

Dahlin's Control Technique to Controlling the Temperature in a Glycerin Bleaching Process

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Abstract

An ideal distinctiveness of glycerin is obvious colour, low bitterness and is clinically harmless for human cause it to be broadly used as a one of the substances in several industries named as food and cosmetics industry. Frequently, glycerin is produced or generated by performing any of these processes giving by splitting, saponification & transesterification on vegetable or animal fats and oil. One of the major process that give to the success of the glycerin purification process is bleaching process in which the process of erasing the pigment color as from crude glycerin by adsorbent materials occurs. During the process, the temperature would regulate exactly because of fact that the optimal temperature will raise the effectiveness of adsorption process. Yet, any inappropriate control performance given by overshoot should cause useless side response that goes to degradation of end product quality. It is desirable to find proper control technique for regulating the temperature of glycerin bleaching process in order to prevent any degradation of end product quality. Controlling slow dynamic process such as temperature for glycerin bleaching process is inherently difficult. This is due to the unfavorable characteristic of the system that possess nonlinearities caused by actuator constraint that will lead PID controller produce inadequate performance due to windup phenomenon. This paper shows the implementation of the Dahlin's Controller Algorithm to control the temperature in Glycerin Bleaching process. The process model is taken as using first order plus dead time (FOPDT) model. Two controllers, given by the PID Controller and Dahlin's Controller are to be implemented and compared through simulation. The analysis of the performance for both the techniques will be based on, rise time, settling time; percent overshoot and time to recover load disturbances.

Keywords- First order plus time delay system, Proportional Integral Derivative (PID) controller, Dahlin's Controller, Dahlin's Algorithm, Time delay systems.

I. INTRODUCTION

The important processes that contribute to the achievement of the glycerin purification process is bleaching process where the process of eliminating the pigment color from adsorbent materials occurs [1]. Throughout this process, the crude glycerin by temperature should normalize accurately due to reality that the optimal temperature will increase the efficiency of adsorption process. But, any inappropriate control performance given by overshoot will cause unnecessary side reaction that lead to happen the degradation of end product quality [2]. By taking this factor or cause mentioned it is enviable to find appropriate (accurate) controller to regulate the temperature in glycerin bleaching process in sequence to prevent dreadful conditions of end product quality. Proportional Integral Derivative (PID) control technique is considered even as design the appropriate control technique for temperature controlling of the glycerin bleaching process. This is because of the advantages of PID that have a straightforward structure and theoretically more easy to understand and at also time assure is an satisfactory performance for the majority of the manufacturing & Industrial process. Besides, PID controller [3,4] residue then nearly everyone and widely using the controller adopted in process & manufacturing industry and surveys indicated that, higher than 97% from 11000 industries uses PID controller algorithmic technique to control their process.

On the other hand, to give a robust controller that able to meet necessity system performance for slow dynamic process given by like temperature controlling for the glycerin bleaching process is not a simple job. The continuation of critical features of the process for occurrence, nonlinearities of the system dynamic cause by actuator control, will show the way the PID controller to provide unsatisfactory performance given by the high overshoot and long settling time. This condition is usually known as integral windup occurrence.

Most of the Chemical process & Thermal Process are using the Delay's process Transfer function. For the PID Controller is perfectly suitable for the less delay time. In this Glycerin bleaching process the delay time is more. For this above disadvantages in the PID Controller Dahlin's Controller [9] is proposed. To implement Dahlin's Controller [5] discrete transfer function is determined.

The remaining parts of this paper are arranged as follows. Section II will give the glycerin bleaching process plant and the system interfacing. Section III describes the derivation of the first order plus dead time (FOPDT) model for the system, Section IV will explain the Dahlin's Controller, Section V and Section VI will shows the results and conclusion of the study.

II. SYSTEM EXPLANATION

This process study was conceded out based on glycerin bleaching process pilot plant located at Distributed Control

System (DCS) Laboratory of Electrical Engineering in UiTM, Shah Alam as shown in Figure.1. The Piping & Instrumentation diagram of the reactor tank of the plant in which the temperature is to be calculated and controlled is as shown in Fig. 2. The inner side temperature of the reactor is measured by Resistance Temperature

Detector PT100-3 wires and to heat the compound inner side of the reactor, double band heaters with 8 inch width are distributed around the tank. Every one of the heater has a power mark of 1.5kW and determined by 25 AC power controllers. In order to provide identicalal location of heat released inner side of the reactor and to make sure compound inside the reactor are well mixed the Agitator (AG) with a speed of 480 RPM is positioned at the middle of the reactor.



Figure 1: Glycerin Bleaching Process pilot plant[11]

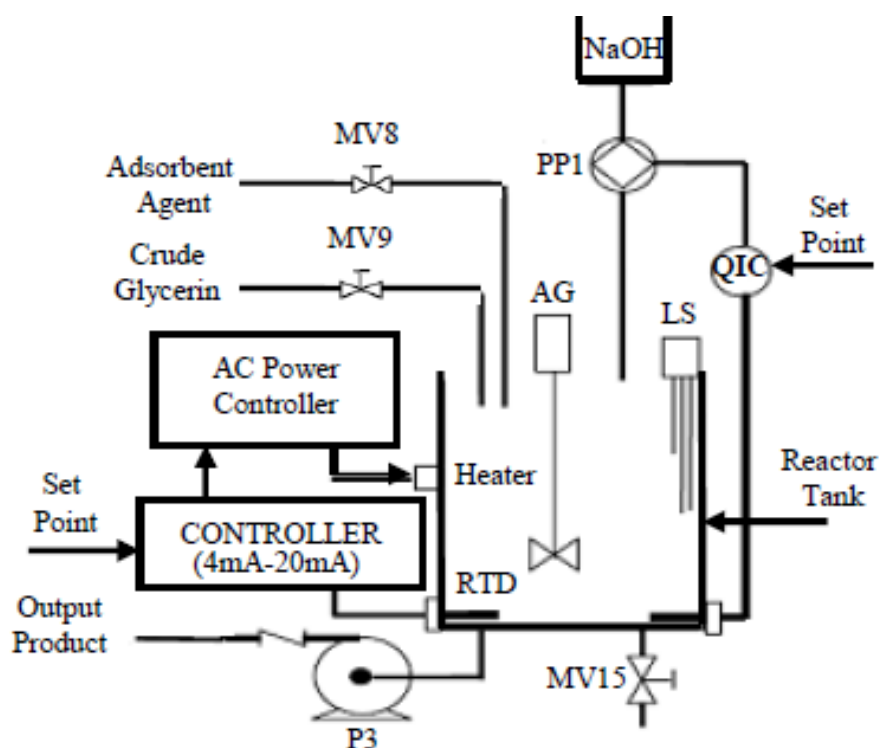


Figure 2: Pipes & Instrumentation diagram of reactor tank of glycerin bleaching pilot Plant [11]

Anticipated to manage and examine the temperature in the interior the reactor, the reactor has been interfaced with the computer by a NI data acquisition card. The configuration of interfacing for the system is as exposed in Fig. 3. In this case, the Lab Views software is used as a control platform for controlling and monitoring the temperature inside the reactor tank. The temperature in the interior of the reactor is measured by Resistance Temperature Detector Pt100 in the type of ohmic resistance and then it will be feed into NI9217 to translate the ohmic resistance to degree Celsius. The temperatures in the reactor are synchronized based on a control signal that is in between 4mA to 20mA via NI9265. Data acquisition card which directly being feed into an AC power controller to drive the heater. All over the process, the data are captured and monitored with 1 second sampling period.

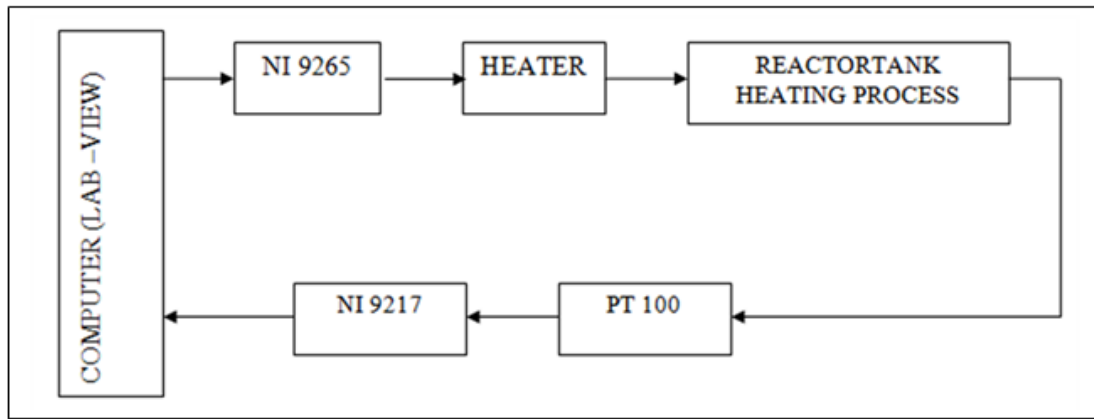


Figure3: Configuration of system interfacing

III. MODELING APPROACH

Frequently, due to difficulty and unknown factor of the plant, the experimental method is used in modeling the system dynamic. The First Order Plus Dead Time (FOPDT)[5] model is one of the models that industrial based observed method which has been normally that often used for identifying dynamic model due to fact that it has a simple procedure and provides sufficient model to describe the dynamic behavior of the system. Furthermore many methods in determining the PID [8] parameter are based on FOPDT model. Fundamentally the evaluation parameters of the FOPDT model are calculated by performing step test experiment to the process [6, 7]. Detail procedures for developing FODPT model are as described in [8]. The mathematical model of FOPDT model is shown in Eq (1).

$$G(s) = \frac{u(s)}{r(s)} = \frac{K e^{-\theta s}}{TS+1} \quad (1)$$

Where, T is known as time constant, is θ known as time delay, and K is given by as process gain. To get the FOPDT model for heating process of glycerin bleaching process, full step change between 4mA to 20mA, given by 16 mA, has been

injected into the plant. Based on the information of output response from the process, the parameter of the FOPDT model for heating process of the glycerin bleaching plant process is estimated and the model is shown in Eq (2).

$$G(s) = \frac{u(s)}{r(s)} = \frac{5393e^{-125s}}{1832s+1} \quad (2)$$

IV. DAHLIN'S CONTROLLER

A very famous Straight method digital control algorithm [10] was proposed by Eric Dahlin's in 1968. Dahlin's controller is in the form of the discrete form. Mostly this controller is used in the paper industry. Now in modern days is used in all chemical & Thermal process Industries.

In many cases, it is possible to get two dissimilar kinds of characteristic processes in industry: the ones is model by a motionless gain K , a dead-time τ and some time constants T_i ($i = 1, 2, \dots, n$). The transfer function is given by the

$$G_p(s) = \frac{k_p}{(1+T_1s)(1+T_2s)\dots\dots(1+T_ns)}e^{-\theta s} \quad (3)$$

The a new one is described with an integrator, a velocity gain K , a delay-time is θ and time constant T_i ($i = 1, 2, \dots, n$), and the transfer function given by

$$G_p(s) = \frac{k_p}{(1+T_1s)(1+T_2s)\dots\dots(1+T_ns)}e^{-\theta s} \quad (4)$$

In above two cases, the left side of $G_p(s)$ shows the delay open of process, and two of supposed models (3) and (4) can be taken into consideration as generalization of more accurate models. The Block diagram of Dahlin's algorithm based controller is shown in Fig.4, where T is sampling time, $G_h(s) = \frac{1-e^{-Ts}}{s}$ is zero-order hold, $D(z)$ represent the Dahlin's controller and $G(z)$ refers to the Z-transform of the zero order-hold device in series with the process being on is

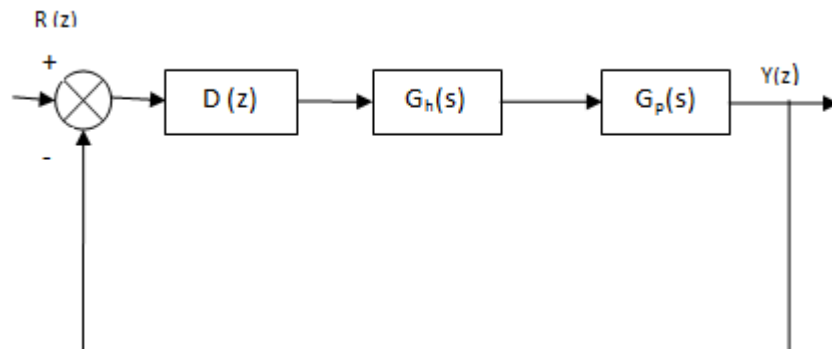


Figure 4. Block Diagram of Dahlin's Controller controlled.

The Dahlin controller[9, 10] is based on a direct control synthesis. The feedback formulas is given by the

$$W(z) = \frac{D(z)G(z)}{1 + D(z)G(z)} \quad (5)$$

Where $D(z)$ is given by the

$$D(z) = \frac{1}{G(z)} \frac{W(z)}{1 - W(z)} \quad (6)$$

Dahlin's Controller Design for the FOPDT Transfer function is given by is simple method, first we given by the first order plus delay time is given by the

$$G(s) = \frac{u(s)}{r(s)} = \frac{K e^{-\theta s}}{TS + 1} \quad (7)$$

For that Delay for the Dahlin's controller is given by the first we find the $G(z)$
The $G(z)$ is given by the

$$G(z) = Z\left[\frac{1 - e^{-Ts}}{s} Gp(s)\right] \quad (8)$$

Then the Dahlin's algorithm $D(z)$ is given by the

$$D(z) = \frac{1}{Gp(z)} \frac{(1 - \alpha)z^{-(N+1)}}{1 - \alpha - z^{-1} - (1 - \alpha)z^{-(N+1)}} \quad (9)$$

For the glycerin bleaching process we taken the FOPDT model transfer function shown in above .We taken the sampling period of that process is 125 seconds. Then the $D(z)$ is given by the equation

$$D(z) = \frac{0.656z + 0.0654}{377.54z^2 - 35.112z - 26.47}$$

V SIMULATION RESULTS

For Dahlin's Controller

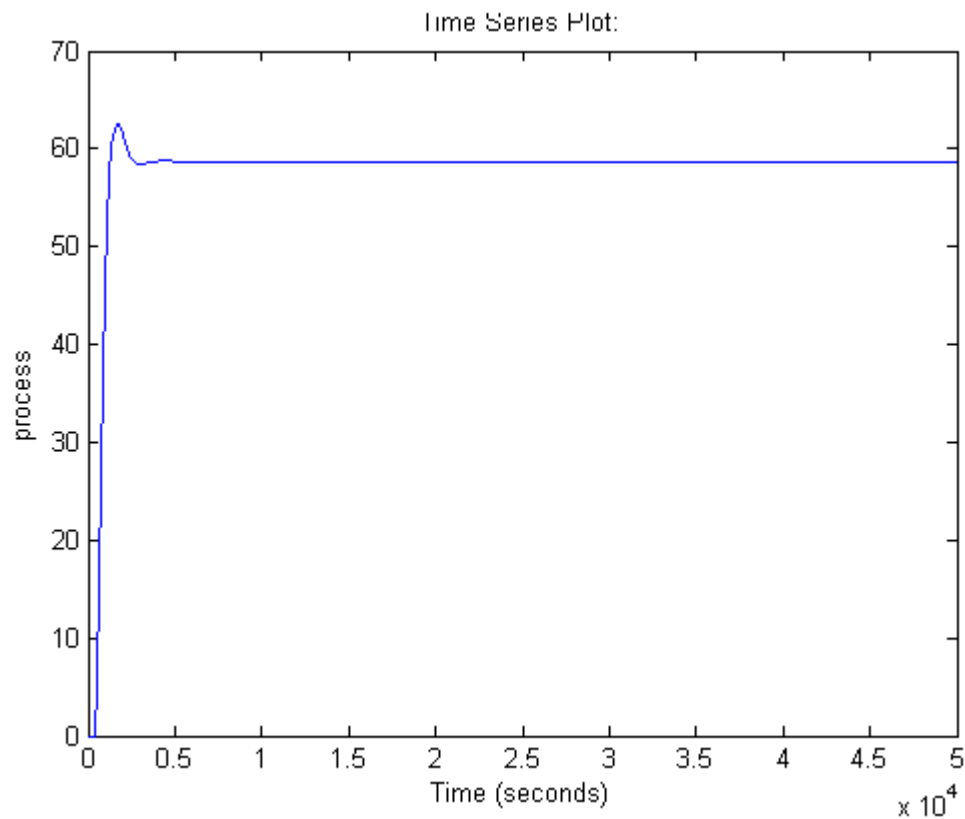


Figure 5 Simulation Result for Dahlin's Controller for Glycerin Bleaching Process for set-point 58.

TABLE I

Controller	Settling time (seconds)	Raise Time (seconds)	Peak overshoot (°C)
Dahlin'sController	4500	2000	4
PID Controller	10290	6500	6.5

In the above table we compared the results of the both controllers given by the Dahlin's controller & PID Controller by settling time, rise time & peak overshoot.

VI. CONCLUSION

Dahlin's controller is simple, familiar control algorithm and good for controlling processes with long dead times. The Dahlin algorithm is a simple solution to those problems and was used to improve the performance of classical PID controller for

plants with time delay. The benefits of Dahlin's Controller are discrete time systems are that digital controllers can be designed through straight techniques. The above Dahlin's structure is suitable for the controlling the huge time delay system. So, we compare the both techniques given by the PID controller, Dahlin's Controller by Settling time, Rise time, Overshoot. So for the Long Dead time Process as discussed in the article, the Dahlin's Controller gives better response.

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