FLC are used because of a several control. They have different advantages and they need different of their inputs. It is more practical for engineering applications in the online control of two-interacting tank process.