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Design of Self-Tuning Fuzzy PI controller in LABVIEW for Control of a Real Time Process

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Abstract- Pressure control systems constitute the heart of many process plants. Linguistic modeling and decision-making processes like fuzzy and neural controller are very much useful to control the complicated processes. An intelligent control strategy has been proposed and successfully applied to a real time water pressure control system. For the variation of set point change and load disturbance, an intelligent control scheme has been developed by integrating self-tuning scheme with fuzzy PI controller. Satisfactory industrial application results show that such a control scheme has enhanced adaptability and robustness to the complex processes. To demonstrate the performance of the self-tuning fuzzy PI controller (STFPIC), results are compared with a fuzzy PI controller (FPIC). It is observed that the proposed controller structure is able to quickly track the parameter variation and perform better in load disturbances and also for set point changes.

Keywords – Fuzzy controller, Self-Tuning, Pressure Control

I. Introduction

The result of automatic control must always be evaluated in terms of the quality of the finished product rather than in terms of accuracy or deviation of the controlled variable. The general purpose of automatic control is to obtain maximum efficiency of process operation. The PID controllers can successfully regulate a majority of industrial processes by meeting various specifications under consideration. However, the capabilities of the PID controllers are significantly reduced when they are applied to systems with nonlinearities such as saturation, relay, hysteresis, and dead zone. Also classical control theory requires mathematical model for the plant that allows for the design of the controller. The fact that there are fuzzy logic approaches that allow controllers to be designed without any need for a plant model, can be considered as very positive. It has been reported that fuzzy logic controllers (FLCs) are suitable for high-order and non-linear systems and even with unknown structure [1-3].

The aim of fuzzy techniques is to get ahead of the limits of conventional techniques, and to improve existing tools by optimizing the closed-loop dynamical performances. A number of approaches have been proposed to implement hybrid control structures that combine conventional controllers with fuzzy logic techniques to control the nonlinear systems [4, 5]. Among the various types of hybrid controllers, just like the widely used conventional PI controllers [6] in process control systems, PI-type FLC's are most common and practical followed by the PD-type FLC's [7, 8]. Because proportional (P) and integral (I) actions are combined in the proportional-integral (PI) controller to take advantages of the inherent stability of proportional controllers and the offset elimination ability of integral controllers.

It is well known that most industrial control systems in practice are usually non-linear and higher order systems with considerable dead time, and their parameters may be changed with changes in ambient conditions or with time. In a conventional FLC, like fuzzy PI controller (FPIC) this non-linearity is tried to be eliminated by a limited number of IF-THEN rules, but it may not produce desired control performance with fixed valued SFs and simple membership functions (MFs). In spite of a number of merits, there are many limitations while designing a fuzzy controller, since there is no standard methodology for its various design steps, and no well-defined criterion for selecting suitable values for its large number of tunable parameters. Attempts have been made to tune the control rules to achieve the desired control objectives. But, the tuning of a large number of FLC parameters can be a tough task [2]. Such problems may be eliminated by adopting self-tuning schemes [9-12]. Here, a simple self-tuning scheme is used to continuously update the controller gain with the help of fuzzy rules.