Tuning of the PID Controller to the System with Maximum Stability Degree using Genetic Algorithm

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Abstract—**In this paper is proposed a tuning algorithm of PID controller that offers the maximum stability degree of the control system, based on the genetic algorithm. The tuning algorithm was designed based on the maximum stability degree method with iterations, where the tuning parameters depend on maximum stability degree which is varied. Based on its values, it was proposed to implement genetic algorithm to find the tuning parameters. The maximum stability degree method permits to obtain the high stability and high performance of the system, but this method has some limitations in case when control object is described by the model of object with inertia low order. In this case to find the best tuning parameters was proposed to use the genetic algorithm. For efficacy analysis of the proposed algorithm, there are presented some case studies and practical applications.**

Keywords—PID controller; genetic algorithm; automatic control system; maximum stability degree method

I. INTRODUCTION

Proportional (P), Proportional Integral (PI) and Proportional Integral and Derivative (PID) controllers have been the heart of control engineering practice for seven decades [3], but the practice of the automation of the technological processes demonstrates that PI and PID controllers remain poorly understood and poorly tuned in many industrial applications. In case when controller is tuned incorrectly, it can lead to low performance of the automatic control system and as result low quality of the output final product. Nowadays, there are proposed many methods for tuning the P, PI and PID controllers:

- experimental methods, which start from the some simple assumptions and obtained values of the tuning parameters. One of these methods is the Ziegler-Nichols method, where the calculation of the tuning parameters of the PID controller are simple. However, this method provides the oscillating transient processes with a low damping rate [1-4];

- the graph-analytical methods offer to the designed system the satisfactory performance, but require a big volume of calculations and graphical representation [1-4];

- the optimization methods which can offer so good performance of the control systems and can be applied to the complex model objects, but these methods are required big volume of calculations.

Besides this, nowadays the artificial intelligence approaches such as evolutionary algorithms, fuzzy logic, neuronal network are widely used in case of optimization problem of tuning the PID controller [14-17].

In [5, 10], it is proposed the maximum stability degree method for tuning the typical controllers. This method permits to obtain the high performance and good robustness of the automatic control system. But this method in the classical version it is not applied in case of tuning the PID controller to the model of object with first and second order inertia, and it is applied the iterative procedure for finding the tuning parameters [11-12].

According to this, in this paper was proposed to tune the PID controller to the model of object with first and second order inertia using the maximum stability degree method with iterations, but the iterative procedure of finding the tuning parameters of the PID controller, it was proposed to be optimized based on the evolutionary approach and namely the genetic algorithm.

II. TUNING OF THE PID CONTROLLER BY THE MAXIMUM STABILITY DEGREE METHOD WITH ITERATIONS

One of the criteria, which is used for designing of the automatic control systems, is the maximum stability degree criterion [13]. This criterion supposes the maximum displacement in the complex half-plane of the nearest characteristic equation's roots of the designed system to the imaginary axe $Re\ p_i \leq 0$ (Fig. 1). This permits to obtain the reducing of the duration of the transient response and to ensure the high stability degree of the system.

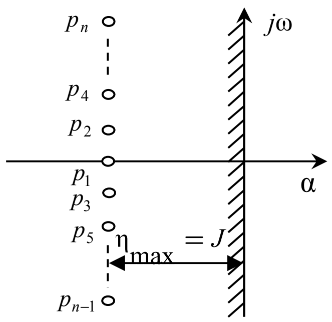

Fig.1. Placement of the characteristic equation's roots in the complex plane for the system with maximum stability degree.