TUNING AND CONTROL STRATEGIES OF TATORAY SPLITTER

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Abstract - This paper describe on various methods to tune the PI and PID controller for a first order plus time delay (FOPTD) transfer function and to develop block diagram for various control strategies. FOPTD transfer function estimation has been performed using MATLAB Identification Toolbox which input output data is acquired from splitter unit. Parameters gains from FOPTD are used to simulate the PI and PID tuning for each control strategies develop in the SIMULINK block diagrams. Analysis made based on the closed loop performance criteria that indicate the most stable system, good set- point tracking, offset elimination, and robust control system. The performance of a control system relates to its ability to deal with the deviations between controlled variables and their set-points. Graph analysis from PID output performance required less oscillation, fast settling time, and rapid response to input change.

Index Terms - Control, Splitter, Strategies, Tuning

I. INTRODUCTION

The PID controller is the most popular controller used in process control, because of its remarkable effectiveness and simplicity of implementation. Although significant developments have been made in advanced control theory, more than 95% of industrial controllers are still PID, mostly PI, controllers [1]. Even if more sophisticated control laws are used it is common practice to have a hierarchical structure with PID control at the lowest level. Although this controller has only three parameters, it is not easy to find their optimal values without a systematic procedure [2]. As a result, good PID tuning methods are extremely desirable due to their widespread use.
The purpose of tuning is to adjust the controller parameters so that the control system can achieve that balance as quickly as possible. Two early controller tuning relations were published by Ziegler and Nichols and Cohen and Coon. The closed loop control system attempts to achieve a balance between supply and demand by comparing the controlled variable to the set point and regulating the supply to an amount which will maintain the desired balance [3]. PID is a continuous feedback loop that keeps the process flowing normally by taking corrective action whenever there is any deviation from the desired value (set point) of the process variable. An "error" occurs when an operator manually changes the setpoint or when an event (valve opened, closed, etc.) or a disturbance changes the load, thus causing a change in the process variable. The PID controller receives signals from sensors and computes corrective action to the actuators from a computation based on the error (proportional), the sum of all previous errors (integral) and the rate of change of the error (derivative) [4]. In this research, the dynamic model of the splitter is constructed in simulink. Output performance of conventional PID tuning formulas can be performed and analyze through various control strategies using M-File and Simulink. First is to develop the mathematical model for the process. Then the transfer function for the process. Develop M-File coding and block diagrams for various control strategies. The response of the process in closed loop tuning PID controller using simulation.

II. METHODOLOGY

A. Process model

Any description of a system could be considered to be a model of that system. Although the ability to encapsulate dynamic information is important, some analysis and design techniques require only steady-state information. Models allow the effects of time and space to be scaled, extraction of properties and hence simplification, to retain only those details relevant to the problem. The use of models therefore reduces the need for real experimentation and facilitates the achievement of many different purposes at reduced cost, risk and time. In terms of control requirements, the model must contain information that enables prediction of the consequences of changing process operating conditions. Model could be a mathematical, statistical or qualitative description of specific aspects process behavior.

B. Transfer function

A transfer function is a mathematical representation of the relation between the input and output of a system .The transfer function is commonly used in the analysis of single input single output systems. The term refers to linear, time-invariant systems (LTI). Most real systems have non-linear input/output characteristics, but many systems, when operated within nominal parameters have behavior that is close enough to linear that LTI system theory is an

acceptable representation of the input/output behavior.

Most processes can be modelled by equations of the following form in the Laplace domain. Many processes may be higher order than second order plus delay time model. Below is some of the process model characteristics consist of gain K, time constant T and delay time τ.The steady state gain is the ratio of the output variable change to an input variable change when the input is adjusted to a new value and held there, allowing the process to reach a new steady state.

First order

$$\frac{Y}{X} = \frac{K}{Ts + 1}$$

First order delay time

$$\frac{Y}{X} = \frac{Ke^{-\tau s}}{Ts + 1}$$

Second order

$$\frac{Y}{X} = \frac{K}{(T_1 s + 1)(T_2 s + 1)}$$

Second order delay time

$$\frac{Y}{X} = \frac{Ke^{-\tau s}}{(T_1 s + 1)(T_2 s + 1)}$$

X = input
Y = output
τ = delay time
s = Laplace operator T, T1, T2 = time constants

C. Control strategies

Adaptive control systems have evolved and attempt to avoid degradation of the dynamic performance of a control system when environmental variations occur. Adaptive is oriented toward the elimination of the effect of structural perturbations upon the performances of the control system

Feedback is designed to achieve and maintain the desired process output conditions by measuring the output variable and checking its value against a preset target point (the set point), then modifying the controlled input variable to reach this set point .Feedback control is more successful in reaching the target set point than feedforward control but it responds more slowly since it reacts only to an output upset that is detected only a certain length of time after a process input has changed and caused the upset.

Feedforward control is based on measuring the change in a process unit, anticipating the effect that the change will have on the process and automatically taking corrective action on another input variable to counteract the change . It is usually specified where changes in process inputs occur so frequently that the feedback controller cannot keep up or if the disturbances are so large that the controlled variable cannot be kept within tolerable limits.

In certain processes, it is often necessary to maintain the relative proportions of two variables constant by ratio control. Ratio control is a special type of feedforward control that has been widely used in the process industries. The main purpose is to maintain the ratio of two variables at a specified value. The actual ratio of the two process variables is controlled rather than controlling the individual variables

Cascade control design considers the likely disturbances and tailors the control system to the disturbance(s) that strongly degrades performance. The control uses an additional, “secondary” measured process input variable that has the important characteristic that it indicates the occurrence of the key disturbance. In another words, a cascade control strategy combines two feedback controllers, with the primary controller’s output serving as the secondary controller’s set point.

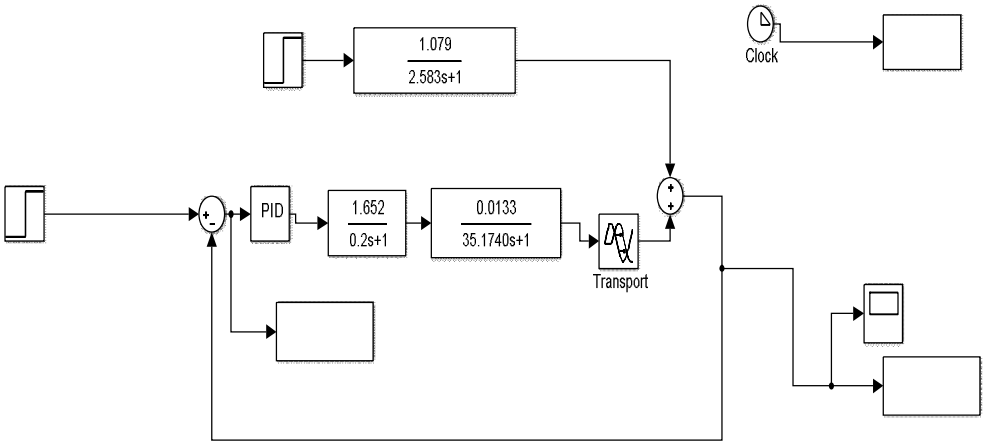


Fig 1 Feedback control strategies in SIMULINK

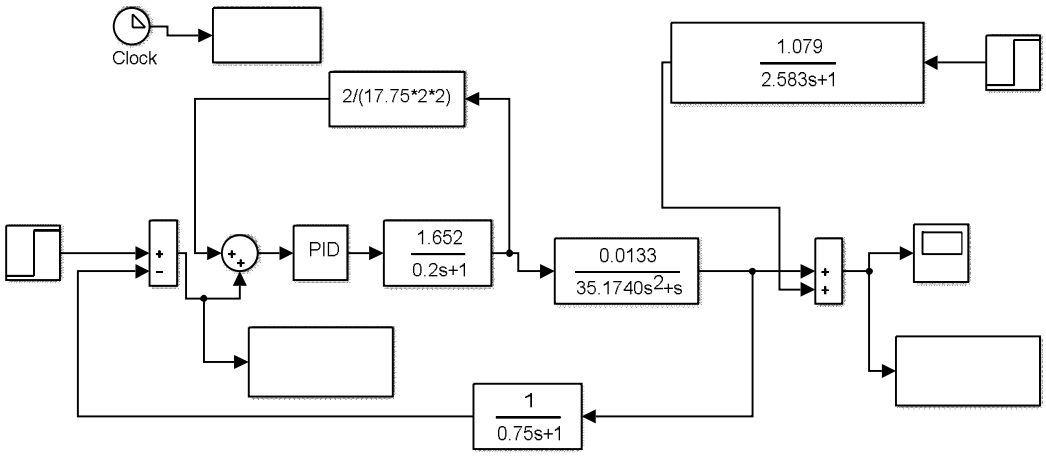


Fig 2 Adaptive control strategies in SIMULINK

As a first step of the devise method, the process to be controlled is modelled from sample data as a first-order plus dead-time (FOPDT) transfer function by estimation of Process Model, a simple continuous time model consists of transfer function parameters. Identification process had been done using MATLAB System Identification Toolbox. PI and PID controllers tuning formula according to several methods proposed in the literature. Both controllers applied to various control strategies develop in the MATLAB Simulink block diagram

III. RESULT AND DISCUSSION

Different tuning methods have been applied for PI and PID controllers. Comparison of the best performance output response to set point had been done for each control strategy. The optimum performance require less oscillation , less overshoot , less error and fast settling time to the set point. From analysis, Cohen Coon tuned PI controller generally give optimum performance for all control strategies and tuning method by Zhuang Atherton is favorable for PID controller.

The reasons for selection are:
Faster settling time - means that the controlled variables reach the steady state in very short period of time. Thus, the interruption cause by the set point is being minimized.
Less overshoot – normally related to the deviation in the manipulated variables or the relative valve opening.
Less oscillation– less error occur between the set point and the current value of the controlled valve. This can improve the stability of the process and minimize the interruption of the process.
Case A: Best performance selected for PI controller

Generally from the sample case study below show that TRC and TRC1 give optimum response to Cohen Coon tuned PI controller while TRC2 and TRC3 are not well response.

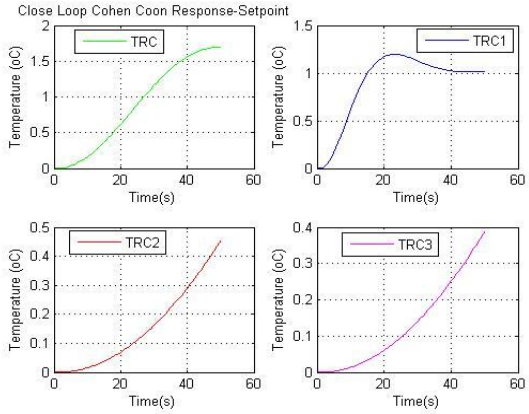


Fig. 3 Temperature vs. time for Adaptive control

First graph is not that favorable as control variable TRC do not reach the set point value after 40 sec. TRC 1 give optimum response with slightly overshoot and reach steady state after 40 sec. Meanwhile, TRC2 and TRC3 are not well response with Cohen Coon tuned PI controller as it takes long time to reach steady state.

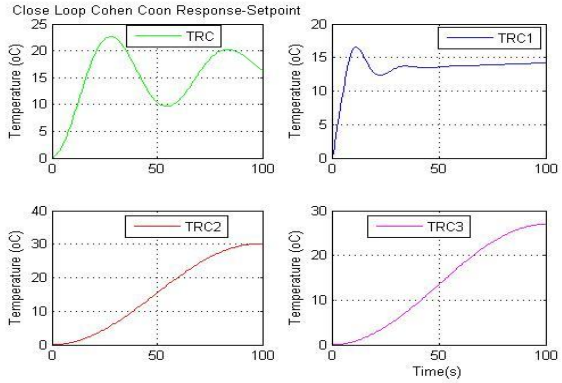


Fig. 4 Temperature vs. time for Classical control

TRC give some oscillation before settles at 100 sec. For TRC1 slightly overshoot and deviates within first 25 sec before reach steady state. In this figure shows that TRC2 and TRC3 give favorable response to Cohen Coon method compare to other control strategies

Case B: Best performance selected for PID controller

PID controller give better performance for this process control due to most of the graphs for TRC2 and TRC3 are well response to the set point changes compare to the PI controller. Zhuang Atherton tuning formula shows high performance than other tuning method for all control strategies applied.

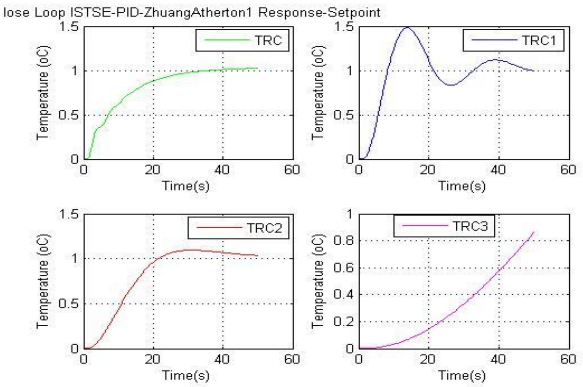


Fig.5 Temperature vs. time for Adaptive control

First graph give optimum performance with no oscillation, deviates up at 25 sec and settles almost at 30 sec. Oscillation occurs in the second graph up to 50 second before reach the set point value. For TRC2 also give optimum response with no oscillation .Slightly overshoot before reach steady state at 50 sec. TRC3 is not well perform as it takes long time to settle for steady condition.

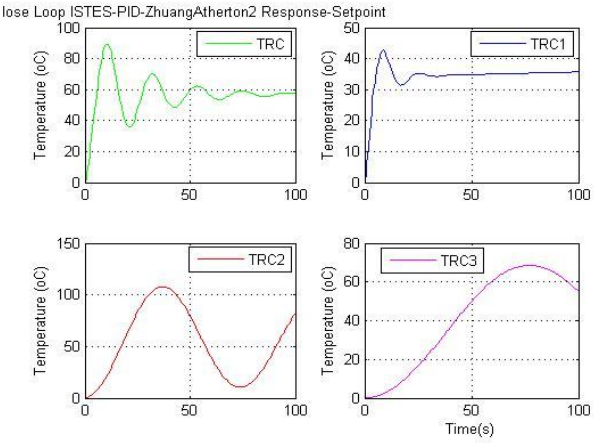


Fig. 6 Temperature vs. time for Feedback control

Some oscillations occur before TRC output reach set point at 100 sec. TRC1 gives fast settling time at 40 sec with slightly overshoot at the beginning. Tuning for TRC 2 is not that favorable due to some oscillations and still not reach settling time.TRC3 is slightly overshoot within 100 sec before settles to set point.

CONCLUSION

Comparison have been made to show the area under the graph obtain for all output applied to differ control strategy. The results shows that for TRC and TRC1, feedback control is outperform than other control strategies. While classical control gives the best control strategy for output TRC2 and TRC3. These control strategies give better performance when using PI controller. For PID controller shows the same feedback strategy outperform for both TRC and TRC1 while for TRC2 and TRC3, adaptive control gives the best performance of control system . In overall performance, feedback control gives more superior control for PID controller and classical control gives optimum performance for PI controller for this process.

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