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TITLE:

COMPARISON OF RULE-BASED TUNING FOR PI CONTROLLERS

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AUTHOR’S DECLARATION

“I hereby declare that this report is my own work except for quotations and summaries which have been duly acknowledge.”

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ABSTRACT

This study explores the efficiency of different PID controller tuning methods, including Ziegler-Nichols, Cohen-Coon, and Takahashi, in process control systems. PID controllers are widely used in industrial settings, particularly for temperature control, but traditional tuning methods often come with challenges like instability and overshooting. Through experimental analysis, the study finds that the Cohen-Coon method outperforms the others by reducing settling time and Integral Absolute Error (IAE), making it more stable and effective in handling system disturbances.

The research also delves into the core concepts of open-loop and closed-loop control systems. Open-loop systems operate using preset inputs without feedback, while closed-loop systems continuously adjust based on real-time feedback to maintain desired performance. This feedback mechanism plays a key role in achieving precise control and improving energy efficiency in industrial operations.

Using experimental analysis, the study evaluates PID controller performance based on parameters derived from the Ziegler-Nichols open-loop test, such as response rate, dead time, and time constant. The comparison of tuning methods highlights Cohen-Coon as the most effective in ensuring quick stabilization and minimal error. These findings offer valuable insights for optimizing future process control systems and developing more adaptive industrial automation strategies.

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CHAPTER 1

BACKGROUND

1.1 Introduction

PID (Proportional-Integral-Derivative) controllers are widely used in industrial applications because they are simple, flexible, and easy to implement. They play a crucial role in controlling processes like temperature and flow, making up about 90% of the industry's control loops. However, for more complex and dynamic systems, traditional tuning methods like Ziegler-Nichols (Z-N) often fall short of delivering optimal performance. Issues such as high overshoot, sensitivity to parameter variations, and inadequate transient responses have led to the need for more advanced tuning techniques (Chopra, Vikram, 2014/ Bob81, Vladimir). The Ziegler-Nichols tuning method is one of the oldest and most commonly used approaches for determining the optimal parameters of PID controllers. It simplifies the tuning process by analysing how the system responds to step changes, providing key parameters such as Proportional Gain (Kp), Integral Time (Ti), and Derivative Time (Td) to achieve a balance between stability and performance. While this method is beneficial, it often results in oscillatory responses and significant overshoot, particularly in systems with complex dynamics. (Wiharya, C, 1 Feb 2021, Riyanto, Agus, 2018).

In recent years, advanced tuning methods like Cohen-Coon (C-C) and Takahashi have been introduced to enhance PID controller performance. These techniques adjust PID parameters dynamically based on changing system conditions, resulting in faster settling times, reduced overshoot, and greater stability. Additionally, modern approaches such as recursive identification techniques and sophisticated algorithms have been used to develop digital PID controllers with auto-tuning capabilities. This allows for real-time, adaptive control in industrial settings, making these methods particularly useful in applications like power plant systems and fermenter temperature control. (Bob81, Vladimir). Temperature control is crucial in industrial systems, particularly in processes like water heating and heat exchangers. Maintaining precise temperature levels ensures energy efficiency, process stability, and high product quality. PID (Proportional-Integral-Derivative) controllers remain the preferred choice for temperature regulation due to their simplicity, reliability, and effectiveness in maintaining consistent control. (Wiharya, C, 1 Feb 2021, Riyanto, Agus, 2018, Khare, Yuvraj Bushan, Yaduvir Singh, 10 Oct 2010).

Process control systems are generally classified into two main types: open-loop and closed-loop control. Open-loop control systems, also known as non-feedback systems, operate without monitoring or adjusting based on the output. In these