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Cascade PID-Lead Compensator Controller for Non-overshoot Time Responses of unstable system

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Abstract

In process control industries, one of the major and serious problems is presence of overshoot on controlled variables. This paper deals with the elimination overshoot in step response by using conventional PID controller with cascading of lead compensator. The proposed cascade technique consists of inner loop with lead compensators and outer loop with PID controller. The processes industry consists of many control loops and most of the control loops are consists of PI and PID controller. The PI/PID controller is used in the control loop with unstable system, the time response is oscillatory due to gain margin and phase margin. The proposed idea is to use the cascade control principle to control the unstable system with cascaded PID and Lead compensator. The compensator is used to compensate desired phase margin value of system and then make use of the PID controller is to control the system with robust, reduced order response, and thus, suppressing the overshoot in time response. The validity of the proposed approach is verified through simulation for the level control of unstable biochemical reactor.

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Keywords: PID Controllers, Cascade Control, Overshoot, Unstable System,Bioreactor.

1. Introduction

The conventional PID controller is still standard in process industry because it is an efficient control method compare to other controllers. The most important issue of PID controller is to design the control for unstable First Order Plus Dead time (FOPDT) system. Many methods are used to determine the Proportional plus Integral plus Derivative (PID) controller parameters in Single Input Single Output (SISO) unstable FOPDT systems. The methods

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for tuning of PID controller parameters for the control of unstable FOPDT systems are modified with the help of Ziegler- Nichols (Z-N) method, IMC tuning method, pole placement method, optimization method, two degrees of freedom method and synthesis. However, these methods are somewhat complicated when compared to the simple tuning method proposed by method proposed by Padma Sree et.al [8] and the PID controller parameters equations are related to process parameters.

The many controller structures are used for process control applications and one of the most popular structures is cascade control and it is used to improve the dynamics response of the closed loop system. A cascade control system is used to every control feedback problem and it consists of inner and outer feedback loops. The inner loop has good impact over the outer loop. The inner loop controller actions should affect the primary control variable in a desirable way. The inner loop is fast response than the outer loop. It allows the secondary controller sufficient time to compensate for inner loop feedback before they can affect the outer loop feedback. In recently, the cascade controller design for unstable FOPDT system was brought attention to the researchers. A parallel cascade controller is implemented for the open loop unstable control processes [1]. The secondary loop of parallel cascade controller is proportional (P) controller and primary loop is proportional integral controller is used. Three case studies are considered in this proposed work and simulated. The first case involves a stable secondary loop process and an unstable primary process, the second case involves both unstable primary and secondary processes and the third one, a simulation application to a nonlinear bioreactor model equations. This method provide gives improved performance and more robust while comparing with relay auto-tuning method, synthesis method and minimizing ISE criterion method.

A finest H_∞ internal mode controller [2] is designed to control the unstable cascade processes with time delays. The primary controller of cascade control structure is designed with a PID in series with a lead-lag filter based on IMC scheme using optimal H_∞ minimization. This proposed method provides significant improvement and also provides robust closed loop performances. A new series cascade control structure [3] to improve the closed loop performance which is proposed for integrating and time delay processes. IMC approach based inner loop controller is designed and primary set-point filter is based on optimal performance index. Simulation shows satisfactory nominal and robust performance which demonstrates efficiency of the proposed method. An Internal Model Control plus Proportional-Integral-Derivative (IMC–PID) tuning procedure for cascade control systems [4] is proposed based on the inner loop and outer loop gain and phase margin specifications. This technique is precise and simple, suitable technique for the PID tuning of cascade control systems in different applications such as mechanical, electrical or chemical systems. A new cascade controller [5] is designed based on typical forms are suggested to improve the performance of cascade control. The proposed controller is demonstrated and its advantages over some existing design methods. Most of the methods in the literature, based on the enhancement of existing cascade controller. This paper also deals with enhance the cascade controller performance for the control of unstable FOPDT system is shown in Fig.1.This control technique consists of PID controller in outer loop of cascade control and Lead compensator is act as inner loop. This proposed method is to provide a closed loop response without peak overshoot and improve the speed of the response.

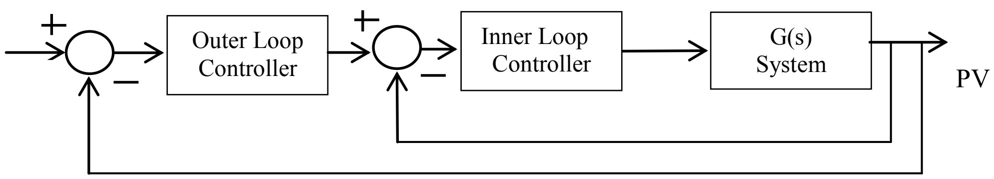

Fig. 1. General Structure of Cascade control system

The concentration control of unstable bioreactor is considered and designs a cascade controller for concentration control of bioreactor system without any additional actuator. A control valve can manipulate a feed flow rate instantaneously in comparison with actual level and desired tank level. The disturbance to the inflow rate is considered in the inner loop and a control valve adjusts the inflow rate in comparison with measured actual inflow and easily controlled by the flow controller. The inner loop disturbances are as much as low than the outer loop disturbances. Or else, the secondary controller will be correcting disturbances of secondary process constantly and unable to apply corrective efforts to the primary process. The main drawback of cascade control is increment of overall equipment cost and more complicate than single-measurement controllers, requiring twice as much tuning.